NAME (please print) _____ SID _____

UNIVERSITY OF CALIFORNIA

College of Engineering
Department of Electrical Engineering and Computer Sciences

EECS 145L: Electronic Transducer Laboratory

FINAL EXAMINATION Fall 2003

You have three hours to work on the exam, which is to be taken closed book.
Calculators are OK, equation sheet provided.
You will not receive full credit if you do not show your work.
Use back side of sheet if necessary.
Total points = 200 out of 1000 for the course.

1 _____ (48 max) 2 _____ (24 max) 3 _____ (48 max)

4 _____ (34 max) 5 _____ (46 max) TOTAL _____ (200 max)

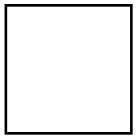
COURSE GRADE SUMMARY

LAB REPORTS (500 points max):
[5 short reports (lowest grade dropped)- 100 points max]
[5 full reports (lowest grade dropped)-400 points max]

4 _____	5 _____	6 _____	7 _____	11 _____
12 _____	13 _____	14 _____	15 _____	16 _____
17 _____	18 _____	19 _____	25 _____	

LAB TOTAL	_____	(500 max)
LAB PARTICIPATION	_____	(100 max)
MID-TERM #1	_____	(100 max)
MID-TERM #2	_____	(100 max)
FINAL EXAM	_____	(200 max)
TOTAL COURSE GRADE	_____	(1000 max)

COURSE LETTER GRADE



NAME (please print) _____ SID _____

PROBLEM 1 (48 points)

In 50 words or less, define the following terms:

1.1 (8 points) Differential gain (of an instrumentation amplifiers)

1.2 (8 points) Actuator

1.3 (8 points) Electronic ice point (for a thermocouple)

1.4 (8 points) Ground fault interrupter circuit

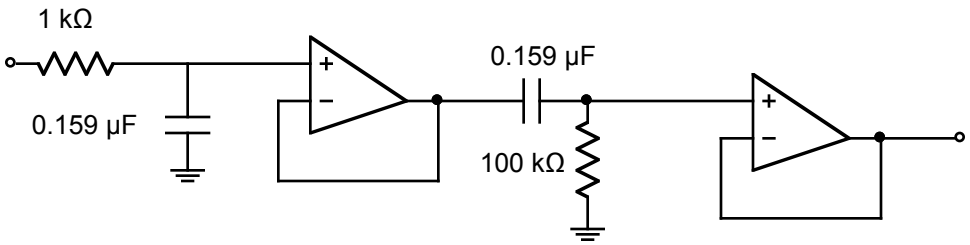
1.5 (8 points) Low-pass filter

1.6 (8 points) Response curve of a sensor

NAME (please print) _____ SID _____

PROBLEM 2 (24 points)

Consider the following filter circuit, which is a single-stage low pass filter followed by a single-stage high-pass filter:



2.1 (12 points) What are the lower and upper corner frequencies (Gain = 0.707)?

2.2 (12 points) At what two frequencies does the gain = 0.1?

PROBLEM 3 (48 points)

Design a system for measuring the liquid level in a large tank.

- The liquid level is to be sensed electronically and the electrical signal is to be connected to the analog input of a microcomputer for display and storage
- the tank is 10 meters in diameter and 10 meters high.
- The liquid absorbs green light with an absorption of 10% per meter
  $I(L) = I(0)e^{-kCL}$, $kC = 0.1\ m^{-1}$
- The liquid has a small ionic conductivity
  (A column of liquid with area A and length L has resistance $R = \rho A/L$)
- The liquid is non-flammable.
- The liquid level is to be measured to an accuracy of 0.1 meter.

3.1 (8 points) Describe in about 50 words and/or a simple sketch how you would measure the liquid level using light sensors.

3.2 (8 points) Describe in about 50 words and/or a simple sketch how you would measure the liquid level using strain gauges.

3.3 (8 points) Describe in about 50 words and/or a simple sketch how you would measure the liquid level using a digital angle sensor.

3.4 (8 points) Describe in about 50 words and/or a simple sketch how you would measure the liquid level using ideal electrodes. (Hint: ideal electrodes transform ionic conductivity in a solution into simple electrical conductivity).

3.5 (8 points) Describe in about 50 words and/or a simple sketch how you would measure the liquid level using a number of thermistors.

3.6 (8 points) Describe in about 50 words and/or a simple sketch how you would measure the liquid level using sound (speaker and microphone).

NAME (please print) _____ SID _____

PROBLEM 4 (34 points)

Design a circuit that can be used to measure the current I_{diode} though the photodiode as a function of the voltage V_{diode} across it, for both forward and reverse voltages. Assume that only voltages will be measured, using a digital voltmeter with a high input impedance.

4.1 (10 points) Sketch your design below. Include sufficient detail so that a skilled technician could build it

4.2 (12 points) List the steps necessary for making the voltage measurements and converting them to V_{diode} and I_{diode}.

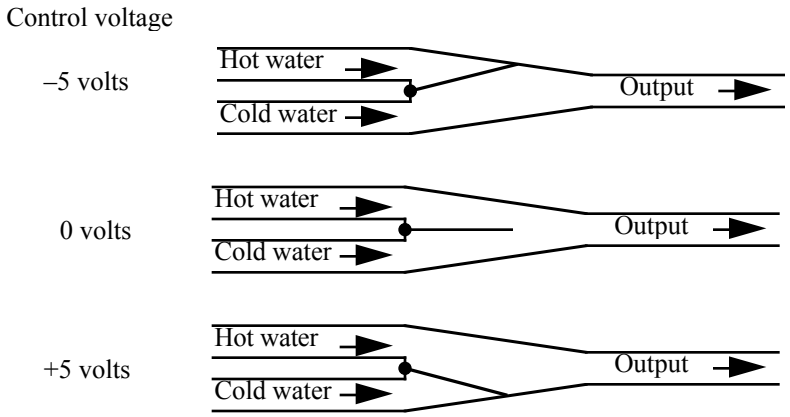
4.3 (12 points) Under conditions of (1) darkness and (2) a light level that produces 1 mA of electron-hole current, plot what you would expect to measure in a figure below and label the axes with numbers and units.

PROBLEM 5 (46 points)

Design a control system for mixing hot and cold water to produce water at a desired temperature. The user can specify any desired temperature between 20C and 80C by setting a voltage between 2.0 and 8.0 volts.

You are provided with:

- A voltage-controlled water valve with two water pipe inputs and one water pipe output. By setting the control voltage in the range between –5 and +5 volts, any ratio of hot and cold water can be produced. (See figure below).
- A power op-amp
- A temperature sensor of your choosing
- A cold water temperature of 20C and a hot water temperature of 80C.



5.1 (16 points) Sketch a block diagram of your design. Provide enough details so that a skilled technician could understand how it works and build it. Label all essential components and signals and specify the location of your temperature sensor.

5.2 (10 points) Describe the voltages in your control system when the system is controlling at the set point temperature of 20C.

5.3 (10 points) Describe how the voltages in your control system change after the set point temperature is changed from 20C to 60C.

5.4 (10 points) Starting from a state where the system is controlling at a set point temperature of 60C, describe how the voltages in your control system change after the temperature of the hot water supply is reduced to 70C