Midterm #2 Solutions – EECS 145L Fall 2003

1a

Properties that differ	**Pt resistance thermometer**	**Thermocouple**
material	metal	semiconductor
R with increasing T	linear increase	exponential decrease
maximum temperature	high (800 °C)	low (100 °C)

[full credit for 2 correct different properties; 2 points off for each missing entry]

1b

Properties that differ	**Incandescent lamp**	**Fluorescent lamp**
temperature	hot (3000K filament)	cool
mechanism	black body radiation	discrete energy change of electrons
wavelength spectrum	broad	discrete lines
energy efficiency	low	high

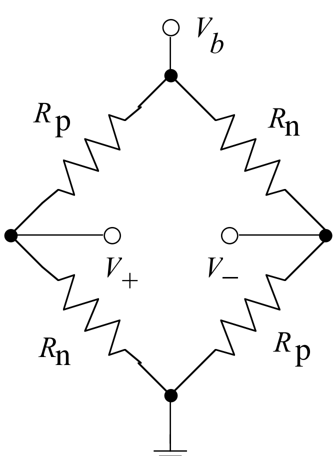
[full credit for 2 correct different properties; 2 points off for each missing entry]

1c

Properties that differ	**PIN photodiode**	**Light Emitting Diode (LED)**
input	photons	current
output	current	photons
electronic transducer type	sensor	actuator

[full credit for 2 correct different properties; 2 points off for each missing entry]

2a



The proper bridge circuit has the p-type gauges in opposing positions and the n-type gauges in opposing positions. Note that compression makes $\Delta R/R < 0$ for the p-type gauges and $\Delta R/R > 0$ for the n-type gauges.

2b

$$V_0 = \frac{R_n}{R_p + R_n} - \frac{R_p}{R_p + R_n} = \frac{(R + \Delta R_n) - (R + \Delta R_p)}{2R + \Delta R_p + \Delta R_n}$$

$$V_0 = \frac{\Delta R_n / R - \Delta R_p / R}{2 + \Delta R_p / R + \Delta R_n / R} = \frac{200\Delta L / L}{2 + 20{,}000(\Delta L / L)^2} = \frac{100\Delta L / L}{1 + 10{,}000(\Delta L / L)^2}$$

[6 points off for not writing down the bridge equation]

[4 points off for writing down the bridge equation but not correctly deriving $V_0(\Delta L/L)$]

[3 points off for $V_0 = 100\ \Delta L/L$]

2 c For $V_b = 1$ volt, bridge sensitivity is 0.1 mV per µstrain

2 d For $L/L = 10^{-3}$, $V_0 = 99$ mV, which is 1 mV (1% or 10 µstrain) lower than the straight line extrapolation.

[A correct answer would have to be consistent with the answer to 2b]

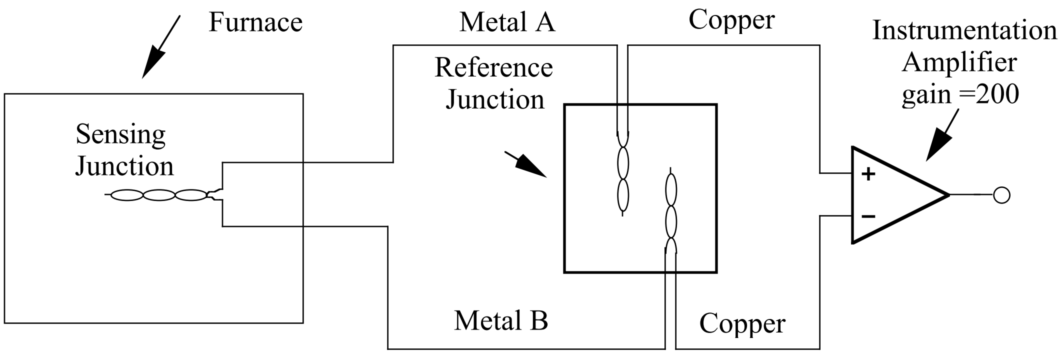
2 e 100 metric tons = 10^8 g, which exerts a force of 10^{11} dynes over 10^4 cm^2

$F/A = 10^7$ dynes/cm^2

$\Delta L/L = (F/A)/E = 10^7$ dynes/cm^2 / 10^{11} dynes/cm^2 = 10^{-4} = 100 µstrain

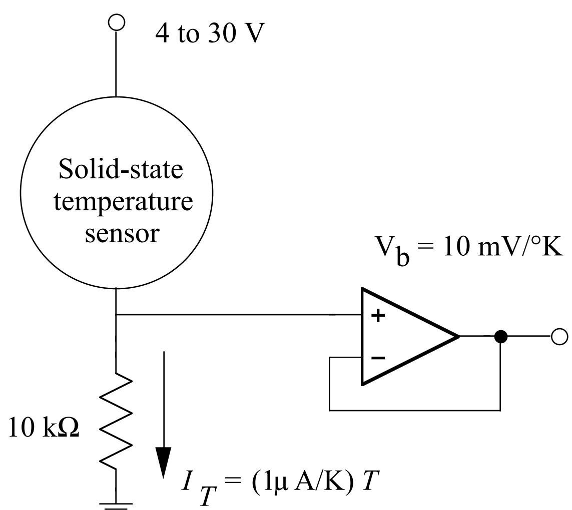
With a sensitivity of 0.1 mV/µstrain, $V_0 = 10$ mV

3a



Since the thermocouple has a sensitivity of 50 µV/°C, we need a differential gain of 200 to get the required 10 mV/°C

3b

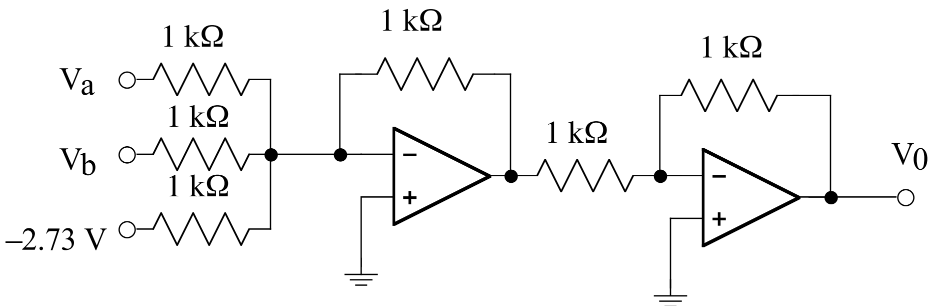


With a sensitivity of 1 μA/K, a series resistor of 10 kΩ will give us the required 10 mV/K. A buffer amplifier prevents loading of the summing amplifier, but was not required for full credit.

[2 points off for using a 1 kΩ resistor]

[4 points off for a design that does not specify the sensitivity]

3c



The output $V_0 = V_a + V_b - 2.73$ V.

As a check, consider the following situation: The sensing and the reference junction are both at 0 °C, so Va = 0.0 V. The solid state temperature sensor is at 273K and V_b = 2.73V. The above circuit produces V_0 = 0.0 V, as desired.

[2 points off for omitting the 2.73 volt bias]

145L midterm #2 grade distribution:

Problem	
1	25.3(3.0 rms) (30 max)
2	35.8 (6.0 rms) (40 max)
3	28.2 (3.1 rms) (30 max)

maximum score =	100	
average score =	89.3 (8.8 rms)	
30-39	0	F
40-49	0	D
50-59	0	C-
60-69	1	C
70-79	2	B-
80-89	6	B
90-99	14	A
100	1	A+