

Rebounding Lab

(adapted from Texas Instruments Inc.)

Exponential Functions

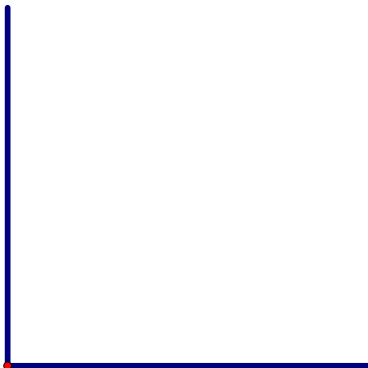
Objectives: Model an exponential function with bounce height data.

Materials: Ball (Racquetball or basketball work well).
TI-83 Plus or TI-84 Plus graphing calculator
CBR 2 motion detector
Easy Data Application

Procedure:

1. Set up Motion Detector and calculator.
 - Open pivoting head to the CBR 2. (Set sensitivity to normal)
 - Turn on calculator and connect to the CBR 2.
2. Position CBR 2 about 1.5 meters above the floor, so the disc is pointing straight downward.
3. To make the data collection go more smoothly use three students; one to hold the CBR 2, one to release the ball and one to run the calculator.
4. Set up EasyData for data collection.
 - Start the EasyData application, if it is not already running.
 - Select FILE from main screen and then select **New** to reset the application.
 - Select SETUP from the main screen, and then select **Ball Bounce**.
5. Practice dropping the ball so that it bounces straight up and down beneath the CBR 2. Minimize the ball's sideways travel. Dropping the ball from waist high works well. The ball must never get closer than .5 meters from the CBR 2. Pull your hands away from the ball so the CBR 2 does not detect your hands.
6. Select START to begin data collection. Follow the instruction on your screen for the Ball Bounce activity to collect data.
7. When the data collection is complete, a graph of distance versus time plot will be displayed. Examine the graph; it should contain a series of **at least five** parabolic arches.
(If necessary, to repeat the data collection, select MAIN to return to the main screen and repeat step 6.)

Graph A: Draw a sketch of your graph here:



Analysis:

The rebound height of the ball (maximum height for a given bounce is approximated by:

$$y = ab^x$$

where y is the rebound height, a is the height from which the ball is dropped (sometimes called the initial height), b is a constant, and x is the bounce number.

1. The plot is in TRACE mode. Trace to the right to find the maximum height of each bounce.
(Round the values to the nearest 0.001 m.)

Initial height: _____

Max of Bounce 1: _____

Max of Bounce 2: _____

Max of Bounce 3: _____

Max of Bounce 4: _____

Answer question #1 on your Student Worksheet.

2. Select MAIN to return to the main screen. Choose QUIT and then select OK to quit Easydata.

3. Press (2nd) STATPLOT, Select **On** for plot 1 and make sure your Xlist : L1 and Ylist : L2. Now select GRAPH to view the graph of your data. You may want to press ZOOM then select ZoomStat to view your data better.

4. To enter the information from #1 in this section in your Data Table:

- Press STAT then ENTER to view the data lists. (Info from your ball drop should be in these lists.

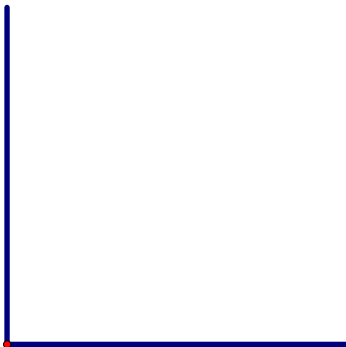
- Use your cursor to get over to the L3 header, and press clear on the L3 to clear the list, press ENTER get to the first element of the list. Do the same with L4.

- In L3 enter the bounce numbers, starting with 0 and ending with 4. Press ENTER after each entry.

- In L4 enter the rebound heights, starting with the release height. Both L3 and L4 should have five elements in them.

5. Press (2nd) STATPLOT, Select **On** for plot 2 and make sure your Xlist : L3 and Ylist : L4. Now select GRAPH to view the graph of your data. You should see your original graph and a new graph. Draw what you see here.

Graph B:



6. In the Y= menu, enter the vertex form of the quadratic function for Y_1 , as follows

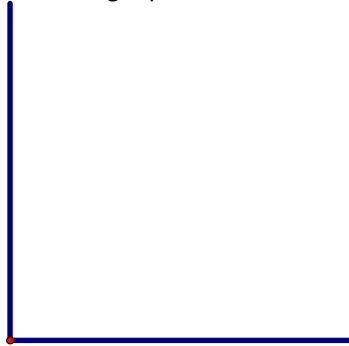
$$Y_1 = A \cdot B^X$$

7. On the Home Screen, store the value of your starting height as variable A ; store the value 1 for B .

For example, to store the value 2.5 into the variable A , Press
2.5 STO> ALPHA A ENTER (stores the number 2.5 into the variable A)

8. Press GRAPH to display the graph.

Graph C: Draw a sketch of the graph here:



6. Try $b = 2, 0.5, 0.25$. Complete the chart on the student worksheet question # 5.

7. Choose a value of your own for b until it is a good match with Graph that connects your maximum heights.

Student Worksheet

Objectives: Model an exponential function and determine how the constants affect the function.

Materials: Ball (Racquetball or basketball work well).
 TI-83 Plus or TI-84 Plus graphing calculator
 CBR 2 motion detector
 EasyData Application

Questions:

The rebound height of the ball (maximum height) for a given bounce is approximated by:

$$y = ab^x$$

where y is the rebound height, a is the height from which the ball is dropped (sometimes called the initial height), b is a constant, and x is the bounce number.

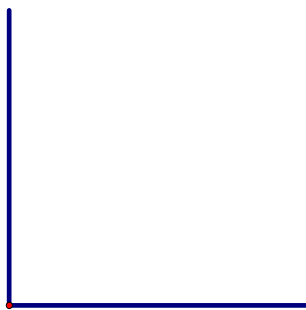
1. When you connect all the maximum heights of your parabolas, what do you predict the graph will look like?

2. Which variable, distance or time, is the independent variable? _____

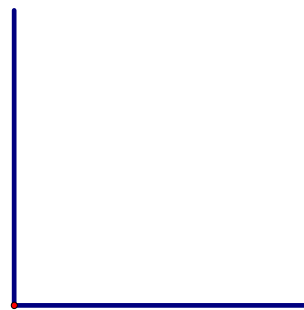
3. Which variable, distance or time, is the dependent variable? _____

4. Explain why a is the y -intercept of the graph.

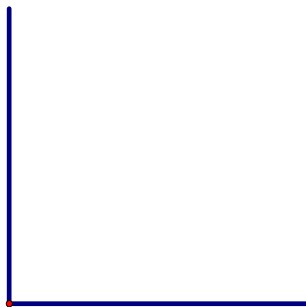
5. Draw your graph when $b = 1$.



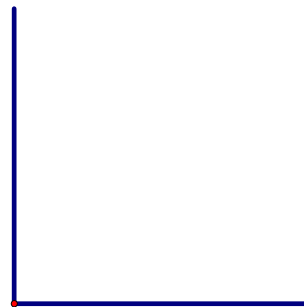
Draw your graph when $b = 2$.



Draw your graph when $b = 0.5$.



Draw your graph when $b = \underline{\hspace{1cm}}$ (your best fit).



6. What do you suspect the constant, b , represents in the exponential function model?

7. What is the model of your function, to the best fit?

$$y = \underline{\hspace{2cm}}$$

8. Suppose you repeated this activity with a ball that was slightly deflated from the one you used today. How would constants a and b be affected in your above equation?

9. Using your model that you developed through this activity, determine the smallest number of bounces required by the ball for the rebound height to be less than 10% of its starting height. Remember that the number of bounces must be an integer.