NAME (please print) ______________________________ Student ID_______________

UNIVERSITY OF CALIFORNIA, BERKELEY
Electrical Engineering and Computer Sciences Department

EECS 145L Electronic Transducer Lab
MIDTERM #2 Fall 2001 (100 points maximum)

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

PROBLEM 1 (20 points)

1a (10 points) What are the technical requirements of the ground fault interrupter circuit?

1b (10 points) Describe how the ground fault interrupter circuit functions to meet those requirements.

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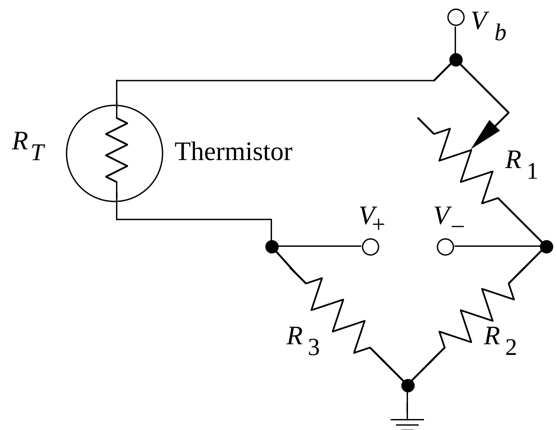
PROBLEM 2 (40 points)

You wish to measure air temperatures near 20°C using the thermistor bridge shown below.



Assume the following:

- $R_2 = R_3 = 10$ kΩ.
- You use an instrumentation amplifier with a gain of 5: $V_0 = 5\,(V_+ - V_-)$.
- The thermistor resistance R_T is 10.0 kΩ at 20 °C
- $dR_T/dT = -300$ Ω/°C at 20 °C.

You then perform a series of experiments to explore the thermistor self-heating of your system.

Experiment 1: With $V_b = 1$ volt and the thermistor in **water** at 20°C, you adjust R_1 to make the amplifier output $V_0 = 0.000$ volts. (Assume that there is no self heating in water)

2a. (4 points) What are the values of R_1 and R_T?

2b. (8 points) What electrical power is produced in the thermistor?

Experiment 2: You then move the thermistor to **air** at 20 °C, wait a while, and find that the amplifier output $V_0 =$ 0.05 volts ($V_b = 1$ volt).

2c. (8 points) What is the thermistor resistance R_T?

2d. (7 points) What is the temperature of the thermistor?

2e. (7 points) What electrical power is produced in the thermistor?

2f. (6 points) What is the thermal dissipation coefficient in W per C°?

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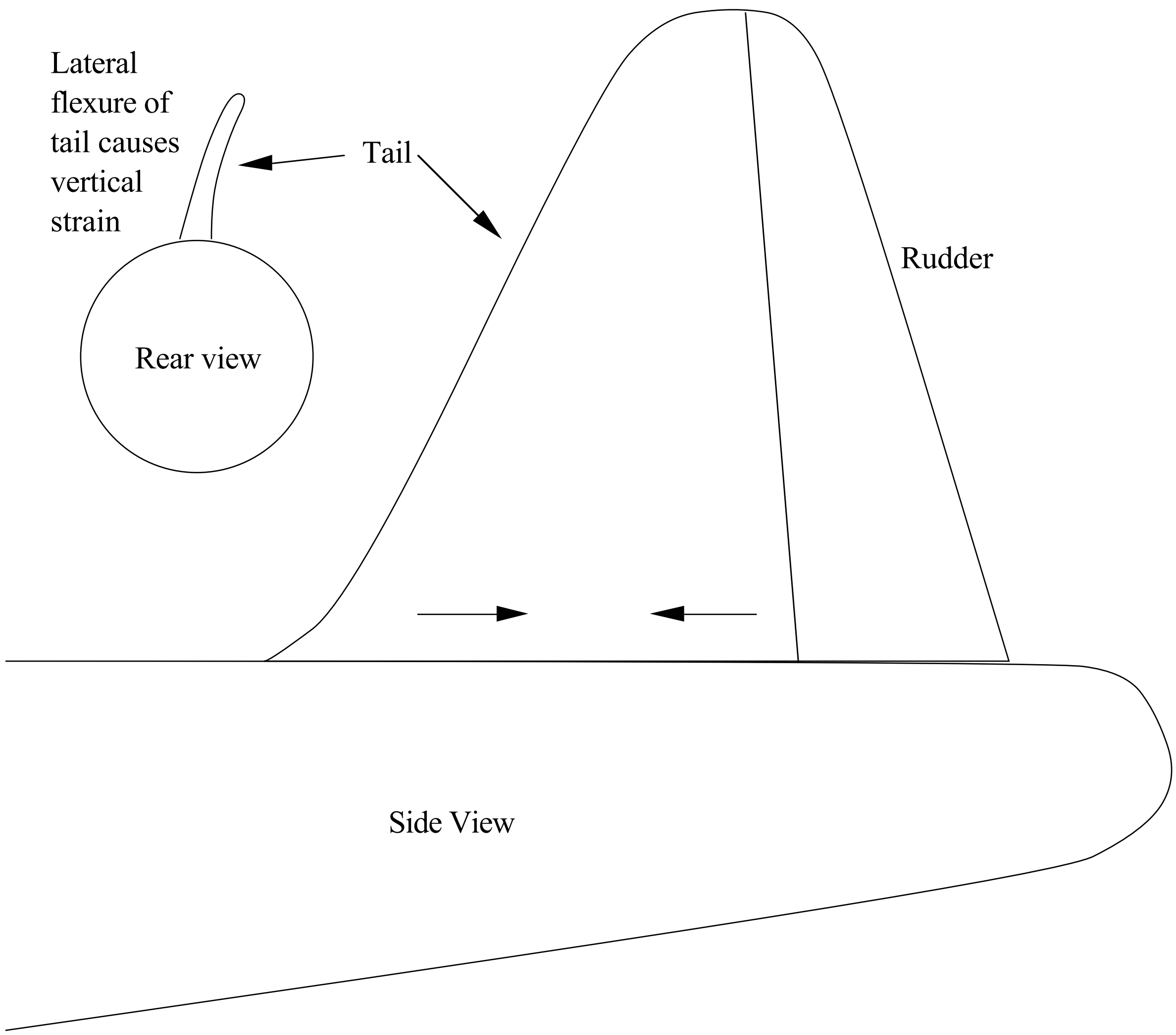
PROBLEM 3 (40 points)

Recent events have stressed the importance of accurately measuring the strain on aircraft structures (1) during in-flight turbulence and emergency maneuvers and (2) during full-scale laboratory testing. Important questions include (1) Do repeated stresses cause a gradual weakening of the structure? and (2) Is the weakening associated with permanent deformation?

For this problem, show how you would use two p-type and two n-type semiconductor strain gauges to measure the ***vertical*** strain ***on one side*** of the tail section of a passenger aircraft ***between the two arrows*** shown in the sketch below. The p-type have the strain relationship: $\Delta R/R = 100\ \Delta L/L + 10{,}000\ (\Delta L/L)^2$, and the n-type have the strain relationship: $\Delta R/R = -100\ \Delta L/L + 10{,}000\ (\Delta L/L)^2$.

3a. (8 points) Draw the four gauges in the sketch below, showing orientation and type.



3b. (8 points) Draw a bridge circuit to measure the vertical strain on the tail section. Indicate the positions of the p-type and n-type strain gauges

3c. (8 points) Derive an expression relating the bridge output to the vertical strain on the surface of the aircraft tail.

3d. (8 points) What is the sensitivity of the bridge in terms of millivolts per microstrain at small strain? (Assume a 1 volt bridge excitation.) ($\Delta L/L = 10^{-6}$ corresponds to 1 microstrain)

3e. (8 points) Limited by the Johnson noise in the strain gauges (assume that their noise is the same as ideal resistors), what is the minimum strain that can be detected at 16 Hz?