# ME 450 - MODELING OF DYNAMIC SYSTEMS – SPRING 2009

**COURSE:** ME 450: Modeling of Dynamic Systems
Section 1, MWF 11:15A - 12:05, 358 WILLARD
3 credits

**INSTRUCTOR:** Professor C. D. Rahn
150A Hammond, 865-6237, cdr10@psu.edu
http://www.me.psu.edu/rahn/
Office Hours: 3:30 – 4:30 MWF or by appointment

**TA:** Willie Streeter
337 Reber, Desk 58, wcs149@psu.edu
Office Hours: 3:30 – 5:30 Th

**TEXT:** Dynamic Modeling and Control of Engineering Systems, Kulakowski, Gardner, and Shearer, 3rd Edition, Cambridge University Press, 2007.

**PREREQUISITES:** ME 345, ME 370

**COURSE DESCRIPTION:** Modeling and analysis of dynamic interactions in engineering systems. Classical and state variable methods; digital simulation; stability and dynamic response.

**GRADING:** Subject to later revision, the two midterm exams, final exam, projects, and homework will contribute to the final grade in the following percentages:

| | |
|---|---|
| **Midterms** | **20% each** |
| **Final Exam** | **25%** |
| **Projects** | **9% each** |
| **Homework** | **14%** |
| **Class Participation** | **3%** |

Homeworks and projects are due at the beginning of class on the date specified in the attached schedule. Late homeworks and projects will be accepted only under extenuating circumstances (*e.g.* illness or death in the family). The TA under my direction will grade the homeworks and projects. I will provide the TA with solutions and determine the points awarded for each correct part of the solution. Copies of the solutions will be available on Angel. If you feel you have been graded unfairly or your work has been misinterpreted, please see the TA **within one week** after the homework is returned. There will be no makeup midterms. If you are unable to attend a midterm due to extenuating circumstances and notify me in advance, I will release you from having to take the midterm and weight the other midterm 30% and the final 35%.

**ACADEMIC HONESTY:** Students are expected to conform to the highest standards of honesty and integrity. Cheating of any kind will not be tolerated and any infraction will be rigorously

prosecuted through the appropriate university channels. Students may work together in the preliminary stages of individual homework assignments but the final work must reflect individual efforts. The projects require group effort and are assigned a group grade. The College of Engineering academic integrity policy includes a statement of behaviors that are in violation of academic integrity and the review process for violations. (http://www.engr.psu.edu/CurrentStudents/acadinteg.aspx).

**CLASS ATTENDANCE:** Class attendance is expected but not required. You are responsible, however, for all material discussed and presented in class and 3% of your grade will be based on class participation. A significant portion of the lecture material will not directly follow the text.

**COMPUTER USAGE:** Some of the homework and projects require the use of the software package MATLAB and/or SIMULINK. You are expected to become proficient at using these software packages.

**PROJECT:** Pairs of students will complete a project in two parts during the semester. Part I will be modeling and Part II will be control.

**COURSE OBJECTIVES:** Upon completion of this course, students should be able to:

1. Recognize energy storing elements in an engineering system and distinguish appropriate state variables.
2. Write ODE's which describe the dynamic behavior of lumped parameter systems including mechanical, fluid, thermal and electrical elements.
3. Analytically solve linear ODE's for response to initial conditions, external disturbances, and known forcing functions.
4. Evaluate stability of linear-time-invariant systems.
5. Evaluate system performance in terms of “time constant” for first-order LTIs and “damping ratio” and “natural frequency” for second-order LTI systems. Students should understand how to approximate behavior of high-order LTI systems with low-order models as well as a steady-state response.
6. Analyze nonlinear systems by local linearization around nominal operating points.
7. Draw block diagrams for LTI systems from the system equations and vice versa: write system equations from block diagrams.
8. Understand the basic concepts of feedback control, the objectives and functions of proportional (P), integral (I), and derivative (D) feedback controls. Design PID feedback controllers for simple linear systems.
9. Sketch bode and root-locus plots and use these sketches to analyze system stability and expected performance.
10. Use Matlab/Simulink as a tool to study system stability and performance both in time and frequency domain.
11. Apply system knowledge to contemporary systems and the surrounding world.

# ME 450 MODELING OF DYNAMIC SYSTEMS

COURSE SCHEDULE - SPRING 2009

| Date | | Chapter | Topic | Material Due |
|---|---|---|---|---|
| 12-Jan | M | 1 | Introduction | |
| 14-Jan | W | 2 | Mechanical Systems | |
| 16-Jan | F | | " | |
| 19-Jan | M | **MLK Day - NO CLASS** | | |
| 21-Jan | W | **Out of Town - No Class** | | |
| 23-Jan | F | | Mechanical Systems | HW #1 |
| 26-Jan | M | 3 | Mathematical Models | |
| 28-Jan | W | | " | |
| 30-Jan | F | 4 | Analytical Solutions of System Equations | HW #2 |
| 2-Feb | M | | " | |
| 4-Feb | W | | " | |
| 6-Feb | F | 5 | Numerical Solution of ODEs | HW #3 |
| 9-Feb | M | 6 | Simulation of Dynamic Systems | |
| 11-Feb | W | | " | |
| 13-Feb | F | | " | HW #4 |
| 16-Feb | M | ProjA | Project Example | |
| 18-Feb | W | | Review | |
| 18-Feb | W | **MIDTERM #1: 6:30 - 7:45 PM** | | |
| 20-Feb | W | | Project Example | |
| 23-Feb | M | 7 | Electrical Systems | |
| 25-Feb | W | | " | |
| 27-Feb | F | 8 | Thermal Systems | Project A |
| 2-Mar | M | 9 | Fluid Systems | |
| 4-Mar | W | 10 | Mixed Systems | |
| 6-Mar | F | | " | HW #5 |
| 9-Mar | M | **SPRING BREAK - NO CLASSES** | | |
| 11-Mar | W | | | |
| 13-Mar | F | | | |
| 16-Mar | M | | Mixed Systems | |
| 18-Mar | W | | " | |
| 20-Mar | F | | " | HW #6 |
| 23-Mar | M | 11 | System Transfer Functions | |
| 25-Mar | W | | " | |
| 27-Mar | F | 12 | Frequency Analysis | HW #7 |
| 30-Mar | M | | " | |
| 1-Apr | W | | Review | |
| 1-Apr | W | **MIDTERM #2: 6:30 - 7:45** | | |
| 3-Apr | F | | Frequency Analysis | HW #8 |
| 6-Apr | M | | " | |
| 8-Apr | W | | " | |
| 10-Apr | F | 13 | Closed Loop Systems | HW #9 |
| 13-Apr | M | | " | |
| 15-Apr | W | | " | |
| 17-Apr | F | | " | HW #10 |
| 20-Apr | M | 14 | Control Systems | |
| 22-Apr | W | | " | |
| 24-Apr | F | | " | |
| 27-Apr | M | ProjB | Project Example | |
| 29-Apr | W | | " | |
| 1-May | F | | Review | Project B |
| **FINAL EXAM: TBD** | | | | |