ME 450 -Modeling of Dynamic Systems

Spring 2009, Sec 2 MWF 1:25-2:15P 258 Willard Bldg

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Text: Dynamic Modeling and Control of Engineering Systems by B. T., Kulakowski, J. F. Gardner, and J. L. Shearer, Third Ed., Cambridge University Press 2007.

Prerequisites: ME 370, ME 345

Grading Policy , Course Objectives, Course Outcomes, Course Conduct , Tentative Schedule , Homework , Projects , Notes

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Grading Policy:

Homework	35% (drop worst hw)
One Computer Project	10%
Midterm	15%
Two Quizes	15%
Final	25%

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 (LTIs); 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, thermal and fluid systems and their combinations (mixed systems).
2. To solve the model equations analytically and/or numerically using Matlab/Simulink.
3. To relate the solution of the model equations to the physical response of the system.
4. To acquire basic control concepts with working knowledge on transfer function, frequency response, system stability and steady-state error.
5. To perform basic design/analysis of control systems.

Course Outcomes:

1. Recognize energy storing elements in an engineering system and choose appropriate state variables.
2. Develop ordinary differential equations (ODEs) that describe the dynamic behavior of lumped parameter systems including mechanical, fluid, thermal and electrical elements.
3. Analyze nonlinear systems by local linearization around nominal operating points.
4. Draw system block diagrams from the system equations and vice versa: write system equations from block diagrams.
5. Analytically solve linear ODE's for responses to initial conditions and to given excitations such as a step input.
6. Evaluate system performance in terms of "time constant" for first-order linear time-invariant systems (LTIs) and "damping ratio" and "natural frequency" for second-order LTI systems. Understand how to estimate the asymptotes of high-order LTI systems.
7. Understand numerical methods of solutions to ODEs. Use Matlab/Simulink to implement various system models.
8. Understand the Laplace transform of linear ODEs and the concept of transfer functions. Perform frequency-response analyses for linear systems.
9. Understand the basic concepts of feedback control. Determine system stability and stability limits for certain classes of feedback systems.
10. Perform design/analysis calculations for basic linear-feedback control systems. Understand the objectives and functions of proportional (P), integral (I), and derivative (D) feedback controls. Design PID feedback controllers for simple linear systems.

Course Conduct:
Academic Integrity Policy (University Policy 49-20)

- Class attendance is highly recommended as material is frequently presented which departs from the text.
- Homework problems will be assigned approximately once a week and will be due one week later.
- Absolutely no late homework will be accepted.
- Consulting/studying in teams is encouraged. However, each team member must work on all parts of the homework and projects and must hand in their own individual work.
- All exams will closed book. However, you may bring with you up to four pages of notes.

Tentative schedule

This is a tentative schedule and it should be used only as a guideline. This schedule may be changed and it is the student's responsibility to be aware of any changes.

Week		Date	Topic	Reading
1	M	1/12	Introduction	1.1, 1.2
	W	1/14	System var & elm	1.1, 1.2
	F	1/16	Trans. mechanical systems	2.1, 2.2
2	W	1/21	Rot. mechanical systems	2.3
	F	1/23	I/O model	3.1, 3.2
3	M	1/26	I/O model	3.1, 3.2
	W	1/28	State-space model	3.3
	F	1/30	State-space model	3.3
4	M	2/2	State-space model	3.4
	W	2/4	Solving 1st-order models	4.1-4.3
	F	2/6	Solving 2nd-order models	4.4
5	M	2/9	Quiz #1	
	W	2/11	Third & higher-order models	4.5
	F	2/13	Solving state-space models	5.1-5.2
6	M	2/16	Solving state-space models	5.1-5.2
	W	2/18	Numerical methods	5.3-5.5
	F	2/20	Laplace Transformation	App2
7	M	2/23	Block Diagram	6 & App3
	W	2/25	Matlab/Simulink	

	F	2/27	Matlab/Simulink (Handout computer project)	6 & App3
8	M	3/2	Linearization	6 & App3
	W	3/4	Linearization	1.3
	F	3/6	Electrical systems, Components & circuit laws	7.1-7.3
10	M	3/16	Review for Midterm	
	W	3/18	Midterm 8:15-10:15pm	
	F	3/20	Analysis of elec. Systems	7.4
11	M	3/23	Analysis of elec. systems	7.4
	W	3/25	Hydralic systems	9.1-9.3
	F	3/27	Mixed systems	10
12	M	3/30	Mixed systems	10
	W	4/1	Transfer function	11.1-11.3
	F	4/3	Transfer function	11.4-11.5
13	M	4/6	Frequency response	12.1-12.2
	T	4/8	Bode plot	12.3
	F	4/10	Closed-loop system	13.1-13.2
14	M	4/13	Quiz #2	
	W	4/15	Closed-loop system	13.1-13.2
	F	4/17	Stability	13.3
15	M	4/20	Routh-Hurwitz	13.3
	W	4/22	Nyquist	13.4
	F	4/24	Control systems	14.5
16	M	4/27	Control systems	14.5
	W	4/29	Review for Final	
	F	5/1	Control systems	

Homework

HW1 , due Jan 25
HW2, due Feb 2

Projects

Notes

Laplace transform
euler2 : 2 equations Euler code
spr_mas_damper fucntion
Matlab tutorial 1
Matlab tutorial 2
