

Óbuda University Bánki Donát Faculty of Mechanical and Safety Engineering		Institute of Mechatronics and Vehicle Engineering			
Subject title and code:		Robotics II. (BMXRTE6BNF)		Credits: 5	
Full-Time Study	2025/2026	ac. year	II.	semester	
The course is available at:		Mechatronic Engineering			
Supervised by:		Dr. István Nagy		Lecturers: Bence Varga	
Prerequisite (neptun code):		Robotics I. (BMXRTE5BNF)			
Weekly number of lessons					
Lecture:	2	Exercise:	-	Laboratory ex.:	3
Way of assessment:		Exam (oral)			
Online Consultation (in case it's required):			-		
Educational goal:	<p><i>The objective of the course is to provide students with comprehensive, engineering-oriented foundations in the modeling and control of robot motion, with particular emphasis on dynamic phenomena and their practical significance. The course aims to help students understand the role of trajectory planning in robot control, acquire the ability to apply Lagrangian mechanics and the Euler–Lagrange equations of motion to simple mechanical systems and industrial robots, and develop the capability to interpret the general form of robot dynamics from a physical perspective. The subject places particular emphasis on developing actuator-level thinking, understanding independent joint control and simple PID-based solutions, and subsequently introduces the principles of model-based control through the computed torque method. The laboratory courses of the course aims to provide students with practical experience in the application and programming of industrial robots. During the laboratory sessions, students work with FANUC educational robot cells and the RoboGuide simulation environment, where they become familiar with the fundamentals of safe robot operation, the use of coordinate systems and motion instructions, I/O handling, and the programming structure of typical industrial robot applications. Throughout the semester, students work in teams on a complex automation and system integration project, which provides an opportunity to apply the theoretical knowledge acquired during the course in a practical setting. The project work contributes to the development of students' professional competencies, particularly in the design, programming, and documentation of industrial robot applications. In addition, the team-based project supports the development of essential soft skills, including teamwork, technical communication, task allocation, responsibility, and problem-solving abilities, which are critical in modern engineering and research-and-development environments.</i></p>				
Schedule					
Education week	Topics				
1.	<p>Lecture: Introduction to the concepts of path and trajectory in robotic motion, and the role of time parameterization in robot control. Basic polynomial interpolation methods are presented, with emphasis on ensuring position and velocity continuity in joint space.</p> <p>Laboratory: Safety briefing and overview of safe robot operation procedures. Introduction to basic robot motions and practical demonstration of tool calibration (tool frame measurement).</p>				

2.	<p>Lecture: Overview of commonly used practical velocity profiles, trapezoidal trajectories. Trajectory planning through sequence of points, linear trajectories with parabolic blends.</p> <p>Laboratory: Group I: Configuration of work coordinate systems. Development of a simple robot program, with an overview of motion instructions and their parameterization.</p>
3.	<p>Lecture: Positioning of rigid bodies, description of position and orientation. Rotation matrices, special orthogonal group.</p> <p>Lab: Configuring motion paths in RobotStudio, specifying tool position and orientation. Basics of the RAPID programming language.</p>
4.	<p>Lecture: Introduction to the Lagrangian formulation of mechanics, including its motivation and main advantages. The concept of generalized coordinates is introduced, along with the role of kinetic and potential energy in system modeling.</p> <p>Laboratory: Group I: Handling of digital inputs and outputs, use of control structures and registers. Implementation of a palletizing task.</p>
5.	<p>Lecture: Derivation of the Euler–Lagrange equations of motion and interpretation of their physical meaning. Introduction to generalized forces and torques, and modeling of actuator-driven systems.</p> <p>Laboratory: Group II: Handling of digital inputs and outputs, use of control structures and registers. Implementation of a palletizing task.</p>
6.	<p>Lecture: Application of the Lagrangian formulation and Euler–Lagrange equations through the solution of example problems.</p> <p>Laboratory: Group I: Safety zones and the FANUC Dual Check Safety (DCS) system. Practical exercises.</p>
7.	<p>Lecture: The general dynamic equation of robot manipulators and its main components: the inertia matrix, Coriolis and centrifugal terms, and the gravity vector. Assignment of semester project tasks.</p> <p>Laboratory: Group II: Safety zones and the FANUC DCS system. Practical exercises.</p>
8.	<p>Lecture: Key properties of robot dynamics, discussed from the perspective of stability and model-based control.</p> <p>Laboratory: Project consultation and open laboratory session.</p>
9.	<p>Lecture: Dynamic modeling of a cylindrical robot manipulator.</p> <p>Laboratory: Project consultation and open laboratory session.</p>
10.	<p>Lecture: Fundamental concepts of control in robotic applications, including the role of feedback and the capabilities and limitations of classical PID control.</p> <p>Laboratory: Project consultation and open laboratory session.</p>
11.	<p>Lecture: Modeling of electrical actuators and independent joint control. Analysis of open-loop and closed-loop behavior and implementation of a basic PID controller.</p> <p>Laboratory: Project consultation and open laboratory session.</p>

12.	Lecture: Model-based robot control and the computed torque method. Laboratory: Project consultation and open laboratory session.				
13.	Lecture: Limitations of the computed torque method and the impact of model inaccuracies. Laboratory: Project consultation and open laboratory session.				
14.	Presentation and evaluation of the project assignments.				
Mid-semester requirements					
Test		Assignment to be submitted		Lab measurements	
Amount	Schedule	Amount	Deadline	Amount	Schedule
-	-	1	13. week	-	-
According to the Study and Examination regulations of Óbuda University attendance of group seminars and lab exercises are mandatory					
Other requirements for participation in sessions not covered by the regulations and restrictions on substitutions:					
<p>Participation in laboratory sessions is permitted only if students arrive on time at the scheduled time indicated in the timetable. Students arriving after the start of the session are not allowed to participate due to the safety-critical operation of the robot cells.</p> <p>Failure to follow the instructions of the laboratory instructor, or any behavior during robot operation that endangers the physical safety of other students or the safe operation of the equipment, may result in immediate removal from the laboratory session. In serious or repeated cases, the student may be prohibited from completing the course.</p> <p>Attendance at lectures is mandatory.</p> <p>Completion of the course includes a team-based project assignment, which students must complete and present during the semester. The project cannot be made up during the examination period. The submission deadline for the project is Week 13 of the semester, with a single make-up opportunity available only in Week 14.</p>					
Test		Assignment to be submitted		Lab Measurement	
maximum points available	minimum score required to pass /test	maximum points available	minimum score required to pass / assignment	maximum points available	minimum score required to pass /lab
-	-	50 points	25 points	-	-
Total number of points achievable in semester:			100 points		
Grading thresholds	Pass from 50 %	Average from 60 %	Good from 70 %	Excellent from 80 %	

During the semester, students work in teams of 5–6 to complete a complex automation and system integration project. The objective of the project is to design, implement, and document a robotic application. As part of the assignment, students are required to prepare comprehensive technical documentation of their solution.

The project is evaluated by the laboratory instructor on a **0–50 point scale**, and the corresponding **group project grade** is determined based on predefined grading thresholds.

After the project evaluation, students **anonymously assess the contributions of their teammates** using grades on a **1–5 scale**. The average of the received evaluations determines each student’s **individual midterm grade**.

The instructor verifies whether the average of the individual grades within the team is consistent with the group project grade. If significant discrepancies are observed, the laboratory instructor may adjust the individual grades based on the students’ observed contributions during the open laboratory sessions and the project presentation.

To obtain the course signature, students must achieve at least a **passing (grade 2) midterm grade**.

Students who obtain the course signature may take the **oral examination during the examination period**. The **final course grade** is calculated by weighting the **project grade at 50%** and the **oral examination result at 50%**.

Student may be dropped from class if:

- their absences exceed the maximum limit permitted by the **Study and Examination Regulations**;
- they display **undisciplined or unsafe behavior during laboratory sessions**, thereby endangering their own physical safety, the safety of other students, or the safe operation of laboratory equipment;
- they fail to follow the **instructions of the laboratory instructor**, particularly those related to the operation of the robot cells and occupational safety regulations;
- they switch the robot to **automatic mode without authorization**, or execute a robot program without the instructor’s permission;
- they use the laboratory equipment **improperly**, or perform any intervention on the robot controller or cell that may compromise the system’s operation or safety.

Required references:

Siciliano, B., & Al, E. (2010). *Robotics : modelling, planning and control*. Springer.
Spong, M. W. (2012). *Robot Modeling And Control*. John Wiley & Sons.

Recommended references:

Lynch, K. M., & Park, F. C. (2017). *Modern robotics : mechanics, planning, and control*. University Press.

Quality assurance methods of the subject:

Things, that are not included, can be found within the regulations of Óbuda University.