About the Lesson

In this activity, students will explore how to find the mathematical equation that describes a linear plot. As a result, students will:

- apply the slope-intercept form of a line.
- use linear regression to find the best-fit line for a data set.

Vocabulary

- equation
- slope
- speed
- rate
- linear regression
- slope-intercept form

Teacher Preparation and Notes

- Decide beforehand if you want the students to walk in front of the CBR 2 (with the CBR 2 stationary) or if the students in pairs walk with the CBR 2 pointed toward a wall with one student holding the CBR 2 and the other holding the calculator (the CBR 2 moving).
- Arrange the room so that each group of students have about 8 feet of walking space.
- Students will be using the Vernier EasyData® App in this activity. See the additional information in the Teaching Notes.

Activity Materials

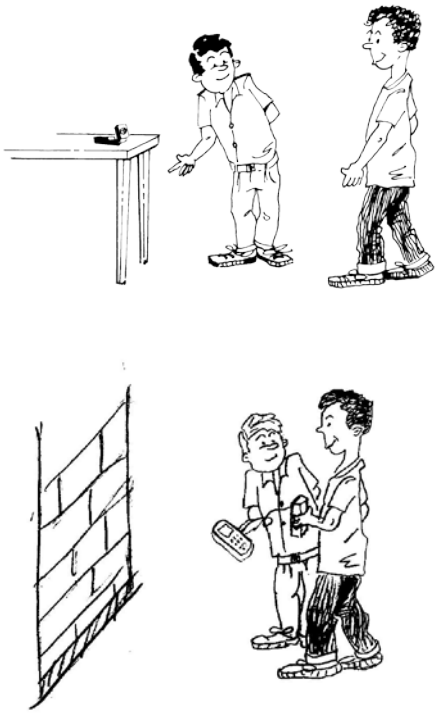
- Compatible TI Technologies:

  TI-84 Plus*
  TI-84 Plus Silver Edition*
  TI-84 Plus C Silver Edition
  TI-84 Plus CE

***** *with the latest operating system (2.55MP) featuring MathPrint™ functionality.*

- CBR 2™ motion sensor unit with mini-USB connecting cable
- Vernier EasyData® App

Set up options:



Tech Tips:

- This activity includes screen captures taken from the TI-84 Plus CE. It is also appropriate for use with the rest of the TI-84 Plus family. Slight variations to these directions may be required if using other calculator models.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials
- Any required calculator files can be distributed to students via handheld-to-handheld transfer.

Lesson Files:

- Walk_the_Line_Student.pdf
- Walk_the_Line_Student.doc

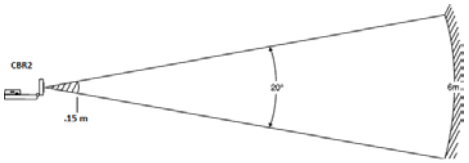
Tech Tip: While using the EasyData app, the tabs at the bottom of the screen indicate menus that are accessed by pressing the key directly below it. A frequent example is shown below:

Introduction to Walk the Line

When students first encounter y = mx + b, it may be too abstract for some students. Walking to make the distance-time graph gives students a physical meaning for slope and y-intercept. Having students find the equation that matches their walk helps students make the connection between mathematics and the real world.

Teaching Notes:

- The path of the CBR 2 beam is not a narrow, pencil-like beam, but fans out in all directions up to 10° in a cone-shaped beam.



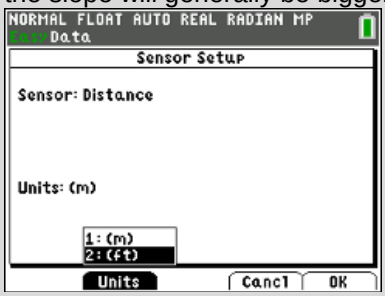
- To avoid interference from other objects in the vicinity, try to establish a clear zone in the path of the CBR 2 beam. This helps ensure that objects other than the target are not recorded by the CBR 2. The CBR 2 records the closest object in the clear zone.

- Be sure that students stay within the range of the CBR 2 (0.15 – 6 meters).

- When using a stationary CBR 2, most students prefer to face the CBR 2 when walking. This allows them to stay directly in front of the unit during data collection.

Collecting the Data

Tech Tip: If you prefer to do this activity using feet instead of meters, select Setup by pressing window. Select Units by pressing window and select (ft). When this activity is done in meters, the slope is usually less than 1. Done in feet, the slope will generally be bigger than 1.



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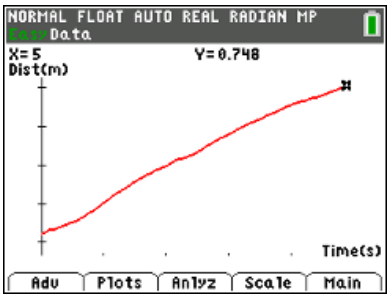
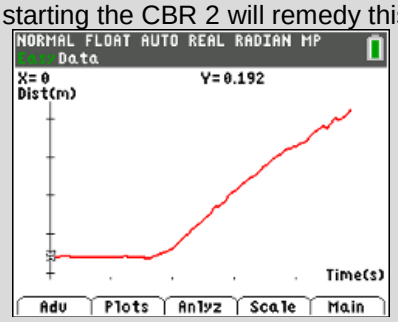
Students will be walking at a constant speed to make a distance time plot. Instruct students to either walk in front of the CBR 2 (with the CBR 2 stationary) or if the students in pairs walk with the CBR 2 pointed toward a wall, one student holding the CBR 2 and the other holding the calculator (the CBR 2 moving). For best results, aim the CBR 2 at the walker's torso, not his or her knees or legs since this could cause the CBR 2 to pick up erroneous distance variations.

As the students move in front of the CBR 2, they should continue walking at a constant rate for the entire sampling time. Stopping early could cause inconsistent results when the linear regression is computed.

When students have made a graph, to find their distance at the end of the walk, they can use the right arrow key to move through the data. The coordinates of each data point appear at the top of the screen. This can be used to find the coordinates of two points to use to calculate the slope in question 9.



Tech Tip: The first time students try to walk the previous plot their graph may look like the graph at the right. Some students may ask how to take out the horizontal section at the start. You can facilitate this situation by asking the students, "What can you do differently at the start of your next attempt?" It may take them a few more attempts to realize that moving at a steady rate before starting the CBR 2 will remedy this issue.



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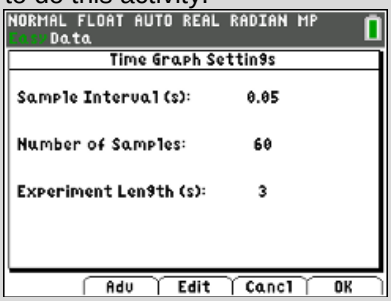
Tech Tip: The student directions use the default Experiment Length (5 s.). If this is not working well for students, you can change the sampling time to a different duration. Select window [Setup], and the **2: Time Graph** settings. An example is shown for reducing the time to 3 seconds. If you have limited space in your classroom, this reduces the walking distance required for students to do this activity.



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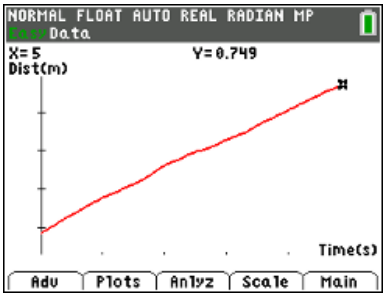
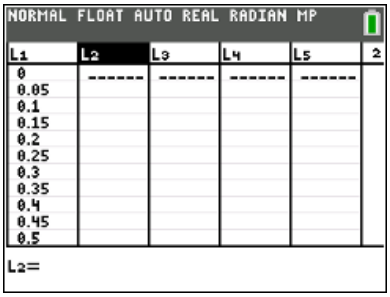
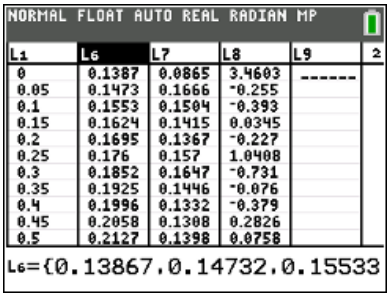
The students' walk may resemble the one shown. The starting point of this example is at a distance of 0.139 m, and the walk ends at a distance of 0.749 m.



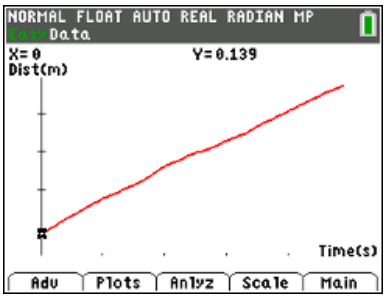
If you want your students to look at the data numerically, go to stat[edit] enter when they exit the EasyData App. Time is in L1 and distance is in L6. To view the lists side by side, go to the header of L2 and press del until L6 is next to L1.

L7 contains the velocity and L8 is the acceleration values calculated based on the distance data.





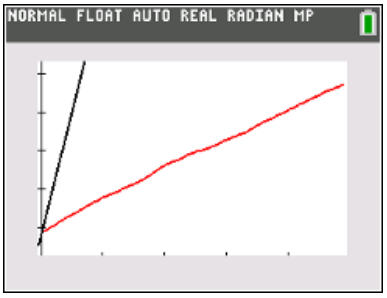
Looking at the Results



1. Use the arrow keys on the calculator to move the cursor along the Distance-Time plot. Identify the starting value (the Y-value when X = 0) and record this below as the y-intercept.

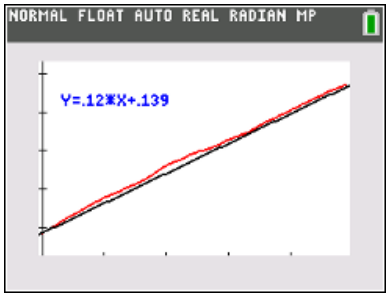
   Student answers will vary.

   Sample response: B = 0.139 meters.



M = 1

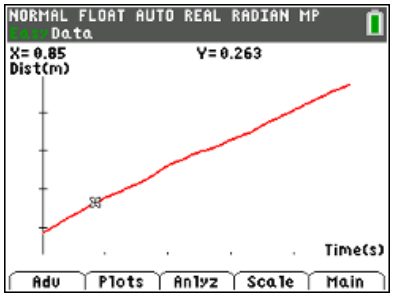
2. No answer required. Using the variables available in the calculator will help students get a better understanding of variables in mathematical equations.
3. No answer required.
4. No answer required.
5. No answer required.
6. No answer required.



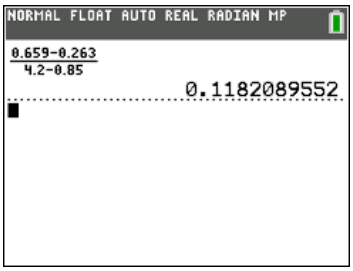
7. After several trials in this example, a slope of 0.12 fits the example data rather well. Student answers will vary.
8. Using the value for M that fits best and the B from question 1, complete the slope -intercept form of the equation and record it below.

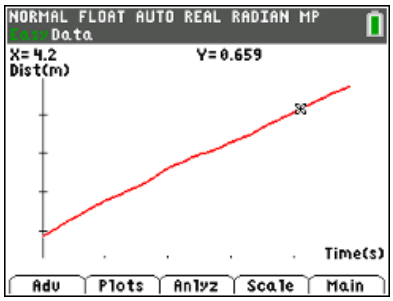
   Student answers will vary.

   Sample response: Y = 0.12 X + 0.139 in this example.



9. For this example, the fraction template alpha [f1] [n/d] can be used to calculate slope which is close to the guess-and-check value of 0.12. See below.

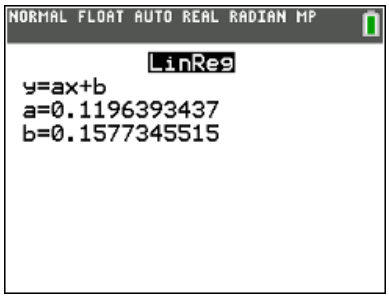




10. How do the values of a and b in the regression model compare to the values of M and B you found earlier?

Student answers will vary.

Sample response:
The linear regression in the example data results in the equation Y = 0.1196X+0.1577. This is very close to the guess-and-check equation.



11. Based on this statement, what are the units of measurement for slope in this activity?

Student answers will vary.

Sample response: In this activity, slope represents a change in distance divided by a change in time. The units of measurement for slope are meters per second.

12. As mentioned earlier, the intercept value, B, can be interpreted as the starting position or the starting distance from the CBR 2. What does the value of **M** represent physically?

Sample response: The value of **M** represents the walker's velocity.

Going Further

1. Repeat the activity, this time walking away from the CBR 2 at a slower rate than before. Find the linear equation associated with this data set. How does the slope of this equation compare with the slope of your original equation? How do you think the slope would compare if you walked away from the CBR 2 at a much faster pace? Generally, how is the slope (steepness) of a linear plot related to the speed of the walker?

   Student answers will vary.

   Sample response: Generally, the faster the speed of the walker, the steeper the linear plot of distance versus time.

2. Repeat the activity again, this time starting several meters from the CBR 2 and walking toward it at a slow and steady pace. Find the linear equation associated with this data set. How does the slope of this equation compare with the slope of your original equation? Generally, how is the sign (positive or negative) of the slope related to the direction in which you are moving?

   Student answers will vary.

   Sample response: If the walker moves away from the CBR 2, the slope of the Distance-Time plot is positive; if the walker moves towards the CBR 2, the slope is negative.