Monitoring Temperature Lab Report

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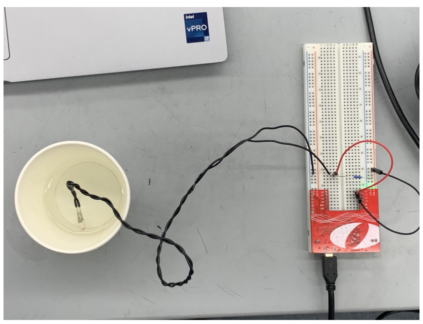
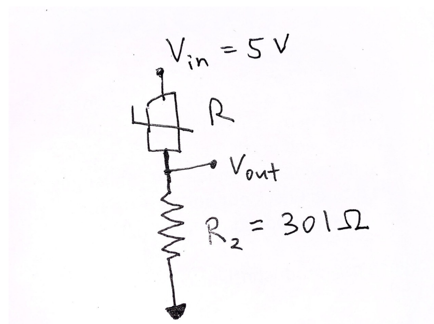
1 Circuit Image and Schematic



(a) Circuit with the thermistor in the cup with cooling water



(b) Hand-drawn circuit schematic

Figure 1: Circuit image and hand-drawn schematic

2 Experimental Methods

To obtain the temperature of the cooling water, a thermistor was used to observed the change in the voltage readings caused by its change increase in resistance as temperature dropped. 60mL of hot water was initially used but was intervened with 20mL of ice water 3 minutes after the experiment began. OScope used to record the voltage data while the hot water cooled for a total of about 6 minutes. The exported CSV file was imported to MATLAB to transform the voltage data into temperature data as seen Results section below.

A 301Ω resistor was chosen for the instrumentation circuit to maximize the range of voltage readings, assuming the temperature changed from about 100°C to room temperature of about 25°C. The rating of the resistor was an important decision in setting up the circuit since using very high or very low (10,000Ω/10Ω) resistance would have resulted in a poor range of voltage readings and possibly hindered the analysis of the temperature due to the decreased precision, especially since there were multiple conversions that needed to take place in order to reach information about the temperature. Although the range does not significantly differ between 100Ω and 1000Ω resistors, since utilizing as close to 5V was considered to improve the accuracy of the measurements, further exploration on the optimal resistance value was conducted.

$$R = 1000\Omega * e^{-3528\left(\frac{1}{298} - \frac{1}{T}\right)}$$

Using the given equation, the resistance of the thermistor was calculated to range from about 92Ω (at 100°C) and 1000 Ohm (at room temperature).

$$V_{out} = \frac{R_2 * V_{in}}{R + R_2}$$

Then using Ohm's Law, the range of voltage readings throughout the experiment were estimated. After some trials, 301Ω resistors were found to give a range between 1.2V and 3.8V, which was a slightly better compared to other resistors like 1000Ω resistors that would have given readings between 2.5V and 4.6V.

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3 Results

```
% Import the voltage measurements from the OScope
voltage_readings = readtable("thermistor.csv");

% Symbolically solve for the resistance of the thermistor
% V_out = V_in * (R_2 / R_2 + R_thermistor)
syms V_out V_in R_2 R_thermistor;
eqn_R = V_out == V_in * (R_2 / (R_2 + R_thermistor))
```

eqn_R =

$$V_{\text{out}} = \frac{R_2 \, V_{\text{in}}}{R_2 + R_{\text{thermistor}}}$$

```
S_R = solve(eqn_R, R_thermistor)
```

S_R =

$$\frac{R_2 \, V_{\text{in}}}{V_{\text{out}}} - R_2$$

```
% Experiment set up input
V_in = 5;
R_2 = 301;

% Using Ohm's Law
func_R = @(V_out) ((R_2*V_in) / V_out) - R_2;

% Calculate the resistance according to the changes in the voltage
```

```
% measurements
voltage_readings.R_thermistor = rowfun( ...
    func_R, voltage_readings(:, 2), 'OutputFormat', 'uniform' ...
    );

% Symbolically solve for the temperature with the given calibration
% eqn for the thermistor:
% Resitstance = 1000 Ohm * e^(-3528 * ((1/298)-(1/Temperature)))
syms T
eqn_temp = R_thermistor == 1000 * exp(-3528 * ((1/298) - (1/T)))
```

eqn_temp =

$$R_{\text{thermistor}} = 1000\,\mathrm{e}^{\frac{3528}{T} - \frac{1764}{149}}$$

```
S_temp = solve(eqn_temp, T)
```

S_temp =

$$\frac{1}{\frac{\log\left(\frac{R_{\text{thermistor}}}{1000}\right)}{3528} + \frac{1}{298}}$$

```
% Calculating the temperature numerically using the calculated resistance
% of the thermistor
func_temp = @(R_thermistor) 1 / ((log(R_thermistor/1000)/3528) + 1/298);
voltage_readings.Temperature = rowfun( ...
    func_temp, ...
    voltage_readings(:,5), ...
    'ExtractCellContents', 1, ...
    'OutputFormat', 'uniform' ...
    );

% Plotting Temperature vs Time
clf
plot(voltage_readings{:, 1} + 375, voltage_readings{:, 6}); hold on
axis([0 380 320 360])
title("Temperature vs Time")
xlabel("Time (sec)")
ylabel("Temperature (K)")
yline(340.6, '-.r')
yline(356.5, '-.r')
yline(324.5, '-.r')
yyaxis right
yticks([0.05 0.7])
```

```
yticklabels ({'\DeltaT_2=-4.4K', '\DeltaT_1=-15.9K'})
hold off
```

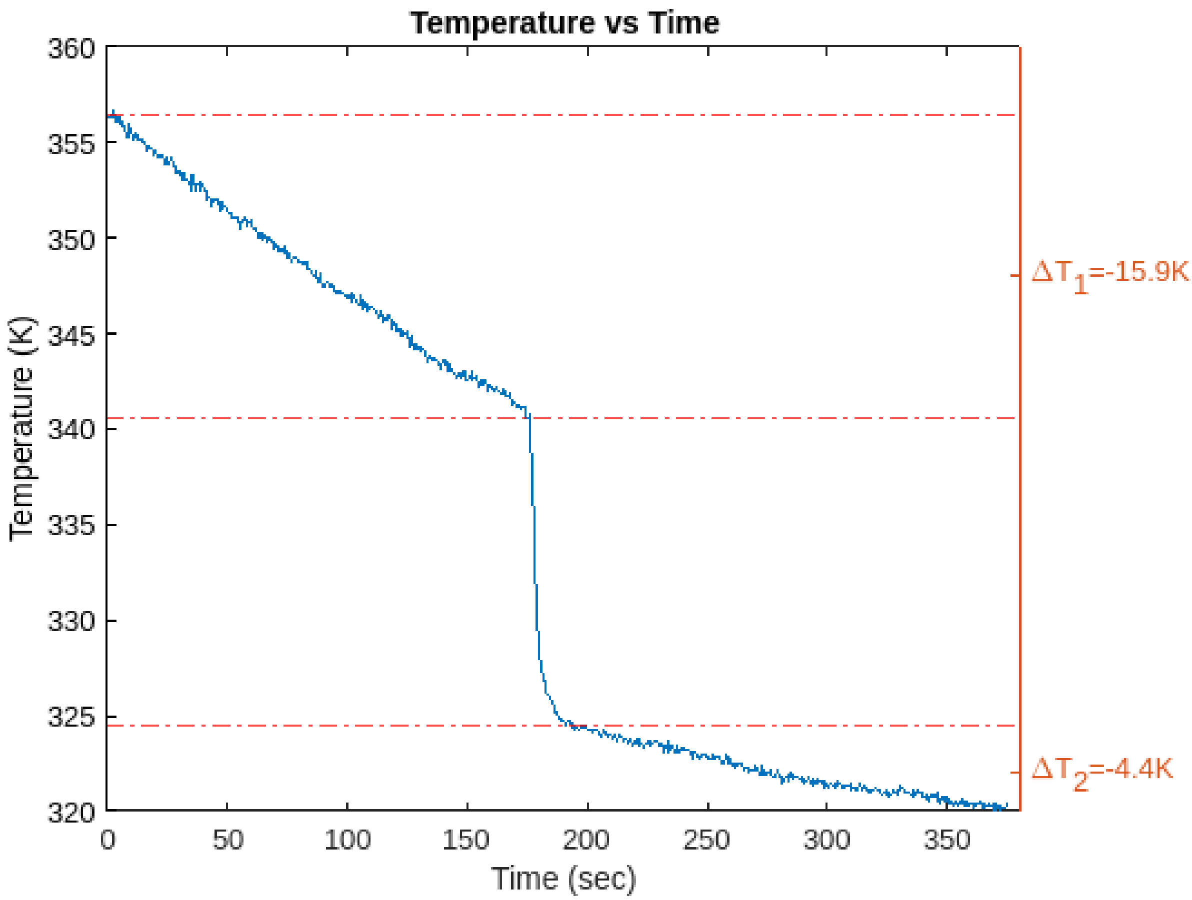

Figure 2: Temperature vs time for the cooling experiment. The measured voltage values from the OScope were used to calculate the corresponding temperatures. After about 180 seconds the start of the experiment, 20mL of ice water was added to the container with 60mL of hot water.

The temperature drop of ΔT_1 is much greater than that of ΔT_2 though it the period of measurements were about the 3 minutes each. From this phenomenon, the rate of cooling seems to decrease significantly as it gets closer to room temperature of about 298K.