Slow Down Speed Up

About the Lesson

In this activity, students will explore the relationship of a changing rate of movement and the distance-time graph of the motion. As a result, students will be able to:

- Know that a concave down distance time graph represents a decreasing rate
- Know that a concave up distance-time graph represents an increasing rate

Vocabulary

- rate
- distance-time plot
- speeding up
- slowing down

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 EasyData® App in this activity. See the additional information in the Teaching Notes.

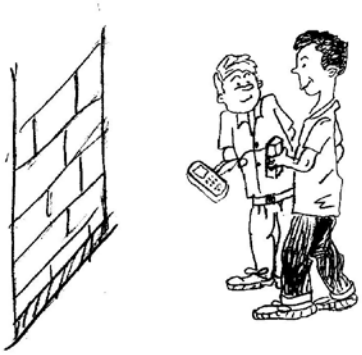
Activity Materials

- 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



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:

- Slow_Down_Speed_Up_Student.pdf
- Slow_Down_Speed_Up_Student.doc

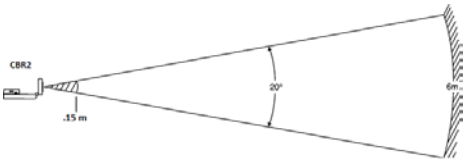
Tech Tip: While using the EasyData app, the tabs at the bottom of the screen indicate menus that are accessed by pressing the key directly below it. A frequent example is shown below:

Introduction to Slow Down Speed Up

In this activity, students walk at changing speeds. First students walk at a medium rate and then slow down. The second trial starts with students walking slowly then walking faster. Students experience a changing rate of change and analyze the resulting distance-time graph. Rate of change is a frequent topic in higher level mathematics.

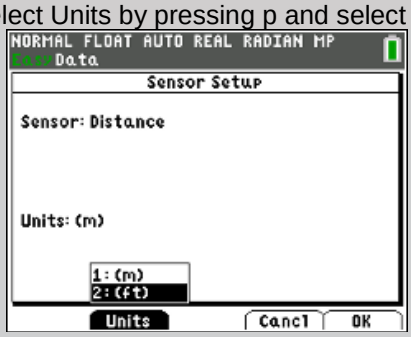
Teaching Notes:

- 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.

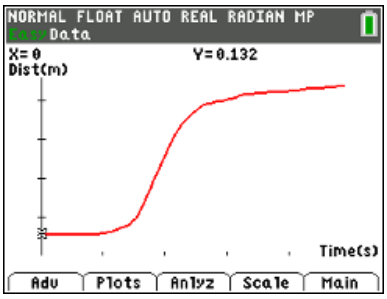


- To avoid interference from other objects in the vicinity, try to establish a clear zone in the path of the CBR 2 beam. This helps ensure that objects other than the target are not recorded by the CBR 2. The CBR 2 records the closest object in the clear zone.
- Be sure that students stay within the 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, select Setup by pressing window. Select Units by pressing p and select (ft).



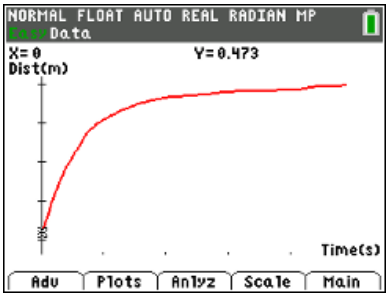
Trial 1 (close to far)



Write how you would walk in front of the CBR 2 in order to make the distance-time graph at the right. Record your description using accurate terms (where you started, which direction you walked, what changes in speed, etc.).

Student answers will vary.

The first graph that students make might look like the one on the right. You can facilitate this situation by asking the students, "What can you do differently on the next attempt to take out the horizontal part at the start?" It may take them a few more attempts to realize that moving at an increasing rate **before** starting the CBR 2 will remedy this issue.

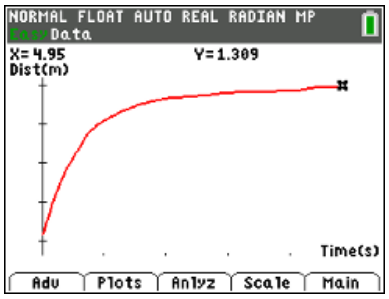


If the graph is not what you want, go to the Main Menu by pressing graph to start again. Select OK to overwrite the latest run. Before repeating, think about what you need to do differently to change the shape of the graph. Were you able to make the right shape? Describe how you walked.

Student answers will vary.

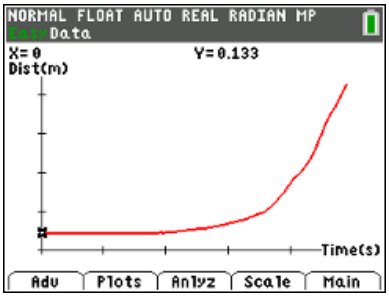
Sample response: Starting 0.473 meters away, I walked away from the CBR 2 at a fast rate for about 1 second. Then I slowed down for another second and was hardly moving for the last three seconds. I ended up 1.309 meters away.

For students to see the coordinates at the end of their walk, use the arrow keys ▶◀ to move through the data. The coordinates are displayed at the top of the screen.



Trial 2 (close to far)

Write a description of how you would walk in front of the CBR 2 to make the distance-time graph at the right. Be precise using accurate terms (where did you start, which direction, how fast, changes in speed, etc.).



Student answers will vary.

Sample response: I started at 0.133 meters away and very slowly moved away for two seconds. Then I walked faster and faster for the remaining 3 seconds until I was 1.2 meters away.

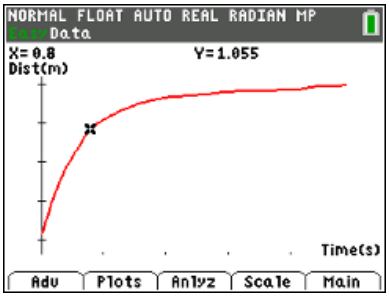
Looking at the Results

1. Each plot in *Trial 1* and *Trial 2* contains a section that is level or flat in appearance. What were you doing during this part of each plot?

   Student answers will vary.

   Sample response: The flat or almost horizontal parts of the plots are where I was moving very slowly or hardly at all.

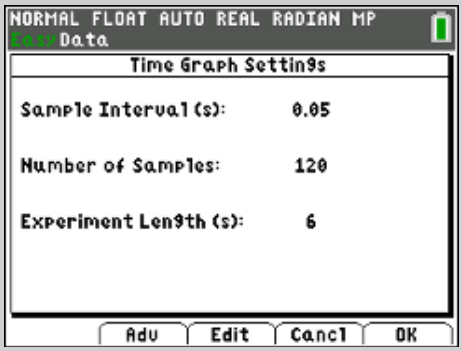
2. Look at the plot for *Trial 1*. Compare how you walked during the first second of the graph with how you walked the rest of the time (t = 1 sec to t = 5 sec).



   Student answers will vary.

   Sample response: In the first 0.8 seconds, I traveled 0.922 meters which is about 1.15 m/sec. In the remaining 4 seconds, I traveled only 0.254 meters which is about 0.06 m/sec. That is much slower than the first second.

Tech Tip: The default Time Graph Settings for the CBR 2 is 5 seconds. If the students need more time to make their graphs, the sampling time can be changed to a different duration. Select, [Time Graph], and the settings. The settings shown indicates an experiment length of 6 seconds. Note: The longer collection time means that students need more room to walk a longer distance.



3. Discuss the similarities between the two trials. What causes them to curve? (Be sure to use the words "time," "distance," and "rate" in your answer.)

   Student answers will vary.

   Sample response: Both plots contain horizontal and curved sections. The curved portion of the plots occur because of the gradual change in rate (speed). In Trial 1, less and less distance is being covered over equal time intervals, so the graph flattens out slowly and smoothly. In Trial 2, more and more distance is being covered during equal time intervals (the rate increases), so the plot becomes steeper.

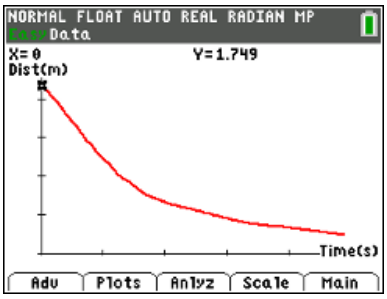
4. Describe in words how the plots above would have looked if you started at about 2 meters away and moved toward the CBR 2 with the same variations in speed as in Trials 1 and 2.

   Student answers will vary.

   Sample response:
   Trial 1: Walk fast at about 2 meters away toward the CBR 2 for about 2 or three seconds. Then slow down until you are hardly moving for the remaining seconds.

   Trial 2: I would start at about 2 meters and walk slowly toward the target for about 2 seconds. Then continually speed up (increase the rate) for the remaining seconds.

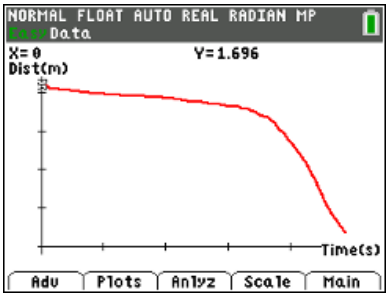
5. Sketch your written descriptions of walking Trial 1 and 2 toward the CBR 2 in the graphs below.



Student answers will vary.

For **Trial 1 (far to close),** the graph will resemble the plot to the right

For **Trial 2 (far to close),** the graph will resemble the plot to the right.



6. Try walking your descriptions from question 5 using the CBR 2. Take your place at a distance of about 2 meters. Go back to the Main menu. When you are ready, select Start. If you get a message about overwriting the latest run, select OK and the CBR 2 will immediately start collecting data. Record what happened below.

Student answers will vary. Graphs should resemble those shown above in #5.

7. In your own words, what is the effect of speeding up and slowing down on the distance-time plot?

Student answers will vary.

Sample response: When the rate of motion is changing the distance-time graph will curve either up or down.

Going Further

1. Describe what a plot of the following motion would look like. Stand approximately 2 meters from the CBR 2. When data collection begins, move toward the CBR 2 at a medium pace but then slow down until you come to a stop about 0.5 meter from the CBR 2. This motion should take almost 2 seconds. After a 0.5 second pause begin slowly moving away from the CBR 2. Then steadily increase speed until moving at the same medium rate that you began with. The total collection time will be about 5 seconds.

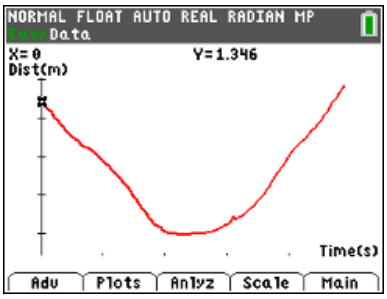
Student answers will vary.

Sample response: The plot will slope down at a moderate rate during the first 2 seconds. Then the plot will be horizontal (the distance doesn't change) for about 1 second. Then the plot will rise at a moderate rate for the last 2 seconds. The plot looks like a valley between two mountains.

2. Make a sketch of your prediction about the motion in question 1 on a set of axes. Next, try it. Make a sketch of the plot you created on a second set of axes.

   Student answers will vary.

   The sketch should resemble the plot shown to the right.



3. Discuss any differences between your prediction in question 1 and your plot in number 2 and why the differences occurred.

   Student answers will vary.