Freie Universität Bozen
Libera Università di Bolzano
Università Liedia de Bulsan

Syllabus

Descrizione corso

Titolo insegnamento	Ricerca Operativa
Codice insegnamento	42150
Titolo aggiuntivo	
Settore Scientifico-Disciplinare	MATH-06/A
Lingua	Inglese
Corso di Studio	Corso di laurea in Ingegneria Industriale Meccanica
Altri Corsi di Studio (mutuati)	
Docenti	dr. Saman Babaiekafaki, Saman.Babaiekafaki@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/48578
Assistente	
Semestre	Secondo semestre
Anno/i di corso	2
CFU	6
Ore didattica frontale	40
Ore di laboratorio	20
Ore di studio individuale	90
Ore di ricevimento previste	18
Sintesi contenuti	The course mainly aims to acquaint students with mathematical modelling and analysis of the real-world decision-making problems, algorithmic tools for finding optimal solutions of the models, as well as the popular OR software. At the end of the course, the students are expected to be able to formulate a practical decisions-making problem in the framework of a linear (integer) programming model, suggest appropriate algorithms for solving the model, find an optimal solution of the model by a software, and finally, conduct the post-optimal analysis.

	- Mathematical Preliminaries - Linear Programming: Modelling - Linear Programming: Geometric Interpretations - Linear Programming: The Simplex Algorithm - Linear Programming: Duality and Sensitivity Analysis - Transportation and Assignment Models - Network Flow Problems - Integer Programming: Modelling - Integer Programming: Algorithms - Dynamic Programming - Heuristic Algorithms - Goal Programming - Nonlinear Programming.
Argomenti dell'insegnamento	- Linear Programming (LP): LP Definition, Model Manipulations, Standard and Conic Forms of LP, and Geometric Solutions and Analysis - Modelling with LP: Fundamental Models in Production Planning, Resource Allocation, Diet Planning, Transportation, and Cutting Stock Problem - Geometry of LP: Vector and Matrix Spaces, Special Matrix Formats, Linear Systems, Elementary Matrix Operations, Gaussian Reduction, Convexity of Sets, Cones and Functions, Hyperplanes and Half-Spaces, and Polyhedral Geometry - Simplex Algorithm for Solving LPs: Basic Feasible Solutions, Key Idea of the Simplex Method, LP Representation, Geometric and Algebraic Aspects of the Simplex Method, Termination of the Simplex Method, The Simplex Algorithm in Tableau Format, Initialization with Artificial Variables, Two-Phase and Big-M Methods, Degeneracy and Cycling, and Pivoting Rules - Duality Theory of LP: Dual Formulation, Relationships Between Primal and Dual Models, Weak and Strong Duality, Complementary Slackness, Dual Simplex Method, and Sensitivity (Post-Optimal) Analysis - Transportation and Assignment Models: Transportation Model Definition, Characterization of a Basis in the Transportation Tableau, Simplex Algorithm for the Transportation Problem, Assignment Model Definition, Reduced Assignment Matrix, and the Hungarian Algorithm for the Assignment Problem - Network Flow Models: Basic Graph Theory, Minimum-Cost Network Flow Problem, Network Simplex Algorithm, Maximum Flow

	and Minimum Cut Problems, and Shortest Path Problem - Integer Programming (IP): Definitions and Fundamental Models in Capital Budgeting, Project Selection, Set-Covering, Job Sequencing, and Facility Location - IP Algorithms: Cutting-Plane and Branch-and-Bound Methods - Dynamic Programming: Definition, Dynamic Programming Method for Binary and Integer Knapsack Problems, and Bellman–Ford Method for the Shortest Path Problem - Metaheuristic Algorithms: Basic Concepts of Soft Computing, Traveling Salesman Problem (TSP), Encoding, Genetic Algorithms, and Simulated Annealing Method - Nonlinear Programming (NLP): Definitions, Geometric Solutions and Analysis, Nonlinear Facility Location Problem, Linear Regression, Portfolio Optimization, Optimality Conditions, Lagrange Multipliers, and Karush–Kuhn–Tucker (KKT) Conditions - Goal Programming: Multiobjective Optimization and the Weighted-Sum and Preemptive Methods
Parole chiave	Mathematical programming, Modelling, Linear programming, Simplex algorithm, Duality theory, Sensitivity analysis, Transportation model, Network flow problems, Integer programming, Dynamic programming, Goal programming, Nonlinear programming.
Prerequisiti	Students are expected to be familiar with the fundamental concepts of linear algebra and calculus.
Insegnamenti propedeutici	
Modalità di insegnamento	Lectures + Exercices + Software Lab.
Obbligo di frequenza	Highly recommended (not compulsory).
Obiettivi formativi specifici e risultati di apprendimento attesi	Intended Learning Outcomes (ILO) Knowledge and Understanding: 1. Knowledge of the main concepts of the OR 2. Understanding of the analytical origins of the OR algorithms 3. Knowledge of the OR applications in science and engineering Applying Knowledge and Understanding: 4. Ability to formulate some real-world problems in the framework of the linear (integer) programming models 5. Ability to deal with some problems in the practical fields such as transportation, network flows and supply chain management Making Judgments:

	6. Ability to evaluate reliability of the linear (integer) programming models 7. Ability to assess efficiency of the OR algorithms Communication Skills: 8. Ability to interpret different parts of the well-known OR models 9. Ability to analyse complexity and performance of the OR algorithms 10. Ability to conduct post-optimal analysis Learning Skills: 11. Ability to design heuristic algorithms for high-dimensional complex OR models 12. Ability to design (use) a proper software to solve the practical OR models.
Obiettivi formativi specifici e risultati di apprendimento attesi (ulteriori info.)	
Modalità di esame	- Formative Assessments: This part is carried out by assigning weekly exercises to students, which support and enhance their understanding of the course material. - Summative Assessments: Students' knowledge is additionally assessed through a final examination, which includes: - A written exam; - An oral exam (Optional); - A course project (Optional). Assessment Format: - 40% Weekly Exercises; ILOs assessed: 1-12; - 40% Final Exam: Computation; Duration: 2 hours or more; ILOs assessed: 4, 6, 7, 10; - 20% Final Exam: Theory; Duration: 1 hour or less; ILOs assessed: 1, 9; - Oral Exam (Optional); ILOs assessed: 2, 8; - Course Project (Optional); ILOs assessed: 3, 5, 11, 12.
Criteri di valutazione	- Weekly Exercises: Certain exercises are assigned to students on a weekly basis, closely aligned with the course content of the corresponding week. Solutions should be submitted within approximately 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 various aspects of the mathematical models as well as the OR algorithms. - Oral Exam (Optional): Students may further choose to participate in an oral exam in which their understanding of the general concepts of the course is assessed. - Course Project (Optional): Students are encouraged to address a well-known real-world problem in order to enhance their practical experience with OR models. The project must be presented, and a written report must also be submitted.
Bibliografia obbligatoria	- Hamdy A. Taha, *Operations Research: An Introduction*, 10th Edition, Pearson, 2021.
Bibliografia facoltativa	- Amir Beck and Nili Guttmann-Beck, *A First Course in Linear Optimization*, SIAM: Philadelphia, 2025. - Mokhtar S. Bazaraa, John J. Jarvis and Hanif D. Sherali, *Linear Programming and Network Flows*, 4th Edition, Wiley, 2010.
Altre informazioni	Software: CPLEX in the OPL Environment (TORA and MATLAB are also briefly introduced.)
Obiettivi di Sviluppo Sostenibile (SDGs)	Istruzione di qualità, Innovazione e infrastrutture, Buona occupazione e crescita economica, Energia rinnovabile e accessibile