NAME (please print) _____

UNIVERSITY OF CALIFORNIA
College of Engineering
Department of Electrical Engineering and Computer Sciences

EECS 145L: Electronic Transducer Laboratory

FINAL EXAMINATION   December 16, 1999   12:30 - 3:30 PM

You have three hours to work on the exam, which is to be taken closed book.
Calculators are OK, use 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 _____ (30 max)   2 _____ (30 max)   3 _____ (50 max)

4 _____ (50 max)   5 _____ (40 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)   COURSE LETTER GRADE

MID-TERM #1   _____   (100 max)

MID-TERM #2   _____   (100 max)

FINAL EXAM   _____   (200 max)

TOTAL COURSE GRADE   _____   (1000 max)

PROBLEM 1 (30 points)

In less than 50 words, describe the *essential differences* between the following two items:

1a. (10 points) [ideal op-amp] and [ideal instrumentation amplifier].

1b. (10 points) [incandescent lamp] and [fluorescent lamp]

1c. (10 points) [platinum resistance thermometer] and [thermistor]

PROBLEM 2 (30 points)

Describe how each of the following *actuators* converts an electrical signal into a physical quantity

2a.　(10 points) Peltier thermoelectric heat pump.

2b.　(10 points) Stepping motor

2c.　(10 points) Light Emitting Diode

PROBLEM 3 (50 points)

You are designing a temperature sensor using a thermistor, a resistive bridge, and an instrumentation amplifier.

- When the termistor temperature is T = 30 °C, its resistance is R_T = 10,000
- When the termistor temperature is T = 31 °C, its resistance is R_T = 9,608
- Design your bridge circuit for maximum sensitivity (dV_{Bridge}/dT) at 30 °C.
- To limit self-heating, use a bridge voltage of 0.1 V
- The instrumentation amplifier output V_0 should be zero at 30°C and 1 V at 31°C (dV_0/dT = 1 V/°C).
- The instrumentation amplifier voltage noise is 1 $\mu V/Hz^{1/2}$ rms relative to the input.
- The instrumentation amplifier gain-bandwidth product is 10^6 Hz.

3a. (26 points) Sketch the circuit. Show and label all necessary components and wires.

3b. (6 points) What is the gain and bandwidth of the instrumentation amplifier in your design?

3c. (6 points) What is the rms value of the output noise of the instrumentation amplifier in your design?

3d. (6 points) At 30°C, what temperature rms does this instrumentation amplifier voltage noise (from 3c) correspond to? (Hint: use dV_0/dT)

3e. (8 points) If the temperature to be measured cannot change faster than 1 Hz, how could you reduce the noise without significantly affecting the temperature signal?

PROBLEM 4 (50 points)

Normal plants grow best with 16 hours of light and 8 hours of darkness per 24 hour day but you have developed a new species of tomato plant that grows even better with constant illumination.

- You want to design a greenhouse that uses natural sunlight as much as possible (to save energy and money) and supplements the light level with artifical illumination as needed to maintain maximal growth. Your design must compensate for changes in natural lighting due to clouds and the darkness of night.

- For simplicity, assume that sunlight and your artificial lights have the same color spectrum and that the average energy per photon is 2 eV.

- You have determined that your plants grow at a rate that is proportional to the amount of light received up to 1000 W/m^2, which is the same as full sunlight. The growth rate does not increase beyond that level.

4a   (5 points) Your new plant uses chlorophyll, just like normal plants. What does the green color of chlorophyll tell you about the colors of the light that is absorbed? (Hint: consider the colors of the rainbow.)

4b   (5 points) Which is more energy efficient for producing visible light, incandescent or fluorescent?

4c (20 points) Sketch your photosensor and light control circuit design, showing and labeling all necessary components, signals, and signal levels. Assume that the area of your photosensor is 1 cm^2. Provide sufficient detail so that it could be built by a skilled technician.

4d (20 points) Sketch your overall control system design, showing and labeling all necessary components and signals. You can show the greenhouse as a simple room with glass windows, tomato plants on the ground, and artifical lights attached to the glass ceiling.

PROBLEM 5 (40 points)

Name a sensors/acuators pair that would be good for the following situations:

5a. (10 points) sensing and controlling the temperature of a 1 cm^3 environmental chamber from +10 °C to +40°C.

5b. (10 points) sensing and controlling the temperature of an oven from +100 °C to +500 °C.

5c. (10 points) sensing and controlling hydrostatic pressure of a fluid from 1 atm to 100 atm.

5d. (10 points) sensing and controlling angle over 360° to an accuracy of 1°.