Newton's Cool!

INTRODUCTION:

Have you ever burned your tongue on hot chocolate, and then have it get too cold too quickly to even warm you up? As soon as a hot cup of liquid is poured, it begins to cool. After a period of time, the temperature of the hot liquid eventually reaches room temperature. Newton summarized temperature variations for such cooling objects. He stated that the rate at which a warm body cools is approximately proportional to the temperature difference between the temperature of the warm object and the temperature of its surroundings.

In this activity we will use the CBL and a temperature probe to collect data which will allow us to simulate the temperature variations that occur as a liquid is cooling.

MATERIALS:

CBL unit	Temperature Probe for the CBL	TI-83 calculator
Styrofoam cups	Hot and Cold water	NEWTON.83p

SETUP:

1. Pre-load the activity program "NEWTON.83p" in the TI-83 calculators
2. Connect the CBL to the TI-83 calculator with the link cable. Press in firmly.
3. Connect the temperature probe to **Channel 1 (CH1)** input on the top edge of the CBL
4. Turn on the CBL and the TI-83. The CBL is now ready to receive commands from the TI-83
5. Start the experiment by pressing [PRGM] and select the program **NEWTON.**
6. Press [ENTER]
7. Follow the instructions on the TI-83 screen and procedure section.

PROCEDURE:

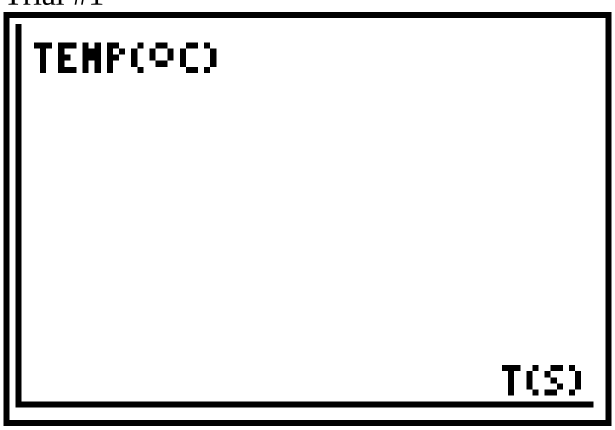
1. Get a cup of hot water to be used in this experiment. The water should be very hot, although it does not need to be boiling.
2. Place the temperature probe in the beaker of hot water for about 60 seconds.
3. Remove the temperature probe from the hot water and press [ENTER] to start collecting data.
4. The probe should remain exposed to the air while the temperature data is being collected. Avoid placing the probe directly on the tabletop, and keep it away from any drafts to avoid conduction and evaporation effect.
5. Observe the resulting variations in temperature on the TI-83 display as the data is being collected.

6. On the space provided below for Trial #1 draw the graph and label the x- and y-axis.
7. Explain the graph in your own words.
8. Answer the questions in the analysis section as you look at your results.
9. Discuss the cooling to room temperature vs. Zero degrees Celsius.
10. Press [CLEAR][ENTER] on the calculator.
11. Rerun the experiment following steps 1 and 2 on the Procedure section. Then place the probe into a glass of ice water.
12. Press [ENTER] immediately to start collecting data.
13. On the space provided below for Trial #2 draw the graph and label the x and y axis.
14. Explain the graph in your own words.
15. Complete the Conclusion section of this packet.

DATA RECORDING:

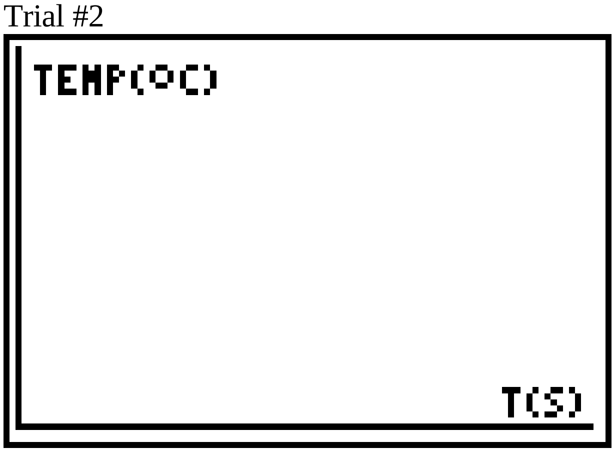
Draw a graph of your findings from the calculator on the cooling of the temperature. Be sure to label the x- and y-axis including the initial and final temperatures. Then explain your findings.

Trial #1



Explain why the graph looks this way:

Trial #2



Explain why the graph looks this way:

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ANALYSIS:

1. When did it gain or loose the most heat energy—at the beginning or at the end of the data collection? ____

2. Did it gain or loose the heat evenly? ________________________________

3. Using the graph, what is the basis for your decision?

   ____

   ____

4. How does the graph for Trial #2 differ from the graph for Trial #1?

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   ____

5. Which graph seems to show the greatest change in heat energy? ________________

6. Explain what characteristics of the graphs made you give this answer for question 5.

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MODELING:

The data from Trial #2, in which the hot temperature probe was placed in ice water, can be described using an exponential model in the form $y = A*B^x$ by pressing [Y=] and at Y1= enter [ALPHA][A][×] [ALPHA] [B] [^] [X,T,Θ,n] where A is the starting temperature, B affects the shape of the curve, x is time, and y is temperature. A guess-and-check method will be used to arrive at the equation. Follow the procedures below using the data from Trial #2. Then answer the questions relating to the determined model.

1. Press [TRACE] on the TI-83 to move along the data plot for trial 2. Use [◄] and [►] to position the cursor at the starting temperature value. Record this y-value, to the nearest hundredth, as A below.

   A = __________

2. Press [Y=] [CLEAR] to clear the Y1 function register. Now enter the expression A*B^X, but type in the numerical value for A.

3. To obtain a good fit, you will need to adjust the value of B. Press [2nd] [QUIT] to return to the home screen. Begin with a starting value of B = 1 by pressing [1] [STO▶] [ALPHA] [B] [ENTER] to store the value 1 to variable B. Then press [GRAPH] to display the data and model on the same screen. Repeat this process until the best value of B, to the nearest hundredth, is found. Record this value below. (Hint: Try values of B that are larger and smaller than 1.)

   B = __________

4. Record the complete equation below, using the numerical values for A and B.

   y = ______________________________

5. Describe how well the model fits the data.

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   ____

6. How does the B-value affect the shape of the graph?

   ____

   ____

7. How do you think the B-value found for Trial #2 would compare to the B-value for Trial #1? Explain why you think this is so. ______________________________

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