ISIM Lab No. 2 Report: Concerning Thermistors

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1 In-Lab

In this lab, I used two temperature-variable resistors to measure the temperature of two cups of hot water. The primary goal of my experiment was to determine the answer to "Suppose I stop on the way to work to pick up a cup of coffee, which I take with milk. Assuming that I want the coffee to be as hot as possible when I arrive at work, should I add the milk at the coffee shop or wait until I get to work?"

I initially misread the lab instructions for when to put in the cold water, so I waited 10 minutes with both cups full of only hot water (140mL), then added 10mL of cold water to each at the 20 and 30 minute marks respectively. I used the extra data I accidentally collected to calibrate the thermometers, as the voltages across each resistor varied slightly when they should have been exactly the same. In the end, this actually made it easier to see the actual gap between ending temperature values.

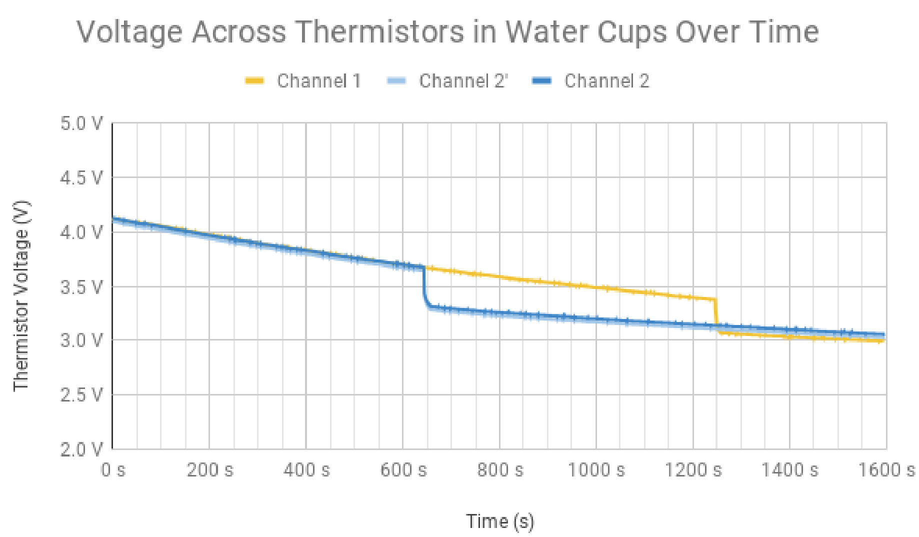

Figure 1: The graph above plots the voltage across the thermistor on the y-axis, and time horizontally. The orange "Channel 1" line represents the first cup of hot water, modeling waiting until reaching work to add cold liquids. The light blue "Channel 2'" line is the actual data from the second thermistor, which consistently showed slightly lower values than its Channel 1 counterpart while the temperature of both cups of water was the same. The darker blue "Channel 2" represents the data for the second cup, corrected from the aforementioned error. From this point on, we will use only the corrected values.

2 Resulting graphs

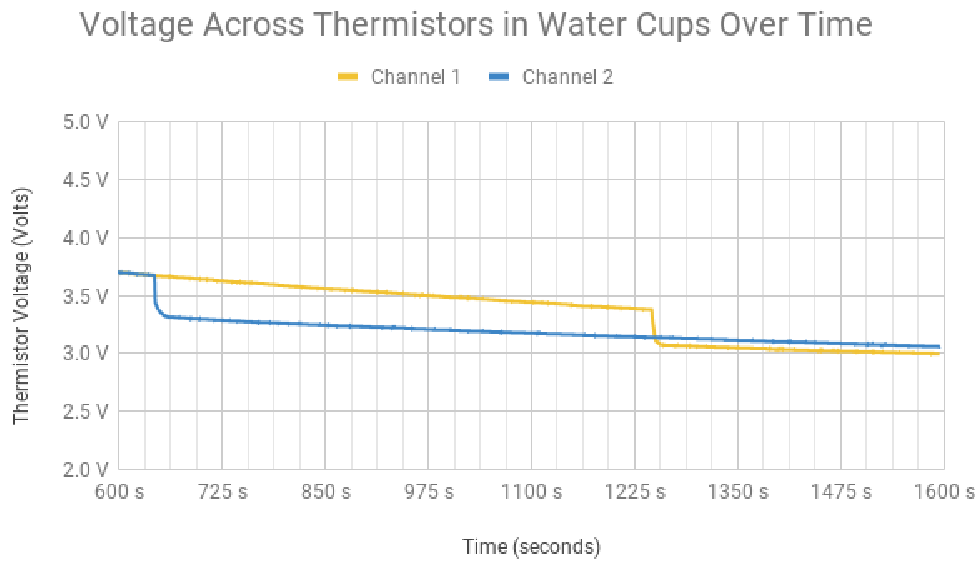

Figure 2: Zooming into just the 600 to 1600 second marks, we can more clearly see the curves created by the cooling of water in each of the two cups. We can also note that there is a discernible gap between the ending temperatures, confirming that there is indeed a difference between pouring in the "milk" at the coffee shop vs. at work.

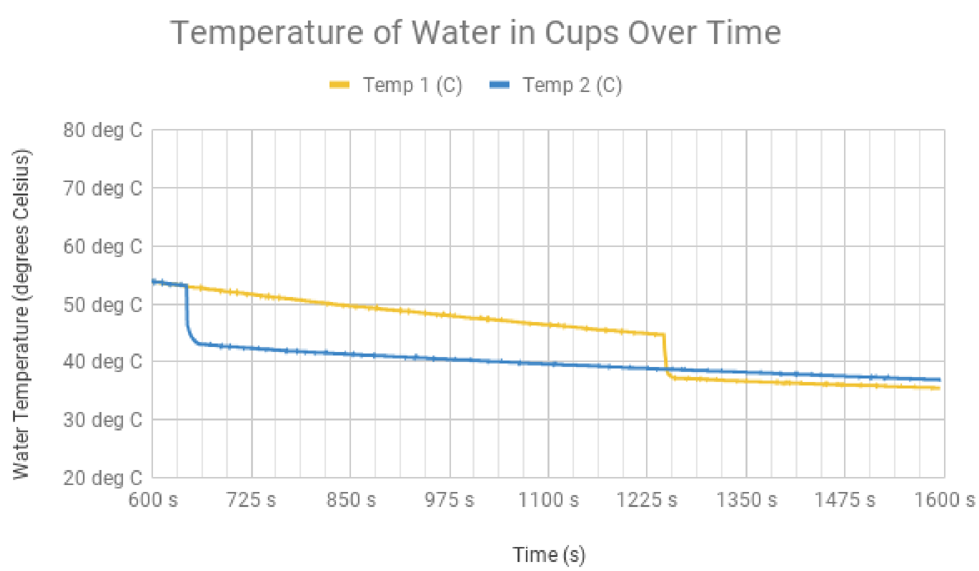

Figure 3: After converting voltage across the variable resistor to the thermistor's calculated resistance at every timestep using the equations $R = \frac{5000}{Vout} - 1000$ and $R = 1000 \times e^{-3528(\frac{1}{298} - \frac{1}{T})}$. Seeing this graph, we can confirm that the ending temperature is higher for the second cup, which we poured cold liquid into earliest.

3 Curve-Fitting

Lastly, I demonstrated that the reason for this difference in temperature based only on the time the cold liquid was added is a result of temperature being an exponential function asymptotic to room temperature (about 22 degrees). I plotted the function $T(t) = 22 + (T(t = 0) - 22)e^{-t/\tau}$ and varied τ until the curve seemed to visually fit my data well. Using a t_0 of 670 seconds into the experiment (timing it to coincide with the water returning to a normal cooling rate after the first cold water pour) and the $T(t_0)$ at that time of 42.97 degrees Celsius, I found τ to be approximately 2650.

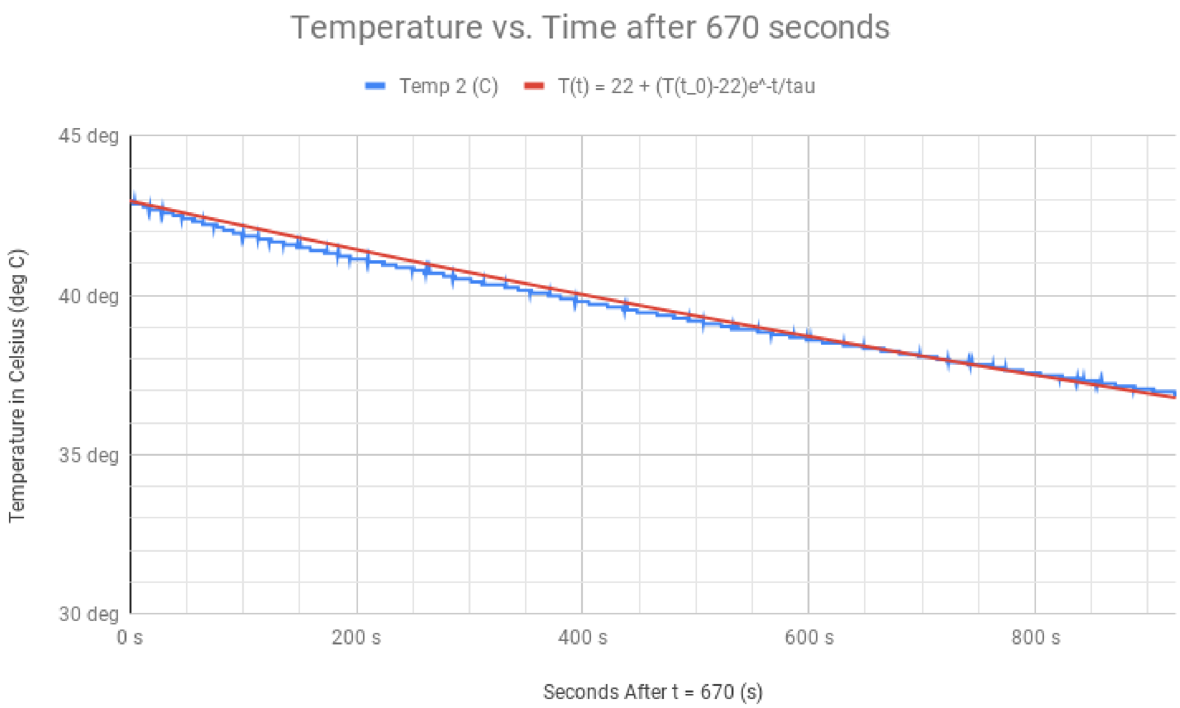

Figure 4: Here I have plotted the temperature of the second cup in blue, and the best fit exponential curve for this segment in red. The y-axis is in degrees Celsius (as before) and I have changed the horizontal axis to show seconds since pouring temperature re-equilibrium after pouring the cold water. With correctly substituted values, the numerical equation for the red line is $T(t) = 22 + (42.97 - 22)e^{-t/2650}$.