



How Does It Bounce?

Student Activity

Name _____

Class _____

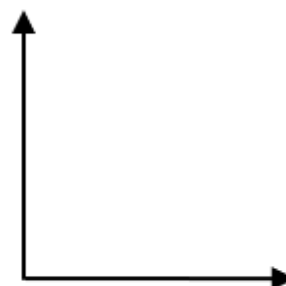
Introduction

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 determine the rebound percentage of a ball and how that percentage and the drop height relate to the height of a ball bounce as a function of bounce number.

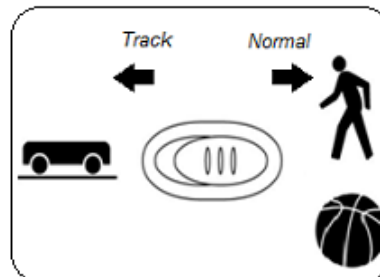
Before collecting data, predict the graph of bounce height as a function of bounce number. Sketch your prediction to the right. Be sure to label the axes.

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



Setup

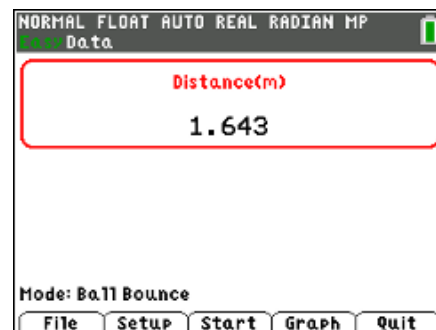
1. This activity is best performed with at least three students: one to hold the CBR™ 2 and press the trigger, one to release the ball, and one to run the calculator.
2. Lift the pivot head on the CBR 2 and set the sensitivity on the CBR 2 to Normal.



3. Attach the CBR 2 to the calculator using the CBR 2 to calculator cable. The EasyData App launches automatically when you plug in the sensor.

Note: In the EasyData App, the tabs at the bottom of the screen indicate the menus that can be accessed by pressing the calculator keys directly below the tabs.

Note: The default unit of measurement for the CBR 2 in the EasyData App is meters.





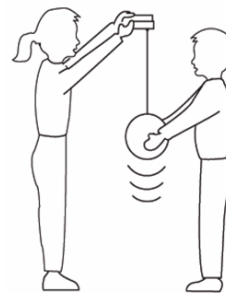
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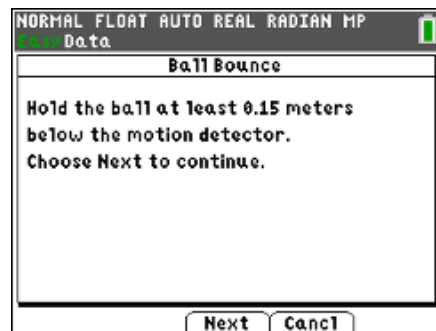
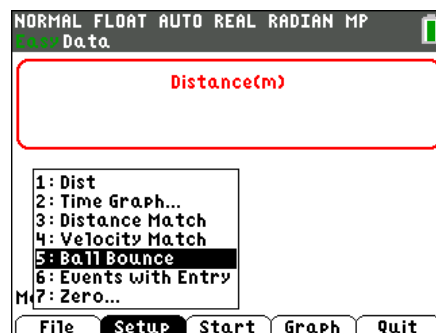
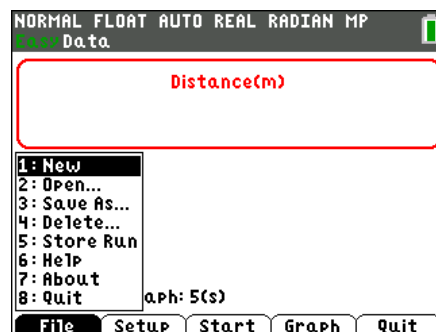
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4. Practice dropping the ball under the CBR 2. This is a practice run to determine if the ball is bouncing on a flat surface.
 - Position the CBR 2 at least 15 centimeters (approximately 6 inches) above the ball.
 - Hold the sensor directly over the ball and make sure that there is nothing in the Clear Zone.
 - Hold the sides of the ball and then quickly move your hands outward to release the ball. Drop the ball (do not throw it).



Data Collection

1. You cannot place the CBR 2 on the floor and bounce the ball on it, but you can use the Ball Bounce Setup option to reverse the positions so that the data will appear as though it was collected with the floor as the zero height.
 - Press **[Y=]** to select **File** from the Main screen, and then select **New** to reset the application.
 - Press **[window]** to select the **Setup** menu. Select **Ball Bounce**.
 - After selecting **Ball Bounce**, press **[zoom]** to select **Start**.
 - Follow the instructions displayed.
2. One person holds the CBR 2 while another person holds the ball at least 15 centimeters beneath the CBR 2. Press **[zoom]** to select **Next**.





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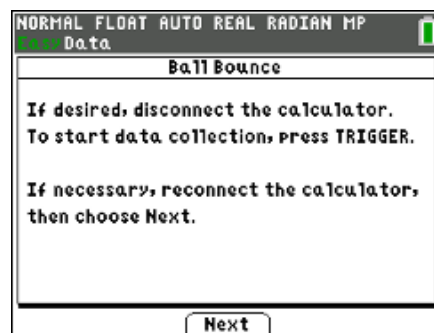
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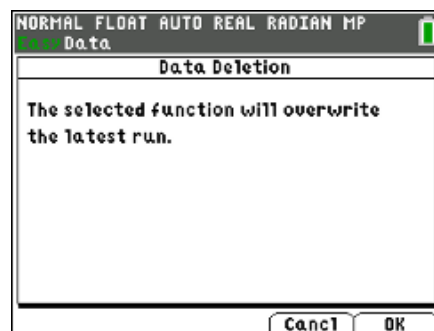
Class _____

3. Follow the on-screen directions. At this time, you may disconnect the CBR 2 from the calculator or you may leave it connected.

Important: Whether you leave the CBR 2 connected or not, you will need to press the **TRIGGER** on the CBR 2 to begin collecting data. (Do not press **zoom** to select **Next** yet.)



4. Press the **TRIGGER** on the CBR 2 and when the CBR 2 begins clicking, release the ball, and then step back.
- Data will be collected every 0.05 seconds for 5 seconds.
 - If the ball bounces to the side, move to keep the CBR 2 directly above the ball, but **be careful not to change the height of the CBR 2**.
 - When the clicking stops, reconnect the CBR 2 to the calculator (if necessary) and press **zoom** to select **Next**.
 - The collected data is transferred to the calculator. A screen displays a notice to wait as it is transferred.
5. As soon as the data are sent, the calculator displays the distance versus time graph. Your distance versus time graph should contain a series of at least five parabolas. If it does not, try again. Show the graph to your teacher before proceeding to the next section of the activity.
6. To repeat the sample, press **graph** to return to the Main screen. Press **zoom** to select **Start** and repeat the data collection process.
- You will get a warning screen telling you the new data will overwrite any previous data. Press **graph** to select **OK**.
 - Follow the on-screen directions.





Data Analysis

1. Use the arrow keys to determine the maximum height of the first bounce. Record it in the data table as the maximum height for Bounce Number 1. Then move the cursor to each successive maximum bounce height, and record the maximum heights of bounces 2 – 5 in the table below.
Record each maximum bounce height in meters, rounded to three decimal places.

Bounce Number	Maximum Bounce Height (m)	Ratio of Bounce Heights
1	$H_1 =$	
2	$H_2 =$	
3	$H_3 =$	
4	$H_4 =$	
5	$H_5 =$	

2. Examine the maximum bounce height data in the table. Is the relationship linear? How can you tell?
3. Is the relationship quadratic? How can you tell from the differences in heights?
4. Divide *each* bounce height by the previous bounce height. For example, divide the height of Bounce 2 by the height of Bounce 1. Write each ratio as a decimal value, rounded to two decimal places, in the right column of the table.
5. What do you notice about the bounce height ratios shown in the right column of the table?
6. Find the average of the bounce height ratios. _____
7. How could you use the average of the bounce height ratios and the height of the first bounce (H_1) to estimate the drop height of your ball? Show your work and record the drop height (in meters).
Round your answer to two decimal places.

Estimated Drop Height = _____



8. If you didn't know the height of the first bounce, H_1 , you could use the average of the bounce height ratios and the estimated drop height of your ball to predict that height.

$$H_1 = (\text{drop height}) * (\text{average bounce ratio})$$

If you didn't know the height of the second bounce, H_2 , you could still use the average of the bounce ratios and the estimated drop height of your ball to predict the height of the second bounce.

Since $H_2 = (H_1) * (\text{average bounce ratio})$, we know that

$$H_2 = ((\text{drop height}) * (\text{average bounce ratio})) * (\text{average bounce ratio}).$$

How could you predict the height of Bounce 3 using *only* the estimated drop height and the average bounce ratio?

$$H_3 = \underline{\hspace{10cm}}$$

9. Using *only* your estimated drop height of your ball and the average of your bounce ratios, write an equation for each bounce height in the table below.

$H_1 =$
$H_2 =$
$H_3 =$
$H_4 =$
$H_5 =$

10. Exponential decay (this type of relationship) and exponential growth occur when an amount decreases or increases, respectively, at a rate proportional to the preceding amount. An exponential function has the form $y = a(b)^x$. In this example, b is the average rebound percentage written as a decimal. What does a represent?

11. Write the equation for the height of the ball at any bounce as a function of bounce number, x , for your set of data.

$$y = \underline{\hspace{10cm}}$$



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- a. Press **stat** **enter** to enter the data list edit.

Note: To delete any data in the lists, use the arrow keys to select the list heading (L1, L2, etc.), and then press **clear** **enter**.

- b. In List L1, enter bounce numbers 1 - 5.

- c. Enter the maximum heights of bounces 1 - 5 in list L2.

13. To graph the maximum bounce height vs. bounce number, press **[2nd]** **[stat plot]** to enter the Stat Plot menu.

Note: Make sure all the other plots or equations are turned off before plotting your data.

- a. Choose Plot 1 by pressing **enter**. On the resulting screen, turn on the plot by using the arrow keys and pressing **enter** when **On** is highlighted.

- b. On the Type row, choose a scatter plot by using the arrow keys and pressing **enter** on the first pictured graph type.

- c. Plot the bounce number on the x-axis by selecting L1 (press **[2nd]** **[L1]**) for the **Xlist**. Plot the maximum height of each bounce on the y-axis by selecting L2 (press **[2nd]** **[L2]**) for the **Ylist**. Press **[enter]**.

- d. To set the scaling values for the graph window, press **zoom**. Select **ZoomStat** to have the calculator automatically set the window scaling to your data.

14. Sketch the graph of your data at the right.

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







NORMAL FLOAT AUTO REAL RADIAN MP					
L1	L2	L3	L4	L5	L6
1	-----		-----	-----	
2					
3					
4					
5					

L1(6)=

NORMAL FLOAT AUTO REAL RADIAN MP


Plot1 Plot2 Plot3

On Off

Type:      

Xlist:L1

Ylist:L2

Mark :  + * .

Color: BLUE

NORMAL FLOAT AUTO REAL RADIAN MP

ZOOM MEMORY

1:ZBox

2:Zoom In

3:Zoom Out

4:ZDecimal

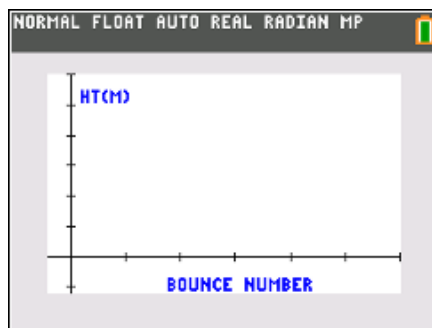
5:ZSquare

6:ZStandard

7:ZTri9

8:ZInteger

9ZoomStat





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16. Check to see how well the equation you found in Step 11 matches the data.
- Press $y=$ to enter your equation for the maximum bounce height as a function of the bounce number. You must use x for the bounce number in the equation.
 - Press graph .
 - Is the equation you entered a good model the data? If not, make adjustments in the equation, and regraph. If any adjustments were made, record your new equation.
17. Use your equation to predict the height of a tenth bounce. Show your work. Is your answer reasonable?
18. Jackie bounced a different type of ball and determined that it had an average rebound percentage of 71%. Her drop height was 1.45 meters.
- Write an equation for bounce height, y , as a function of bounce number, x .
 - Predict the height of the ball's 7th bounce.
 - At what bounce number would the height of the bounce be approximately 0.5 meters?