MASTER OF SCIENCE
IN ENGINEERING

Module Description

Optimization

General Information

Number of ECTS Credits

3

Abbreviation

FTP_Optimiz / FTP_Optimiz_DE / FTP_Optimiz_EN

Version

07.03.2016

Responsible of module

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Language

	Lausanne	Bern	Zurich DE	Zurich EN
Instruction	☐ E ☒ F	☐ D ☐ E ☐ F	☒ D ☐ E	☐ D ☒ E
Documentation	☐ E ☒ F	☐ D ☐ E ☐ F	☒ D ☐ E	☐ D ☒ E
Examination	☐ E ☒ F	☐ D ☐ E ☐ F	☒ D ☐ E	☒ 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

This course offers an introduction to optimization, emphasizing basic methodologies and underlying mathematical structures. Optimization refers to the application of techniques and mathematical methods to decision-making problems. A large number of quantitative real-world problems can be modeled and solved in this general framework. Applications of optimization comprise, for instance, decision problems in production planning, distribution networks, blending of components, work scheduling, telecommunication network design, and road traffic management.

Aims, content, methods

Learning objectives and acquired competencies

- The student has an overview of the various fields and approaches to optimization.
- The student has a basic mathematical and algorithmic understanding of the major optimization methods used in practice (LP, ILP, graphs, metaheuristics).
- The student is able to analyze basic real-world decision problems and formulate appropriate optimization models.
- The student is able to implement and solve basic LP/ILP models in a spreadsheet, or through the use of a special-purpose language (like AMPL, LPL, etc.) in combination with a solver.
- The student has developed a certain intuition on how to approach and analyze complex real-world problems, to correctly estimate their complexity, and to choose an appropriate modeling approach and implementation tool.

Contents of module with emphasis on teaching content

Week	Topics
1	**Introduction to Optimization** • Basic concepts: models, variables, data, constraints, objective, optima • Examples of models/problems of different types: linear/nonlinear, discrete/continuous, deterministic/stochastic, constrained/unconstrained • Solution methods: exact, approximative, heuristic • Global vs. local optima, basic ideas of convex optimization
2	**Linear Programming** • Mathematical formulation and terminology, canonical and standard form, transformations • Geometry: polyhedra, graphical representation, examples
3	

4	• Simplex algorithm • Sensitivity analysis
5	
6	**Integer Programming** • From LP to ILP: Why rounding does not work. • Branch-and-Bound, Branch-And-Cut • Typical applications • Modeling techniques: knapsack problem, set covering, packing and partitioning, etc.
7	
8	**Nonlinear Optimization** • Unconstrained multidimensional optimization: optimality conditions, Gradient- and Newton-methods
9	**Graphs and Networks** • Decision trees and heuristics • Paths and cycles • Network flows • Selected combinatorial optimization problems: traveling salesman problem, graph coloring, vehicle routing problem, multicommodity flows, etc.
10	
11	
12	**Heuristics and Metaheuristics** • Trajectory-based methods: hill climbing, tabu search, simulated annealing • Population-based methods: evolutionary algorithms, ant colony optimization
13	
14	

Teaching and learning methods

Lectures and exercises

Prerequisites, previous knowledge, entrance competencies

Linear algebra:

- Solving systems of linear equations with Gauss algorithm
- Vectors and matrices, eigenvalues and eigenvectors

Analysis:

- Calculus with functions of one variable
- Zeros of functions (Newton algorithm)

Programming:

- Basic concepts of procedural programming: elementary data types, variables, control structures (it, for, while) arrays, functions, parameter passing

Literature

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Assessment

Certification requirements for final examinations (conditions for attestation)

None

Written module examination

Duration of exam : 120 minutes

Permissible aids: Open book