Information Technology University
Department of Electrical Engineering

EE361: Control Systems			
Course Code	EE361	**Semester**	6th
Credit Hours	3+1	**Term**	Spring 2019
Instructor	Usama Bin Sikandar	**Pre-Requisites**	Electrical Network Analysis
Office	Room 9, 4th floor	**E-mail**	usama.sikandar@itu.edu.pk
Department	Electrical Engineering	**Discipline**	Engineering
Teaching Assistant	Khansa Rasheed	**Office Hours**	Fri 12-1 pm
Lab Engineers	Abdullah Baig, Asif Ali	**Lab Timings**	Fri 2-5 pm

Course Description

This course teaches the students how to control the behavior of a physical system, which can be modeled by linear differential equations, and make it compliant. The course focuses on control design through pole-placement for performance specifications such as stability, reference tracking, disturbance rejection and sensitivity reduction. The lectures will be complemented by labs to provide the students with a hands-on experience of the design techniques in software and hardware.

Course Outcomes/Objectives

On the completion of the course, the student will be able to demonstrate the following:

- Model physical systems using control systems conventions and terminology
- Convert the differential equations to state-space and transfer function representations
- Analyze a linear system stability characteristics
- Understand why feedback is helpful in control systems
- Design a suitable controller to obtain the desired referencing-tracking for a standard input
- Design a suitable controller to obtain the desired frequency response
- Use MATLAB, Simulink and LabView to model physical systems and design the control techniques for physical systems interfaced with these software.

Books

Text Book:	*Control Systems Engineering* (7th Edition) by N. S. Nise.
Reference Books:	1. *Modern Control Systems*, 12th edition, by Dorf and Bishop 2. *Feedback Control of Dynamic Systems*, 6th edition, by Franklin, Powell and Emami-Naeini

Course Assessment Distribution

Quizzes:	10 % (6 quizzes)
Assignments:	15 % (6 homework assignments)
Mid-term Exam:	20 %
Final Exam:	30 %
Lab Performance	25 % (Project 10%, Labs 15%)

Weekly Lecture Breakdown			
Week 1:	Mathematical modeling	Week 10:	Feedback
Week 2:	Laplace transform	Week 11:	Pole-placement
Week 3:	Transfer functions	Week 12:	PID
Week 4:	State-space representation	Week 13:	Root Locus
Week 5:	State-space to transfer function	Week 14:	Controllability and Observability
Week 6:	First and 2nd order systems	Week 15:	Frequency response and Bode plots
Week 7:	Stability	Week 16:	Sketching and interpreting Bode plots
Week 8:	Reference tracking	Week 17:	Prep week
Week 9:	**Midterm exam**	Week 18:	**Final exam**

Chapter	Lecture Topics	No. of Lectures
Nise Ch 1	**Introduction to Control** ● Motivation ● Design process ● Mathematical modeling of electrical circuits, mechanical systems, heat and fluid-flow systems ● Analytical solutions of linear ODEs ● Input-output modeling	2
Nise Ch 2, 5	**Modeling in Frequency Domain** ● Laplace transform and s-domain ● Transfer functions ● Poles and zeros ● Initial and final value theorems ● Block diagrams and signal-flow graphs ● Dynamic Response	4
Nise Ch 3	**Modeling in Time Domain** ● Time-varying systems ● State-variables and state-space representation ● State-transition matrix ● Transforming state-space to transfer function ● Linearization	3
Nise Ch 4	**System Response** ● Impulse and step response ● Effect of poles ● First order system parameters ● Second order system parameters ● Effect of additional poles ● Effect of zeros ● Solutions in s-domain and t-domain	3
Nise Ch 6	**Stability** ● Internal and BIBO stability ● Location of poles ● Routh-Hurwitz criterion ● Routh's table ● Stability in state-space	2

Nise Ch 7	**Reference Tracking** ● Step, ramp and parabolic inputs ● Steady-state error from transfer functions and State-space ● System types ● System specifications ● Disturbance ● Sensitivity	2
Mid Term Exam		
Nise Ch 8	**Feedback Control Design** ● Feedback ● Effects of feedback ○ Disturbance rejection ○ Sensitivity reduction ○ Stability properties ● Control goals and pole-placement ● Proportional control ● Proportional and derivative control ● Proportional and integral control ● Proportional, integral and derivative (PID Control) ● Lead and lag compensation ● Control design using pole placement ● Sketching and interpreting root locus ● Design of controllers/compensators using root locus	7
Nise Ch 12	**Control Design in State-space** ● Signal flow graphs ● Full-state feedback ● Controllability ● Controller design using Ackermann's formula ● Observability ● Observer design using Ackermann's formula	
Nise Ch 11	**Frequency Response Design** ● Frequency response ● Sketching and interpreting Bode plots ● Gain and phase margins	7
Final Exam		

Lab#	Lab Topics	Date
1	Differential equations modeling in Simulink	
2	Transfer function representation of systems 1	
3	Transfer function representation of systems 2	
4	State-space representation of systems	
5	Dynamic response of 1^{st} and 2^{nd} order systems	
6	Dynamic response of higher order systems	
7	Stability properties of systems	
8	Steady-state error analysis	
9	DC motor speed control	
10	DC motor angular position control	
11	HVAC Control	

12	Inverted pendulum control	
13	Vertical take-off and landing 1	
14	Vertical take-off and landing 2	
15	Project Evaluation	
Final Exam		

Course Learning Objectives (CLOs):

CLO	Description	BT	PLOs
1	Model physical systems using control systems conventions and terminology	C3	1, 4
2	Analyze a linear system stability characteristics	C4	1, 2
3	Design a suitable controller to track a reference signal and obtain the desired frequency response	C3	2, 3, 5
4	Use MATLAB, Simulink and LabView to simulate physical systems and design the control techniques for systems interfaced with these software and additional hardware	C6	1, 5, 6

Mapping of CLOs to Assessment Modules:

Assessments	CLO1	CLO2	CLO3	CLO4
Quizzes	✓	✓	✓	✓
Assignments	✓	✓	✓	✓
MidTerm	✓	✓	✓	
Final Exam	✓	✓	✓	✓
Lab Performance		✓		✓
Project	✓	✓	✓	✓

Mapping of CLOs to Program Learning Outcomes (PLOs):

PLOs/CLOS	CLO1	CLO2	CLO3	CLO4
PLO 1 (Engineering Knowledge)	✓	✓		✓
PLO 2 (Problem Analysis)		✓	✓	
PLO 3 (Development of Solutions)			✓	✓
PLO 4 (Investigation)	✓			
PLO 5 (Modern tool usage)			✓	✓
PLO 6 (The Engineer and Society)				✓
PLO 7 (Environment and Sustainability)				
PLO 8 (Ethics)				
PLO 9 (Individual and Team Work)				
PLO 10 (Communication)				
PLO 11 (Project Management)				
PLO 12 (Lifelong Learning)				

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<tr><th colspan="2">Grading Policy:</th></tr>
<tr><td>Quiz Policy</td><td>The quizzes will take place in the lecture right after the submission of a homework assignment and will be totally based on one of the problems in that assignment. So, in order to score well in quizzes, students must spend sufficient time solving the homework problems individually. Grading for quizzes will generally be on a scale of 0 to 10.</td></tr>
<tr><td>Assignment Policy</td><td>In order to develop a comprehensive understanding of the subject and push the students out of their comfort zone in the subject, challenging problems will be assigned as homework. The students must do the homework individually. Copying of homework or any kind of plagiarism is highly discouraged and violations will be dealt with severely by referring any occurrences to the disciplinary committee and a straight-away zero. Homework submitted late by one day will be penalized by 20%, but after that nothing will be accepted. All homework assignments will count towards the total (no ‘best-of’ policy). The problems in the assignment are meant to be challenging to raise the students’ caliber in the subject, give them confidence and enable them to prepare not just the exams but the real world scenarios.</td></tr>
<tr><td>Plagiarism</td><td>The course has a zero-tolerance policy towards plagiarism. While collaboration in this course is highly encouraged, you must ensure that you do not claim other people’s work/ ideas as your own. Plagiarism occurs when the words, ideas, assertions, theories, figures, images, programming codes of others are presented as your own work. You must cite and acknowledge all sources of information in your assignments. Failing to comply with the plagiarism policy will lead to strict penalties including a failing grade in the course and referral to the Disciplinary Committee for a strict action, which may possibly lead to failing grades in all the courses of the semester.</td></tr>
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<tr><td>Grade</td><td>A+</td><td>A</td><td>A-</td><td>B+</td><td>B</td><td>B-</td><td>C+</td><td>C</td><td>C-</td><td>D+</td><td>D</td><td>F</td></tr>
<tr><td>Cutoff</td><td>>90</td><td>>80</td><td>>75</td><td>>70</td><td>>65</td><td>>60</td><td>>55</td><td>>50</td><td>>45</td><td>>40</td><td>>35</td><td><35</td></tr>
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