OPTIMAL CONTROL

COURSE OUTLINE

Responsible: Alina Ektami

1. GENERAL			
SCHOOL	School of Engineering		
ACADEMIC UNIT	Department of Mechanical Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	0813.8.018.0	**SEMESTER**	2nd
COURSE TITLE	Optimal Control		

INDEPENDENT TEACHING ACTIVITIES if credits are awarded for separate components of the course	**WEEKLY TEACHING HOURS**	**CREDITS**
	5	6
Total	**5**	**6**

COURSE TYPE general background, special background, specialised general knowledge, skills development	Advanced Specialization Course
PREREQUISITE COURSES	None
LANGUAGE OF INSTRUCTION and EXAMINATIONS	English
OFFERED TO ERASMUS STUDENTS	Yes (in English) — Spring Semester
COURSE WEBSITE (URL)	

2. LEARNING OUTCOMES

Learning outcomes

The course focuses on the principles of optimal control, with an initial emphasis on the theory and application of optimal control to linear systems. Students will acquire the knowledge and skills required to design controllers that optimize system performance. Towards the end of the course, fundamental concepts of nonlinear optimal control are introduced.

Upon successful completion of the course, students will be able to:

- Design optimal controllers for linear systems using methods such as the Linear Quadratic Regulator (LQR).
- Apply numerical techniques and software tools to solve optimal control problems.
- Demonstrate a basic understanding of the challenges and methods associated with nonlinear optimal control.
- Apply optimal control methods to engineering problems involving real-world data.

General Competences

- Search for, analyze and synthesize data and information using appropriate technologies.
- Work independently.
- Work effectively in teams.
- Make decisions.
- Work in an interdisciplinary environment.

3. SYLLABUS

Theoretical Part (Lectures)

- Introduction to Optimal Control: Definition and applications of optimal control to real-world problems (e.g., automatic control systems, robotics, and logistics).
- Fundamental concepts: system state, control variables, and optimization criteria.
- Optimal Control Methods for Linear Systems: Linear Quadratic Regulator (LQR).
- Practical applications.
- Introduction to Nonlinear Systems: Fundamental differences between linear and nonlinear systems.
- Overview of methods for the control of nonlinear systems (e.g., linearization and optimal control based on Pontryagin's Maximum Principle).

Laboratory Part

- Solving optimal control problems using analytical and numerical methods.
- Use of software tools (MATLAB and Python) for system analysis and controller design.

Individual or Group Project

Students will develop a project involving the design of an optimal control system based either on real-world data or on the simulation of a practical application. Examples include:

- Trajectory optimization for a robotic vehicle, where the objective is to determine an optimal trajectory that minimizes travel time or energy consumption or maximizes passenger comfort.
- Warehouse management, involving the optimal control of incoming and outgoing product flows to minimize storage costs and maximize operational efficiency. The objective is to maintain inventory at an optimal level while avoiding both overstocking and stock shortages.

4. TEACHING and LEARNING METHODS - EVALUATION	
DELIVERY Face-to-face, Distance learning, etc.	Face-to-face
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY Use of ICT in teaching, laboratory education, communication with students	• Use of Information and Communication Technologies (ICT) in teaching. • Use of Information and Communication Technologies (ICT) for communication with students through the e-Class platform.
TEACHING METHODS The manner and methods of teaching are described in detail.	<table><tr><th>Activity</th><th>Semester workload</th></tr><tr><th>Course total</th><td></td></tr></table>
STUDENT PERFORMANCE EVALUATION Description of the evaluation procedure	1. Written final examination (70%). 2. Individual or group laboratory project (written report and oral examination) (30%). The assessment criteria are announced to students at the beginning of the semester and are available on the course webpage in the e-Class platform.

5. ATTACHED BIBLIOGRAPHY

- Bryson, A. E., & Ho, Y.-C. (1975). *Applied Optimal Control: Optimization, Estimation, and Control*. Taylor & Francis.
- LaValle, S. M. (2006). *Planning Algorithms*. Cambridge University Press.
- Bertsekas, D. P. (2017). *Dynamic Programming and Optimal Control* (Vols. 1–2). Athena Scientific.
- Laporte, G., & Vogiatzis, C. (2016). *Introduction to Vehicle Routing Problem*. Springer.

- Krikelis, N. (2000). *Modeling and Optimal Control of Systems*. Fountas Publications. *(in Greek)*