EXPLORATIONS

Name ________________________

Date ________________________

ACTIVITY 11

Curve Ball

You use the formula $A = x^2$ to find the area of a square whose side is x. This is a *quadratic relation* between the side length and area of the square since the variable x is raised to the second power. There are many examples of quadratic relations in the real world, including height and time variations for a bouncing ball.

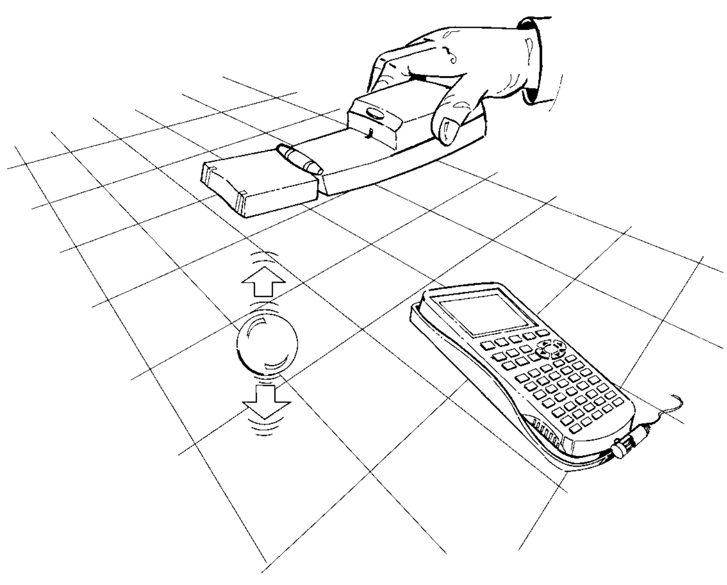
Objectives

In this activity you will:

- Create a Height-Time plot for a bouncing ball.
- Use a *quadratic equation* to describe the ball's motion.

You'll Need

- CBR unit
- TI-82 or TI-83 and calculator-to-CBR cable
- A bouncing ball (Racquetballs and basketballs work well.)



CBR Setup

1. Connect the CBR to your calculator using the link cable.

2. Turn on your calculator. If you have not already loaded the **RANGER** program into your calculator, follow these steps:

a. Press [2nd] [LINK] [▸] [ENTER]. The calculator displays **Waiting ...**

b. Press the (82/83) transfer button on the CBR.

3. Run the **RANGER** program on your calculator:

a. Press [PRGM].

b. Choose **RANGER**.

c. Press [ENTER].

4. From the **MAIN MENU**, select **3: APPLICATIONS**.

5. From the **UNITS?** menu, choose **1: METERS**.

6. From the **APPLICATIONS** menu, select **3: BALL BOUNCE**.

Collecting the Data

1. Position the CBR at shoulder-height and hold the ball 0.5 meters below it, as shown in the setup diagram. Press [ENTER].

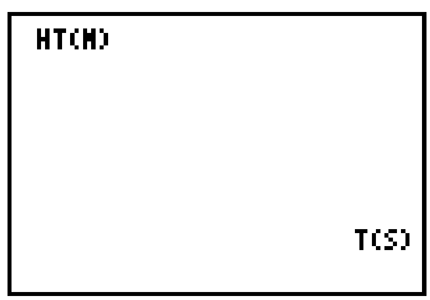
2. If desired, detach the CBR from your calculator. Press [ENTER].

3. Get ready to release the ball when the CBR starts clicking. Be sure to move your hands out of the way after the ball is released. When you are ready to start, press (TRIGGER) on the CBR.

4. You may resample as often as needed by pressing (TRIGGER) again. When you are finished, reattach the CBR to your calculator and press [ENTER].

Your plot only needs to have two complete bounces.

5. If you are satisfied with your plot, press [ENTER], sketch your plot to the right, and go to the next section. If not, press [ENTER], select **5: REPEAT SAMPLE** from the **PLOT MENU**, and try again.



Looking at the Results

1. For any one bounce, a plot of Height-Time has a parabolic shape. The equation that describes this motion is quadratic:

$y = A(x - H)^2 + K$

where A affects the width of the *parabola* and (H,K) is the *vertex* of the parabola. In this activity, the control variable, x, represents time and y represents height.

This equation is called the *vertex form* of the quadratic equation. Use the arrow keys on your calculator to move the cursor along your Height-Time plot. Identify the vertex of the first complete bounce and record the x- and y-coordinates as H and K below.

H = __________ K = __________

When you've finished tracing on the data, press [ENTER]. From the **PLOT MENU**, select **7: QUIT**. Press [CLEAR].

2. Press [Y=] and enter the expression **A(x – H)2 + K**, substituting your values of H and K from question 1, leaving A as a variable. Press [2nd] [QUIT] to return to the home screen.

a. To find the equation of the parabola, use a guess-and-check method to find the value of A.

b. Start with an initial guess of A = 1. Store this value to A by pressing [1] [STO▶] [ALPHA] [A] [ENTER].

Press [GRAPH] to see the equation with the data. If the equation doesn't fit the data well, press [2nd] [QUIT] to return to the home screen and store a different value to A using the method described in a. above.
Hint: Try negative as well as positive values.

For each new value of A that you test, press [GRAPH] to view your adjusted equation. Experiment until you find one that provides a good fit for the data. Record the value of A that works best in the space below.

A = __________

3. Using this value of A and the H and K values found in question 1, write the vertex form of the quadratic equation below.

y = ____________________________

4. What effect does the sign (positive or negative) of A have on the parabola?

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5. What effect does increasing the size of A have on the shape of the parabola? What effect does decreasing the size of A have on the shape of the parabola?

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6. How do you think the equation of the second bounce parabola would change, if at all?

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7. Would you expect your classmates to have the same value of A for their trials, or do you think the A value would vary?

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8. Find out the value of A from the other groups of students in your class. How do these values compare to your value of A?

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9. What conclusion can you make about the value of A for a quadratic equation for a bouncing ball?

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Going Further

Answer these questions on a separate sheet of paper. Show all work.

1. Using what you discovered about the value of A in a quadratic equation for a bouncing ball, write the equation of a parabolic ball bounce with a vertex of (7,0.48).

2. Find the equation of the second parabola of your bounce plot. Then, type it in Y1 of the Y = editor and graph it to see how well it matches.

3. If a ball that was more or less bouncy was used instead, would it affect the value of A in the equation? If so, describe how.