22.451 Dynamic Systems
Fall 2006

Description:
Dynamic modeling of mechanical, electrical, hydraulic and thermal components. Response of these systems to initial conditions, and to transient and steady sinusoidal inputs. Use of block diagrams, numerical simulation (MATLAB/Simulink), characteristic equation root plots and transfer functions.

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Prerequisites:  16.211 (Circuits), 22.213 (Dynamics), 92.234 (Differential Equations)
Course Website:  http://pavitabile.caeds.eng.uml.edu (main website for instructor courses)
http://faculty.uml.edu/pavitabile/22.451/ME22451_PDF_downloads.htm

Course Goals and Learning Objectives:
The general goal of this course is to develop an understanding and ability to model, analyze and design/modify mechanical and electromechanical systems to achieve desired response to various inputs.

Outcomes: Upon completion of this course, the student will be able to:
- Model simple mechanical, hydraulic, heat transfer and electrical systems with linear ordinary differential equations
- Solve, analytically, first and second order differential equations with constant coefficients using classical, Laplace and Fourier series approaches
- Relate the transient response characteristics (ie, time constant, damped natural frequency, etc) to the values of the roots of the characteristic equation
- Derive the system transfer function in the Laplace domain for a given linear dynamic system
- Define system response characteristics such as rise time, settling time, steady state error, overshoot and damping ratio
- Linearize models of nonlinear systems about an operating point
- Develop appropriate analytical models for simulation using MATLAB and SIMULINK

Prerequisites by Topic:
- Rigid body dynamics and free body diagrams
- Ordinary differential equations
- Laplace transforms
- Kinetic and potential energy
- Computer literacy
- Circuit theory

Specific Schedule: A definitive schedule will be developed as the semester progresses
Topics to be Addressed:

- Introduction – Chapter 1
- Review of Differential Equations for 1st and 2nd order systems – Chapter 3
- Review of Laplace Transforms – Chapter 3
- Review of Fourier Series – Supplemental Notes
- Review of Rigid Body Dynamics – Chapter 2
- Mechanical Systems – Chapter 4
  - Mechanical Elements, Free Body Diagrams, Equations of Motion, Energy Approaches
    - Solution by Classical Approach, Transfer Function Method and Fourier Series Approach
    - Development of Computer Models using MATLAB and Simulink with various inputs
      - (1st order system model development, 2nd order system model development)
      - Representation of ME Lab I – Mass, Spring, Dashpot System Measured
- System Model Representation – Chapter 5
  - State Representation, Input-Output Relationships, Transfer Function, Linearization
- Electrical and Electromechanical Systems – Chapter 6
- Fluid and Thermal Systems – Chapter 7
- Time Domain System Response – Chapter 8
  - Transient and Steady State Solutions
- Frequency Domain System Response – Chapter 9
  - Transient and Steady State Solutions
- Introduction to Control Systems – Chapters 10 and 11

Reading Assignments for Chapters – students responsible to be prepared for lecture readings

Chapter 1 - Pay Special Attention (PSA) to 1.2, 1.3, 1.6 (1.4, 1.5 are concepts already known)
Chapter 3 - PSA to 3.1, 3.2, 3.3, 3.4, 3.5, 3.6 (impulse), 3.8 (MATLAB examples)
Chapter 2 - PSA to 2.1 (basic translation), 2.2 (basic rotation)
Chapter 4 - PSA to 4.1, 4.2, 4.3, 4.4, 4.6 (MATLAB examples)
  (Mechanical) Do Example 4.6.2 example using Simulink
Chapter 5 - PSA to 5.1, 5.2, 5.3, 5.4, 5.5 (MATLAB examples)
  (State Space, Block Diagram, Simulink)
Chapter 6 - 6.1 (Definition), 6.2 Example, 6.3 (Transfer Function), 6.5 (Op Amp),
  (Electrical) 6.8 (MATLAB examples), 6.9 (Simulink examples)
  6.5, 6.6, 6.7 (Electromechanical Systems - reference only)
Chapter 7 - 7.1, 7.2, 7.3, 7.4, 7.6, 7.7, 7.8, 7.9 (MATLAB/Simulink examples)
  (ThermoFluids) Example 7.3.1, 7.3.2
Chapter 8 - 8.1, 8.2, 8.3, 8.4, 8.8 (MATLAB/Simulink examples)
  (Time Domain)
Chapter 9 - 9.1, 9.2, 9.3 (Examples), 9.4 (Filter Property)
  (Frequency Domain)
Chapter 10 - 10.1, 10.2, 10.3, 10.4 (PID) (Examples), [10.5, 10.6, 10.7, 10.8 Extra]
  (Controls) 10.9 (MATLAB examples), 10.10 (Simulink examples)
Chapter 11 - 11.1 (Root Locus), 11.2 (Compensation), 11.3 (Bode Control), 11.4 (Feedback),
  (Controls) 11.5 (Tuning), 11.6 (Saturation)
Course Evaluation Mechanisms:
During this course there will be various mechanisms used to evaluate student performance. These will include tests, quizzes, and projects.
- Tests – there will be either two or three tests given during the course of the semester.
- Final Test – there will be a final test given.
- Homework Assignments – due one week after assigned
- Quizzes – there will be quizzes given at the beginning of class covering any of the material covered in previous classes or in the reading material required.
- There will be either two or three projects; one will be an individual report and one a group effort.

Course Rules:
You are expected to be in class during all lectures in order to understand the material. A few course rules exist and must be strictly adhered to.
- There are no cell phones, text messaging or other PDA devices allowed to be on in class.
- Homework assignments are due at the start of class – late assignments are not accepted.
- Projects are due at the start of class on due date – late projects are not accepted.
- During tests, several additional rules apply. Hats with brims are not allowed (or can be reversed if desired). You may not leave the class during the test for any reason. If a critical emergency exists you may request to leave but only at the discretion of the instructor. If you have some pre-existing medical condition that requires you to leave the room, then a properly annotated university medical leave form must be provided.
- It is preferred that students do not leave the class room during the lectures to take care of personal business. It is disruptive to the class and is not considered proper behavior. Take care of personal business either before or after class lecture times.

Grading: At this time the distribution of your grade will be based on:

In-class quizzes, homework and participation (10%)
Incremental exams (30%) – either 3 separate exams or one following each major topic covered (TBD)
Final Exam (20%) – comprehensive exam
Individual project(s) (40%) – three separate projects (15%, 15%, 10%)

Homework will be reviewed and solutions posted. The class following the homework submission, there will be a one question “homework quiz” that will be similar to one of the homework problems; this will be graded and returned.