Required for Mechanical & Aerospace Engineering

# MAE106: Mechanical Systems Laboratory
## Spring Quarter 2009

**Catalog Data:** MAE106 Mechanical Systems Laboratory Units: 4
Experiments in linear systems, including op-amp circuits, vibrations, and control systems. Introduction to digital sampling concepts. Emphasis on demonstrating that mathematical models are useful tools for analysis and design of electro-mechanical systems.
Prerequisites: MAE140 or MAE147; ECE72
Course Overlap: MAE170 covers control theory related to this course
Cross Listed Course(s): none
Restrictions: none; (Design Units: 2)
Lecture Location: ELH 100, Tues Thurs 8:00-9:20 Lab Location: EG2102

**Textbook:** System Dynamics, 2nd Edition, William J. Palm III, McGraw Hill, 2009, ISBN 9780073529271 (1st edition is OK)

**References:** Course Web Site: http://www.eng.uci.edu/~dreinken/MAE106/mae106home.htm

**Coordinator:**
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**Goals:** This course covers theory and experiments on motor control systems, electrical filters, amplifiers, structural resonance and vibration. These topics are important for building robots, mechatronic devices, and structures. These systems will be described by linear, ordinary, differential equations. Key goals of the class are to use these equations to predict, understand, and control the behavior of machines, and to design, build, and test a robotic device as a final project.

**Prerequisites by Topics:**
Introduction to Engineering Analysis II (MAE140)
Vibrations (MAE147)
Network Theory and Operational Amplifiers (ECE72)

**Lecture Topics:**
**Week 1** Lab 1 Part 1: Laboratory Tools
3/31 Lecture 1: Overview, Design Exercise, Review of Circuit Analysis
4/2 Lecture 2: DC Brushed Motors
**Week 2** Lab 1 Part 2: Motor Control
4/7 Lecture 3: Time and Frequency Domains 1 (Overview)
4/9 Lecture 4: Time and Frequency Domains 2 (Low-pass filter)
**Week 3** Lab 2: Electrical Filters and First-Order Systems
4/14: Lecture 5: Introduction to Control Theory
4/16: Lab 1 Quiz; Lecture 5 cont: Proportional Feedback Control
**Week 4** Lab 3: P-Type Velocity Control of a Motor
4/21: Lecture 6: Integral feedback control
4/23: Lab 2 Quiz; Lecture 7: Second Order systems: Time and Frequency domain
**Week 5**: Lab 4: Vibration I: Lightly Damped Second Order Systems
4/28 Lecture 8: PD Motor Control
4/30 Midterm and Lab 3 Quiz
**Week 6:** Lab 5: Feedback II: P and PD Motor Position Control; Final project preliminary test of Mechanical System
5/5 Lecture 9: Systems with Two Modes of Vibration
5/7 Lab 4 Quiz; Lecture 9 cont: Design of a Vibration Isolator

**Week 7** Lab 6: Vibration II: System with Two Masses
5/12 Lecture 10: Computer-based control of a motor
5/14 Lab 5 quiz; Review
**Week 8** Lab 7: Computer Control of a Motor
5/19 No Lecture
5/21 Lab 6 quiz and Design Exam
**Week 9** Final Project Round 1 Competition in Lab
5/26 No Lecture
5/28 No Lecture
**Week 10**: Working on final projects in lab
6/2 No Lecture
6/4 Final Project Grand Finale

**Computer Usage:** For laboratory write-ups and data acquisition.

**Laboratory Projects:** **Laboratory Location:** Engineering Gateway 2102

**Laboratory times:**
Section 1: Mon 9-12
Section 2: Tues 9:30-12:30
Section 3: Tues 2-5
Section 9: Tues 5-8
Section 4: Wed 9-12
Section 5: Thurs 9:30-12:30
Section 6: Thurs 2-5
Section 7: Friday 9-12
Section 8: Friday 2-5

**Laboratory Exercises:** Handouts that describe the experiments will be made available on the course web site, along with their solutions. You should work through the lab, referring to the solution. The solution is provided to help relieve time pressure and to act as a "consultant" if you get stuck. You can also ask the TA for help if you are confused. Be creative, explore, and have fun in the lab. This is your opportunity to build things that move and see how they work.

**Lab Pre-Quizzes:** There will be a brief quiz at the beginning of each lab testing whether you have read the experiment handout before coming to laboratory.

**Lab Practical Exams:** You will have to demonstrate working experiments in lab to get credit for the lab.

**Lab Write-Up:** Each student will be required to turn in a brief write-up for the lab. The write-up must be typed. You must use a computer graphing program (e.g. Microsoft Exel or Matlab) for all graphs. Zero credit if you don't do this!

**Lab Post-Quizzes:** There will be a 30-minute quiz at the end of lecture the Thursday following each laboratory.

**Final Project** There will be a final project competition involving the design and head-to-head testing of a robotic device. The final project tournament will take place on the last scheduled day of lecture. There will also be a write-up due on that day.

**Design Content Description:** This course requires solution of design problems related to control and vibration, as well as design and construction of a robotic device for the final project.

**Grading Criteria:** Lab Pre-Quizzes: 7%; Lab Practical Exams: 7%; Lab Write-Ups: 7%
Lab Post-Quizzes: 14% ➔ LAB TOTAL = 35%
Mid-term exam: 20%
Design exam: 20%
Final project: 25%

**Estimated ABET Category Content:**

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| Engineering Science: | 2 | credits or | 50% |
| Engineering Design: | 2 | credits or | 50% |

**Prepared by:** Prof. David Reinkensmeyer **Date:** 3/30/09