ME/EE 351/351L: Mechatronics and Measurement Systems

CATALOG DATA:
ME/EE351 – Mechatronic and Measurement Systems: (3-1) 4 Credits

Prerequisite: CSC 150 and EE 220 or EE 301. This course will encompass general measurement techniques found in Mechanical and Electrical Engineering. These include measurement of force, strain, frequency, pressure, flow rates, and temperatures. Elements of signal conditioning and data acquisition will be introduced. In addition, the course will have a Mechatronics approach reflected in the combined applications of electronic, mechanical, and control systems. EE 351 and ME 351 are cross-listed.

TEXTBOOK AND MATERIALS:
PEL4, Experimental Circuit Board, 1 per team, sold in bookstore

COORDINATORS:
Elaine Linde, Instructor
Nian Zhang, Assistant Professor

GOALS:
The objective of this course is to introduce the field of mechatronics. The students will focus on integrating systems that include various sensors and actuators with a microcontroller. There is also an emphasis on developing skills to have successful multi-disciplinary teams.

CLASS SCHEDULE:
Lecture: 3 hours per week. (1:00 – 1:50 MWF, EP254)
Laboratory: 3 hours per week (8:00-10:50 or 1:00-3:50 Tues., EP338)

INSTRUCTOR INFORMATION:
E-mail: Elaine.Linde@sdsmt.edu, Office: EP 316; Phone: 394-5196
Office Hours: 10:00 – 11:00, 2:00-4:00 MWF
E-mail: Nian.Zhang@sdsmt.edu, Office: EP 315; Phone: 394-2452
Office Hours: 10:00 – 12:00 T, 2:00-4:00 Th

TENTATIVE TEST SCHEDULE:
• One short quiz each week, (random day)
• One mid-term examination, One final examination

TENTATIVE GRADING POLICY:
10 Labs 20%
Robot Project 20%
Team Chosen Project 20%
Homework 5%
**10 Quizzes 5%
**Midterm 15%
**Final 15%

** A passing grade MUST be obtained on the average of these measures (quizzes and exams) to pass the class.

ADA INFORMATION:
Students with special needs or requiring special accommodations should contact the instructor, Elaine Linde at 394-1219 and/or the campus ADA coordinator, Jolie McCoy at 394-1924 at the earliest opportunity.

ELECTRONIC DEVICE POLICY:
Unless otherwise specified, no electronic devices are to be used in class. An exception to this is a notebook computer that can be use for taking notes. It must be flat on the desk in note-taking configuration using that function only and must not be a distraction to other students.
FREEDOM IN LEARNING:

Under Board of Regents and University policy student academic performance may be evaluated solely on an academic basis, not on opinions or conduct in matters unrelated to academic standards. Students should be free to take reasoned exception to the data or views offered in any course of study and to reserve judgment about matters of opinion, but they are responsible for learning the content of any course of study for which they are enrolled. Students who believe that an academic evaluation reflects prejudiced or capricious consideration of student opinions or conduct unrelated to academic standards should contact the dean of the college which offers the class to initiate a review of the evaluation.

Topics:
1. Introduction to Mechatronics:
2. Measurement Fundamentals:
3. Electrical Circuits and Components:
   a. Review of Circuit Analysis
4. Semiconductor Electronics:
   a. Diodes and LED’s
   b. Transistors (Common Emitter BJT circuit)
5. System Response:
   a. First Order Systems
   b. Second Order Systems
6. Analog Signal Processing Using Operational Amplifiers
   a. Basic Op-Amp Circuits
   b. Differential Amplifier
7. Digital Circuits and Systems
   a. Basic Logic Gates
   b. Relationship to Programming and PLC’s
8. Data Acquisition
9. Sensors
10. Actuators

LABORATORY:

Several lab assignments are done to teach the students the basics of a Mechatronic system and interfacing digital and analog inputs and outputs to the PEL4. A one credit hour laboratory ME/EE351L accompanies this course. The laboratory meets for three hours every week. The following laboratories are performed: (tentative)
1. Analog Inputs
   a. Calibration of PEL4 Analog Input
   b. Introduction to PICC, Compiling, and Downloading
   c. Study of Process Variation of Resistors
2. Temperature Sensor
   a. Calibration Curve of Resistance and Temperature for a Thermistor is Developed
   b. Voltage Divider Circuit is Used to Construct a Digital Thermometer
   c. Programming is done to interface input to screen output.
3. First Order Response
   a. Determine the time response of a first order system
   b. Compute the time constant of a first order system
   c. Program to take data values at fixed time intervals
4. Brainstorming on Free Project and Robot Design
   a. Based on the video (IDEO design team), use several of the techniques to develop ideas for the free project and robot.
   b. Examine a mouse for Mechatronic systems.
5. **DC Motor Control**
   a. Design a transistor motor driver.
   b. Use a digital output signal to switch the motor on/off.
   c. Use Pulse Width Modulation to control the motor speed.

6. **Frequency Domain Analysis**
   a. Program the PEL4 to sample a waveform.
   b. Read the data into a spreadsheet and plot it.
   c. Use the FFT to transform the data into the frequency domain to be plotted and analyzed.
   d. Study an interesting signal (instrumental, whistles, etc.) in the frequency domain.
   e. Examine impedance matching between the signal generator and the oscilloscope.

7. **Robot Sensor and Switch Implementation**
   a. Experiment with the dynamics and implementation of the sensor for the robot.
   b. Implement a 2 pin switch with a digital input.

8. **DC Robot Motor Modification and H-bridge Implementation**
   a. Modify the servomotors to run continuously in both directions.
   b. Use the L298 dual full-bridge driver (H-bridge) to control a servomotor.

9. **Sensors**
   a. Study various sensors (strain gauge, accelerometer, LVDTs, IR sensor)
   b. Strain gage/Wheatstone bridge/Data Acquisition

10. **Actuators**
    a. Pneumatic actuators (using trainers in ME dept.)
    b. Hydraulic actuators (using trainers in ME dept.)

11. **Projects and Robot**
    a. Remaining labs are used for completing team projects

**COMPUTER USAGE:**
Student will use PICC to program a PIC microcontroller.

**Course Expectations:**
Students coming into ME/EE 351 are expected to have:
1. Basic knowledge in circuit analysis
2. Basic knowledge in physics, which includes fluids, dynamics, and thermal bases
3. Basic knowledge in programming including algorithm development skills

**COURSE OUTCOMES:**
Upon completion of this course, students should demonstrate the ability to:
1. Apply the basic methodology of electronic measurements.
2. Apply the basics of signal conditioning.
3. Perform basic computer interfacing for measurements and control.
4. Select a transducer for standard measurements (temperature, flow, pressure, strain, displacement, velocity and acceleration etc.)
5. Select an electronically controlled actuator.
6. Apply the process of design of a mechatronic system.
7. Implement a mechatronic system.
8. Present a project via a creative video.
9. Demonstrate the fundamentals of working in a team.
10. Deal with issues that arise within a team such as conflict resolution, communication, trust development, and mutual accountability.

**RELATION OF COURSE TO PROGRAM OUTCOMES:**

These course outcomes fulfill the following program outcomes:

(a) An ability to apply knowledge of mathematics, science, and engineering.
(b) An ability to design and conduct experiments, as well as to analyze and interpret data.
(c) An ability to design a system, component, or process to meet desired needs.
(d) An ability to function on multi-disciplinary teams
(e) An ability to identify, formulate, and solve engineering problems.
(f) An understanding of professional and ethical responsibility
(g) An ability to communicate effectively
(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context
(i) A recognition of the need for, and an ability to engage in life-long learning
(j) A knowledge of contemporary issues
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

The following table indicates the relative strengths of each course outcome in addressing the program outcomes listed above (on a scale of 0 to 4 where 4 indicates a strong emphasis):
### Relation of Course Outcomes to Program Outcomes:

#### ME Program Outcomes

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* (For a list of Program Objectives and Program Outcomes, please go to [http://www.hpcnet.org/assessment](http://www.hpcnet.org/assessment)*

#### EE Program Objectives

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**Prepared By:**