Fakultät für Ingenieurwesen
Facoltà di Ingegneria
Faculty of Engineering

COURSE DESCRIPTION – ACADEMIC YEAR 2024/2025

Course Title	**Optimization**
Course Code	42169
Scientific Sector	MAT/09
Degree	Bachelor of Engineering
Semester	2
Year	2+
Credits	6
Modular	No

Total Lecturing Hours	40
Total Lab Hours	20 (Exercise + Lab)
Attendance	Highly recommended (not compulsory)
Prerequisites	The students should be familiar with the basic concepts of linear algebra and calculus.
Course Page	-----

Specific Educational Objectives	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 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.

Lecturer	Saman Babaie–Kafaki https://www.unibz.it/en/faculties/engineering/academic-staff/person/48578-saman-babaiekafaki
Contact	B1.5.12: Faculty of Engineering, Free University of Bozen-Bolzano, 39100 Bolzano, Italy
Scientific Sector of Lecturer	Mathematics
Teaching Language	English
Office Hours	20+ Hours during the semester (can be set by appointment)
Lecturing Assistant	-----
Contact LA	-----
Office Hours LA	-----
List of Topics	➢ Mathematical Preliminaries ➢ Practical Optimization Models ➢ Optimality Conditions for Unconstrained Optimization ➢ Least Squares Models ➢ First Order Algorithms ➢ Second Order Algorithms ➢ Convexity and Convex Optimization ➢ Optimality Conditions for Linearly Constrained Problems ➢ The KKT Conditions ➢ Duality Theory ➢ Topics in Data Mining and Regression Analysis
Teaching Format	Lectures + Exercices + Software Lab

Learning Outcomes	**Intended Learning Outcomes (ILO)** **Knowledge and Understanding:** 1. Knowledge of the main concepts of the 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 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 optimization models 7. Ability to assess efficiency of the optimization algorithms **Communication Skills:** 8. Ability to interpret different parts of the classic optimization models 9. Ability to analyse performance of the optimization algorithms based on the computational results 10. Ability to conduct post-optimal analysis **Learning Skills:** 11. Ability to modify classic optimization models for specific real-world problems 12. Capability to adapt classic optimization algorithms for high-dimensional optimization models 13. Ability to design (use) software to solve the practical optimization models

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.

Assessment Format

Assessment Form	Weight	Duration	ILOs Assessed
Weekly Exercises	40%	-----	1-12
Final Exam: Computation	40%	≥ 2 Hours	5, 6, 7, 9, 10
Final Exam: Theory	20%	≤ 1 Hour	1, 4
Oral Exam (Optional)	-----	-----	2, 8
Course Project (Optional)	-----	-----	3, 11, 12, 13

Assessment Language	English

Evaluation Criteria and Criteria for Awarding Marks	▪ **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, 2014. https://sites.google.com/site/amirbeck314/books
Supplementary Readings	- Jorge Nocedal and Stephen J. Wright, *Numerical Optimization*, Springer, 2006. - Neculai Andrei, *Modern Numerical Nonlinear Optimization*, Springer, 2022.
Software	MATLAB