MAE 170

Experimental Techniques (4 units)

Class/Laboratory Schedule: two hours lecture, three hours lab, seven hours outside preparation. 12 hours/week total

Course Coordinator(s): Farhat Beg, Nicholas Boechler, Javier Garay, Ratnesh Lal

Textbook: None (course materials supplied by instructors)

Catalog Description: Principles and practice of measurement and control and the design and conduct of experiments. Technical report writing. Lectures relate to dimensional analysis, error analysis, signal-to-noise problems, filtering, data acquisition and data reduction, as well as background of experiments and statistical analysis. Experiments relate to the use of electronic devices and sensors.

Prerequisites: grade of C– or better in Physics 2C and (Physics 2CL or MAE140) and (MAE08 or CENG15). Enrollment restricted to engineering majors only.

Course Type: Required

Performance Criteria:

- Arduino Assignments (7 at 2% each) 14%
- Lab Worksheets (6 at 3% each) 18%
- Entire Lab Section Attendance (8 at 1% each) 8%
- Full Lab Report 1 and peer review (assigned week 3) 13%
- Full Lab Report 2 and peer review (assigned week 7) 16%
- Midterm Exam (Tuesday, April 30) 8%
- Lab Practical Final Exam (held Week 10) 12%
- Final Exam (Thursday, June 13) 11%

Course Objectives:

1. Design and execute an experimental approach given a measurement objective, be able to characterize its effectiveness, and visualize potential improvements.
2. Become comfortable with the implementation and underlying principles of experimental data acquisition, conditioning, and analysis methods, and understand how they are universally applicable across disciplines.

3. Given an experimental dataset and available analytical and computational models, be able to evaluate the data set, and extract meaningful trends and conclusions.
4. Understand the current standards of technical writing, recognize the underlying features that are present in high quality technical writing, and perform high quality technical writing that clearly conveys meaningful scientific and engineering insight.
5. Understand and apply ethical standards in experiment design, data interpretation, team-work, and technical communication

ABET Student Outcomes Satisfied:
(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
(3) an ability to communicate effectively with a range of audiences
(4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
(5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
(6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
(7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
(ME8) an ability to work professionally in mechanical systems areas.
(ME9) an ability to work professionally in thermal systems areas.
(ME10) an ability to apply principles of engineering, basic science, and mathematics (including multivariate calculus and differential equations).
(ME11) an ability to model, analyze, design, and realize physical systems, components or processes.

Course Topics:
Lab topics:

- Introduction to Oscilloscope, Signal Generator, Digital Multi-Meter (DMM), and Resistor circuits
- A/D Conversion and Sampling Rates
- RC Filters and Amplifiers for Signal Conditioning
- Measurement of Pressure and Acceleration
- Measurement of Strain
- DC Motor Control
- Heat Transfer
- Digital Image Processing

Lecture topics:

- Arduino
- Technical writing
- How to use the signal processing devices and related electronic equipment
- Ohm's and Kirchoff's laws
- Analog vs. digital signals
- Resolution (time, space, frequency)
- Noise and averaging (time vs. frequency domain)
- Aliasing
- Features of signals in time and frequency domain
- Discrete Fourier transform properties
- Analog filtering
- Gain and decibels
- Transfer functions, Bode plots, and transmission spectra
- AC / DC coupling
- Amplification and Op-Amps
- Signal processing elements in series
- Concepts used to characterize a measurement system: Accuracy, resolution, linearity, repeatability, hysteresis
- Error analysis
- Uncertainty propagation
- Significant figures
- The concept of calibration
- Sensors and transduction mechanisms: Pressure, acceleration, strain
- Wheatstone bridge
- Sensitivity (of a sensor) / gage factors for strain gages
- Experimental automation, servo motors, and the importance of feedback
- Obtaining decay rates and slopes from exponential data (using logarithms)
- Non-dimensionalization and normalization