ME 450

Modeling of Dynamic Systems

Summer 2021 (May 17-August 13, Final on August 13)

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Teaching Assistant: N/A

Office Hours: Via E-Mail

Class Location and Time: On-Line

Text: Palm III, William, System Dynamics, 4th edition, 2021. (The third edition would also be ok)

Prerequisites: ME 370, ME 345 (concurrent)

Note: It is important to have a solid foundation in dynamics and differential equations

Grading:

Tests (2)	40%
Homeworks/Projects	35%
Final (comprehensive)	25%

Final Average	> 93.0	89.0-92.99	85.0-88.99	80.0-84.99	78.0-79.99	72.0-77.99	69.0-71.99
Letter Grade	A	A-	B+	B	B-	C+	C

Final Average	60-68.99	<60
Letter Grade	D	F

Course Description

This course covers modeling, analysis, and control of single and multiple degree-of-freedom dynamical systems, including mechanical, electrical, thermal, fluid systems and their combinations (mixed systems). The processes of energy storage and dissipation, which are common for different kinds of dynamic systems, will be emphasized in investigating general principles for modeling various dynamic systems. Basic concepts in system theory such as state variables and stability notions will be introduced. Most of the content will be restricted to linear-time-invariant systems; however, local linearization around nominal operating points will be taught to analyze nonlinear systems. Introduction to classical control analysis and design methods will also be given.

Course Objectives

1. To model various engineering systems, including mechanical, electrical, fluid, thermal systems and their combinations.
2. To solve the model equations analytically and numerically using Matlab/Simulink.
3. To relate the solution of the model equations to the physical response of the system.
4. To understand basic control concepts with working knowledge of transfer functions, frequency response, system stability, and steady-state error.
5. To perform basics design/analysis of control systems.

Course Outcomes

After completing this course, the student should be able to:

1) Derive equations describing the transient behavior for various engineering systems through the application and integration of physical principles.

2) Recognize energy storage elements for various engineering systems and determine the order of a system.

3) Analyze nonlinear systems by linearizing the equations around an equilibrium condition.

4) Solve the equation of motion (typically a first-order or second-order ordinary differential equation) to obtain the time-dependent response.

5) Analyze the time-dependent response of generic types of first and second order systems for various inputs.

6) Draw block diagrams representing the dynamics of complex systems (multiple ODEs) and vice versa (obtain system equations from block diagrams).

7) Use MATLAB/Simulink to analyze and simulate the response of a dynamic system.

8) Analyze the response of systems under various harmonic inputs and represent the frequency-dependent response of these systems.

9) Understand basic concept of feedback control applied to simple linear time invariant systems.

Academic Integrity

The University defines academic integrity as the pursuit of scholarly activity in an open, honest and responsible manner. All students should act with personal integrity, respect other students' dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts (refer to Senate Policy 49-20). Dishonesty of any kind will not be tolerated in this course. Dishonesty includes, but is not limited to, cheating, plagiarizing, fabricating information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. Students who are found to be dishonest will receive academic sanctions and will be reported to the University's Office of Student Conduct for possible further disciplinary sanctions (refer to Senate Policy G-9).

An important part of learning how to solve engineering problems is homework assignments. It is assumed that each student will hand in solutions that are largely the results of his/her own efforts. A good indicator of whether or not the solution represents your own work is to ask yourself if you fully understand every step of the solution. Homework assignments will be handed out regularly and are to be handed in by date listed on the assignment itself. The assignments will be posted on Canvas. **NO LATE HOMEWORK OR PROJECTS WILL BE ACCEPTED!** Although I do not require a certain type of paper and rigid format requirements for the homework, I do expect it to be neat and your answers clearly indicated.

Examination Information

"This course may require you to take exams using certain proctoring software that uses your computer's webcam or other technology to monitor and/or record your activity during exams. The proctoring software may be listening to you, monitoring your computer screen, viewing you and your surroundings, recording and storing any and all activity (including visual and audio recordings) during the proctoring process. By enrolling in this course, you consent to the use of the proctoring software selected by your instructor, including but not limited to any audio and/or visual monitoring which may be recorded. ***Please contact your instructor with any questions****."*

Please find below a tentative schedule with the topics to be covered. Each lecture will have a powerpoint presentation associated with it. There will be audio with the presentation.

Tentative Schedule

Week	Lecture#	Chapter	Topic
1: 5/17-5/21	1,2,3,4	1	Introduction, Course Objectives, Examples
			Review of ME 450 Prerequisites
			System Classification, Mechanical Systems
2: 5/24-5/28	5,6,7,8	3, 4	Mechanical Systems
			System Representation: I/O and State Space
			Equilibrium, Linearization
3: 5/31-6/4	9,10,11	2	Solution of ODE's-Time Domain
			Laplace Transform
			Solution of ODE's –S-Domain
			Transfer Functions, Stability
4: 6/7-6/11	12, 13, 14		**Test 1**
5: 6/14-6/18	15, 16, 17	8	Time Domain Analysis-First Order Systems
			Time Domain Analysis-Second Order Systems
6: 6/21-6/25	18,19,20,21	9, 12	Frequency Response, Bode Plots
7: 6/28-7/2	22,23,24,25	6	Introduction to Simulink, Electrical Systems
8: 7/5-7/9	26, 27, 28	7	Electric Motors, Thermal Systems
9: 7/12-7/16	29, 30, 31, 32	7	Fluid Systems, **Test 2**
10: 7/19-7/23	33, 34, 35		Mixed Systems
11: 7/28-7/30	36,37,38,39	10	Introduction to Feedback Control
			Stability of Closed-Loop Systems
			Pole Placement
12: 8/2-8/6	40, 41	10	Pole Placement and PID Controller, Case Study
13: 8/9-8/13			Review, **Final Exam**