INTERNATIONAL MASTER'S
SIMOS
SIMulation and Optimization of energy Systems

Numerical tools for optimization

Subject Information	
Code	UE3 S3
Credits (ECTS)	7
Semester	2 (mid-January - June)
Time Allocation (Lec. / Prac. / Lab/ Project)	20 h / 30 h / 0 / 50 h
Lecturer	Pr. Jean-Michel RENEAUME, Dr Sylvain SERRA.
Pre-requisites	
Assessment	Final written examination + project

Lec. : Lectures *Prac. : Practical works ("small classes")* *Lab.: Laboratories*

Subject Description	
Introduction	Optimization is one of the major quantitative tools for decision-making. Acquainting students with the optimization problem formulation (objective function, optimization variables and constraints) and solution (algorithms and software tools) is the primary aim of this subject.
Learning outcomes	After this course, students should: - be able to formulate an optimization problem - be able to characterize the formulated problem (LP, NLP, MILP, MINLP…) and select an appropriate optimization algorithm (Simplex, SQP, Branch and Bound, OA/ER) - have a basic knowledge of the main algorithm - be able to use the main tools: Excel®, GAMS®
Content	**I. Introduction** Motivation, scope, general formulation procedure, examples… **II. Unconstrained Optimization** 1. Basic Concepts Continuity, convexity, extremum, necessary and sufficient condition… 2. One-dimensional Search Scanning and bracketing procedure, Newton-like method… 3. Multivariable Optimization Direct methods, indirect methods, random search…

III. Continuous Constrained Optimization

1. Linear Programming
   Simplex method
2. The Theory of Constrained Optimization
   Lagrange multipliers, first and second order condition, duality…
3. Quadratic Programming
   Equality constraints, active set method…
4. Non Linear Programming
   Penalty function, Successive Quadratic Programming,

IV. Discrete Constrained Optimization

1. Dynamic Programming
   Bellman's principle
2. Mixed-Integer Programming
   Multi-period optimization, Branch and Bound
3. Mixed-Integer Non Linear Programming
   Bender's decomposition, Outer Approximation…

V. Multi-objective Optimization

Pareto optimal solution, ε -constraints Method, random search…

VI. Dynamic Optimization

1. Multi-period optimization
2. Discretization Methods

Control Vector Parametrization

3. Variational Methods
   Optimal control, Pontryagin's Maximum Principle…

VII. Global Optimization

Stochastic/deterministic methods

VIII. Process Optimization

1. General Environments
   GAMS, Excel…
2. Flowsheeting Environments
   ProSim Plus…

Typical Projects:

Heat Exchanger Network (HEN) Optimization
Synthesis of General Distillation Sequences
Pump Network Synthesis

Literature

Nonlinear and Mixed-Integer Optimization – Fundamentals and Applications. C.A. Floudas. Oxford University Press, 1995

Practical Methods of Optimization. R. Fletcher. Second Edition. Wiley-Interscience Publication, 1996

Optimization of Chemical Processes. T.F. Edgar and D.M. Himmelblau. McGraw-Hill International Editions, 1989.