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Homework 1

Question 1

a) We can calculate the value of the resisitor by using the desired current and the voltage drop across the resistor.

$$24\,\text{V} - 2.2\,\text{V} = x\,\Omega \cdot 20\,\text{mA}$$
$$x = 1090\,\Omega$$

b) To replace the resistor with a capacitor, we must set the desired impedance values of the capacitor and resistor equal. We must take into account the frequency of the voltage source and the desired resistance on the component.

$$C = \frac{1}{2\pi f X_c} = \frac{1}{2\pi(70\,\text{Hz})(1090\,\Omega)} = 2.085\,\mu\text{F}$$

c) While the circuit with only the capacitor is far more efficient on power usage, if the circuit is energized on one of the AC current extremas, too much current would pass through the circuit while the capacitor is charging up. This large amount of instantaneous could burn out the LED.

Question 2

First we must adjust the read voltage to account for the 33 °C reference.

$$34\,\text{mV} + 1.745\,\text{mV} = 35.745\,\text{mV}$$

Now extract the relevant columns from the JTC referance table.

644 °C	645 °C
35.704 mV	35.764 mV

Applying a linear interpolation to determine a more exact approximation of the temperature at 35 mV.

$$\frac{y - y_0}{x - x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$
$$\frac{y - 644}{35.745 - 35.704} = \frac{645 - 644}{35.764 - 35.704}$$
$$y = 644.683\,^\circ\text{C}$$

Question 3

We will perform the exact same steps with a different reference temperature of $-33\,°\mathrm{C}$.

$$34\,\mathrm{mV} + -1.626\,\mathrm{mV} = 32.374\,\mathrm{mV}$$

587 °C	588 °C
32.338 mV	32.396 mV

$$\frac{y - 587}{32.374 - 32.338} = \frac{588 - 587}{32.396 - 32.338}$$
$$y = 587.621\,°\mathrm{C}$$

Question 4

$$\begin{aligned} R[T] &= R[T_0](1 + \alpha_0(T - T_0)) \\ x &= 500\,\Omega(1 + 0.0039\,°\mathrm{C}^{-1}(100\,°\mathrm{C} - 25\,°\mathrm{C})) \\ x &= 646.25\,\Omega \end{aligned}$$

Question 5

First find the power comsumption of the sensor.

$$\begin{aligned} P &= I^2 R \\ &= 25\,\mathrm{mA}^2 \cdot 500\,\Omega \\ &= 0.025^2 \cdot 500 = 312.5\,\mathrm{mW} \end{aligned}$$

Find the added temperature produced by the power consumption in the sensor.

$$\begin{aligned} \delta T &= \frac{P}{P_D} = \frac{312.5\,\mathrm{mW}}{35\,\mathrm{mW}/°\mathrm{C}} \\ &= 8.929\,°\mathrm{C} \end{aligned}$$

Because the sensor is originally put in a $25\,°\mathrm{C}$ environment, it should now read $33.929\,°\mathrm{C}$.

Question 6

$$\begin{aligned} R[T] &= R[T_0]e^{\beta(\frac{1}{T}-\frac{1}{T_0})} \\ x &= 3.3\,\mathrm{k\Omega}\cdot e^{2250\,\mathrm{K}(\frac{1}{349\,\mathrm{K}}-\frac{1}{273\,\mathrm{K}})} \\ &= 548.35\,\Omega \end{aligned}$$

Question 7

A sensor with low accuracy and high precision is better than a sensor with high accuracy and low precesion. This is because high precision will group the measured points around some offset from the actual “true” reading. This will mean a simple calibration step will be required to account for this offset. With low precision and high accuracy, there is no constant offset that may be applied to all measured points to improve the sensor readings.