Syllabus

Course Description

Course Title	Optimisation
Course Code	42169
Course Title Additional	
Scientific-Disciplinary Sector	MAT/09
Language	English
Degree Course	Bachelor in Industrial and Mechanical Engineering
Other Degree Courses (Loaned)	
Lecturers	Dr. Saman Babaiekafaki, Saman.Babaiekafaki@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/48578
Teaching Assistant	
Semester	Second semester
Course Year/s	2
CP	6
Teaching Hours	40
Lab Hours	20
Individual Study Hours	90
Planned Office Hours	18
Contents Summary	- Mathematical Preliminaries and Topological Aspects of Nonlinear Optimization - Modelling in the Framework of Nonlinear Optimization - Optimality Conditions for Unconstrained Optimization Models - Least Squares Models - First Order Algorithms for Unconstrained Optimization - Second Order Algorithms for Unconstrained Optimization - Convexity and Convex Optimization - Optimality Conditions for Linearly Constrained Nonlinear Optimization Models - The KKT Conditions for Constrained Nonlinear Optimization

	Models - Basis of the Duality Theory in Optimization - Basic Structure of the Constrained Nonlinear Optimization Algorithms - Topics in Data Mining and Regression Analysis.
Course Topics	- Applied nonlinear optimization models - Optimality conditions - Convexity and convex optimization - Unconstrained optimization: Theory and algorithms - Constrained optimization: Theory and algorithms
Keywords	Unconstrained optimization, Constrained optimization, Modelling, Least squares, Convex optimization, Optimality conditions, KKT Conditions, First order algorithm, Second order algorithm, Line search, Global convergence, Local convergence, Large scale optimization
Recommended Prerequisites	The students should be familiar with the basic concepts of linear algebra and calculus.
Propaedeutic Courses	
Teaching Format	Lectures + Exercises + Software Lab
Mandatory Attendance	Highly recommended (not compulsory).
Specific Educational Objectives and Learning Outcomes	The course mainly aims to acquaint students with practical continuous nonlinear optimization models and algorithms, as well as the optimization with MATLAB. At the end of the course, the students are expected to be able to formulate a real-world optimization problem in the framework of a nonlinear programming model, analyze various optimality features of the model, suggest suitable algorithms for solving the model, and finally, determine an approximation of the optimal solution of the model using MATLAB (or another software). Intended Learning Outcomes (ILO) Knowledge and Understanding: 1. Knowledge of the main concepts of the nonlinear optimization theory 2. Understanding of the analytical origins of the optimization algorithms 3. Knowledge of the optimization applications in data mining and machine learning Applying Knowledge and Understanding:

	4. Ability to formulate some real-world problems in the framework of the nonlinear optimization models 5. Ability to deal with some problems in the fields of data mining and machine learning Making Judgments: 6. Ability to evaluate reliability of the nonlinear optimization models 7. Ability to assess efficiency of the nonlinear optimization algorithms Communication Skills: 8. Ability to interpret different parts of the classic optimization models 9. Ability to analyse performance of the nonlinear optimization algorithms based on the computational results 10. Ability to conduct post-optimal analysis Learning Skills: 11. Ability to modify classic nonlinear optimization models for specific real-world problems 12. Capability to adapt classic nonlinear optimization algorithms for high-dimensional optimization models 13. Ability to design (use) software to solve the practical optimization models.
Specific Educational Objectives and Learning Outcomes (additional info.)	
Assessment	- Formative Assessments: This part is carried out by assigning weekly exercises to the students, which are also helpful in understanding the concepts of the course. - Summative Assessments: Students' knowledge is also evaluated through a final exam, which includes: - A written exam; - An oral exam; - A course project. The detailed structure of the assessment is given in the following table. 40% weekly exercises; ILOs assessed: 1 - 12; 40% final exam: computation; duration: 2 hours or more; ILOs assessed: 5, 6, 7, 9, 10; Oral exam (optional); ILOs assessed: 2, 8.;

	Course project (optional); ILOs assessed: 3, 11, 12, 13. * Note: A portion of the oral exam is carried out during the course.
Evaluation Criteria	- Weekly Exercises: Certain exercises are assigned to students each week (approximately), which are closely connected to the course contents of the corresponding week. The answers should be submitted within about one week. - Final (Written) Exam: The main part of the final exam is devoted to numerical problems in which the students should implement the algorithmic approaches for certain problems. In addition, there are theoretical problems in which the students should analyze the convergence behavior of the algorithms, discuss special aspects of the mathematical models, or evaluate the accuracy of the solutions. - Oral Exam: Students can decide to take part in an oral exam in which their comprehension of the general concepts of the course is evaluated. - Course Project: The students are encouraged to address a well-known real-world problem to enhance their practical experience with optimization models. The project should be presented, and its written report should also be submitted.
Required Readings	- Amir Beck, *Introduction to Nonlinear Optimization: Theory, Algorithms, and Applications with MATLAB*, SIAM: Philadelphia, 2014. https://sites.google.com/site/amirbeck314/books.
Supplementary Readings	- Amir Beck, *First-Order Methods in Optimization*, SIAM: Philadelphia, 2017. - Jorge Nocedal and Stephen J. Wright, *Numerical Optimization*, Springer: New York, 2006.
Further Information	Software: MATLAB
Sustainable Development Goals (SDGs)	Quality education, Industry, innovation and infrastructure, Decent work and economic growth, Affordable and clean energy