



### About the Lesson

In this activity, students will explore the relationship between how fast they move in front of a CBR 2 and the resulting distance-time graph. As a result, students will:

- Know that walking slowly at a constant rate away from the CBR 2 makes a distance-time graph that is a straight line and gently sloping.
- Know that walking faster away from the CBR 2 makes a distance-time graph that is a steeper sloping line.

### Vocabulary

- rate
- speed
- distance-time plot
- steepness

### 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 moving).
- Arrange the room so that each group of students have about 8 feet of walking space.
- Students will be using the 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\*

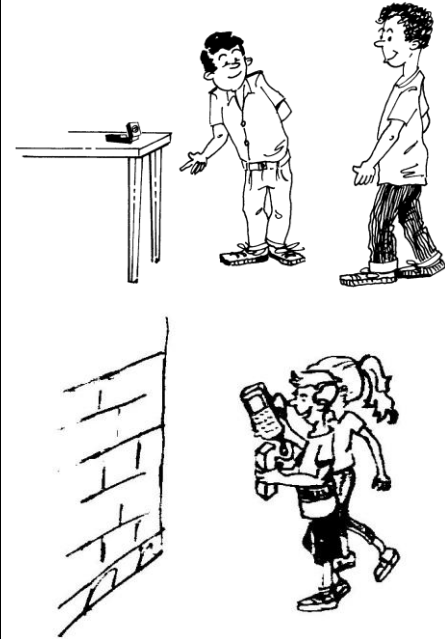
 TI-84 Plus C Silver Edition

 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/calculator/spd/US/Online-Learning/Tutorials>
- Any required calculator files can be distributed to students via handheld-to-handheld transfer.

### Lesson Files:

- What's\_Your\_Speed\_Student.pdf
- What's\_Your\_Speed\_Student.doc
- What's\_Your\_Speed\_Teacher.pdf

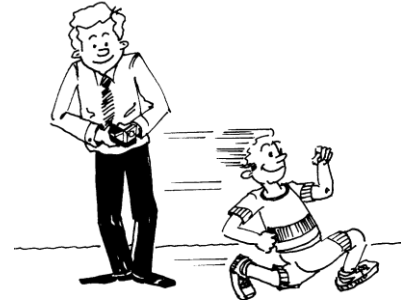


**Tech Tip:** While using the EasyData app, the tabs at the bottom of the screen indicate menus that are accessed by pressing the key directly below it. A frequent example is shown below:



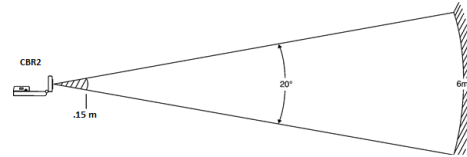
### Introduction to What's Your Speed?

The relationship between a distance-time graph and rate of motion is foundational to higher mathematics and to physics. This activity is building students' experiential knowledge of this topic that can seem abstract to students.

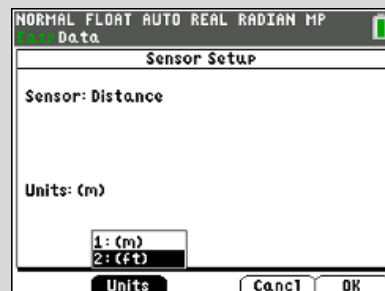


### Teaching Notes:

- The path of the CBR 2 beam is not a narrow, pencil-like beam, but fans out in all directions up to  $10^\circ$  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.

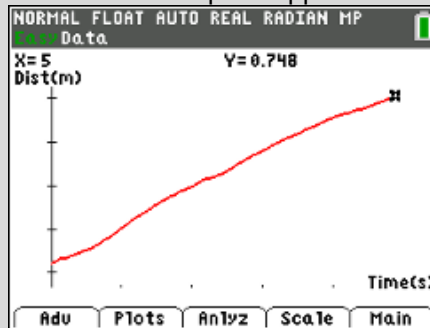


**Tech Tip:** If you prefer to do this activity using feet instead of meters, select Setup by pressing **window**. Select Units by pressing **window** and select (ft).





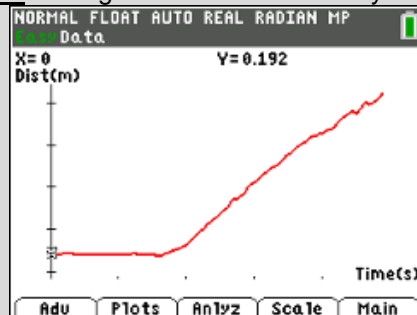
**Tech Tip:** When students have made a graph, to find their distance at the end of the walk, they can use the right arrow key  $\rightarrow$  to move through the data. The coordinates of each data point appear at the top of the screen.



### Collecting the Data

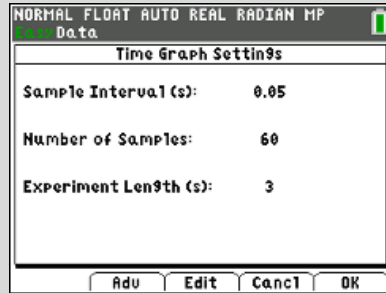
You can practice this activity by referring to the sample screen shots provided. Keep in mind that student generated plots will differ slightly from the sample screens but are still correct provided that the general shape remains the same.

**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 on the 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.

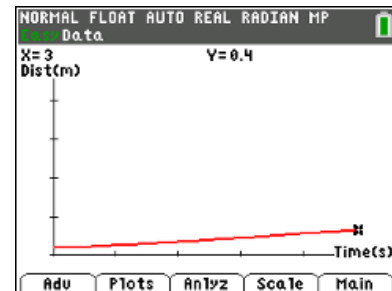




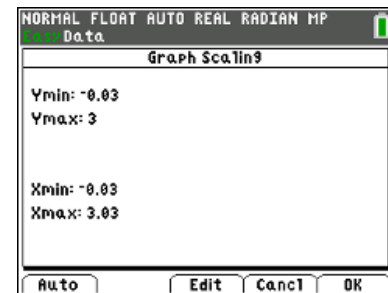
**Tech Tip:** The student activity has directions for changing the sampling time to a different duration. Select **Setup**, [Time Graph], and **Edit** the settings. The settings shown indicate an experiment length of 3 seconds. If you have limited space in your classroom, this reduces the walking distance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



Make sure to instruct students to rescale the plot before they make their sketch. The sample distance-time graph for Trial 1 at the right has been re-scaled according to the settings below. The reason for rescaling is discussed in the following note.

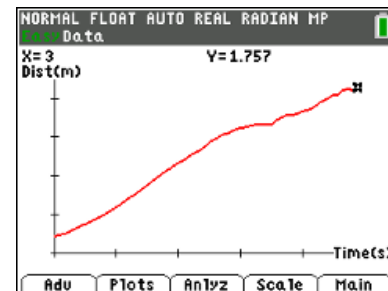


**Teaching Note:** In order to compare the Trial 1 graph with the Trial 2 graph, the same graph scaling settings need to be entered after students get a good graph for each trial. Every time the CBR 2 collects data, the window is changed to zoom in on the data collected. If the window is not changed back to the one at the right (or something appropriate to the distances that will be walked for Trials 1 and 2), it will be more difficult for students to see the difference in the slopes of the lines in the two trials. See the student activity for directions on how to re-scale the graph.



### Trial 2

The sample graph at right has been re-scaled to the same graph settings for Trial 1 so a valid comparison can be made between Trial 1 and Trial 2. Before rescaling, the plots for Trial 1 and Trial 2 will look very similar.





### Looking at the Results

1. Which trial had the steeper line? (Be specific using words like “time” and “distance” in your response to describe both lines.)

**Student answers will vary.**

Sample response: The plot for Trial 2 is steeper because the walker covered a greater distance in less time.

2. In general, what effect does your speed or rate have on the distance-time graph?

**Student answers will vary.**

Sample response: The faster the rate, the steeper the line. This is true when moving toward or away from the CBR 2.

3. Describe in writing what the plot would look like if you started 0.15 meter (6 inches) away from the CBR 2, walked very slowly away from the CBR 2 for about 3 seconds, and then began walking quickly for another 3 seconds.

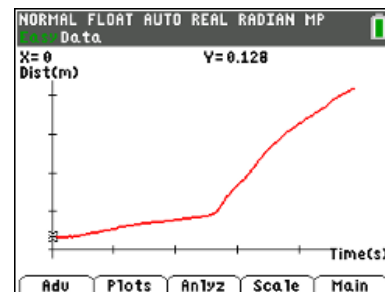
**Student answers will vary.**

Sample response: The plot would consist of two linear sections. The first section would rise slowly as it moved from left to right. The second section would be much steeper.

4. On the axes on the left sketch the distance-time graph that would result from the walk in #3. Walk according to the description in #3 and record your walk in the axes on the right. Increase the number of samples from 60 to 120 so that you will collect data for 6 seconds.

**Student answers will vary.**

The plot and sketch should resemble the one shown.



5. How well did your plot match the graph of the description? Discuss the reasons for any differences.

**Student answers will vary.**

**Going Further**

1. How would your results have differed in Trials 1 and 2 if you had begun 3 meters from the CBR 2 and had been approaching rather than walking away from the CBR 2? Try another sample if you are not sure.

**Student answers will vary.**

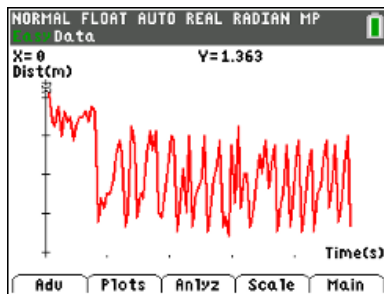
Sample response: The lines would be falling as they moved from left to right. They would both begin at approximately 5 meters, but the plot of the walker for Trial 2 who was moving at the faster rate would slope down much steeper.

2. What do you think the plot would look like if you simply stood still?

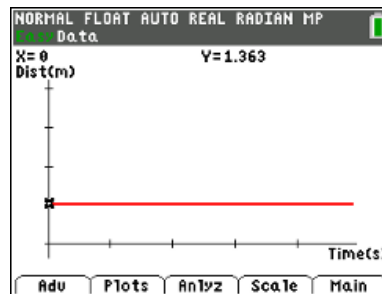
**Student answers will vary.**

Sample response: If a student stands still in front of the CBR 2, the plot should be a horizontal line. But the way the EasyData app zooms into to the range of the collected data makes the graph of no movement look as if the student had moved a lot (screenshot A). See the Tech Tip below on how to remedy this issue. (screenshot B)

Screenshot A (original):

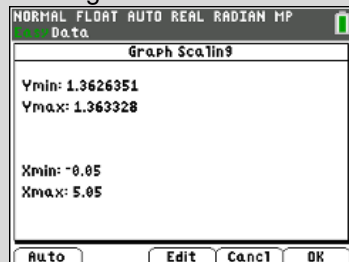


Screenshot B (after rescaling):

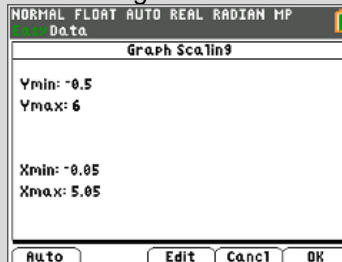


**Tech Tip:** Because EasyData zooms in to the extremely small variations while the student is not moving in front of the CBR 2, a graph of “no movement” may look as if the student had moved a lot. When the graph at the right has the y-axis rescaled properly, the graph will be a horizontal line, and look to students that there was no movement. To rescale the erratic looking graph on the left, select **Scale** by pressing **[trace]**. Then select **Edit** by pressing **[window]** to enter the min and max numbers below or according to values that will show your graph correctly. A sample is shown below.

The original scale:



Edit scaling to:





3. Make a sketch of how the plot would look if you kept changing speeds from slow to fast every couple of seconds. Then try it.

***Student answers will vary.***

The sketch should resemble the graph at the right.

