Investigation
Cooling

You will need

- a cup of hot water (optional)
- a temperature probe
- a data collection device
- a second temperature probe (optional)

In this investigation you will find a relationship between temperature of a cooling object and time.

Step 1 Connect a temperature probe to a data collector and set it up to collect 60 data points over 10 minutes, or 1 data point every 10 seconds. Heat the end of the probe by placing it in hot water or holding it tightly in the palm of your hand. When it is hot, set the probe on a table so that the tip is not touching anything and begin data collection. [▶ See **Calculator Note 5E.** ◀]

Step 2 Let t be the time in seconds, and let p be the temperature of the probe. While you are collecting the data, draw a sketch of what you expect the graph of (t, p) data to look like as the temperature probe cools. Label the axes and mark the scale on your graph. Did everyone in your group draw the same graph? Discuss any differences of opinion.

Step 3 Plot the data in the form (t, p) on an appropriately scaled graph. Your graph should appear to be an exponential function. Study the graph and the data, and guess the temperature limit L. You could also use a second temperature probe to measure the room temperature, L.

Step 4 Subtract this limit from your temperatures and find the logarithm of this new list. Plot data in the form $(t, \log(p - L))$. If the data are not linear, then try a different limit.

Step 5 Find the equation that models the data in Step 4, and use this to find an equation that models the (t, p) data in Step 3. Give real-world meaning to the values in the final equation.

EXERCISES

Practice Your Skills

1. Prove that these statements of equality are true. Take the logarithm of both sides, then use the properties of logarithms to re-express each side until you have two identical expressions.

a. $10^{n+p} = (10^n)(10^p)$ **b.** $\frac{10^d}{10^e} = 10^{d-e}$

2. Solve each equation. Check your answers by substituting your answer for x.

a. $800 = 10^x$ **b.** $2048 = 2^x$ **c.** $16 = 0.5^x$

d. $478 = 18.5(10^x)$ **e.** $155 = 24.0(1.89^x)$ **f.** $0.0047 = 19.1(0.21^x)$

3. Suppose you invest \$3000 at 6.75% annual interest compounded monthly. How long will it take to triple your money?