NAME (please print) ______________________________ SID __________________

UNIVERSITY OF CALIFORNIA, BERKELEY
Electrical Engineering and Computer Sciences Department

EECS 145L Electronic Transducer Lab
MIDTERM #2 (100 points maximum)
November 12, 2003

(Closed book, calculators OK, equation sheet provided)
(You will not receive full credit if you do not show your work)

PROBLEM 1 (30 points)

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

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

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

1c (10 points) [photodiode] vs. [light-emitting diode]

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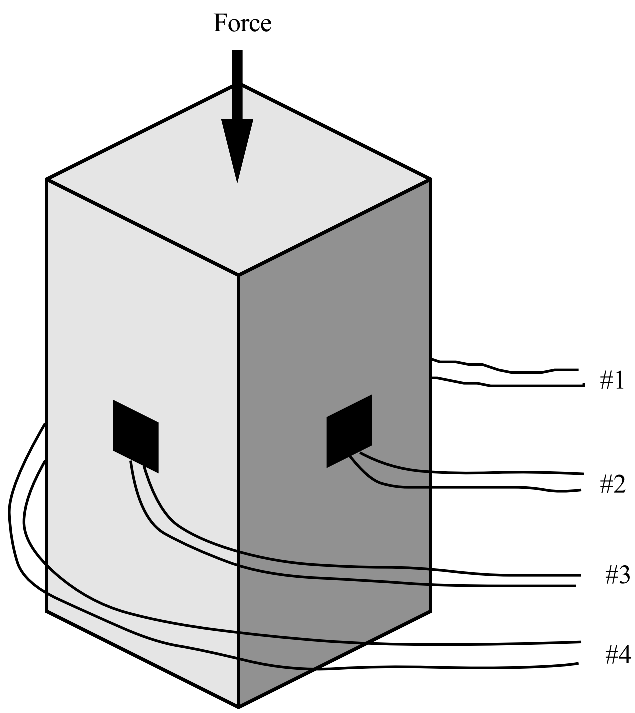
PROBLEM 2 (40 points)

A railroad track support column has four solid-state strain gauges cemented to it, as shown in the Figure below. The force on the column is straight down (no bending, only compression). Your goal is to measure the strain on the column as trains pass over it. Two of the strain gauges are p-type, with the strain relationship: $\Delta R/R = 100\ \Delta L/L + 10{,}000\ (\Delta L/L)^2$, and the other two are n-type, with the strain relationship: $\Delta R/R = -100\ \Delta L/L + 10{,}000\ (\Delta L/L)^2$. Assume that all gauges have the same unstrained resistance R.



Do the following:

2a (10 points) Draw a bridge circuit to measure the compressive strain on the beam. Indicate the positions of the p-type and n-type strain gauges

2b (10 points) Derive an expression relating the bridge output to the compressive strain on the column.

2c (7 points) What is the sensitivity of the bridge in terms of millivolts per microstrain at very small strain? (Assume a 1 volt bridge excitation.)

2d (7 points) For a strain of $\Delta L/L = 0.1\%$ (1000 microstrains), how far does the actual output deviate from a straight line passing through zero with the slope given in part c? (Assume that the gauge factor remains constant.)

2e (6 points) If the support column measures 1 m x 1 m, and the Young's modulus $E = (F/A)/(\Delta L/L) = 10^{11}$ dynes/cm^2, what is the bridge output due to a 100 metric ton railroad engine that has stopped on the top of the column? (Hint: 1 g exerts a force of $\approx 10^3$ dynes at the surface of the Earth)

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PROBLEM 3 (30 points)

You are designing a thermocouple-based system for measuring the temperature of a furnace (T_f) over the temperature range from 25 °C to 500 °C with an absolute accuracy of 2 °C and do not want to provide ice to stabilize the temperature of the reference junction at 0 °C. Instead, you decide to leave the reference junction in the air of the room and measure the temperature of the room (T_r) with a solid-state temperature sensor. The correction of the thermocouple output for room temperature will be done by a voltage-summing circuit.

Assume the following:

- The thermocouple sensitivity is 50 μV/°C.
- The solid state temperature sensor passes a current $I = (1\ \mu A)\ T$ where T is its temperature in K and the voltage across it is in the range from 3 to 40 volts. Note that 0 °C = 273 K.

3a (10 points) Sketch a circuit that uses a thermocouple to produce an output $V_a = 0.25$ V when the temperature difference between the sensing and the reference junction is 25 °C and $V_a = 5.00$ V when the temperature difference is 500 °C. Label all necessary analog circuit elements and signal lines. Include the thermocouple wires and furnace. (It is not necessary to include analog filtering).

3b (10 points) Sketch a circuit that converts the solid-state temperature sensor current into a voltage V_b that has the same sensitivity (V/°C) as the thermocouple circuit **a**. Draw a block diagram and label all necessary analog circuit elements and signal lines. Show where the solid-state temperature sensor is placed in the diagram of part **a.** above. (It is not necessary to include analog filtering)

3c (10 points) Sketch a circuit that combines the outputs of circuits **a.** and **b.** to provide a voltage V_c that is proportional to the furnace temperature (0.25 V at 25°C and 5.00 V at 500 °C) and does not depend on the room temperature.