GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Optimization and Decision Support, PG_00056863		
Field of study	Automation, Robotics and Control Systems		
Date of commencement of studies	October 2023	Academic year of realisation of subject	2024/2025
Education level	first-cycle studies	Subject group	
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	2	Language of instruction	Polish
Semester of study	4	ECTS credits	5.0
Learning profile	general academic profile	Assessment form	exam
Conducting unit	Department of Control Engineering -> Faculty of Electrical and Control Engineering		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. Anna Witkowska	
	Teachers		

Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	24.0	6.0	0.0	0.0	60
	E-learning hours included: 0.0						
	Additional information: Laboratory, lecture and excercise - stationary Lecture, exercises, laboratory - classes conducted in stationary form Exercises- blackboard classes, implementation of tasks, activating methods Lecture - presentation, discussion Computer laboratories - practical and independent implementation of tasks by students.						

Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
	Number of study hours	60	8.0	57.0	125

Subject objectives	The aim of the course is to acquaint students with the basics of the theory of optimization and decision support and preparation for independent solving basic optimization problems.

Learning outcomes	<table><tr><th>Course outcome</th><th>Subject outcome</th><th>Method of verification</th></tr><tr><td>[K6_K05] can think and act in an entrepreneurial way</td><td>Based on the analysis of the optimization problem, it can classify and then formulate the optimization task, define target functions, decision variables and constraints. Evaluates and properly interprets the solution received.</td><td>[SK5] Assessment of ability to solve problems that arise in practice</td></tr><tr><td>[K6_U05] can use analytical and simulation methods to solve tasks in the field of automation and robotics and use various techniques to carry out engineering tasks related to automation and robotics devices and systems</td><td>He can choose and apply the appropriate method and algorithm to solve the task optimization for advanced problems in engineering practice (eg to choose the parameters of the regulator, allocate forces to an excess set of executive devices, determine the production volume that maximizes profit, minimize losses, to solve the transport problem and allocation).</td><td>[SU1] Assessment of task fulfilment</td></tr><tr><td>[K6_W01] has basic knowledge in the field of mathematics including algebra, geometry, mathematical analysis, probabilistics, numerical methods - necessary to describe and analyze automation and robotics systems</td><td>He knows and has a basic knowledge of analytical and numerical algorithms for solving basic tasks of linear and nonlinear optimization.</td><td>[SW1] Assessment of factual knowledge</td></tr></table>
Subject contents	1. Formulation of the task of optimization. Stages of solving optimization tasks. Classification of optimization tasks. 2. Basic division of optimization tasks. Convex vs. non-convex optimization. Types of constraints in an optimization task. 3. Formulation of a linear programming task in general form, in vector form. Stages of solving the ZPL by geometric method. 4. Examples of linear programming tasks. Formulation of the mathematical model of the optimization task (selection of production mix, allocation of machines, mixing of raw materials, transportation task), dedicated algorithms. 5. Formulation of the task of nonlinear (quadratic) optimization. The method of least squares. 6. Necessary conditions for optimization of an unconstrained objective function (what is a hessian?). 7. Necessary conditions for optimization of the objective function with equality constraints. 9. The method of Lagrange multipliers for tasks with equality constraints. Relationship of the method of Lagrange multipliers to the necessary conditions for optimization of the objective function with equality constraints. 8. Necessary conditions for optimization of the objective function with inequality constraints. 9. Kuhn -Tucker conditions for tasks with inequality constraints. Relationship of the method of Lagrange multipliers with the necessary conditions for optimization of the objective function with inequality constraints. 10. Numerical methods of optimization in the direction for unconstrained tasks - general characteristics and general classification. Gradient-free methods of optimization in the direction. Gradient methods of optimization in the direction. 11. Formulation of a multi-criteria optimization task. Efficient solution vs. compromise solution. Methods for obtaining compromise solutions for a WPL (multi-criteria linear programming) task.Pareto front, dominated solutions, non-dominated solutions, Pareto cone. 12.Multi-objective and multi-attribute decision support - differences, methods. 13. what is a function. How does it differ from the objective function? Formulate the task of static and dynamic optimization - differences, methods used. Bellman's principle of optimality.
Prerequisites and co-requisites	Ability mathematical description of physical and technical processes. Knowledge of basic mathematic differential theory and numerical methods.
Assessment methods and criteria	<table><tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr><tr><td>lecture</td><td>50.0%</td><td>40.0%</td></tr><tr><td>excercises</td><td>50.0%</td><td>40.0%</td></tr><tr><td>labolatory</td><td>50.0%</td><td>20.0%</td></tr></table>
Recommended reading	<table><tr><td>Basic literature</td><td>• Amborski, Podstawy metod optymalizacji, Oficyna Wydawnicza Politechniki Warszawskiej, 2001 • Arabas G.: Wyklad z algorytmow ewolucyjnych, PWN, Warszawa 2003. • Optymalizacja. Wybrane metody z przykładami zastosowań. Kusiak Jan , Danielewska-Tułecka Anna , Oprocha Piotr . Wydawnictwo Naukowe PWN 2009. • Marianna Jacyna. Wspomaganie decyzji w praktyce inżynierskiej. PWN. Warszawa 2022.</td></tr><tr><td>Supplementary literature</td><td>• Rothlauf F. (2011) Optimization Methods. In: Design of Modern Heuristics. Natural Computing Series. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-72962-4_3</td></tr><tr><td>eResources addresses</td><td>Adresy na platformie eNauczanie:</td></tr></table>

Example issues/ example questions/ tasks being completed	Example 1. The electrical nodes there are receivers receiving currents shown on the drawing. How do I connect (which segments of he electrical web) the final receivers from the supply point to minimise the voltage drop between them Example2. The company produces two products: W1 and W2 of three materials: S1, S2 and S3. For manufacturing of the product W1 needs 2 units of S1, one unit of S2 , and 4 units of S3. To produce a product W2 respectively needs 2 units of S1 , 2 units of S2. Daily limit is: 14 units of S1, 8 - S2 and 16 - S3. Product prices are as follows: 2 zł for W1 and 3 zł for W2. Find the production plan to maximize the benefits from the sale by using graphical method. Example 3. Application of numerical optimization algorithms to the tuning of PID controller parameters on the example of optimization of a ship's course control system with Nomoto first-order model.
Work placement	Not applicable