1. **Department, number and title of course:** Electrical Engineering and Computer Sciences: EECS C145L, Introductory Electronic Transducer Laboratory

2. **Catalog Description:** (3 units) Laboratory exercises exploring a variety of electronic transducers for measuring temperature, force, displacement, sound, light, ionic potential. Covers principles of operation, construction, response, signal to noise. Use of circuits for analog signal processing and microcomputers for digital sampling and storage.

3. **Prerequisites:** EECS 40.

4. **Textbooks and/or other required material:**

**References:**

5. **Course objectives:**
   - To be able to amplify signals from sensors that have low-level, differential, high impedance outputs
   - To learn about noise sources and how to use shielding, grounding, and analog filtering to enhance the signal-to-noise ratio
   - To learn the properties of a number of useful sensors for measuring position, temperature, strain, force, light, ionic potentials, biological signals, ionizing radiation, etc.
   - To be able to design instrumentation that senses desired quantities, transduces to an electrical signal, and amplifies and filters that signal for interfacing to a microcomputer
   - To be able to design simple analog control systems, using sensors, amplification, filtering, controller circuits, power amplifiers, and actuators
   - To make analog circuits work (design and debugging)
   - To write clear, concise, informative laboratory reports

6. **Topics Covered:**
   - Properties of the ideal and the realistic op-amp
   - Op-amp properties: Open-loop Bode plot, gain-bandwidth product, risetime, slewing rate
   - Amplifier circuits using the op-amp and negative feedback: inverting, non-inverting, buffer, differential, current summing, low-level rectification; Bode plot, risetime
   - Instrumentation amplifier circuit and properties: common mode and differential gains
   - Isolation amplifiers- electromagnetic and optical
   - Gaussian curve of error and error propagation
   - Johnson and shot noise- combined amplifier noise
   - Interference, grounding, and shielding
   - Analog filtering using op-amps and negative feedback: gain and phase shift vs. frequency- simple filters and multi-pole Butterworth and Bessel filters
   - Notch filter and analysis
   - Power op-amp
   - Introduction to A/D and D/A conversion- data acquisition using the microcomputer
• Definition, general characteristics, and examples of sensors and actuators
• Position and angle sensors: resistive, Piezoelectric, and optical
• Gray and binary codes
• Position actuators: Piezoelectric, solenoid, and stepper motor
• Thompson, Peltier, and Seebeck emfs
• Thermocouple properties and electronic ice points
• Thermistor properties and optimized bridge readout; self-heating
• Platinum resistance and solid state temperature sensors
• Infrared sensing and imaging
• Thermoelectric heat pump- thermal efficiency and heat transfer equations
• Strain gauge sensors, bridges, and force transducers
• Piezoelectric properties and measurement of force, acceleration, pressure
• Production and measurement of vacua
• Silicon photodiode: construction, properties, and uses
• Production of light: incandescent, fluorescent, lasers
• Electrochemical reactions and the Ag(AgCl) skin electrode
• The characteristics and detection of alpha, beta, x-ray, and gamma radiation, and practical applications in industry and medicine
• Electrical safety: accident scenarios; grounding, isolation transformers and amplifiers, ground fault interrupters, circuit breakers, surge protectors
•Signals from the human heart: electrocardiogram, phonocardiogram, blood pressure
• Skeletal muscle and the electromyogram
• The electrooculogram and the mechanics of eye motion
• Analog control systems: sensors, instrumentation amplifiers, controller circuits, power amplifiers, and actuators; on-off, proportional, PID controllers

7. **Class/laboratory schedule:** Two hours lecture and three hours laboratory per week.

8. **Contribution of course meeting the professional component:** This class contributes to the engineering topics requirement. It is approximately 1/3 science and 2/3 design. It provides a major design experience.

9. **Relationship of course to program objectives:** This course requires students to use and apply their knowledge of math, science and engineering to engineering problems. Students learn to use modern tools, skills and techniques to identify, formulate and solve challenging problems. They learn to communicate effectively with their lab partners.

10. **Prepared by:** Professor Steve Derenzo, April 6, 2006.