LESSON 5: THE BOUNCING BALL

Lesson Objectives
In this lesson, you will . . .
• collect data from an experiment noting the independent variable and the dependent variable
• see the graphical relationship between the two variables
• predict values for data not gathered using interpolation and extrapolation
• use the trend line to locate the $x$- and $y$-intercepts and identify the specific meaning they have for this experimental data

Materials
• two meter sticks or one tape measure per group
• masking tape
• balls that bounce to different heights
• one calculator per group

ACTIVITY 1 — THE BOUNCING BALL

Setup: Tape two meter sticks or a tape measure (for a combined height of 2 meters) to the wall (see Figure 14a below). Leave these taped up through Question 8 of this activity. Choose one ball for the experiment (a tennis ball, racquetball, superball, etc.).

Figure 14
Figure 14b
Figure 14c
This activity has three roles for group members:

- The **dropper** will hold the ball at the various heights given in Table 13 and then will select three more heights from which to drop the ball (see Figure 14b). The dropper should tell the recorder the drop height before dropping the ball.

- The **spotter(s)** will watch for the rebound height and tell the recorder (see Figure 14c).

- The **recorder** will record the data in Table 13 and calculate the average in the last column.

1. Drop the ball to the floor and record the height the ball reaches on its first bounce. To reduce errors in your readings, drop the ball three times from the same height and calculate the average of these three trials. Use the drop heights given and three more of your choosing.

<table>
<thead>
<tr>
<th>Drop Height (cm)</th>
<th>Rebound Height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
</tr>
<tr>
<td>60</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td></td>
</tr>
<tr>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>

Table 13

2. Because we can drop the ball from any height we choose, the drop height is called the **independent variable**. But since the rebound height depends on the drop height, the rebound height is called the **dependent variable**.

a. As a rule, we graph the independent variable on the horizontal axis and the dependent variable on the vertical axis. Anticipate that you will be making predictions for drop heights from 0 cm to 250 cm, so leave enough room on the \( x \)-axis.

b. You will need to leave room on the \( y \)-axis for the corresponding rebound heights.

c. Plot the average rebound height versus the drop height on the grid in Figure 15. (Note: The words written before *versus* signify the dependent variable; the words written after *versus* signify the independent variable.)
3. Draw the trend line through the points you plotted in Figure 15.

4. Calculate the slope by selecting two points on the trend line. What are the units for slope in this example?

5. Use the graph to predict the rebound height of a ball dropped from 130 centimeters and a ball dropped from 225 centimeters.

Example

Now calculate the rebound height from 130 centimeters. This method is called interpolation, when the value to be calculated lies within your data.

Suppose that a certain racquetball has the following measurements.

<table>
<thead>
<tr>
<th>Drop Height (cm)</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Trial 3</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>27</td>
<td>29</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>150</td>
<td>41</td>
<td>42</td>
<td>37</td>
<td>40</td>
</tr>
</tbody>
</table>

- First determine the slope between the two points you know: \((100,28)\) and \((150,40)\).

\[
m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{40 - 28}{150 - 100} = \frac{12}{50} = \frac{0.24}{1}
\]

- On a graph this is 0.24 unit rise for each unit to the right.

- Since 130 is 30 units to the right of 100, the total vertical change from the point \((100, 28)\) is \((0.24)(30) = 7.2\).

- Therefore, the \(y\)-value at \(x = 130\) is \(28 + 7.2 = 35.2\).
6. Use the data from your experiment and choose a point on each side of 130 centimeters to compute the slope (express this slope as a decimal result that is accurate to at least two places). Calculate the rebound height at \(x = 130\) using the "rise over run" process in the example.

Now calculate the rebound height from 225 centimeters. This method is similar to interpolation, but is called **extrapolation**, when the value to be calculated lies outside the data.

7. Choose a data value below 225 centimeters from your experiment and use the decimal slope you obtained in Question 6 to calculate the rebound height (\(y\)-value) when \(x = 225\) centimeters.

8. Now drop the ball from 130 centimeters and 225 centimeters. Were your predictions close?

Use the graph you made in Figure 15 to answer Questions 9–12 below.

9. What is the approximate drop height if your ball bounces 75 centimeters?

10. If your ball bounces 50 centimeters, what is the approximate drop height?

11. Should the trend line go through the origin—that is, the \((0, 0)\) point? Why or why not?

12. What does this tell you about the value of the \(y\)-intercept?
Use complete sentences to discuss the following:

1. Pick one measured point from your data set in this lesson. What is the meaning of the relationship between the $x$-coordinate and the $y$-coordinate of this point?

2. Is there a relationship between slope of the linear model in this lesson and the type of bouncing ball used?