MASTER OF SCIENCE
IN ENGINEERING

Module description

Multiphysics Modeling and Simulation

General information

Number of ECTS Credits

3

Abbreviation

TSM_Multiphy

Version

22.03.2016

Responsible of module

Dr. Jürgen Schumacher, ZHAW

Language

	Lausanne	Bern	Zürich
Instruction	☐ E ☒ F	☐ D ☐ E ☐ F	☐ D ☒ E
Documentation	☒ E ☒ F	☐ D ☐ E ☐ F	☐ D ☒ E
Examination	☐ E ☒ F	☐ D ☐ E ☐ F	☐ D ☒ E

Module category

☐ Fundamental theoretical principles
☒ Technical/scientific specialization module
☐ Context module

Lessons

☒ 2 lecture periods and 1 tutorial period per week
☐ 2 lecture periods per week

Brief course description of module objectives and content

The module gives students insight into the modeling and simulation of coupled effects (multiphysics). Students learn the methodical procedures that are necessary for successfully solving modeling and simulation problems in the different areas of engineering and physics. The consolidation and deepening of the theoretical knowledge is achieved on the basis of specific problems that are solved with the appropriate methods and programs (MatLab, Comsol Multiphysics) .

Aims, content and methods

Learning objectives and acquired competencies

Students are in a position to model and simulate local and spatially distributed systems of the type that are encountered in the engineering sciences.
Students are in a position to describe a real problem in physical and mathematical terms. They are able to recognize symmetries and to benefit from them. They are aware of which simplifications can be made and what influence they have on the results.
The students know different numerical solution methods and the available equation solvers and finite element packages for solving ordinary and partial differential equations.
Students learn how to develop reliable models, to validate these and to designate their validity limits.
Students are in a position to critically interpret simulation results.

Contents of module with emphasis on teaching content

- Brush-up: ordinary and partial differential equations, starting/boundary conditions, general methods for solving differential equations.
- Modeling uncoupled physical phenomena through the application of conservation equations and material laws: transport of mass, energy, charge, momentum. Structural mechanics and flow mechanics are similarly covered in the course.
- Numerical discretization methods for solving partial differential equations: finite differences, finite elements, finite volumes and time discretization.
- Analysis of a multiphysics problem which is formulated analytically and can be solved with paper and pencil, e.g. coupling charge and energy transport in a single dimension.
- Introduction to the modeling of multiphysics problems that are solved with the finite element method. Exercises on the computer: input of the model geometry, generating a discretization grid, specification of physical material properties in the model.

- Case studies and exercises on the modeling of coupled problems: thermoelectric transport, fluid-structure interaction, coupling an incompressible flow with energy transport, micro-mixer, modeling of time and location-dependent signals in a human heart.
- Advanced multiphysics modeling: "coefficient form" of a conservation equation, conversion of a partial differential equation into the weak form. The weak form constitutes the basis for the finite element method.
Model validation and recognition of the validity limits of a model.

Teaching and learning methods

- Frontal teaching
- Practical work with suitable software packages
- Exercises
- Private study and literature study
- Individual and group assignments

Prerequisites, previous knowledge, entrance competencies

- Bachelor level in physics and mathematics (Newtonian mechanics, ordinary differential equations, elementary knowledge in vector and matrix calculation).
- Elementary knowledge of MatLab/Simulink or similar software packages

Literature

Assessment

Certification requirements for final examinations (conditions for attestation)

Successful completion of the modeling and simulation exercises.

Written module examination

Duration of exam: 120 minutes

Permissible aids:
- Module documents
- Textbooks