About the Lesson

In this activity, students will explore what different shapes they can make with a CBR 2™ motion sensor. As a result, students will:

- Use the effects of changing speed and changing direction on distance-time plots to make different shapes.
- Observe which shapes can or cannot be made with the CBR 2™ motion sensor.
- Formulate a rule that determines which shapes can or cannot be made using the CBR 2™ motion sensor.

Vocabulary

- rate
- distance-time plot
- constant
- changing rate of change

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

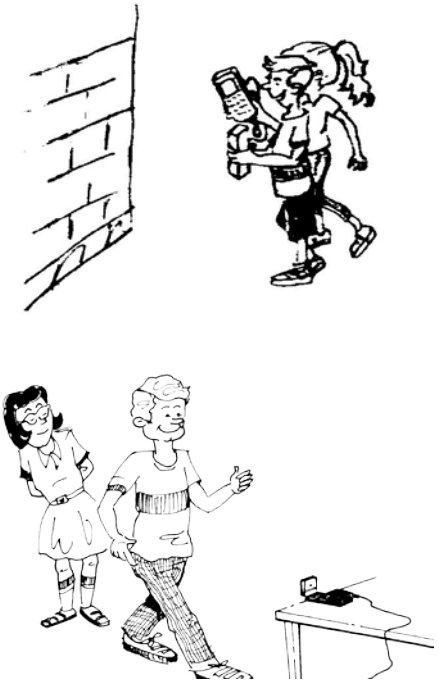
- Compatible TI Technologies:

  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.

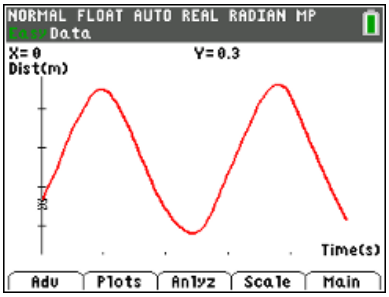
Lesson Files:

- Shape_Up_Student.pdf
- Shape_Up_Student.doc

Tech Tip: While using the Vernier 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:

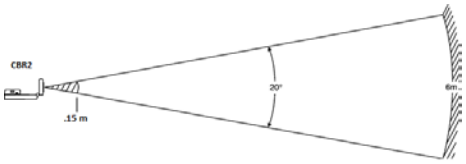
Introduction

Changing rate of change compared with constant rate of change is a concept that will help students in their understanding of higher mathematics. This activity also requires students to apply their understanding of distance-time plots in order to walk in a way that will produce different shapes in the graph.



Teaching Notes:

- The path of the CBR2 beam is not a narrow, pencil-like beam, but fans out in all directions up to 10° in a cone-shaped beam.

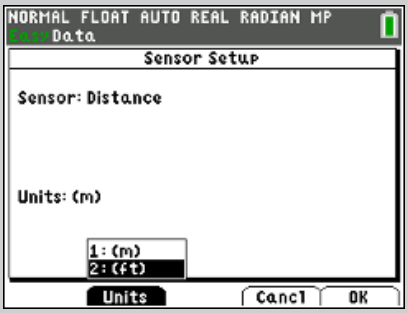


- To avoid interference from other objects in the vicinity, try to establish a clear zone in the path of the CBR 2™ beam. This helps ensure that objects other than the target are not recorded by the CBR 2. The CBR 2 records the closest object in the clear zone.

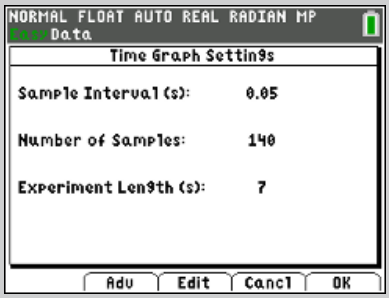
- Be sure that students stay within the range of the CBR2 (0.15 – 6 meters).

- When using a stationary CBR2, most students prefer to face the CBR2 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: Monitor your students as they make the graphs to see if you think changing the sampling time to a different duration would help them. Select [Time Graph], and the settings. The settings shown indicate an experiment length of 7 seconds which is increases the default time of 5 seconds. Adjust the time according to your students' needs.



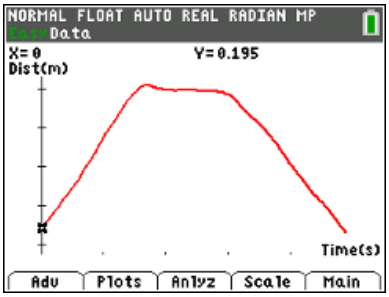
Looking at the Results

1. Describe how you would have to move in order to create a distance-time plot that resembles a mountain with a plateau on top.

Student answers will vary.

Sample response: Start at about 0.2 m, walk away at a constant rate, stop for about 2 seconds, and walk back at a constant rate to where you started.

2. Create the plot that you described above by walking as you described in your answer to question 1. If you are satisfied with the resulting plot, sketch it on the axes to the right.



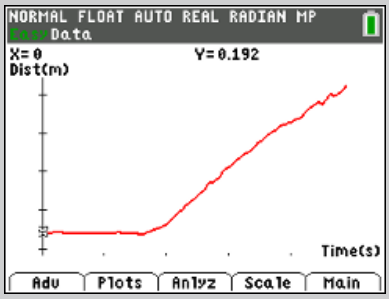
Student answers will vary.

The sketch should resemble the graph to the right.

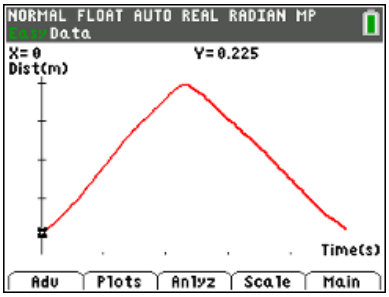
3. Did the plot in question 2 produce the desired shape? Describe any problems that you encountered while trying to make the plot and how you eliminated the problem.

Student answers will vary.

Tech Tip: The first time students try to make a graph, a common occurrence can be a horizontal portion at the start. 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 CBR2 will remedy this issue.



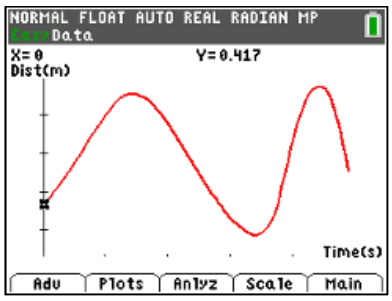
4. Describe the way you would move to create a mountain with a sharp peak



Student answers will vary.

Sample response: I started close walking away at a constant rate, quickly reversed direction at about 2.5 seconds, and walked at the same speed back to where I started.

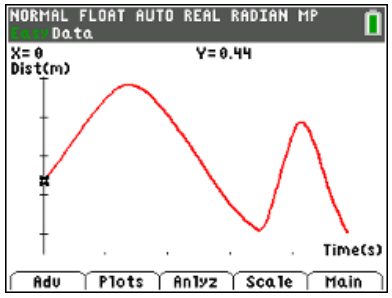
5. Using the method described in question 4, walk to create a mountain range consisting of at least two mountains, both with sharp peaks of equal heights. Make the sides of the second mountain steeper than those of the first. Describe how you walked.



Student answers will vary.

Sample response: I started close and walked away at a constant moderate rate for 1.5 seconds. I quickly changed direction and walked back at the same constant moderate rate. Quickly changing direction, I walked away at a constant faster rate for about 1 second, quickly changed direction, and walked back at the same faster rate.

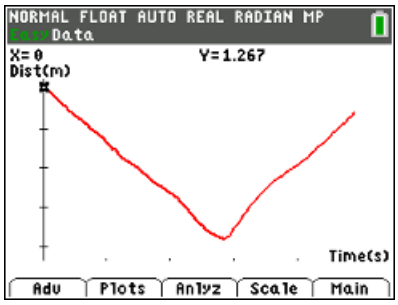
6. How would your motion change if you wanted the second peak to be only half as high as the first peak?



Student answers will vary.

Sample response: I started close and walked away at a constant moderate rate for 1.5 seconds and quickly changed directions and walked back at the same constant moderate rate. Quickly changing direction, I walked away at a constant faster rate and changed direction sooner than the first direction change and walked back at a constant fast rate.

7. Suppose you wanted to make a plot of the uppercase letter **V**. Describe how you would walk to create this plot.



Student answers will vary.

Sample response: Starting far away at about 1.27 m., I walked at a moderate constant rate for about 2.5 seconds. I quickly changed direction and returned to where I started at the same constant moderate rate.

8. Describe a difficulty that you had, and describe what you did to correct the issue. Use the axes at the right to sketch one of your first attempts.

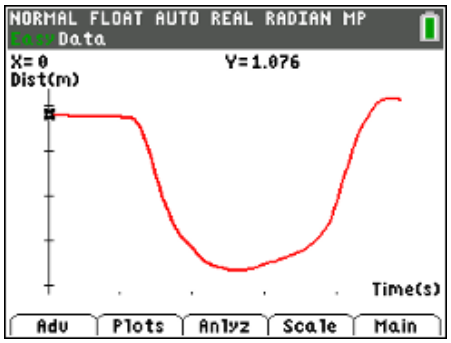
Student answers will vary.

Common difficulties are: changing direction quickly enough, walking the same speeds in both directions, changing direction at half way through the time. In the graph above, the walker did not change direction soon enough and did not reach the beginning point.

9. What change in your motion would result in a **U** rather than a **V**?

Student answers will vary.

Sample response: Instead of a quick change in direction and instead of keeping a constant speed, I had to walk faster at first then slow down as I approached the change of direction. Then when I changed direction, I increased my rate slowly at first then sped up quickly for the last second when I was going as fast as I could. I tried to stop at the same spot that I started, but I stopped a little farther away than I started.

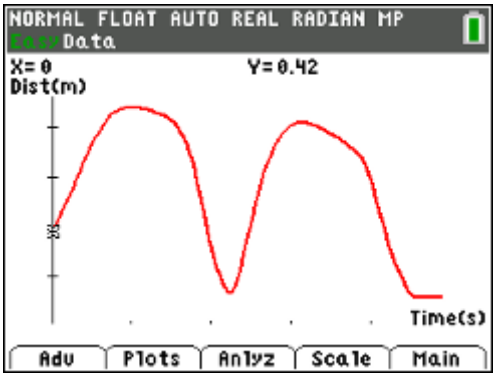


10. Suppose you wanted to make the lowercase letter m. Describe how you would walk to create this plot. Be sure to discuss the speed as well as the direction of your motion.

Student answers will vary.

Sample response:

Starting close, move away fast, slow down, change direction, speed up slowly. Then go as fast as possible, change direction as fast as possible and repeat the first part of the walk.

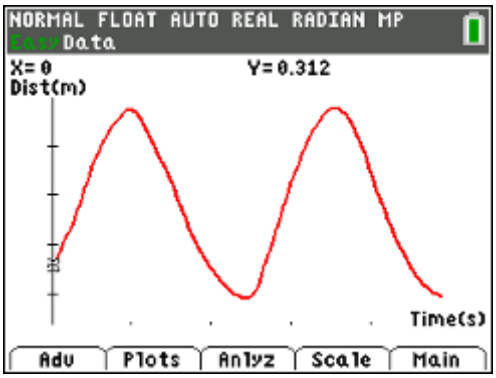


11. What problems did you have in making the **m**? What did you do to resolve them? Sketch you results to the right.

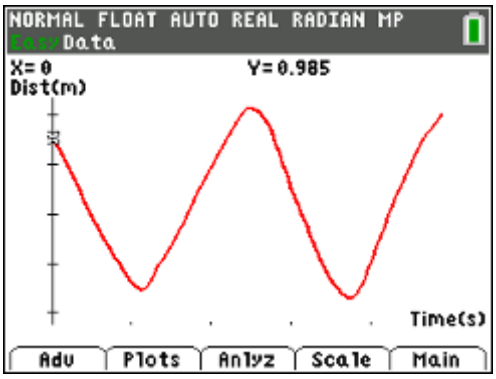
Student answers will vary.

Sample response:

If a lowercase **m** is to be made using a CBR2, then time would need to stand still at the second change of direction and at all vertical parts of the letter. So it is impossible to make the lowercase **m.** An uppercase **M** is also impossible to make with vertical sides. An uppercase **M** with slanted sides is shown.



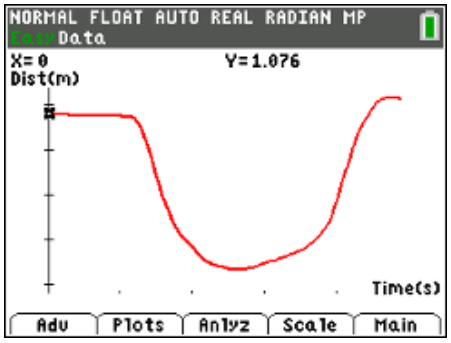
12. How could you change your motion to make a W?



Student answers will vary.

Sample response:
For a W, start far and walk closer at a constant rate, change directions quickly three times while walking at the same constant rate.

Going Further



1. Some of the figures you plotted had sharp corners and others had rounded edges. What was the key factor in your movement that determined which type was plotted? Explain why this factor affects the plot in this way. (Be sure to use the word "rate" in your answer.)

Student answers will vary.

Sample response:
A sharp corner means that you changed directions quickly. The curves in a distance-time graph occur when the rate of walking is changing at a changing rate. The left half of the letter U occurs when the rate decreases at a decreasing rate. The right half starts with the rate increasing at an increasing rate.

2. Make a distance-time plot in the shape of a circle. Describe a difficulty that you had, and describe what you did to correct the issue. Use the axes at the right to sketch one of your first attempts.

Student answers will vary.

Sample response:
Since it is impossible for time to move backwards, it is impossible to make a circle using the CBR 2.

3. Make a list of letters (uppercase or lowercase) that you would want to try to make with a distance-time plot. Briefly explain your choices.

Student answers will vary.

Sample response:
Any letters that do not involve going right to left and do not have vertical lines can be made with the CBR2. So M, N, U, V, W, v, and w can be made if the sides are slightly slanted.

4. Think of a shape or letter. Write a description of a walk that would make that shape. Have a classmate tell you what the shape is based only on your verbal description. Then ask your classmate to walk the graph with the CBR 2. Make a sketch of the walk.

Student answers will vary.

5. What determines which shapes are possible to make with the CBR 2?

Student answers will vary.

Sample response:
Possible shapes with the CBR2 are ones that can be made moving to the right and do not involve vertical lines.