How Does It Bounce?

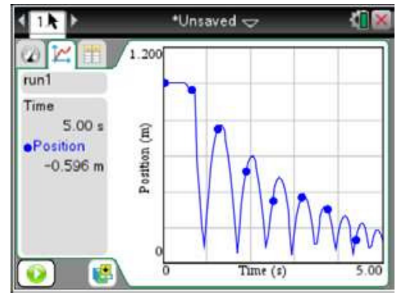
Student Activity

Name ________________

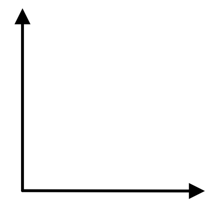
Class ________________

How do balls bounce and rebound?

When you drop a basketball, it does not rebound to the same height from which you dropped it. But how high does it bounce? The rebound height of a basketball can be used to determine whether the ball is inflated to the correct pressure. You will sometimes see basketball referees drop the ball from a certain height to see if it rebounds correctly prior to officiating a game. In this activity, you will explore how the height of a ball varies as a function of bounce number.



Before you begin, predict the graph of height as a function of bounce number. Sketch your prediction to the right. Be sure to label the axes.



Write a sentence to explain why you think the graph will look like your prediction.

Objectives:

- Understand how balls bounce by collecting position data for a bouncing ball and recording the height as a function of bounce number.
- Model the data with the appropriate mathematical function.

Materials:

- TI-Nspire™ handheld or computer software
- Calculator-Based Ranger 2™ data collection device (CBR 2™)
- Ball (Basketballs, racquetballs or kick balls work well. Avoid tennis balls or other fuzzy balls.)

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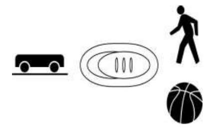
Data Collection:

1. Open a new document on the TI-Nspire^{TM} handheld. Set the switch on the CBR 2 to *normal* and connect it to the handheld with the USB square-end long cable.



2. Find a good location to drop the ball. It should bounce straight up and down without going off to the side. Practice a few times before setting up the CBR 2.
3. You cannot place the motion detector on the floor and bounce the ball on it, but you can reverse the positions so that the data will appear as though it was collected with the floor as the zero height. Set the CBR 2 to a fixed height approximately 1.5 meters above the ground. Select **Menu > Experiment > Set Up Sensors > Zero**. Then select **Menu > Experiment > Set Up Sensors > Reverse**.
4. To show only the position versus time graph, click the **Graph View** tab ( ). Select **Menu > Graph > Show Graph > Graph 1**.
5. Hold the ball at least 15 cm below the CBR 2 and start data collection ( ) just before dropping the ball. You want the CBR 2 to record the initial height of the ball as well as the bounce heights.
6. The position versus time graph should contain a series of at least five parabolas. If it does not, try again. Show your graph to your teacher before proceeding to the next section of the activity. Once your graph is approved, send the document to your other group members.

Data:

Click on the graph to select a data point. Move the tracing cursor to find the starting height. Record it in the data table as the Maximum Height for Bounce Number 0. Then move the cursor to each successive maximum height and record the height in the table below.

Analysis:

1. Enter the Bounce Number and Bounce Height (round to 2 decimal places) data into the table below.

2. Divide each bounce height by the previous bounce height for each set in your data table. For example, divide the height of bounce 1 by the height of bounce 0. Write the ratio as a decimal value in the right column of the table.

Bounce Number	Bounce Height (m)	Ratio of Bounce Heights
0		
1		
2		
3		
4		
5		

3. Examine the data in the table. Is the relationship linear? How can you tell from the differences in the Maximum Height values?

4. Is the data quadratic? How can you tell from the differences in heights?

5. What do you notice about the ratios shown in the right column of the table?

6. Find the average of these values.

7. How could you use the average value and the initial height to find the height of bounce 1 using mathematics?

8. How would you then be able to predict the height of bounce 2?

9. Write the estimation of height 2, H_2 as a function of the initial height, H_o. Now do the same for H_5, the height of the 5^{th} bounce.

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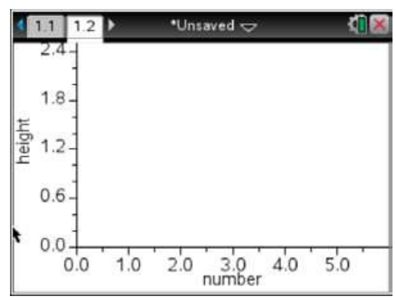
10. This type of function is an exponential function. It has the form, $y = a * b^x$ where b is the percentage of the return written as a decimal. What is the value of ***a***? Hint: think about the height for bounce zero. Explain your reasoning.

11. Write the equation for height as a function of bounce number for this set of data.

12. To check your model, create a graph of maximum height as a function of bounce number on the handheld. First, you must enter the data into the Lists and Spreadsheets application by adding a new page to your document. Name the first column Number and the second column Height. Enter the values from your data table above into the columns on the handheld.

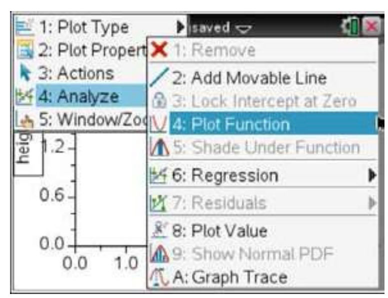
13. Add another new page and choose Data & Statistics. Click on the horizontal axis, and select **Number** for your independent variable. Click on the vertical axis, and select **Height** for your dependent variable.

14. Sketch the graph to the right.



15. How does it compare with the prediction that you made prior to the data collection?

16. Check to see how the equation you found matches with your data. From the menu on the Data and Statistics page, choose Analyze and then Plot Function. Enter the equation for the maximum height as a function of the bounce number. You must use x for the bounce number in the equation.



17. Does the function that you entered match the data? If not, make adjustments. Record the equation that matches your data and any needed adjustments.

18. An exponential equation has the form $y = a \cdot b^x$. Explain what ***a*** and ***b*** represent in this equation.

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19. Use your model to predict the height of the next bounce. Show your work.

20. Why do you think the ball does not bounce as high as the previous bounce?

21. In science, you learn about kinetic and potential energy. How do the concepts of energy relate to this bouncing ball? Is mechanical energy conserved?

22. Summarize what you learned in this activity.

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