Praveen Ravishankar **Fall 2019**
ME 4405 Section B

Lab Assignment Nine

Constructing and Characterizing a Thermal System Using the MSP432 and I2C Serial Communication

Questions:

1. ~~Fill in the missing steps for deriving the open-loop transfer function of the thermal system above, assuming zero initial conditions. This transfer function should describe the input-output relationship between the output T(s) (which is the difference between the canister and outside temperatures) and the input Q_{in}.~~ **(15 points)**

$$(R_T C)\dot{\tilde{T}} + \tilde{T} = R_T Q_{in}$$

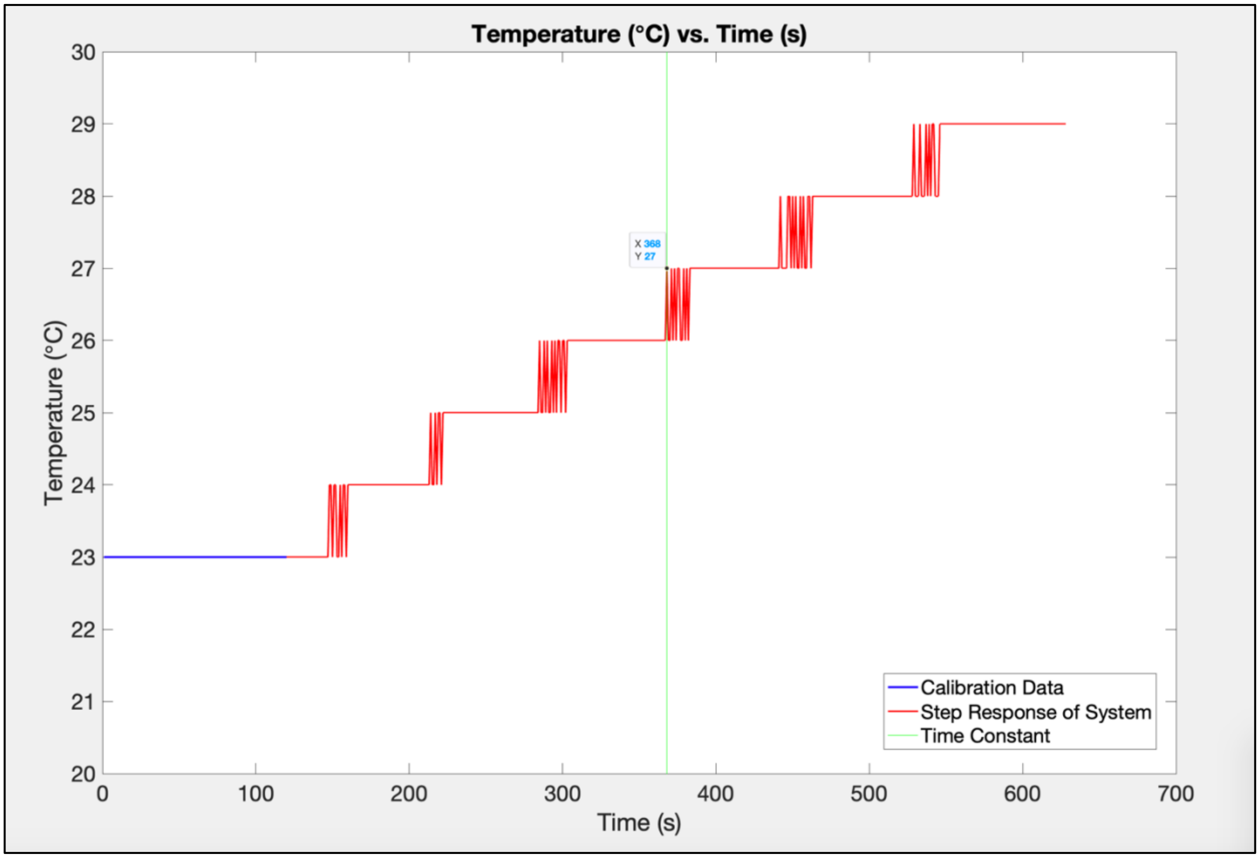
$$L\{(R_T C)\dot{\tilde{T}} + \tilde{T}\} = L\{R_T Q_{in}\}$$

$$(R_T C s)L\{\tilde{T}\} + L\{\tilde{T}\} = R_T L\{Q_{in}\}$$

$$(R_T C s + 1)T(s) = R_T Q_{in}(s)$$

$$\boldsymbol{G(s) = \frac{T(s)}{Q_{in}(s)} = \frac{R_T}{1 + (R_T C)s}}$$

2. Collect the calibration and step response data from your system. Plot the calibration data vs. time (at 0% duty cycle), and the step response data vs. time. Recall that the time constant for a first-order system is the time it takes for the output to reach 63.2% of its final steady-state value, relative to its starting point. Calculate and state the time constant for this system. Show the time constant on your step response plot. **(10 points)**



As seen in the plot above, the initial temperature of the system at 0% duty cycle is 23_{o}C, while the final steady-state value of the 50% duty cycle step response of the system is approximately 29_{o}C:

$$T(t = \infty) = 29℃$$

$$T(t = \tau) = 0.632(29℃ - 23℃) + 23℃$$

$$T(t = \tau) = 26.792℃ \approx 27℃$$

From observing the plot above, the time at which the system first reaches a temperature of 27_{o}C is **368 seconds**:

$$\boldsymbol{\tau = 368\ seconds}$$