		ME 360: Mode Sect	<b>partment</b> eling, Ana ion 001, T	<b>t of Me</b> alysis, a ITh 8:30	) – 10:30am, 1500	ynamic Systems ) EECS	Winter 2008			
Instructors:				ing, Analysis, and Control of Dynamic Systems n 001, TTh 8:30 – 10:30am, 1500 EECS on 002, TTh 12:00 – 2:00pm, 1109 FXB Winter 2008 poulou (AS) (noon section 2), G034 Lay Auto Lab, annastef@umich.edu anier (MC) (morning section 1), 2279 G.G. Brown, mpc@umich.edu s (AH) adhendri@umich.edu ) rakeshmp@umich.edu Tuesday Wednesday Thursday Class (Class/HW MC (2279 GGB) MC (2279 GGB – by appointment) Class RP (LC) Class/HW Class MW Class (LC) AS (G034 AL – by appointment) AS (G034 AL) AH (LC) AH* (TBD) AH+MC (LC) AH* (TBD) RP (LC) sic course information as well as a discussion area and lecture summary. tem Dynamics, Fourth Edition Media Union): k, Modeling and Analysis of Dynamic Systems. y, Analysis, and Control of Dynamic Systems. y, Control Tutorials for Matlab and Simulink : A Web-Based Approach due every Thursday in class. There will be 10 assignments. The lowest be dropped. You may discuss the homework assignments with each tructor, but you <u>must write your own solutions</u> to the homework which rest At 10 min quiz followed by discussion every Tuesday erms and a final exam.						
Teaching Assistants:		Adam Hendricks (AH) <u>adhendri@umich.edu</u> Rakesh Patil (RP) <u>rakeshmp@umich.edu</u>								
Important Hours 8:30-9:30 9:30-10:30 10:30-11:30 12:00-1:00 1:00-2:00 2:30-3:30 3:30-4:30 4:30-5:30 5:30-6:30	s:	<u>Monday</u> AH (Mujo) AH (Mujo) RP (Qzn)	Class Class MC (227 Class Class AS (G03 AH* (TH	79 GGB) 34 AL) 3D)	) RP (LC) AS (LC) AH (LC) AH+MC (LC)	Class/HW Class/HW MC (2279 GGB – by Class/HW Class/HW				
Home Page:		//ctools.umich.edu contain links to l		rse info	rmation as well a	as a discussion area a	nd lecture summary.			
Text:	Requ	equired: K. Ogata, <u>System Dynamics</u> , Fourth Edition								
Homework:	<ul> <li>Optional (reserved in the Media Union):</li> <li>Close and Frederick, Modeling and Analysis of Dynamic Systems.</li> <li>W. Palm, Modeling, Analysis, and Control of Dynamic Systems.</li> <li>Messner and Tilbury, Control Tutorials for Matlab and Simulink : A Web-Based Approach</li> <li>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 <u>must write your own solutions</u> 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 <u>beginning of class</u>. No exceptions will be made.</li> </ul>									
RAT:	Read	diness Assessment Test. A 10 min quiz followed by discussion every Tuesday								
Exams:	Exan Exan Final	ere will be two midterms and a final exam. Im 1: Thurs, February 7 (tentative) Im 2: Thurs, March 20 (tentative) al (morning section 1) Mon, April 21, 8:00-10:00 al (noon section 2) Wed, April 23, 1:30-3:30								
Grading:	Exan Exan		15%, 25% 25% 35%							

## ME 360: Modeling, Analysis, and Control of Dynamic Systems

## **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 steadystate 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].

Date     Heading       1/3     Introduction       1/8     Transforms       1/10     Introduction       1/10     Introduction       1/10     Introduction       1/10     Introduction       1/10     Introduction       1/17     Mechanical system models       1/17     Frequency Domain       1/22     Introduction       1/23     Introduction       1/29     Introduction       1/29     Introduction       1/29     Introduction       1/20     Introduction       1/21     Introduction       1/22     Introduction       1/23     Introduction       1/24     Introduction       1/25     Introduction       1/26     Introduction       1/27     Introduction       1/28     Introduction       1/29     Introduction       1/21     Introduction       1/21     Introduction       1/21     Introduction       1/21     Introduction       1/21     Introduction       1/21     Introduction       1/22     Introduction       1/23     Introduction       1/24     Introduction       1/25 <t< th=""><th>Topics         Block Diagrams; Control Intro; LTI Models         Solving Ord Diff Eqs, Lin &amp; Superp         Laplace; Important Properties; Important Signals         Inverse Laplace, Partial Fraction Exp, Transfer         Functions, Block Diagrams         Mechanical elements: Spring, Damper, Mass; State         Variables: Translation vs. Rotation;         Multimass systems; Equilibrium;Sys ID         Force vibrations; Resonance; Transfer Function         Magnitude and Phase         Bode Gain-Phase; Hand Plotting Rules         Bode Gain-Phase; Matlab         Frequency Domain Specs         Elements, Ohm's Laws, Loop &amp; Node         Switching circuits, Complex Impedance         DC Motors</th><th>Reading         Ch.1 &amp; Handout         2-1 to 2-3         2-3         2-4 to 2-6 &amp; 4         3-1 to 3-2         3-3 to 3-4 &amp; 3-6         9-1 to 9-3         11-1 to 11-2         11-3         11-6         6-1 to 6-2         6-3 to 6-4</th><th>Exams Exams Exams</th><th>HWout  HWout  HWout  HU  HWout  HU  HU  HU  HU  HU  HU  HU  HU  HU  H</th><th></th></t<>	Topics         Block Diagrams; Control Intro; LTI Models         Solving Ord Diff Eqs, Lin & Superp         Laplace; Important Properties; Important Signals         Inverse Laplace, Partial Fraction Exp, Transfer         Functions, Block Diagrams         Mechanical elements: Spring, Damper, Mass; State         Variables: Translation vs. Rotation;         Multimass systems; Equilibrium;Sys ID         Force vibrations; Resonance; Transfer Function         Magnitude and Phase         Bode Gain-Phase; Hand Plotting Rules         Bode Gain-Phase; Matlab         Frequency Domain Specs         Elements, Ohm's Laws, Loop & Node         Switching circuits, Complex Impedance         DC Motors	Reading         Ch.1 & Handout         2-1 to 2-3         2-3         2-4 to 2-6 & 4         3-1 to 3-2         3-3 to 3-4 & 3-6         9-1 to 9-3         11-1 to 11-2         11-3         11-6         6-1 to 6-2         6-3 to 6-4	Exams	HWout  HWout  HWout  HU  HWout  HU  HU  HU  HU  HU  HU  HU  HU  HU  H	
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1/22         Frequency         1/24         Domain         1/29         1/31         2/5         2/7         Electrical         2/12         Systems	Multimass systems; Equilibrium;Sys ID         Force vibrations; Resonance; Transfer Function         Magnitude and Phase         Bode Gain-Phase; Hand Plotting Rules         Bode Gain-Phase; Matlab         Frequency Domain Specs         Elements, Ohm's Laws, Loop & Node         Switching circuits, Complex Impedance	3-3 to 3-4 & 3-6 9-1 to 9-3 11-1 to 11-2 11-3 11-6 6-1 to 6-2	Exam 1	4	
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2/7         Electrical           2/12         Systems           2/14	Elements, Ohm's Laws, Loop & Node Switching circuits, Complex Impedance	6-1 to 6-2	Exam 1	5	;
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