How Cool It Is!

Name ______________________

Class ______________________

Hot drinks such as coffee, tea, and hot chocolate seem to cool slowly when we have to wait to drink them and then cool rapidly once they reach the temperature at which we would like to drink them.

Is this the way it really works, or are we experiencing a lack of patience?

In this activity, you will drop 6 ice cubes into a cup of room-temperature water. With a temperature probe you will stir the water and ice. From the time of the drop, the probe will record the temperature every second for 2 minutes.

Problem 1 – Cool Down

Step 1: Connect the probe to the TI-84 via the mini USB port. Once connected, the Easy Data App will automatically launch.

Step 2: Select **Setup** by pressing the key below it ([WINDOW]) and choose **Time Graph**. The following should appear. If not choose **Edit**.

Sample Interval: 1
Number of Samples: 120
Experiment Length: 120

Step 3: Place the probe in the water. Drop the ice cubes into the container of water and press **Start** ([ZOOM]) at the same time. Constantly stir the water with the probe.

Step 4: When the experiment ends, the calculator automatically graphs **Temp** vs. **Time**.

Exit the **Easy Data** application by selecting **Main** and then selecting **Quit**.
Note: The Time and Temp data are stored in L_1 and L_2 respectively.

1. Determine what type of equation best models this data. Press [STAT], move to the CALC menu, and select the appropriate regression. Then enter **L1, L2, Y1**.

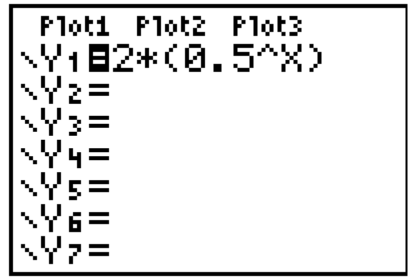
Use Plot1 to create a scatter plot of Temp vs. Time.

2. What was the regression equation initially obtained for the data? Be sure to record the correlation coefficient.

3. Does this regression equation provide a good fit? Explain your reasoning.

4. How might an equation be obtained to better fit the data?

Graph the equation $f(x) = 2 \cdot (0.5)^x$ using window settings *x*: [–2, 6] and *y*: [–1, 7].



While the shape of the graph is similar to the data obtained, there are a couple of significant differences. What are they?

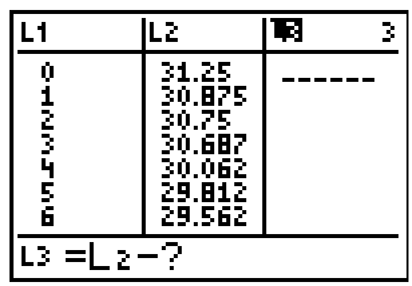
The graph of the equation $f(x) = 2 \cdot (0.5)^x$ appears to have a horizontal asymptote.

5. Observe the data you generated (STAT ENTER). Does it appear to have a horizontal asymptote? If so, where is it located?

Goal: Adjust the regression equation obtained in Question 2 to account for the apparent horizontal asymptote from the obtained data.

Press STAT ENTER and move the cursor to highlight **L3.** Enter **L2 – (value)**, replacing *value* with a value just below the apparent horizontal asymptote.

For example, if a horizontal asymptote appears to be at 5, subtract 4.999.



Now perform a new regression equation using the original time and the newly adjusted temperature data (L1 and L3 respectively) storing the equation in Y2.

6. What is this new regression equation?

7. How do the correlation coefficients (*r*) compare for the initial regression and the regression performed after modifying the data? Which correlation coefficient indicates the best fit for the data?

To observe the scatter plot of the data as well as the two regression equations, press [Y=] and make sure the equals sign of both **Y1** and **Y2** are highlighted.

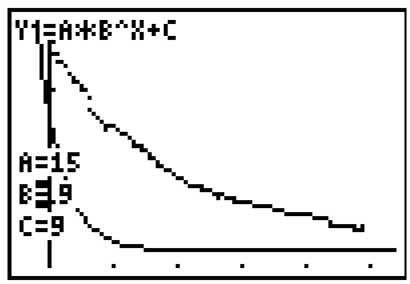
In **Y3**, enter the adjusted regression equation and add the value you subtracted in list L3.

8. Compare the three graphs to the scatter plot. Which equation visually appears to fit the data best?

9. How might a better fitting equation be obtained?

Let's look at manually finding the exponential equation using the Transformation Graphing application.

- Press [APPS] and select **Transfrm**.
- Press [Y=] and enter **A∗B^X + C**
- Press graph and adjust the values for *a*, *b*, and *c* to best fit the data.



10. What equation did you find to best fit the data? How does it compare to the regression equations found earlier?

11. Is it true that very hot drinks cool very slowly at first, then cool rapidly once at a more reasonable temperature? Explain your answer through use of your data, graph, and/or equations generated from the cooling data generated.

Problem 2 – Heating Curve

Now we'll warm things up a bit! The data files L1 and L2 contain heating data for water. If you have time, your teacher may have you heat water and collect data.

Graph the data and find an appropriate equation to model it. Consider making adjustments as were made in the previous situation to see if improvements may be made upon the resulting equation.

12. What was the regression equation initially obtained for the data?

13. Does this regression equation provide a good fit for the data? Explain your reasoning.

14. Does the graph appear to have a horizontal asymptote? If so, where?

15. Adjust the data for an apparent horizontal asymptote as instructed in Problem 1. What regression equation was obtained?

16. How do the correlation coefficients (*r*) compare for the initial regression and the regression performed after modifying the data? Which correlation coefficient indicates the best fit for the data?

17. Compare the graph of the “adjusted” regression equation to the initial equation graph. Which equation visually appears to fit the data best?

Start the **Transformation Graphing** application as outlined earlier and manipulate the equation **A∗B^X + C** to best fit the data.

18. What equation did you find to best fit the data? How does it compare to the regression equations found earlier?