GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Optimization Methods, PG_00057475		
Field of study	Automation, Robotics and Control Systems		
Date of commencement of studies	February 2025	Academic year of realisation of subject	2024/2025
Education level	second-cycle studies	Subject group	
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	1	Language of instruction	Polish
Semester of study	1	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	dr hab. Anna Witkowska dr inż. Krzysztof Armiński	

Lesson types and methods of instruction

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	30.0	0.0	15.0	15.0	0.0	60

E-learning hours included: 0.0

Address on the e-learning platform: https://enauczanie.pg.edu.pl/moodle/course/view.php?id=16631

Additional information:
Lecture, exercises, laboratory - classes conducted in a stationary form

Lecture - conventional lecture, presentation of contents, discussion

Computer laboratories - realization of prepared tasks on a computer workstation.

Project - independent implementation of prepared algorithms in a selected programming environment (Matlab/Python)

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	10.0	55.0	125

Subject objectives

The aim of the course is for the student to master the knowledge of numerical optimisation algorithms and their properties. During the course, the student will acquire the skills of independent implementation of algorithms, selection of parameters, and interpretation of the obtained solutions. These knowledge and skills will be applied to solving automation problems using Matlab software and the Python programming language.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W14] has knowledge of mathematical modelling, identification, optimisation, decision suport decision-making and control, knows methods of implementing advanced control algorithms in industrial equipment	Designs control systems with optimal performance (e.g., minimizing control signals and regulation error). Implements a genetic algorithm for optimizing the control system.	[SW1] Assessment of factual knowledge
[K7_K06] is aware of the impact of engineering activities on the quality of applied solutions and the environment	Examines the quality of the obtained solutions, the impact of algorithms and their parameters on the occurrence of local and global extrema.	[SK2] Assessment of progress of work
[K7_U07] is able to use analytical, simulation and experimental methods to formulate and solve engineering tasks and simple research problems in the field of automation and robotics	Formulates a mathematical model of an optimization problem for selected engineering issues such as thrust allocation, controller parameter tuning, or object model parameter identification (using experimental data). Adapts and independently implements optimization algorithms using MATLAB and Python.	[SU1] Assessment of task fulfilment

Subject contents	A review and extension of topics covered in the course "Optimization and Decision Support" at the undergraduate level. Pareto Front Method. Introduction to Python. Discussion of Python's cvxpy library for convex optimization. Examples of optimization problems in Python.Iterative Algorithms for Unconstrained Optimization: Nelder-Mead method, conjugate gradients, Newton's methods. Examples of implementations in Matlab applied to problems such as measurement data approximation and parametric identification of a marine vessel model.Iterative Algorithms for Constrained Optimization.Direct Algorithms: Random search, sequential linear programming method.Indirect Algorithms: Variable transformation methods, penalty function methods (interior and exterior). Examples of Matlab implementations.Lagrange Method vs. Penalty Function Method: Comparison and applications.Randomized Optimization Algorithms: Monte Carlo method.Metaheuristic Optimization Algorithms:Implementation of a genetic algorithm for PID controller parameter tuning.Swarm intelligence algorithms, such as particle swarm optimization and ant colony optimization. Examples of applications to control system parameter tuning and finding optimal paths in a graph. Control allocation tasks in dynamic positioning systems for ships. Examples of Matlab implementations.Project Presentation and Evaluation: Includes theoretical background, results, and conclusions. **Laboratory**: Study of the properties of selected numerical algorithms for nonlinear optimization based on prepared test problems in the Matlab environment. The considered test problems include a single-criterion problem for identifying an object model, a problem for tuning PID controller parameters in a control system. Minimization of test nonlinear functions with constraints is carried out using the penalty function method.
Prerequisites and co-requisites	Ability to mathematically describe physical and technical processes. Knowledge of the fundamentals of Mathematics, Numerical Methods, Modeling and Identification, Computer Control Systems, Optimization and decision support (within the scope of undergraduate studies). Fundamentals of programming in MATLAB/ SIMULINK, Python

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
laboratory	50.0%	30.0%
egzam	50.0%	40.0%
project	50.0%	30.0%

Recommended reading

Basic literature	1. Arabas G.: Wyklad z algorytmow ewolucyjnych, PWN, Warszawa 2003. 2. Kochenderfer, Mykel J., and Tim A. Wheeler. *Algorithms for optimization*. Mit Press, 2019. 3. Tony Gaddis. *Starting out with Python, 5th Edition.* Pearson, 2021.
Supplementary literature	Marek Gągolewski, Maciej Bartoszuk oraz Anna Cena. *Przetwarzanie i analiza danych w języku Python*. Wydawnictwo Naukowe PWN, 2016.
eResources addresses	Uzupełniające Adresy na platformie eNauczanie:

Example issues/ example questions/ tasks being completed	1. Optimal allocation of controllers in DP system. 2. Optimization of PID controller parameters using genetic algorithm 3. Parametric identification of the model by numerical optimization methods.
Work placement	Not applicable