School of Engineering and Natural Sciences / Electrical and Electronics Engineering (English)

2024 - 2025 Academic Year

CONTROL SYSTEMS

Syllabus

Course Description					
Name	**Code**	**Semester**	**T+A Hour**	**Credit**	**ECTS**
CONTROL SYSTEMS	EEE3234080	Spring Semester	3+0	3	6

Prerequisites Courses	SİNYALLER VE SİSTEMLER; LİNEER CEBİR; LİNEER CEBİR VE DİFERANSİYEL DENKLEMLER
Recommended Elective Courses	Robotics, Medical Robotics, Nonlinear Systems
Language of Instruction	English
Course Level	First Cycle (Bachelor's Degree)
Course Type	Required
Course Coordinator	Assist.Prof. Elif HOCAOĞLU
Name of Lecturer(s)	Assist.Prof. Elif HOCAOĞLU
Assistant(s)	
Aim	Objective of the course is to enable students to• understand the vital role of automatic control in engineering and science, • recognize the fundamental concepts of control systems, • identify when a process is challenging to control, • propose solutions on the purpose of designing controllers for dynamic systems by using relevant mathematical theory and key concepts, • simulate various dynamic models based on different control methodologies and evaluate their behavior and performance by means of computational tools,• apply fundamental control theories to real time systems.
Course Content	This course contains; Introduction to Control Systems, A Perspective on Feedback Control, A Perspective on Mathematical Modeling of Dynamic Systems,Dynamic Models, Laplace Transformation, Inverse Laplace Transformation, Poles and Zeros, Linear System Analysis, The Transfer Functions, The Block Diagram,Transient Response Analysis, Time-Domain Specifications, Design Synthesis, Effect of Zeros and Additional Poles, Stability of LTI Systems, Routh's Stability Criterion,The First Analysis of Feedback, The Basic Equations of Control, Regulation and Disturbance Rejection, PID Control,Control Systems Design by the Root Locus Method, Lead Compensation, Lag Compensation,Frequency Response Design, Bode Diagrams, Bode Diagram Problems, Stability Condition,Bode Diagram Problems, Stability Condition, Stability Margins, Closed-Loop Frequency Response,Control System Design by Frequency Response: Lead Compensation, Lag Compensation, Lag-Lead Compensation, PD-PI-PID Compensations,State-Space Design, System Description in State-Space, Block Diagrams and Canonical Forms: Controllable Canonical Forms,State-Space Design, Observer Canonical Forms, Dynamic Response from the State Equations,Estimator Design, Observability, Reduced Order Estimator Design, Estimator Pole Selection, Compensator Design: Combined Control Law and Estimator,Controllability, Observability, Control System Design in State Space: Pole Placement,Control-Law Design for Full-State Feedback: Observer, Ackermann's Formula,Estimator Design, Observability, Reduced Order Estimator Design, Estimator Pole Selection, Compensator Design: Combined Control Law and Estimator.

Course Learning Outcomes	**Teaching Methods**	**Assessment Methods**
Recognize the efficacy of automatic control, the importance of a proper process design, the concept of feedback in control systems and some of the key design issues.	12, 16, 2, 21, 9	A, E, F
Recognize the fundamental elements taking part in the control systems, such as actuators, sensors, controllers, and converters	2, 21, 3, 9	A, E, F
Develop mathematical models for various dynamic systems by analysing these systems using design principles.	12, 2, 21, 9	A, E, F
Restate transfer functions of the dynamic models using Laplace transform.	12, 2, 21, 3, 9	A, E, F, R
The characteristics of the time response for these models are determined within a simulation environment by redefining the transfer function of dynamic models using Laplace transformation.	12, 2, 21, 9	A, E, F, R
Compare open-loop and closed-loop control with respect to disturbance rejection, tracking accuracy, sensitivity, and steady-state error.	12, 2, 21, 3, 9	A, E, F, R
Design linear control systems utilizing fundamental concepts, such as root locus, frequency response (Bode diagrams), and state-variable feedback both in time and frequency domains and evaluate their effect on the transient and steady-state performance of the system.	12, 2, 21, 3, 9	A, E, F, R
Employ the fundamental digital control concepts for the software and hardware-based implementations.	11, 2, 21, 5	D, F, R
Design physical systems to be fabricated and controlled in real-time in order to solve the identified engineering problems with technical skills.	12, 2, 21, 3, 9	A, D, E, F, R

Teaching Methods	11: Demonstration Method, 12: Problem Solving Method, 16: Question - Answer Technique, 2: Project Based Learning Model, 21: Simulation Technique, 3: Problem Baded Learning Model, 5: Cooperative Learning, 9: Lecture Method
Assessment Methods	A: Traditional Written Exam, D: Oral Exam, E: Homework, F: Project Task, R: Simulation-Based Evaluation

Lecture Schedule

Sequence	**Topics**	**Preliminary Preparation**
1	Introduction to Control Systems, A Perspective on Feedback Control, A Perspective on Mathematical Modeling of Dynamic Systems	Course slides and 1st chapter of the course books
2	Dynamic Models, Laplace Transformation, Inverse Laplace Transformation, Poles and Zeros, Linear System Analysis, The Transfer Functions, The Block Diagram	Course slides and 2nd chapter of the course books
3	Transient Response Analysis, Time-Domain Specifications, Design Synthesis, Effect of Zeros and Additional Poles, Stability of LTI Systems, Routh's Stability Criterion	Course slides and 3th chapter of the course book (Franklin's book) and 5th chapter of the Ogata's book
4	The First Analysis of Feedback, The Basic Equations of Control, Regulation and Disturbance Rejection, PID Control	Course slides, 4th chapter of the course book (book title:Feedback Control of Dynamic Systems), and 8th chapter of the other course book (book title: : Modern Control Engineering)
5	Control Systems Design by the Root Locus Method, Lead Compensation, Lag Compensation	Course slides, 5th chapter of the course book (book title:Feedback Control of Dynamic Systems), and 6th chapter of the other course book (book title: : Modern Control Engineering)
6	Frequency Response Design, Bode Diagrams, Bode Diagram Problems, Stability Condition	Course slides, 6th chapter of the course book (book title:Feedback Control of Dynamic Systems), and 7th chapter of the other course book (book title: : Modern Control Engineering)
7	Bode Diagram Problems, Stability Condition, Stability Margins, Closed-Loop Frequency Response	Course slides, 6th chapter of the course book (book title:Feedback Control of Dynamic Systems), and 7th chapter of the other course book (book title: : Modern Control Engineering)
8	Control System Design by Frequency Response: Lead Compensation, Lag Compensation, Lag-Lead Compensation, PD-PI-PID Compensations	Course slides, 6th chapter of the course book (book title:Feedback Control of Dynamic Systems), and 7th chapter of the other course book (book title: : Modern Control Engineering)

Lecture Schedule		
Sequence	**Topics**	**Preliminary Preparation**
9	State-Space Design, System Description in State-Space, Block Diagrams and Canonical Forms: Controllable Canonical Forms	Course slides, 7th chapter of the course book (book title:Feedback Control of Dynamic Systems), and 9th chapter of the other course book (book title: : Modern Control Engineering)
10	State-Space Design, Observer Canonical Forms, Dynamic Response from the State Equations	Course slides, 7th chapter of the course book (book title:Feedback Control of Dynamic Systems), and 9th chapter of the other course book (book title: : Modern Control Engineering)
11	Estimator Design, Observability, Reduced Order Estimator Design, Estimator Pole Selection, Compensator Design: Combined Control Law and Estimator	Course slides, 7th chapter of the course book (book title:Feedback Control of Dynamic Systems), and 9th chapter of the other course book (book title: : Modern Control Engineering)
12	Controllability, Observability, Control System Design in State Space: Pole Placement	Course slides, 7th chapter of the course book (book title:Feedback Control of Dynamic Systems), and 9th chapter of the other course book (book title: : Modern Control Engineering)
13	Control-Law Design for Full-State Feedback: Observer, Ackermann's Formula	Course slides, 7th chapter of the course book (book title:Feedback Control of Dynamic Systems), and 9th chapter of the other course book (book title: : Modern Control Engineering)
14	Estimator Design, Observability, Reduced Order Estimator Design, Estimator Pole Selection, Compensator Design: Combined Control Law and Estimator	Course slides, 7th chapter of the course book (book title:Feedback Control of Dynamic Systems), and 9th chapter of the other course book (book title: : Modern Control Engineering)

Evaluation Methods	Weight(%)
Midterm Exam	30
General Exam	70

Resources

1. G.F. Franklin, J.D. Powell, A.Emami-Naeini: Feedback Control of Dynamic Systems (7th Edition), Prentice Hall, 2015.

2. Katsuhiko Ogata: Modern Control Engineering (5th Edition), Prentice Hall, 2010.1. MATLAB Control System Toolbox, SIMULINK (Code Examples)
2. Arduino (Built-in Examples)
https://www.arduino.cc/en/Tutorial/BuiltInExamples
3. G.F. Franklin, J.D. Powell, M. Workman: Digital Control of Dynamic Systems (3th Edition), Prentice Hall, 2006.