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 5kΩ 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_{HS} as a function of the potentiometer resistance (over a range of 0 to 5kΩ). Assume the heater is on and the output of the Op-Amp (pin 6) is at +12V.
    b. On the same plot as part a, plot the low threshold voltage V_{LS} as a function of the potentiometer resistance. Assume the heater is OFF and the output of the Op-Amp (pin 6) is at 0V or ground.
    c. Use your formula from last week's lab to convert the voltages V_{HS} and V_{LS} to temperature set points T_{HS} and T_{LS}. 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 ($T_{HS} - T_{LS}$) ?
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_{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_{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 $T(0) = T_{HS}$.
5. Solve Eq. (4) for the temperature vs. time $T(t)$ if the initial temperature is $T(0) = T_{LS}$.
6. Use your answer from #4 to derive an equation for the amount of time it will take to cool down from T_{HS} to T_{LS}.
7. Use your answer from #5 to derive an equation for the amount of time it will take to heat up from T_{LS} to T_{HS}.
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.