The exam will be comprehensive and closed book. No materials other than your pen or pencil may be used.
Study suggestions include:
  o Lecture material from class;
  o Lab material from lab, and lab handouts;
  o Homework specific issues;
  o Student presentation notes;
  o Student test questions from in-class project presentations.

Questions may come from topics covered in our reading, lecture, homework, or labs. Topics in **bold** have been covered since the first exam.

- **Lecture**
  - Course Introduction
    - Reference – Chapter 1
      - Typical instrumentation system components
  - Circuits review
    - Reference – Circuits text book
      - Ohm’s law, power, voltage dividers
      - Instrument loading, input and output impedance
  - AC Signals
    - Reference – Chapter 2.3
      - AC Measurement – True RMS, average values
  - Measurement Characteristics
    - Reference – Chapter 1, Lecture notes
      - Measurement terms – resolution, accuracy, precision, etc.
      - Measurement errors and sources
        - Systematic vs. random sources of error
      - Calibration
      - Sensor overview
  - Data Acquisition and Number Systems
    - Reference – Lecture notes
      - Analog vs. digital
      - Waveform characteristics
      - Binary number system
      - Number systems conversion
  - Digital sampling
    - Reference – Chapter 2.4-5
      - Analog-to-Digital conversion
      - Terms – Full scale range (span), sampling rate, resolution, etc.
      - Other terms – Quantization error, aliasing, Nyquist criteria
  - Data Integrity
    - Reference – Lecture notes
      - Single- vs. differential inputs
Fourier Series and Fourier Transforms
- Reference – Chapter 2.4-5
  - Sampling rate and number of samples in the time domain
    - Nyquist frequency and rate
  - Fourier Series
    - Symmetry – Odd, even
  - Frequency spacing in the frequency domain
Analog and Digital Filtering
- Reference – 6.8
  - Active vs. passive filters
  - Analog vs. digital filters
  - Filter types – low-pass, high-pass, band-pass, and band-stop
Sensor Overview
- Acceleration Sensors and Measurement
  - Reference – 12.2
    - Types and principles of operation
Strain Gauges and Strain Measurement
- Reference – 11.1-6
  - Types and principles of operation
Student Presentations
- Thermocouples
- Resistance Temperature Detectors
- Thermistors
- Pressure Measurement
- Piezo-electric and Piezo-resistive Transducers
- Distance Measurement
- Microelectromechanical Systems (MEMS)
- Force and Torque Measurement
- Acoustical Measurement
- Flow Measurement
- Ultrasonic Measurement
- Hall Effect and Magnetic Sensors

Lab
- Lab #1 – AC and DC Measurements
  - Ohm’s law
  - Voltage division
  - Loading effect
  - Sinusoidal and non-sinusoidal voltage measurement
- Lab #2 – Calibration
- Lab #3 – Data Acquisition
  - Sampling rate, number of samples, arbitrary waveform analysis
- Lab #4 – The Fourier Transform
  - Aliasing, sampling rate
- Lab #5 – Mobile Devices
- Lab #6 – Acceleration and Vibration Testing
  - Time domain and frequency domain (fft’s) analysis
- Lab #7 – Motion Analysis
  - Video analysis
  - Measurement of position, velocity, and acceleration
  - Filtering
• Fourier analysis and frequency components
  o Lab #8 – Strain Gauges and/or Force Measurement (Extra Credit)

• Homework
  o HW#1 – Basic concepts
  o HW#2 – Matlab and number systems
  o HW#3 – A/D Converter characteristics
    ▪ Sampling rate, bit-depth, full-scale range (span), resolution in terms of bits
    ▪ Terms related to ADC’s
  o HW#4 – Sampling and Fourier Series
  o HW#5 – Field trip
  o HW#6 – Matlab mobile app
  o HW#7 – Student presentations