Module Description

Optimization

General Information

Number of ECTS Credits

3

Abbreviation

FTP_Optimiz

Version

01.03.2017

Responsible of module

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Language

	Lausanne	Bern	Zurich
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

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 mathematical models and algorithms to decision making. A large number of quantitative real-world problems can be formulated and solved in this general framework. Applications of optimization comprise, for instance, decision problems in production planning, supply chain management, transportation networks, machine and workforce scheduling, blending of components, telecommunication network design, airline fleet assignment, and revenue 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 (Linear Programming (LP), Integer Programming (ILP), Nonlinear Programming, Optimization in 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.
- The student has developed a certain intuition on how to approach and analyze real-world optimization problems, to correctly estimate their complexity, and to choose appropriate modeling approaches and implementation tools.

Contents of module with emphasis on teaching content

Week	Topics
1	**PART 1:**
2	**Introduction to Optimization** • Basic concepts: models, variables, parameters, constraints, objective, optima • Examples of problems and models of different types: linear/nonlinear, discrete/continuous, deterministic/stochastic, constrained/unconstrained • Solution methods: exact algorithms, constructive heuristics, improvement heuristics • Global vs. local optima, basic ideas of convex optimization
3	**Linear Programming**
4	• Mathematical formulation and terminology, canonical and standard form, transformations • Geometry: linear inequalities, polyhedra, graphical representation, examples
5	• Simplex algorithm
6	**Integer Programming**
7	• Basic concepts • Branch-and-Bound method • Cutting Planes method • Various applications and modeling techniques
8	**PART 2:** **Nonlinear Optimization** • Unconstrained multidimensional optimization: optimality conditions, Gradient- and Newton-methods
9	**Graphs and Networks**
10	• Optimization in graphs • Paths and cycles
11	• Network flows • Selected combinatorial optimization problems
12	**Heuristics and Metaheuristics**
13	• Trajectory-based methods: hill climbing, tabu search, simulated annealing, ... • Population-based methods: evolutionary algorithms, ant colony optimization, ...
14	

Teaching and learning methods

Lectures and exercises

Prerequisites, previous knowledge, entrance competencies

Linear algebra:

- Systems of linear equations, Gauss algorithm
- Basics of vector and matrix algebra, linear spaces

Analysis:

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

Programming:

- Basics of procedural programming and ability to implement small programs in an arbitrary language, e.g. Python, Matlab, R, Java, C#, C++, C, etc.

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