The University of Michigan
Department of Mechanical Engineering
ME 360: Modeling, Analysis, and Control of Dynamic Systems
Section 001, TTh 8:30 – 10:30am, 1500 EECS
Section 002, TTh 12:00 – 2:00pm, 1109 FXB

Winter 2008

Instructors:

Anna G. Stefanopoulou (AS) (noon section 2), G034 Lay Auto Lab, annastef@umich.edu
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Important Hours:	Monday	Tuesday	Wednesday	Thursday
8:30-9:30		Class		Class/HW
9:30-10:30	AH (Mujo)	Class		Class/HW
10:30-11:30	AH (Mujo)	MC (2279 GGB)		MC (2279 GGB – by appointment)
12:00-1:00	RP (Qzn)	Class	RP (LC)	Class/HW
1:00-2:00		Class		Class/HW
2:30-3:30			AS (LC)	AS (G034 AL – by appointment)
3:30-4:30		AS (G034 AL)	AH (LC)	
4:30-5:30		AH* (TBD)	AH+MC (LC)	
5:30-6:30		AH (TBD)	RP (LC)	

Home Page: https://ctools.umich.edu
Will contain links to basic course information as well as a discussion area and lecture summary.

Text: *Required:* K. Ogata, System Dynamics, Fourth Edition

Optional (reserved in the Media Union):

- Close and Frederick, Modeling and Analysis of Dynamic Systems.
- W. Palm, Modeling, Analysis, and Control of Dynamic Systems.
- Messner and Tilbury, Control Tutorials for Matlab and Simulink : A Web-Based Approach

Homework: Problems sets will be due every Thursday in class. There will be 10 assignments. The lowest homework score will be dropped. You may discuss the homework assignments with each other and with the instructor, but you **must write your own solutions** to the homework which reflect your own understanding of the material. You may NOT seek or use solutions from prior semesters. Homework solutions will be posted on ctools and in the engineering library on Fridays. Homework has to be turned in at the **beginning of class**. No exceptions will be made.

RAT: Readiness Assessment Test. A 10 min quiz followed by discussion every Tuesday

Exams: There will be two midterms and a final exam.

Exam 1:	Thurs, February 7 (tentative)
Exam 2:	Thurs, March 20 (tentative)
Final (morning section 1)	Mon, April 21, 8:00-10:00
Final (noon section 2)	Wed, April 23, 1:30-3:30

Grading:

Homework	15%,
Exam 1	25%
Exam 2	25%
Final Exam	35%

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COURSE OBJECTIVES

[Links to Course Outcomes are identified in brackets]

1. To teach students elementary tools of modeling of mechanical, electrical, fluid, and thermofluid systems [1, 5, 11].
2. To teach a basic understanding of behavior of first- and second-order linear time-invariant (LTI) differential equations [1, 12].
3. To teach basic concepts of Laplace transforms, transfer functions, and frequency response analysis [12].
4. To introduce the concept of stability and the use of feedback control to actively control system behavior [1, 3, 5].
5. To provide examples of real-world systems to which modeling and analysis tools are applied (e.g., automotive shock absorber) for the purpose of design [11].
6. To introduce an appreciation for decision-making skills needed to devise models that adequately represent relevant behaviors yet remain simple [1, 5].
7. To teach basic concepts in numerical integration and computer simulation of mathematical models.

COURSE OUTCOMES

[links to Course Objectives are identified in brackets]

1. Given a description of a real-world system, make educated decisions about how to model it in terms of idealized, lumped elements [1, 5, 6, 7].
2. Given a simple system containing some combination of mechanical, electrical, and/or thermofluid elements, write a differential equation describing its input/output behavior [1].
3. Given a first- or second-order LTI differential equation, predict its step response or free response [2].
4. Given a LTI differential equation and a sinusoidal input, predict the gain and phase of the steady-state output as a function of input frequency [3].
5. Given certain desired performance characteristics for a system (such as maximum overshoot due to a step input), translate specifications into design parameters (such as the dimensions of a coil spring) necessary to provide those characteristics [4, 5, 7].
6. Given a physical description of a system and a graphical representation of its time-domain response (step, frequency, etc.), estimate system parameters (i.e. friction or damping coefficient, spring constant) [3, 4, 5].
7. Given a LTI differential equation and an arbitrary input composed of steps, ramps, and other simple functions, set up the solution using Laplace transforms [3].
8. Describe basic applications of proportional and derivative feedback in control systems to improve performance or stability [4].
9. Given a system composed of mixed mechanical/electrical/thermofluid components, write the transfer function describing input-output behavior [1, 3].
10. Given a system with given performance, describe (qualitatively) how behavior can be improved according to specifications such as overshoot and settling time, using some combination of parameter tuning and feedback control [2, 4, 5, 7].
11. Describe how changes in parameter values will affect damping ratio and natural frequency for a system, and how these characteristics are manifested in the system's behavior [2, 3, 7].
12. Implement a mathematical model into commercial simulation software, and exercise the model to make engineering assessments [2, 5, 6, 7].

Course Schedule, ME360 Winter 2008							
No.	**Date**	**Heading**	**Topics**	**Reading**	**Exams**	**HWout**	**HWdue**
1	1/3	Introduction	Block Diagrams; Control Intro; LTI Models	Ch.1 & Handout		1	
2	1/8	Transforms	Solving Ord Diff Eqs, Lin & Superp	2-1 to 2-3			
3	1/10		Laplace; Important Properties; Important Signals	2-3		2	1
4	1/15		Inverse Laplace, Partial Fraction Exp, Transfer Functions, Block Diagrams	2-4 to 2-6 & 4			
5	1/17	Mechanical system models	Mechanical elements: Spring, Damper, Mass; State Variables: Translation vs. Rotation;	3-1 to 3-2		3	2
6	1/22		Multimass systems; Equilibrium;Sys ID	3-3 to 3-4 & 3-6			
7	1/24	Frequency Domain	Force vibrations; Resonance; Transfer Function Magnitude and Phase	9-1 to 9-3		4	3
8	1/29		Bode Gain-Phase; Hand Plotting Rules	11-1 to 11-2			
9	1/31		Bode Gain-Phase; Matlab	11-3			4
10	2/5		Frequency Domain Specs	11-6			
11	2/7				**Exam 1**	5	
12	2/12	Electrical Systems	Elements, Ohm's Laws, Loop & Node	6-1 to 6-2			
13	2/14		Switching circuits, Complex Impedance	6-3 to 6-4		6	5
14	2/19		DC Motors	Handout			
15	2/21		Electromechanical Systems	Handout		7	6
	2/26	Winter Break					
	2/28	Winter Break					
16	3/4		Haptic Interfaces				
17	3/6	Time Domain Analysis	1st ODE, Sys ID, Impluse, Step, Ramp;	8.1-8.3		8	7
18	3/11		Response 2nd ODE	8.3			
19	3/13	Control Design	Specs in time domain; s-domain correlates;	10-4 to 10-5			8
20	3/18		Block Diagrams; Intro to Control ;Proportional, Derivative, Integral Control; Examples;	10-2 to 10-3			
21	3/20				**Exam 2**	9	
22	3/25		Design:motivation, sensitivity, steady-state offset, transient response	10-6			
23	3/27		State Space; Examples	5-1, 5-2, 5-3		10	9
24	4/1		Linearization	Handout, 8-1:2			
25	4/3		Modeling and Control Design Problem				10
26	4/8						
27	4/10						
28	4/15						
	4/21	8:00-10:00	Final Exam – Section 1		**Exam 3**		
	4/23	1:30-3:30	Final Exam – Section 2		**Exam 3**		