EEM 409 – ROBOTIC CONTROL THEORY

Course Code	Course Name	Semester		
EEE 409	Digital System Design	Fall ☒ Spring ☐ Summer ☐		
Hours			**Credit**	**ECTS**
Theory	**Practice**	**Lab**	4	5
3	0	0		

Course Details	
Department	Electrical and Electronics Engineering
Course Language	Turkish
Course Level	Undergraduate ☒ Graduate ☐
Mode of Delivery	Face to Face ☒ Online ☐ Hybrid ☐
Course Type	Compulsory ☐ Elective ☒
Lecturer(s)	
Course Objectives	The objective of this course is for students to learn the fundamental mathematical techniques needed to analyze and design multi-jointed robotic systems. These techniques include understanding robot geometry, such as the position and velocity relationships between robot actuators and the intended motion (kinematics and velocity kinematics). Students will also learn about dynamical models of robots, including the transfer of torque/force from actuators to tasks (robot dynamics), and the control of robot actuators to achieve desired motions (robot control). These techniques apply to both classical robot manipulators and mobile robots, such as wheeled or legged robots. Time permitting, the course will also cover robot path planning, trajectory generation, and more advanced robot control approaches. By the end of the course, students should be able to use this knowledge to advance their research goals or develop more competitive engineering solutions in their work.
Course Content	Evolution of Robots Elements of Robotic Systems Mathematics of Manipulators Homogeneous Transformations Position and Orientation Kinematics Inverse Kinematics Differential Changes Task Planning and Path Planning Manipulator Dynamics Generalized Controller Design
Course Method/ Techniques	Lecture ☒ Question & Answer ☐ Presentation ☐ Discussion ☐

Prerequisites/ Corequisites	
Work Placement(s)	

Textbook/References/Materials

"Introduction to Robotics: Mechanics and Control" by John J. Craig

Course Category				
Mathematics and Basic Sciences	☒		Education	☐
Engineering	☒		Science	☒
Engineering Design	☒		Health	☐
Social Sciences	☐		Profession	☒

Weekly Schedule

No	**Topics**	**Materials/Notes**
1	Introduction to Robotics	Chapter 1
2	Rigid-Body Transformations	Chapter 2
3	Forward Kinematics	Chapter 3
4	Inverse Kinematics	Chapter 4
5	Velocity Kinematics - The Jacobian	Chapter 5
6	Static Forces in Manipulators	Chapter 6
7	Dynamics of Manipulators	Chapter 7
8	Midterm Exam	
9	Trajectory Planning	Chapter 8
10	Linear Control of Manipulators	Chapter 9
11	Nonlinear Control of Manipulators	Chapter 10
12	Force Control of Manipulators	Chapter 11
13	Robot Programming Languages and Systems	Chapter 12
14	Mobile Robots	Chapter 13
15	Advanced Topics in Robotics	Chapter 14
16	Final Exam	

Assessment Methods and Criteria		
In-term studies	**Quantity**	**Percentage**
Attendance		
Lab		
Practice		
Fieldwork		
Course-specific internship		
Quiz/Studio/Criticize		
Homework		
Presentation / Seminar		
Project	1	20%
Report		
Seminar		
Midterm Exam	1	20%
Final Exam	1	60%
	Total	**100%**
Contribution of Midterm Studies to Success Grade	1	40%
Contribution of End of Semester Studies to Success Grade	1	60%
	Total	**100%**

ECTS Allocated Based on Student Workload			
Activities	**Quantity**	**Duration (Hrs)**	**Total Workload**
Course Hours	16	3	48
Lab			
Practice			
Fieldwork			
Course-specific Work Placement			
Out-of-class study time	16	5	80
Quiz/Studio/Criticize			
Homework			
Presentation / Seminar			
Project	1	50	50
Report			
Midterm Exam and Preparation for Midterm	1	23	23
Final Exam and Preparation for Final Exam	1	24	24
Total Workload			**225**
Total Workload / 25			**9**
"1ECTS Credit			**5**

Course Learning Outcomes	
No	**Outcome**
L1	Understand 3D Coordinate Systems
L2	Derive Task-Space Robot Motion
L3	Apply the Jacobian
L4	Model Robot Dynamics
L5	Plan and Control Trajectories

Contribution of Course Learning Outcomes to Program Competencies/Outcomes

Contribution Level: 1: Very Slight, 2: Slight, 3: Moderate, 4: Significant, 5: Very Significant

	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**					**Total**
L1	5	5	5	5	5	5	5	5	4	4	4					-
L2	5	5	5	5	5	5	5	5	4	4	4					-
L3	5	5	5	5	5	5	5	5	4	4	4					-
L4	5	5	5	5	5	5	5	5	4	4	4					-
L5	5	5	5	5	5	5	5	5	4	4	4					-
															Total	-

i. Sufficient knowledge in the fields of mathematics, natural sciences, and related engineering disciplines; the ability to apply theoretical and practical knowledge in solving complex engineering problems.

ii. The ability to identify, formulate, and solve complex engineering problems; the ability to select and apply appropriate analysis and modeling methods for this purpose.

iii. The ability to design a complex system, process, device, or product to meet specific requirements under realistic constraints and conditions; the ability to apply modern design methods for this purpose.

iv. The ability to select and use modern techniques and tools required for the analysis and solution of complex problems encountered in engineering applications; the ability to effectively use information technologies.

v. The ability to design experiments, conduct experiments, collect data, analyze results, and interpret findings for the investigation of complex engineering problems or discipline-specific research topics.

vi. The ability to work effectively in intra-disciplinary and multidisciplinary teams; the ability to work independently.

vii. The ability to communicate effectively both orally and in writing; proficiency in at least one foreign language; the ability to write effective reports, understand written reports, prepare design and production reports, make effective presentations, and give and receive clear and understandable instructions.

viii. Awareness of the necessity of lifelong learning; the ability to access information, track developments in science and technology, and continuously renew oneself.

ix. Acting in accordance with ethical principles, knowledge of professional and ethical responsibilities, and the standards used in engineering applications.

x. Knowledge of business practices such as project management, risk management, and change management; awareness of entrepreneurship and innovation; knowledge of sustainable development.

xi. Knowledge of the impact of engineering practices on health, environment, and safety at global and societal levels, and awareness of contemporary engineering issues; awareness of the legal consequences of engineering solutions.