Physics
Thermodynamics Lab

Name:
Period:

Today we will be beginning a mini unit on Thermodynamics. This will involve some research, a design problem, a simulation, and some reflection. First let's do some research:

1. Research and explain thermal contact, thermal equilibrium, and heat using your own words and examples.

2. Research and explain thermal expansion using your own words and at least one example.

3. Explain how the bimetal strip shown in class (and the picture below) works. What consumer application is it most commonly used in?

4. What mistake did the construction crew (or engineers) most likely make in the picture below? See article below if you are unsure for clues.

http://mankatotimes.com/2016/06/10/roads-buckling-due-to-heat-in-minnesota/

5. Define thermal conductivity in your own words.

6. List some materials with high thermal conductivity. What are some applications that might use materials with high thermal conductivity?

7. Now, list some materials with low thermal conductivity. What are some applications where you would want the materials you are using to have low thermal conductivity?

Now let's take a look at why and how sealed electrical boxes are cooled. Read the following industry document and use it to answer the following questions.

http://www.hoffmanonline.com/stream_document.aspx?rRID=233309&pRID=162533

8. List at least two electrical devices that you use frequently.

9. Why should electrical devices be kept at close to room temperature?

10. Using the vocabulary that you defined earlier, explain how a typical electrical device cooling system works.

11. Now it is time for you to put your designer's hat on. Describe in detail, with at least one diagram, how you would cool a one cubic foot electrical device box that generates moderate heat. Be sure to include at least one specific system mentioned in the article.

12. Read the Wikipedia page on thermal management of electronics found here:

    https://en.wikipedia.org/wiki/Thermal_management_(electronics)

    List three things that you did not know before reading the article.

13. Describe how a heat sink works. Use a drawing to illustrate your point.

Now let's actually see a cooling system in action. You will simulate the heat generated by a CPU chip and the common way it is cooled.   You will use a hot plate to simulate the heat generated by a running processor, a data collection device (TI-CBL 2 with temperature probe) to somewhat accurately measure temperature, and finally a heat sink and battery powered fan to simulate cooling.

Make sure you follow these steps very precisely and carefully. Also, things will get **HOT!** *Be very careful around the hot plate and heat sink.*

1. Turn on your hotplate to temperature setting three. From henceforth be very careful not to touch the hotplate.

2. Insert the temperature probe into the center of the radiator portion of heat sink so that tip of the probe is flush on the far side. It should look like this when completed:

3. Place the heat sink and inserted temperature probe carefully on the hot plate (copper plate down). Be sure the wires for the probe do not touch the hot plate.

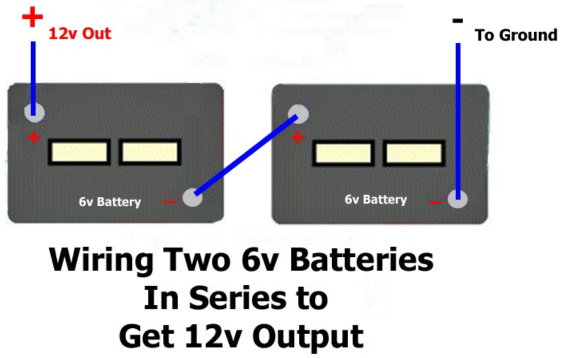
4. Make sure temperature probe is plugged into channel one of the gray CBL 2 data collection device and that the CBL 2 is connected to your graphing calculator.

5. Turn on calculator and start application Datamate found under APPS.

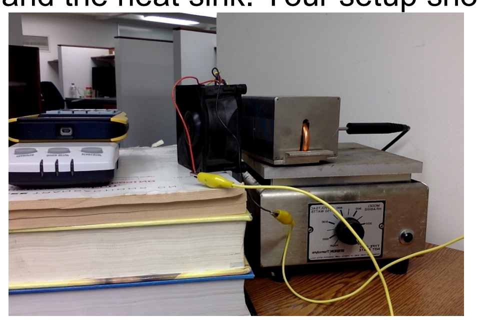
6. Once Datamate is running, you should see a temperature in the upper right hand corner. Note the units. What is the temperature being measured in?

   Do not start a cycle but simply watch the temperature in the top right corner. (It should be rising slowly)

7. Now connect two 6-volt lantern batteries to your fan in series. Make sure you do not short circuit the batteries! Follow these schematics; recognize that the red wire is positive and black is typically negative:



8. Once you have your fan working, turn it off for a moment. Make sure your fan is set to blow into the heat sink's radiator coils. You may need to set some books to create a stand to have it placed at the right height. Be very careful not to let your stand touch the hot plate nor your hand touch the heat sink or hot plate. It is okay for there to be about 4 inches of space between your fan and the heat sink. Your setup should look something like this:



9. When the temperature has reached 100° C, *turn on your fan and start collecting data on your calculator* for the next three minutes. By default, you will be collecting a data point every second.

   To collect data using the APP Datamate follow these steps:
   a. Press 2 from the main menu to start data collection
   b. Once data completion is complete, press enter to return you to the main screen.
   c. Pressing 3 from the main menu will return you to the graph.
   d. STO stops data collection and then you would press enter to return main menu

TURN OFF YOUR HOT PLATE AFTER YOU HAVE COLLECTED YOUR DATA

10. Sketch the graph of the data below making sure to label and scale all axes:

11. What type of graph was produced, linear, quadratic, exponential…? Explain your rationale for what you chose.

12. Was the rate of change of the temperature positive or negative?
(In Calculus rate of change is often synonymous with slope and the sign indicates whether your graph is increasing or decreasing)

13. When was the absolute value of the rate of change of the temperature the greatest?
(i.e. when is the slope the steepest, this is a very common Calculus question)

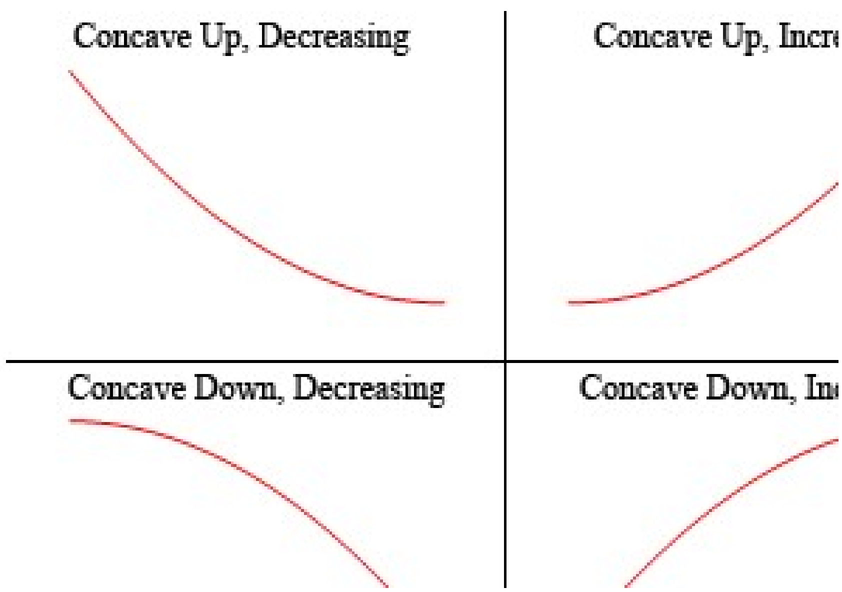
14. When was the graph cooling the quickest? How does this relate to question 13?

15. Hypothesize why you believe that it occurred at that point in time.

16. Does the graph appear to have a horizontal asymptote? I.e. does it appear to level off vertically as you get bigger and bigger x values? (In Calculus this is often asked by finding the limit at infinity)

17. What does this mean in the context of the simulation? I.e. what is the heat sink and fan able or not able to do?

18. An informal definition of concavity is that of a spoon. If it is upright you are concave up, but if the spoon is flipped, then looking from above you have a concave down shape. Is your graph concave up or down?



19. If you were to simply measure the temperature of the hot plate as it was heating up, how do you think it would look? Sketch what you believe this would look like. Also, describe the graph as increasing/decreasing and concave up/down.

20. Overall, this lab has a very rudimentary setup. List at least three sources of errors that were encountered in this simulation and how you could improve this lab to eliminate these errors if money and time were available.

21. Liquid cooling can provide a much more efficient heat sink that is able to cool processors to a greater degree. Why are they not used more often?

22. Read http://www.nytimes.com/2004/05/17/business/technology-intel-s-big-shift-after-hitting-technical-wall.html and describe one of the main issues facing Intel and how they intend to rectify the problem.

23. Reflect in a minimum of three sentences about your feelings about this lab.

Extra credit may be awarded to those that give useful feedback.