Temperature Feedback

1. Webster 10.5
   P'tolectric thermometer
   Shutter
   O
   Tympanic membrane
   [Diagram of sensor and amplifier]
   (Many possible block diagrams)

2. Thermocouple-based T sensor
   Specifications:
   - Temperature range 50-100°C
   - Resolution 0.1°C
   - Frequency of interest 0-5 Hz
   - Thermocouple sensitivity 53 μV/°C

   This is the same as we did in class! Except,
   Thermistor compensation R2

   Same Thermistor
   \[ R_p = 1106 - 19.3 T_2 \]
   when \( T_2 = 50°C \) to subtract thermocouple
   voltage associated with 50°C (i.e.
   50°C output = 0 when \( T = 50°C \))
   \[ R_2 = 141/2 \]
R1 to adjust sensitivity are the same

\[ R_1 \ = \ \frac{5V \cdot 19.3 \text{mV}}{R_1 + 19.3 \text{mV}} \implies R_1 = 1.82 \text{mV} \]

B. Thermistor-based sensor; use 1kΩ linearizing resistor

A. Specifications:
- \( T_{range} = 20 - 40^\circ C \)
- \( D = 2.4 \text{ mW/}^\circ C \)
- \( T_{resolution} = 0.1^\circ C \)
- \( f_{response} = 0 - 0.1 \text{ Hz} \)

B. Estimate equation w/ 1kΩ linearizing resistor:

\[ R_n = -9T + 700 \]

C. Self-heating

- \( P_{max} = 0.12 \text{ mW} \) (same as notes)
- \( R_m \) is same, so
- \( R_1 = 11666 \Omega \) as in notes
3. (cont) Rather than using 10kΩ resistors as in notes, let's assume I decided to use 12kΩ resistors.

\[
\begin{align*}
V_1 &= +5V \
\frac{R_n}{12kΩ + R_n} &= \frac{5(-9T + 700)}{12000 - 9T + 700} \\
\text{Contribution from } 9T \text{ in denominator small compared to other terms} \\
V_1 &= -0.00354T + 0.276 \\
\text{Subtract offset at } T = 42°C \Rightarrow R_3 = R(T) || 1kΩ \\
\text{at } 42°C \\
\Rightarrow R_3 &= R_n \text{ at } 42°C = -9(42) + 700 = 322Ω
\end{align*}
\]
So at 42°C, \( V_1 - V_2 = 0 \)

At 20°C, \( V_1 = -0.00354(20) + 0.276 \)
\[ V_1 = 0.3468 \text{ V} \]

\[ V_2 = 5V \frac{322}{322 + 12000} = 0.1306 \text{ V} \]

\[ V_1 - V_2 = 0.216 \text{ V} \]

So need to amplify 216 mV signal to range of DAQ board, assume 0.5 V

\[ 5V \frac{1}{0.216 \text{ V}} = 23 \]

\[ \text{Ratio} \frac{R_{15}}{R_4} = 23 \text{ , choose 10k & 230k} \]