Module | Modeling of Complex Systems
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Code | MSLS_T15
Degree Programme | Master of Science in Life Sciences (MSLS)
ECTS Credits | 3
Workload | 90 h: Contact 42 h; Self-study 48 h
Module Coordinator | Name: Prof. Dr. Sven Hirsch
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| Life Sciences and Facility Management
| Campus Reidbach
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| CH-8820 Wädenswil
Lecturers | Dr. Sven Hirsch and external lecturers
Entry Requirements | • Students should have basic statistics experience at the bachelor level, including:
| descriptive statistics, two-sample tests (parametric and non-parametric),
| correlation measures, probability distributions such as normal and binomial
| distribution, basics of probability theory.
| • Students should know fundamentals of ordinary differential equations as taught
| at the bachelor level.
| • Students will have to complete an entry self-test (Moodle) in advance of the
| module
| • Students will have to install a systems dynamics software prior to the course
| (details will be provided on Moodle)
Learning Outcomes and Competences | After completing the module students will be able to:
| • describe different aspects of system theory and assess where and how system
| theory is applied to real-world problems;
| • apply different qualitative methods for analyzing system models (graphs,
| feedbacks, active-passive Matrix, Vester’s paper computer);
| • reproduce the key elements of system dynamics and its implications for
| technical implementation;
| • use a mathematical tool (Vensim) to implement and simulate a dynamical
| system;
| • apply optimization techniques to fit model predictions to experimental findings;
| • apply Monte-Carlo simulation to perform parametric studies of a model;
| • apply the learned methods to model and analyze systems on their own;
| • be able to communicate and motivate a model to an audience.
Module Content | The course introduces basic mathematical tools and software used for the modeling
| and analysis of real-world systems in the context of life sciences. The following
| contents are taught in this course:
| • Introduction into system theory / system dynamics
What is a complex system? What is its purpose?
Overview and characterization of various systems (static/dynamical systems, discrete and continuous systems)
Introduction to mathematical models used for the modeling and analysis of systems, including differential equations.
Properties of linear, non-linear and chaotic systems

- Introduction into tools and methods used for system analysis and modeling
  - Basic modeling using software tools (e.g. Vensim, Excel)
  - Analysis of equilibrium and stationary states
  - Numerical integration methods
  - Introduction to stability analysis and convergence testing

- Advanced system dynamics techniques
  - Parameter optimization for fitting model behavior to experimental data
  - Monte-Carlo simulation to perform parametric sensitivity studies

- Detailed case studies of systems and their modeling with examples from environmental sciences, biology, chemistry, industrial processes, and economics, e.g. plant dynamics, bacterial population behavior, drug reactions, or buyer/seller market dynamics

- Practical communication and documentation of a model
  - Argumentation and motivation of a model logic
  - Visualization of the model structure and its behavior

- Project work (self-study/assessment)

### Teaching / Learning Methods
- Lectures ~30%
- Student projects with focus on systems modeling ~50%
- Self study (including e-learning unit) ~20%

### Assessment of Learning Outcome
The assessment consists of a project assignment (practical study). The individual projects will be conceived and developed during the course. The project will be finalized and documented after the module.

### Bibliography
- **Course Book**

- **Introductory material:**
  - D. Aronson, Overview of Systems Thinking, [http://www.thinking.net/Systems_Thinking/OverviewSTarticle.pdf](http://www.thinking.net/Systems_Thinking/OverviewSTarticle.pdf)
  - K. North, An Introduction to Systems Thinking, [http://courses.umass.edu/plmt597s/KarlsArticle.pdf](http://courses.umass.edu/plmt597s/KarlsArticle.pdf)

  Important literature and lecture notes will be provided on Moodle.

### Language
- English

### Comments
- We mainly use Vensim PLE for visual programming of complex systems. A temporary license for Vensim PRO will be provided for the duration of the course.

### Last Update