AME40453Automation and Controls

## C2 Pre-Lab Assignment

For the following questions, please express your answers as algebraic equations in terms of the variables in the lab handout. Write or typeset your answers on a separate sheet of paper, and show your work.

IMPORTANT: transcribe the equations you derive into your lab notebook. You will need them to do the lab exercise.

1. Refer to the circuit in Figure 1 of the lab handout. The $5 \mathrm{k} \Omega$ potentiometer is used to adjust the desired temperature or "set point". Analyze the circuit and compute the following.
a. Make a plot of the high threshold voltage $V_{H S}$ as a function of the potentiometer resistance (over a range of 0 to $5 \mathrm{k} \Omega$ ). Assume the heater is on and the output of the Op-Amp (pin 6 ) is at +12 V .
b. On the same plot as part a, plot the low threshold voltage $V_{L S}$ as a function of the potentiometer resistance. Assume the heater is OFF and the output of the Op-Amp (pin 6) is at 0 V or ground.
c. Use your formula from last week's lab to convert the voltages $V_{H S}$ and $V_{L S}$ to temperature set points $T_{H S}$ and $T_{L S}$. Plot them together as a function of potentiometer resistance on a new graph.
d. What circuit element would you change to change the amount of hysteresis ( $T_{H S}-T_{L S}$ )?
2. When the heater is left OFF, the temperature $T$ will eventually cool down to a constant value. Use Eq. (3) to determine the steady state minimum temperature $T_{\text {min }}$ that the system will eventually reach when allowed to cool for a long time.
3. When the heater is left ON , the temperature $T$ will eventually heat up to a constant value. Use Eq. (4) to determine the steady state maximum temperature $T_{\text {max }}$ that the system will eventually reach when heated for a long time.
4. Solve Eq. (3) for the temperature vs. time $T(t)$ if the initial temperature is $T(0)=T_{H S}$.
5. Solve Eq. (4) for the temperature vs. time $T(t)$ if the initial temperature is $T(0)=T_{L S}$.
6. Use your answer from \#4 to derive an equation for the amount of time it will take to cool down from $T_{H S}$ to $T_{L S}$.
7. Use your answer from $\# 5$ to derive an equation for the amount of time it will take to heat up from $T_{L S}$ to $T_{H S}$.
8. Add your equations from $\# 6$ and $\# 7$ to derive an equation for the total period of the thermostats' oscillations.
9. Use your answers from \#7 and \#8 to derive an equation for the "duty cycle", which is defined as the amount of time that the heater is ON divided by the period of oscillations.
