ME 464/664: Mechanical System Modeling and Design
Spring 2006

Instructor

Dr. Joseph C. Slater
238 Russ Engineering Center
775-5085
http://www.cs.wright.edu/~jslater
Helpful materials are available through the course page:
http://www.cs.wright.edu/~jslater/MechSys.html

Time and Place

Monday/Wednesday 4:10-5:50 PM
152B Russ

Objectives

System Dynamics covers modeling of advanced complex system level modeling of dynamic engineering systems including, but not restricted to, linear and rotational mechanical, fluid, thermal, and electrical systems. Modeling of control devices (e.g. motors, heaters and pumps) is addressed.

The course focuses on a) the development of governing equations, and b) the solution of governing equations, linear and nonlinear. Development of governing equations is by methods appropriate to each subfield. The unifying system level analysis will be taught a) via time domain solutions, b) frequency (Laplace domain) solutions, and c) numerical simulation in Simulink (a modern system simulation tool).

Office Hours

Tentative: Will change depending on student schedules. Tentatively 2-3 PM, Monday and Wednesday, and by appointment. Please use email to contact me when you have questions, and to set up appointments. I check my email throughout the day. You will get a quicker response by email than by any other mode of communication.

Text

System Dynamics, William J. Palm, III.

Prerequisites

ME 213. EE 321 recommended. Senior standing recommended for undergraduates (really!). This course draws on broad based knowledge from a wide variety of areas. The more courses you have taken, the better you will be able to understand and utilize the concepts taught in this course. No in-depth knowledge of any unlisted courses is required, but the broader the foundation you have, the better grasp you will have of the building-blocks that we will use to generate our models.

Prerequisites By Topic (quiz: 5%)

The quiz will be the third scheduled day of class.

1. Newton's laws for a rigid body in 2-D
2. Kinematics of rigid bodies in 2-D
3. Equilibrium of rigid bodies in 2-D

4. Solution to 1st and 2nd order ordinary linear differential equations, homogeneous and particular solution (to sine, cosine, and power of t inputs)
5. Understanding of: power, energy, force, pressure, displacement, velocity, acceleration
6. Solution via Laplace Transform

Objectives

This course is intended to introduce students to design of mechanical systems with some coverage of electrical systems. More specifically, the focus is to teach students how to model a complex mechanical system as a set of simple, effectively equivalent, linear or nonlinear components for the purpose of design at the system level. Students will be introduced to, and use, modern computational tools available for system modeling, analysis, and design.

Course Contents

1. Introduction to Modeling and Analysis, (Chapter 1)
2. Modeling of Rigid Body Dynamics, (review of Dynamics, Chapter 2)
3. Fundamentals of Dynamic Systems Analysis (Chapter 3, not 3.4-3.8)
4. Spring-Damper Elements in Mechanical Systems (Chapter 4)
5. Block Diagrams and State-Variable Models (Chapter 5)
6. Electric and Electro-mechanical systems (Chapter 6)
7. Fluid/Thermal Systems (Chapter 7)
8. System Analysis (Chapter 8)
9. System Analysis in the Frequency Domain (Chapter 9)

Homework (10%)

Homework problems will be assigned at the end of lectures. Homework problem solutions are collected every Wednesday (or another day of the week to be decided by the students and instructor). You will be given no less than one week to do them. If there is a test scheduled on a day homework is due, the homework will be collected the following class period. Each homework problem is worth 1 point. More difficult problems may be weighted accordingly. Your final homework score is your average total score divided by the total number of possible points. Homework grades will be curved such that the class average will be no lower than 85%. You are encouraged to work together in small groups, but keep in mind that homework is assigned in order to help you learn and keep up with the course material. Please see me if you need help with the homework. This class is a cooperative effort between you and me. You are also encouraged to do additional problems out of the text for practice on your own.

Exams (55%)

There will be two tests and a final exam graded on a straight, scale ($\geq 90 = A$, $\geq 80 = B$, $\geq 70 = C$, $\geq 60 = D$, $< 59 = F$). The final exam will count for two test grades. The lowest exam grade of the four will be dropped. An 8.5 in. by 11 in. formula sheet may be used provided there are no derivations, definitions or solved problems on the sheet. Tests will be graded and returned as soon as possible. Solutions will be discussed during the lecture following the exam if time permits. All grading discrepancies must be brought up in writing no later than one week after the exam is returned. A simple note describing your contentions will do.

Design Projects (30%)

Three short design projects will be assigned during the quarter. They are designed to take about one weeks worth of homework effort. Elaborate reports are not required (they need not be typed). The objective of these design projects is to introduce you to design from the whole-system perspective. The result should be a better understanding of: how much detail to include in models used for design, how to perform design of complex systems, and how to specify design criteria for subcomponents. Detailed subcomponent selection is explicitly not part of the projects. Project reports must include the model equations, print-outs of the block diagrams used, and simulation results for a variety of valid subcomponent parameters. Late projects will be penalized 10% per day. Late projects will not be accepted more than three days late.

Programming/Computer Usage

Programming will be done in Simulink in MATLAB. Please consult either the hand-outs, the online MATLAB help, or the documentation I supply on the course website, and the manual in the computer lab. It is highly recommended that you learn to use Simulink on your university UNIX account as soon as possible. Run MATLAB by setting, your display environment from your X-Windows terminal and typing `matlab` at the UNIX prompt. Run Simulink by typing `simulink` at the MATLAB prompt. The best way to learn is to play around with it, and look at some of the examples provided in Simulink.

Problem Solutions

All problem solutions, whether on homework, quizzes, or exams, should be neat and orderly. They should begin with a brief problem statement and figure (Elaborate drawings are not expected).

Important Dates

April 17:	Exam 1
May 10:	Exam 2
June 5 5:45-7:45 PM :	Final Exam