Syllabus

Kursbeschreibung

Titel der Lehrveranstaltung	Operations Research
Code der Lehrveranstaltung	42150
Zusätzlicher Titel der Lehrveranstaltung	
Wissenschaftlich-disziplinärer Bereich	MATH-06/A
Sprache	Englisch
Studiengang	Bachelor in Industrie- und Maschineningenieurwesen
Andere Studiengänge (gem. Lehrveranstaltung)	
Dozenten/Dozentinnen	Prof. Saman Babaiekafaki, Saman.Babaiekafaki@unibz.it https://www.unibz.it/en/faculties/engineering/academic-staff/person/48578
Wissensch. Mitarbeiter/Mitarbeiterin	
Semester	Zweites Semester
Studienjahr/e	2
KP	6
Vorlesungsstunden	40
Laboratoriumsstunden	20
Stunden für individuelles Studium	90
Vorgesehene Sprechzeiten	18
Inhaltsangabe	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. ¿ Linear Programming ¿ Transportation and Assignment Models ¿ Network Flow Problems ¿ Integer Programming ¿ Dynamic Programming ¿ Goal Programming ¿ Nonlinear Programming
Themen der Lehrveranstaltung	- 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 - Goal Programming: Multiobjective Optimization and the Weighted-Sum and Preemptive Methods - Nonlinear Programming (NLP): Definitions, Geometric Solutions and Analysis, Nonlinear Facility Location Problem, Linear Regression, Portfolio Optimization, Optimality Conditions, Lagrange Multipliers, Karush–Kuhn–Tucker (KKT) Conditions, and the Modified Simplex Algorithm for Quadratic Programming - Complementary Topics: Parametric Linear Programming, Decision Making under Uncertainty, and Game Theory
Stichwörter	Mathematical programming, Modelling, Linear programming, Simplex algorithm, Duality theory, Sensitivity analysis, Transportation model, Network flow problems, Integer programming, Dynamic programming, Goal programming, Nonlinear programming, OPL software environment
Empfohlene Voraussetzungen	Students are expected to be familiar with the fundamental concepts of linear algebra and calculus.
Propädeutische Lehrveranstaltungen	
Unterrichtsform	Lectures: The course is delivered using lecture slides, which are regularly uploaded to Microsoft Teams. Additional explanations and derivations are provided on the board to clarify concepts and complement the slide material. Exercises: Topic-oriented exercises are solved, primarily on the board, during class to reinforce students' understanding and help them internalize the theoretical concepts. Software Laboratory: After introducing the main categories of OR models and the underlying theoretical concepts, basic real-world decision-making problems are modeled in the OPL software environment and solved primarily using the CPLEX solver.

	Particular emphasis is placed on interpreting the main output components and understanding the information provided by the solver.
Anwesenheitspflicht	Highly recommended (not compulsory).
Spezifische Bildungsziele und erwartete Lernergebnisse	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.
Spezifisches Bildungsziel und erwartete Lernergebnisse (zusätzliche Informationen)	
Art der Prüfung	- Formative Assessments: Implemented through midterm exams, in-class activities and discussions, which together reinforce students' 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% Formative Assessments; 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.
Bewertungskriterien	- Formative Assessments: At least one and at most two midterm exams are held during the semester. In addition, students' participation and engagement in in-class exercises and activities are taken into account as part of the formative assessment. - Final (Written) Exam: The main part of the final exam is devoted to numerical problems in which students are required to implement algorithmic approaches for selected problems. In addition, the exam includes theoretical questions that require students to analyze the convergence behavior of algorithms, discuss specific aspects of the mathematical models, and evaluate the accuracy of the solutions. - Oral Exam: Students may choose to participate in an oral examination, during which their understanding of the fundamental concepts covered in the course is assessed. - Course Project: Software implementation and programming activities constitute an integral part of the course project. In addition, students are encouraged to formulate and solve a real-world decision-making problem in order to strengthen their practical experience in modeling and solving optimization problems. * Note: Students who, for any reason, are unable to participate in part or all of the formative assessment may compensate for the missing assessment components by completing them as part of the final written examination.

Pflichtliteratur	- Hamdy A. Taha, *Operations Research: An Introduction*, 10th Edition, Pearson, 2021.
Weiterführende Literatur	- 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.
Weitere Informationen	Software: CPLEX in the OPL Environment (TORA and MATLAB are also briefly introduced.)
Ziele für nachhaltige Entwicklung (SDGs)	Hochwertige Bildung, Industrie, Innovation und Infrastruktur, Menschenwürdige Arbeit und Wirtschaftswachstum, Bezahlbare und saubere Energie