NAME (Last, First): ____________________________

• This quiz is closed book, closed note, you may use a calculator for algebra.

• Circle your final answers in the space provided; show your work only on the pages provided.

• Do not attach separate sheets. If you need more space, use the back of the pages.

• Points for each problem are given in [brackets], 100 points total. The quiz is 50 minutes long.
1. [25 pts] A variable low-pass filter is implemented with a turn potentiometer as shown. The total resistance of the potentiometer is 3kΩ and is linearly distributed over the range of angle θ from 0° to 300°.

![Diagram of the filter circuit](image)

a. Derive the transfer function of \( V_{out}(j\omega)/V_{in}(j\omega) \) in terms of θ in degrees (0° ≤ θ ≤ 300°). [10 pts]
b. Derive the cut-off frequency $f_c$ of the low-pass filter as a function of $\theta$, and sketch this function $f_c(\theta)$ for $0^\circ \leq \theta \leq 300^\circ$. Label the axes and indicate numerical values for $\theta = 0^\circ$ and $300^\circ$. [15 pts]
2. [25 pts] Find the Thevenin equivalent between points A and B.
(2. continued)
3. **[25 pts]** A Wheatstone bridge with two thermistors implements a temperature sensor as shown. $T$ is temperature in degrees Celsius ($^\circ$C), and $R_{\text{Therm}_1}$ and $R_{\text{Therm}_2}$ are the thermistor resistances in Ohms as a function of $T$ as given below.

\[
R_{\text{Therm}_2} = R_2 \cdot (1 + \alpha_2 T)
\]
\[
R_2 = 1 \text{k}\Omega
\]
\[
\alpha_2 = -0.02/^\circ\text{C}
\]

\[
R_{\text{Therm}_1} = R_1 \cdot (1 + \alpha_1 T)
\]
\[
R_1 = 2 \text{k}\Omega
\]
\[
\alpha_1 = 0.01/^\circ\text{C}
\]

a. Derive the output voltage $V_o$ as a function of $T$. [10 pts]
b. Write the sensitivity of $dV_o/dT$. Does it depend on $T$? [10 pts]

c. Give values for the output voltage $V_o$ at -10°C and at +25°C. [5 pts]
4. [25 pts] A strain gauge is used as a uniaxial stress transducer as shown. The strain gauge is subjected to tensile stress, and the current through the strain gauge is measured at constant voltage. Assume that the strain gauge has nominal resistance $R_G = 10k\Omega$, gauge factor $G = 50$, and Young’s modulus $E = 10kPa$.

![Diagram of strain gauge circuit](image)

a. Find the sensitivity $\Delta I/\sigma$, where $\Delta I$ is the change in output current in units A, and $\sigma$ is the stress in units Pa. [15 pts]
b. Find the output current $I$ for $\sigma = 0$ and 10 Pa. [10 pts]