FUNCTIONS EXPERIMENT
NEWTON'S LAW OF COOLING

Introduction

The purpose of this experiment is to investigate how objects cool. You will discover that the difference between the temperature of a cooling object and room temperature can be modeled by an exponential function. You will use this pattern to find a formula for the temperature of a cooling object as a function of time.

Equipment

For this experiment you will need a TI calculator with the Vernier PHYSICS program loaded, a CBL unit, a temperature probe, and heated water.

Procedure

First find room temperature by taking 20 measurements of air temperature every 0.5 second. The temperature data is stored in L2, and you can use one of the statistics functions to find the mean of L2. This gives a good estimate for room temperature. Next warm the probe in hot water. Allow a few minutes for the temperature of the probe to reach the temperature of the water. Set the CBL unit to measure temperature every 1 second for 30 seconds. When you are ready, remove the probe from the hot water and begin taking measurements. The graph displayed by the calculator will show the temperature of the probe (in degrees Celsius) as it cools.

Data

Record the temperature of the room: ____________

Record in the following table the temperatures collected by the CBL unit. (Time is measured in seconds and temperature in degrees Celsius.)

Temperature of the Probe

Time	Temperature	Time	Temperature	Time	Temperature
1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

In your analysis of the experiment, you will first work with the difference between the temperature of the probe and room temperature. With the temperature data above in list L4 in your calculator, create a new list in L2 that gives the difference between the temperature of the probe and room temperature. We will use P to represent the temperature of the probe, D to represent the difference between the temperature of the probe and room temperature, and t to represent time in seconds.

Analysis

1. With the time readings in L1, sketch the graph of the data for D versus t (i.e., L2 versus L1) and describe what the graph shows.

2. Create a new list in L3 by taking the natural logarithm of the data in L2. Determine if an exponential model is appropriate for the temperature difference data D (in L2) by graphing $\ln D$ versus t (i.e., L3 versus L1). What characteristics of the graph lead you to conclude (or not to conclude) that D is approximately exponential?

3. Use LinReg(ax+b) L1, L3 to find the equation of the regression line for $\ln D$ against t.

4. Use your answer to Part 3 to find a formula for an exponential function that approximates D.

5. Identify the percentage decay rate in your formula. What does this mean in practical terms?

6. How long does it take the probe to cool to within 1° C of room temperature? Explain how you determined this.

7. What was the temperature of the hot water? Explain.

8. Use your formula for D to find a formula that approximates P, the temperature of the probe.

Conclusions

9. In Exercise 6 from Section 2.4 of the text, we encountered the following formula for the temperature C (in degrees Fahrenheit) of a fresh cup of coffee t minutes after it is poured:

$$C = 125 \times 0.97^t + 75.$$

(Here we have altered slightly the form of the exponential term.) Explain what each of the parameters in the formula means.