Name ______________________________

Date ______________________________

EXPLORATIONS

# ACTIVITY 10

## Velocity and the Bouncing Ball

If you drop a ball from a given height, what does the Height-Time graph look like? How does the velocity of the ball change as the ball rises and falls?

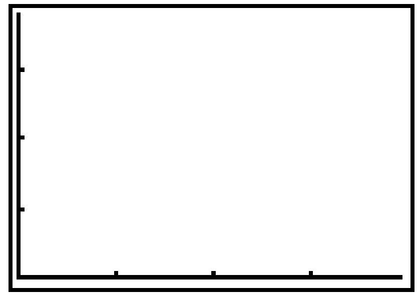
In this activity, you will explore the position of the ball versus time for a single bounce. You will also examine the relationship between the height of the ball and its velocity.

### You'll Need

- 1 CBR unit
- 1 TI-83 or TI-82 Graphing Calculator
- Ball (a racquet ball works well)

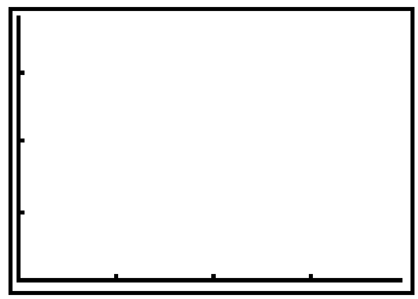
## Instructions

1. Run the **RANGER** program.
2. From the **MAIN MENU** of the **RANGER** program, select **3:APPLICATIONS**.
3. Select **1:METERS**, then select **3:BALL BOUNCE**.
4. Follow the directions on the screen of your calculator.
5. Your graph should have a minimum of five bounces. If you are not satisfied with the results of your experiment, select **5:REPEAT SAMPLE** and try again.
6. When you are satisfied with your data, sketch a Distance-Time plot.



## Data Collection

1. Select one bounce to analyze. Press ENTER to return to the **PLOT MENU**. Select **4:PLOT TOOLS**. Under **PLOT TOOLS**, select **1:SELECT DOMAIN**.
   a. Press ▶ (the right arrow) until you reach the lower left side of one bounce. Press ▶ once more. Press ENTER to select this point as the **LEFT BOUND**.
   b. Press ▶ until you reach the lower right side of one bounce. Press ◀ once. Press ENTER to select this point as the **RIGHT BOUND**.
   c. Sketch a plot of your Distance-Time for this bounce.



2. Press ENTER to return to the **PLOT MENU**. Select **7:QUIT** to exit the **RANGER** program. Press GRAPH.
3. Next find the equation of the quadratic function that best fits this data.

   **For the TI-83:** Press STAT ▶. Select **5:QuadReg**. Press 2nd **[L1]** , 2nd **[L2]** ENTER.

   **For the TI-82:** Press STAT ▶. Select **6:QuadReg**. Press 2nd **[L1]** , 2nd **[L2]** ENTER.

   Record this equation.

   $y$ = ________________________________

   Press Y= and store the equation in **Y1** by entering the equation and pressing ENTER.

4. Press GRAPH. Describe how well this function fits the data.

   ______________________________________________________________________

**5.** Press PRGM. Execute the **RANGER** program. From the **MAIN MENU**, select **4:PLOT MENU**. Select **2:VEL-TIME**. This graph should look linear. If there is extra data at either end of the graph, press ENTER to return to the **PLOT MENU**.

**a.** Select **4:PLOT TOOLS**. Under **PLOT TOOLS**, select **1:SELECT DOMAIN**.

**b.** Press ▸ until you reach the top of the velocity line. Press ENTER to select this as the **LEFT BOUND**.

**c.** Press ▸ until you reach the bottom of the velocity line. Press ENTER to select this as the **RIGHT BOUND**.

**d.** Sketch a plot of your Velocity-Time for this bounce in the space provided.

**6.** Press ENTER to return to the **PLOT MENU**. Select **7:QUIT** to exit the **RANGER** program. Press GRAPH.

**7.** Next find the equation of the line that best fits this data.

> **For the TI-83:** Press STAT ▸. Select **4:LinReg (ax+b)**. Press 2nd **[L1]** , 2nd **[L3]** ENTER.
>
> **For the TI-82:** Press STAT ▸. Select **5:LinReg (ax+b)**. Press 2nd **[L1]** , 2nd **[L3]** ENTER.

Record this equation.

$y$ = ________________________________

Press Y= and store the equation in **Y2** by pressing ▸, entering the equation, and pressing ENTER.

**8.** Press GRAPH. Describe how well this function fits the data.

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## Questions

Graph the Distance-Time and the Velocity-Time for one bounce.

1. Press [Y=]. Highlight the **=** for **Y2**. Press [ENTER] to turn off this graph. Press [2nd] **[STAT PLOT]**. Select **2:Plot2.** Highlight **On**, and press [ENTER]. Select the xyLine plot icon for the **Type**, **L1** for the **Xlist**, **L2** for the **Ylist**, and the **dot** for the **Mark**. This will turn on the scatter plot of the Distance-Time plot. The Velocity-Time plot is in **Plot1** and is already on.
2. Press [GRAPH]. Sketch a plot of Distance-Time and Velocity-Time for this bounce.

3. Press [TRACE] and record the time, height of the ball, and the velocity of the ball. Press [▲] to move from the Velocity-Time graph to the Distance-Time graph. Press [▶] twice and record the time, height, and the velocity of the ball. Continue pressing [▶] twice and recording until the table below is complete.

| Time | Height | Velocity |
|---|---|---|
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a. Describe the characteristics of the velocity of the ball from the time the ball leaves the ground to the time it reaches its maximum height for this bounce.

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**b.** Describe the characteristics of the velocity of the ball as it falls from the maximum height until the time it hits the ground again for this bounce.

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**c.** Where is the ball when its velocity is zero?

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**4.** From the linear equation found earlier, find the time at which the velocity is zero.

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**5.** For the time found in question 4, find the height of the ball.

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**6.** How do these numbers compare with the data from question 3?

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**7.** The standard equation for the position of a projectile is

$s = s_0 + v_0 t + \frac{1}{2} a t^2$.

The quadratic equation that models the position of the ball over time is:

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Identify the initial height, $s_0$, the initial velocity, $v_0$, and the acceleration, $a$, using the position equation.

$s_0 =$ ____________ $v_0 =$ ____________ $\frac{1}{2} a =$ ____________

$a =$ ____________

**8.** The standard equation for the velocity of a projectile is $v = v_0 + at$. The linear equation that models the velocity of the ball over time is:

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Identify the initial velocity, $v_0$, and the acceleration, $a$, using the velocity equation.

$v_0 =$ ____________ $a =$ ____________

**9.** How do the values of $v_0$ and $a$ from the distance and velocity equations compare?

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