

Course Description					
Name	Code	Semester	T+A Hour	Credit	ECTS
ADVANCED ROBOTICS	EEE3215372	Spring Semester	3+2	4	8
Prerequisites Courses	ROBOTİK VE AKILLI SİSTEMLER				
Recommended Elective Courses	Linear Algebra and Differential Equations; Introduction to Programming; Linear Algebra; Differential Equations				
Language of Instruction	English				
Course Level	First Cycle (Bachelor's Degree)				
Course Type	Elective				
Course Coordinator	Assist.Prof. Elif HOCAOĞLU				
Name of Lecturer(s)	Assist.Prof. Elif HOCAOĞLU				
Assistant(s)					
Aim	The scope of an advanced robotics course is expansive, delving into intricate aspects of robot motion, control systems, and sensor technologies. It encompasses advanced topics like differential kinematics, path planning, and trajectory generation, offering students a comprehensive understanding of robot dynamics and control. The course also explores cutting-edge control techniques such as force control, and impedance control, along with admittance control. Students gain hands-on experience in robotics software development, utilizing frameworks and programming languages essential for advanced applications.				
Course Content	This course contains; Definition of Robotics, Robot components and types ,Derivations of the rotation operators to describe and control the orientation of robotic end-effectors. ,Homogeneous transformations that represent the position and orientation of a robotic system in a unified mathematical framework.,Derivation of Forward Kinematics to determine the end-effector position of a robot given its joint variables,Derivation of Inverse kinematics problems to compute the joint variables required to achieve a desired end-effector position and orientation.,The concept of velocity kinematics and its application to analyze the relationship between joint velocities and end-effector velocities in a robotic system.,Derivation of the equations of motion for robotic systems using the Newton-Euler method: Calculation of inertia properties, including mass, center of mass, and inertia tensor, for individual rigid bodies in a robotic system. Apply the recursive Newton-Euler algorithm to compute velocities and accelerations in a robotic manipulator. ,Analyses joint forces and torques, expressing them in terms of external forces, joint accelerations, and inertia properties. Implementation of dynamic simulations of robotic manipulators using the Newton-Euler method.,Derivation of Lagrange's equations in describing the dynamics of mechanical systems. ,Solving dynamics problems in the presence of constraints using Euler-Lagrange equations, such as closed-loop kinematic structures. ,Force Control Fundamentals: 1)Understanding the principles of force control in robotics. 2)Exploring the role of force sensors and tactile feedback in robotic systems. 3) Analyzing the challenges and applications of force control in various scenarios.,Adaptive Control Techniques: 1) Studying adaptive control techniques applicable to robotic systems. 2) Examining how adaptive control can be utilized to enhance the performance of robots in response to changing environmental conditions. ,Real-time Feedback and Control:Implementing real-time feedback mechanisms for force control.,Examining the importance of closed-loop control systems in adapting to dynamic changes..				
Course Learning Outcomes			Teaching Methods	Assessment Methods	
Solve the complexities of robot motion involves understanding and analyzing aspects such as differential kinematics, path planning, and trajectory generation			2, 21	A, D, E, F	
Apply force control, impedance control, and admittance control to effectively govern and optimize robotic behaviour.			2, 21	A, D, E, F	
Applies the theoretical background acquired in robot dynamics and control in practical scenarios.			2, 21	A, D, E, F	
Gain practical experience in robotics software development, utilizing essential frameworks and programming languages for advanced applications and system integration.			2, 21	A, D, E	
Apply design principles, including materials, and fabrication methods for prototyping robotic systems.			2	D, F	
Teaching Methods	2: Project Based Learning Model, 21: Simulation Technique				
Assessment Methods	A: Traditional Written Exam, D: Oral Exam, E: Homework, F: Project Task				
Lecture Schedule					
Sequence	Topics	Preliminary Preparation			
1	Definition of Robotics, Robot components and types	Course presentation			
2	Derivations of the rotation operators to describe and control the orientation of robotic end-effectors.	Course presentation			
3	Homogeneous transformations that represent the position and orientation of a robotic system in a unified mathematical framework.	Course presentation			
4	Derivation of Forward Kinematics to determine the end-effector position of a robot given its joint variables	Course presentation			
5	Derivation of Inverse kinematics problems to compute the joint variables required to achieve a desired end-effector position and orientation.	Course presentation			
6	The concept of velocity kinematics and its application to analyze the relationship between joint velocities and end-effector velocities in a robotic system.	Course slides			
7	Derivation of the equations of motion for robotic systems using the Newton-Euler method: Calculation of inertia properties, including mass, center of mass, and inertia tensor, for individual rigid bodies in a robotic system. Apply the recursive Newton-Euler algorithm to compute velocities and accelerations in a robotic manipulator.	Course presentation			
8	Analyses joint forces and torques, expressing them in terms of external forces, joint accelerations, and inertia properties. Implementation of dynamic simulations of robotic manipulators using the Newton-Euler method.	Course presentation			
9	Derivation of Lagrange's equations in describing the dynamics of mechanical systems.	Course presentation			
10	Solving dynamics problems in the presence of constraints using Euler-Lagrange equations, such as closed-loop kinematic structures.	Course presentation			
11	Force Control Fundamentals: 1)Understanding the principles of force control in robotics. 2)Exploring the role of force sensors and tactile feedback in robotic systems. 3) Analyzing the challenges and applications of force control in various scenarios.	Course presentation			

Lecture Schedule		
Sequence	Topics	Preliminary Preparation
12	Adaptive Control Techniques: 1) Studying adaptive control techniques applicable to robotic systems. 2) Examining how adaptive control can be utilized to enhance the performance of robots in response to changing environmental conditions.	Course presentation
13	Real-time Feedback and Control: Implementing real-time feedback mechanisms for force control.	Course presentation
14	Examining the importance of closed-loop control systems in adapting to dynamic changes.	Course presentation
Evaluation Methods		Weight(%)
Midterm Exam		30
General Exam		70

Resources
Robot Dynamics and Control, Spong, Vidyasagar, John Wiley and Sons, 1989. • MATLAB Control System Toolbox, SIMULINK (Code Examples) • Arduino (Built-in Examples) https://www.arduino.cc/en/Tutorial/BuiltInExamples