Slippery Slope

About the Lesson

In this activity, students will move in front of a CBR 2 to create Distance-Time plots. Then students will calculate the slopes of the plots to interpret the way one physical quantity changes with respect to another. As a result, students will:

- Create and interpret Distance-Time plots
- Calculate the slopes of those plots

Vocabulary

- Distance-Time plot (graph)
- slope
- interval

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

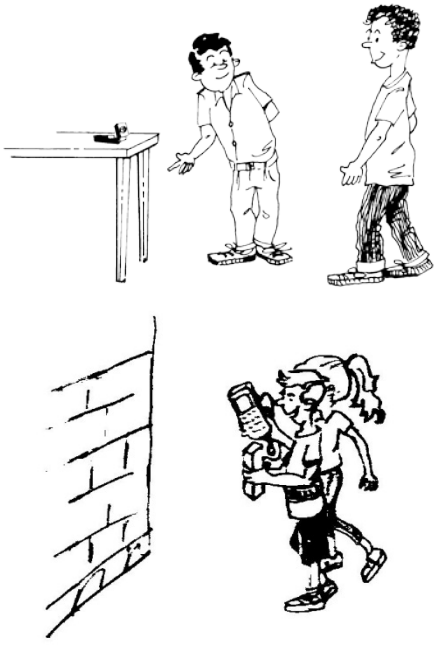
- Compatible TI Technologies:

  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
- Meter sticks, masking tape—if needed

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:

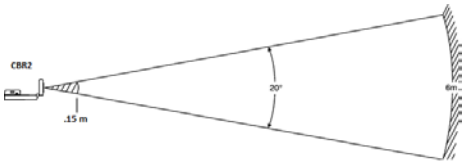
- Slippery_Slope_Student.pdf
- Slippery_Slope_Student.doc

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

Introduction

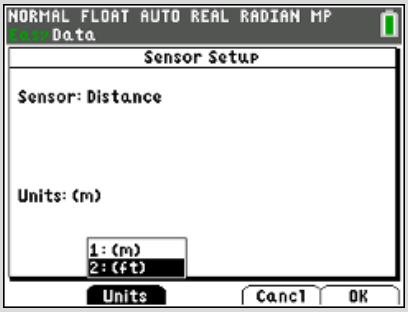
Through any two points in a plane, only one line can be drawn. The steepness of this line is called slope. Slope is defined as the amount of vertical change divided by the amount of horizontal change between the two points. This is a very important concept in mathematics and can be used to interpret the way one physical quantity changes with respect to another.

Teaching Notes:

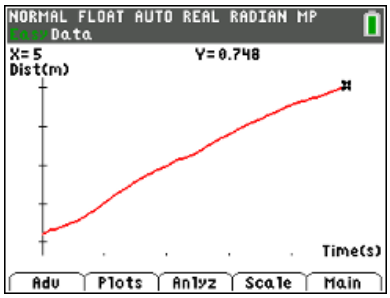


- The path of the CBR 2 beam is not a narrow, pencil-like beam, but fans out in all directions up to 10° in a cone-shaped beam.
- To avoid interference from other objects in the vicinity, try to establish a clear zone in the path of the CBR 2 beam. This helps ensure that objects other than the target 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.

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).



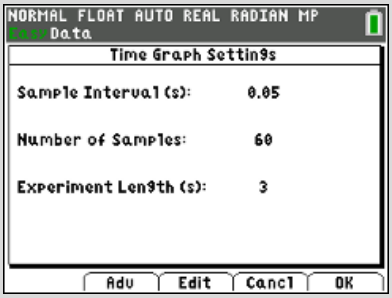
Collecting the Data



Students will be walking four distance time graphs. After each graph is displayed, if they are not satisfied with the graph, select Main ([graph]). **Note:** When you select Start, you will get a warning message, **"The selected function will overwrite the latest run."** As soon as you select, OK, the CBR 2 will immediately start collecting data.

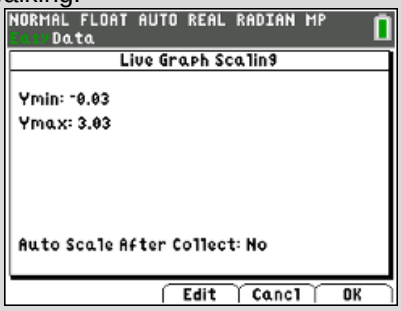
When students have made a graph, to find the coordinates of the starting distance and their choice of two points for the calculation of the slope, they can use the arrow keys ▶◀ to move through the data. The coordinates of each data point appear at the top of the screen.

Tech Tip: The student activity has directions for changing the sampling time to a different duration. Select Setup, [Time Graph], and Edit the settings. The settings shown indicates an experiment length of 3 seconds. If you have limited space in your classroom, this reduces the walking distance required for students to do this activity. Adjust the time according to your needs.

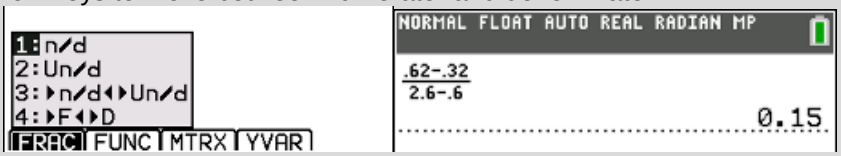


Tech Tip: To change the range of the y-axis so that it will remain the same during all four trials, select Adv (p) and select Scaling by pressing Á. Then Edit the Live Graph Settings by entering the Ymin and Ymax as shown. Be sure to say **No** to **Auto Scale After Collect**. This keeps the scales of the x-axis and y-axis the same from trial to trial automatically.

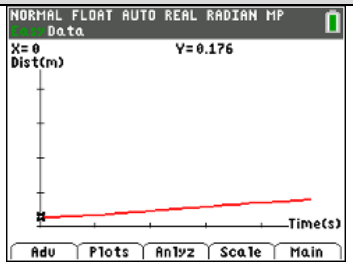
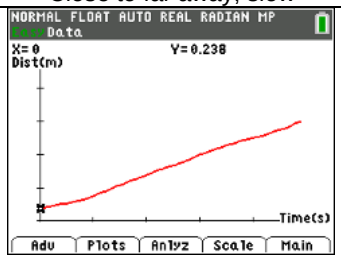
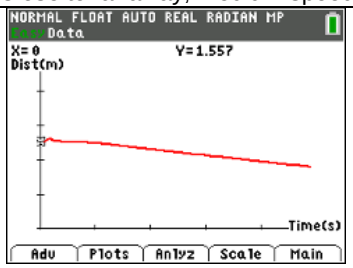
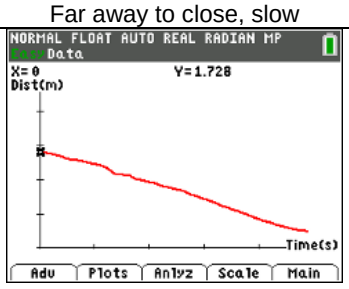
Note: If this is not done, students will need to rescale the graphs manually each time in order to be able to compare the slopes of the plots for different speeds of walking.



Tech Tip: When students are calculating the slope using the coordinates of two points, you can show them the fraction template that is available by pressing *f*^ and selecting numerator/denominator (n/d) and using the arrow keys to move between numerator and denominator.



Looking at the Results. Student results will vary, but their sketches should be similar.

Trial	Starting Distance	Graph of Motion	*x*-coordinate (sec)	*y*-coordinate (m)	Slope (m/s)
1	0.18 m	 Close to far away, slow	$x_1 = 0.6$ $x_2 = 2.6$	$y_1 = 0.32$ $y_2 = 0.62$	0.15 m/sec
2	0.24 m	 Close to far away, medium speed	$x_1 = 0.8$ $x_2 = 2.85$	$y_1 = 0.73$ $y_2 = 1.87$	0.56 m/sec
3	1.56 m	 Far away to close, slow	$x_1 = 0.7$ $x_2 = 2.45$	$y_1 = 1.48$ $y_2 = 1.22$	−0.15 m/sec
4	1.73 m	 far away to close, medium speed	$x_1 = 0.55$ $x_2 = 2.55$	$y_1 = 1.56$ $y_2 = 0.38$	−0.59 m/sec

1. Compare and Contrast:

Student answers will vary.

Compare	The Distance-Time graphs of:	Contrast
Both have positive slopes. The distance increases with time.	Trial 1 and Trial 2	The slope of Trial 2 is steeper. The increase in distance is more for Trial 2 for an equal increase in time.
Both have negative slopes. The graph decreases from left to right.	Trial 3 and Trial 4	The slope of Trial 4 is steeper. The graph of Trial 4 decreases more than Trial 3.
Both are gradual in slope.	Trial 1 and Trial 3	Trial 1 has a positive slope. Trial 2 has a negative slope. We were walking in different directions.
Both are steeper slopes than Trial 1 and 3.	Trial 2 and Trial 4	Trial 2 has a positive slope. Trial 4 has a negative slope.

2. What effect does changing speed have on the Distance-Time plot?

Student answers will vary.

Sample Response: Changing speed changes the steepness of the Distance-time plot. The magnitude of the speed (the absolute value) changes. The faster the speed the steeper the slope.

3. What effect does changing *direction* have on the plot?

Student answers will vary.

Sample Response:

Changing the direction of the walk changes the sign of the slope. If the distance is decreasing with time (walking toward), the slope will be negative. If the distance is increasing with time (walking away), the slope will be positive.

4. Complete the statements to summarize the relationships between motion and the characteristics of the graph and the slope.

a. The faster the speed, the **steeper** the slope.

b. Moving away from the CBR 2 makes a plot with a **positive** slope, and moving toward the CBR 2 makes a plot with a **negative** slope.

Going Further

1. Calculate the slope of a line given the 2 points (1.5, 2.08) and (6, 4.93).

   Answer: Slope = 0.63

2. Explain why the units of slope in this activity are meters per second (m/s).

   Sample Response: The units of slope are m/s because the *y*-axis units, meters, are divided by the x-axis units, seconds, in order to calculate slope.

3. Would the value of the slope change if the formula was changed to the following?

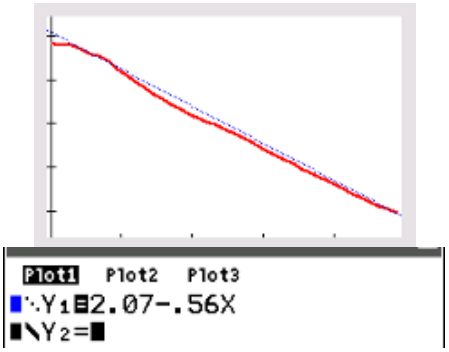
   $$\text{slope} = \frac{y_1 - y_2}{x_1 - x_2}$$

   Explain why or why not.

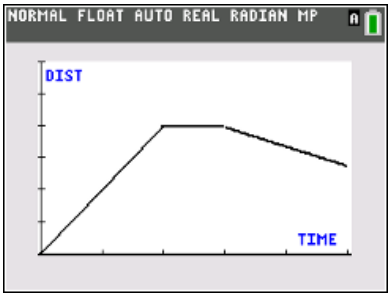
   Student answers will vary.

   Sample Response: The value of the slope would not change since both the *y*- and *x*-coordinates are being subtracted in reverse order. This means the sign of the numerator and the denominator changes—leaving the sign of the slope the same.

4. When students quit the EasyData app, the last data set gathered will be active in Plot1. In the [y=] editor, the student can enter their starting distance and slope that was calculated in their table to enter an equation in Y1.



5. Study the distance-time graph below. Write a story that would match the graph. You can use your own choice of units (miles/feet/kilometers or minutes/hours/days). Be creative.



   Student answers will vary.

   Sample Response: Saturday it was nice weather, and I was riding my bicycle at a moderate speed for two hours. I noticed that my tire had gone flat and had to stop. I found a nail in my tire. So I started to walk my bicycle back home.