POZNAN UNIVERSITY OF TECHNOLOGY
EUROPEAN CREDIT TRANSFER AND ACCUMULATION SYSTEM (ECTS)
pl. M. Skłodowskiej-Curie 5, 60-965 Poznań

COURSE DESCRIPTION CARD - SYLLABUS

Course name
Optimization methods and theory

Course

Field of study Automatic Control and Robotics	Year/Semester 1/2
Area of study (specialization)	Profile of study general academic
Level of study Second-cycle studies	Course offered in polish
Form of study full-time	Requirements compulsory

Number of hours

Lecture 15	Laboratory classes	Other (e.g. online)
Tutorials 30	Projects/seminars	

Number of credit points

3

Lecturers

Responsible for the course/lecturer:
Sławomir Stępień Ph.D., D.Sc, Eng.

Associate Professor

email: Slawomir.Stepien@put.poznan.pl

tel. 61 665 23 64

Faculty of Control, Robotics and Electrical Engineering

Piotrowo 3a, 60-965 Poznan

Responsible for the course/lecturer:

Prerequisites

Knowledge: Student starting this subject should have basic knowledge from linear algebra, matrix calculus, mathematical analysis and calculus, the basics of modeling dynamic system and related theory.

Skills: He should have the ability to solve basic algebra problems, mathematical analysis and geometry, and the ability to obtain information from the indicated sources. Student should also understand the need to broaden its competences.

Social Competence: In terms of social competence, present such attitudes as: honesty, responsibility, perseverance, cognitive curiosity, creativity, personal culture, respect for other people.

Course objective

1. Providing students with basic knowledge for optimization theory and methods, including linear programming, nonlinear programming, dynamic optimization without and with constraints. Optimal and suboptimal control basics.

2. Develop students' ability to solve simplex and graphical linear programming problems, nonlinear programming problems, Lagrange methods in solving optimization without and with constraints for system dynamics. Develop the ability to use optimal LQR and suboptimal SDRE control methods.

Course-related learning outcomes

Knowledge

1. Knowledge related to selected problems of mathematics necessary for formulating and solving complex problems in field of optimization theory and optimal control.

2. Knowledge of linear and nonlinear dynamic systems modelling

3. Knowledge from optimization theory and design and analysis of optimization algorithms including optimal control.

4. Knowledge from selected optimization methods used to solve linear and nonlinear mathematical programming problems, optimal and suboptimal control problems.

Skills

1. Critically use literature information and other sources in Polish and English

2. Build models of simple dynamic, linear and nonlinear systems

3. when formulating and solving optimization tasks, see their non-technical aspects (including environmental, economic and law aspects)

4. Appropriate methods for solving optimization problems

5. Correctly solve simple problems that have been optimized and optimally control

Social competences

Student understands the need and knows the possibilities of continuous further education, professional, personal and social competences. He is aware of the need for a professional approach to technical problems. Understands the need and the possibility of further transfer of acquired knowledge and skills.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

The summary assessment of the lectures concerns the verification of the intended learning outcomes, i.e. the assessment of the knowledge and skills demonstrated in the problem by written examination.

In the field of laboratory exercises, verification of the intended learning outcomes is carried out by continuous evaluation, in each class (oral responses, reports), in addition, by assessing the acquired knowledge and skills through one or two tests in semester.

Programme content

The lecture program covers the following topics: Introduction to optimization theory. Problems of mathematical programming. Linear and nonlinear optimization. The linear algebra basics. Convex harvesting. Linear programming (LP) problems. Troubleshoot linear programming by graphical method. The theoretical basis for Simplex method. Simplex algorithm. Determination of the initial acceptable base solution. Troubleshoot linear programming using simplex method.

Nonlinear programming (NLP). Classification of nonlinear programming problems. Classification of NLP troubleshooting methods. Cases of nonlinear programming problems that can be reduced to LP. Nonlinear programming problems with equality constraints. Lagrange function. Lagrange's terms and conditions. Lagrange's theorem. The problem of nonlinear programming with inequality constraints. Terms of Karush-Kuhn-Tucker (KKT). KKT theorem. KKT method. Square programming, unlimited nonlinear programming, nonlinear programming with equality constraints – Lagrange multiplier method. Dynamic programming – variation account. Hamilton-Jacobi-Bellman equation. Pontriagin Maximum Principle.

LQR linear-quadratic control with finite and infinite time horizon. State-dependent paramatrization SDP. Suboptimal SDRE control with finite and infinite time horizon. The exercises are conducted in the form of fifteen 2-hour meetings. Each meeting is prepared from a single topic.

During the exercises, students solve problems related to material presented in lectures. The curriculum includes:

- linear programming: graphical method, simplex matrix method, simplex method array form, two-phase simplex method- nonlinear programming,

- square programming, nonlinear programming with and without restrictions, Lagrange multiplier method

- dynamic programming - variation account, Pontriagin Maximum principle

- LQR linear-quadratic control

- SDRE control for nonlinear systems

Teaching methods

lecture: multimedia lecture with examples assisted by table explanations

excercises: optimal problems solution and analysis, discussion

Bibliography

Basic

1. Rumatowski K., Królikowski A., Kasiński A., Optymalizacja układów sterowania. Zadania, Warszawa, Wydawnictwa Naukowo-Techniczne 1984

2. Stadnicki J., Teoria i praktyka rozwiązywania zadań optymalizacji z przykładami zastosowań technicznych, Warszawa, Wydawnictwa Naukowo-Techniczne 2006

3. Superczyńska P., Metoda sterowania suboptymalnego z wykorzystaniem linearyzacji układu zamkniętego, Praca doktorska, Poznań 2019.

4. Donald E. Kirk, Optimal Control Theory: An Introduction, Dover Publications, 2004)

Additional

1. Optymalizacja, Kusiak J., Danielewska-Tułecka A., Oprocha P., PWN, 2009.

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,0
Classes requiring direct contact with the teacher	45	2,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	30	1,0

[1] delete or add other activities as appropriate