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): Marko Lubarda, Nicholas Boechler, Farhat Beg, Javier Garay, Ratnesh Lal

Textbook: *Theory and Design for Mechanical Measurements* by Figliola and Beasley, 7th ed., Wiley, 2019

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: PHYS 2C or PHYS 4B and PHYS 2CL or MAE 140 or MAE 40. Enrollment restricted to MC 25, MC 27, MC 29, MC 30–34, MC 35–37, BE 25, BE 27.

Course Type: Required

Course Objectives:

1. Design and conduct an experiment 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 dataset, and extract meaningful trends to reach conclusions.
4. Understand the current standards of technical writing, recognize the defining features of high quality technical writing, and produce 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.

Course Topics:

Lab topics

- Introduction to oscilloscope, signal generator, digital multimeter, resistor circuits, Arduino
- Data acquisition, A/D conversion, sampling rates, signal conditioning with RC filters and amplifiers
- Sensor measurements and calibration (pressure, strain, acceleration, temperature, and acoustic measurements)
- DC motor control with feedback
- Digital image processing

Lecture topics

- Standards of measurement, systems of units
- Analog and digital signals and devices
- Signal analysis: resolution, aliasing, noise and averaging, filtering, discrete Fourier transform
- Measurement system characterization: accuracy, resolution, linearity, repeatability, hysteresis
- Analog electronics: filtering, gain and decibels, transfer functions, Bode plots, transmission spectra, AC/DC coupling, amplification and op-amps
- Sensors and transduction mechanisms, Wheatstone bridge, calibration
- Automation in experiments, servo motors, feedback
- Extracting characteristic quantities of interest from measurement data
- Error analysis, uncertainty propagation, significant figures
- Dimensional analysis, normalization
- Technical writing

Updated: 03/20/2025 by Marko Lubarda