ADVENTURE 3

A Steep Hike

Time:
1 class period

Suggested grade levels: 7-8

Math Objectives:
Calculate slope, Relate rate of change to slope, Graph distance as a function of time, Interpret and analyze graphs

Science Objectives:
Represent motion graphically, Represent the changes in motion graphically

Materials:
TI-73 Explorer™, Calculator-Based Ranger™ (CBR 2™), CBL/CBR™ Application
Metric stick, Masking tape

OVERVIEW

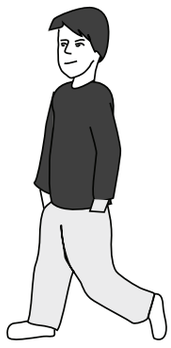
The difficulty of a hike is largely based on the steepness of the trail. Steepness is often referred to as slope. In math, slope is defined as the amount of vertical change divided by the amount of horizontal change between two points on a line.

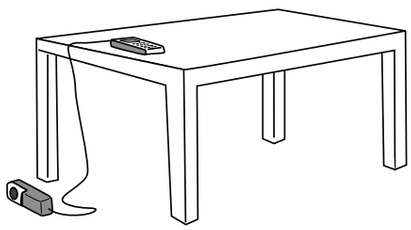
In this adventure, students will observe the effect of two factors on a motion plot. They will walk at two different speeds and walk in two different directions, and deduce how the value of the slope of a line can be "seen" in its graph.

NOTE Demo the activity using the overhead calculator so the entire class can see the process. If you have only one CBR 2, have each group individually perform this activity. If you have enough CBR 2 units, have students work in small groups.

SETUP

1. Connect the CBR 2 to the calculator using the I/O unit-to-unit cable.
2. Set up the activity as shown in the picture. You may place the CBR 2 on a table or desk so that the sensor is aimed at or above the walker's waist.
3. Measure 0.5 meter from the CBR 2 and put a masking tape marker on the floor. Do the same at a distance of 4.5 meters.
4. To launch the CBL/CBR App, press the





APPS key, select **2:CBL/CBR** and then press ENTER to view the CBL/CBR screen. **See Figures 1a-b**.

5. Press ENTER to access the application, then select **3:RANGER**. The Ranger start up screen will launch. Press ENTER to access the application. **See Figures 2a-b.**
6. From the **MAIN MENU** select **2:SET DEFAULTS. See Figure 3.**
7. With the selector arrow (▶) at **START NOW**, press ENTER.

Figure 1a

Figure 1b

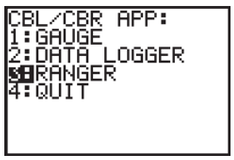


Figure 2a

Figure 2b

DATA COLLECTION

1. Time will be plotted on the horizontal axis. The distance from the CBR 2 to the walker (in meters) will be plotted on the vertical axis.
2. Remember always to stay directly in front of the CBR 2 and not to move to the side.
3. When the students walk toward the CBR 2, they should try to moderate their speed so as not to run out of room before the CBR 2 stops sampling.

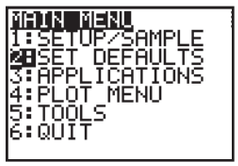


Figure 3

4. This activity consists of four different trials in which several factors are varied in the motion plots. Organize the data in the table on your worksheet.

Trial 1

a. Stand at the 0.5 mark in front of the CBR 2.

b. Press ENTER or the trigger on the CBR 2 when you are ready to collect data. Walk directly away from the CBR 2 at a slow, but steady speed. Once data collection begins, move in this manner for approximately 15 seconds.

c. The plot should look like a straight line rising gently from left to right. If you are satisfied with your plot, sketch it on the axes on your worksheet. If not, press ENTER, choose **3: REPEAT SAMPLE**, and then try again. **See Figure 4.**

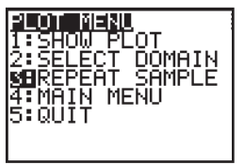


Figure 4

5. Use ▶ and ◀ to move along the Distance-Time plot of the Trial 1 plot. Position the cursor at any point and record the *x*- and *y*-coordinates in the table beside x_1 and y_1 in the table for Trial 1. Round the values to 2 decimal places. **See Figure 5.**

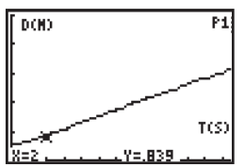


Figure 5

6. Next, position the cursor at a different point (not too close to the previous one) on the plot, and record these *x*- and *y*- values beside x_2 and y_2 in the table for Trial 1. **See Figure 6.**

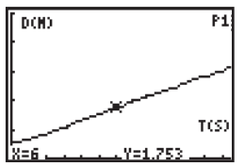


Figure 6

7. The slope, or steepness of a line, is defined as the amount of vertical change divided by the amount of horizontal change between two points on the line.

   Slope = $\frac{y_2 - y_1}{x_2 - x_1}$, where (x_1, y_1) and (x_2, y_2) represent two points.

   Calculate the slope using this formula. Record the computed value, expressed as a decimal to the nearest hundredth, in the table for Trial 1.
8. Repeat for Trials 2, 3, and 4. Answer the remaining questions on your worksheet.

EXTENSION ACTIVITY

1. Calculate the slope of a line given the two points (1.5, 2.08) and (6, 4.93).
2. Explain why the units of slope in the activity are meters per second (m/s).
3. Would the value of the slope change if the formula was changed to $\frac{y_1 - y_2}{x_1 - x_2}$? Explain why or why not.
4. Suppose motion data were collected for a person standing still, 1 meter in front of the CBR 2. Predict what the Distance-Time plot would look like. Repeat the data collection for this situation. Was your prediction accurate? If not, describe the plot that was made. Calculate and record the slope.
5. Sketch the plot of a walker starting 0.5 meter from the CBR 2 and moving away quickly for a few seconds, stopping for a few seconds, then moving toward the CBR 2 slowly. What is the sign of the slope for each section?

DISCUSSION NOTES

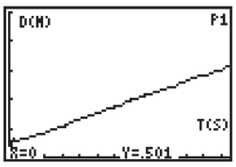
Reinforce the difference between the size (magnitude) and the sign of the slope. The activity and the worksheet take the student through the process of four trials that combine the speed of the walker with the direction of the walker. Point out the differences between the sizes of the slopes that are generated as the walker changes his/her speed. Emphasize that the direction the walker walks determines the sign of the slope. Relate the rate of change to slope by using the visual references of the plots of each trial.

WORKSHEET ANSWERS

NOTE: The data in these tables is simulated. Actual data will be slightly different.

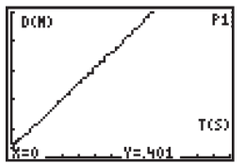
Trial 1

List L1	List L2
0	0.50
2	0.92
4	1.28
6	1.75
8	2.15



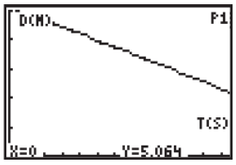
Trial 2

List L1	List L2
0	0.40
2	1.89
4	3.06
6	4.34
8	5.61



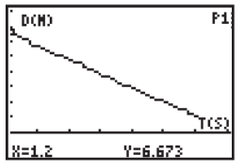
Trial 3

List L1	List L2
0	5.06
2	4.88
4	4.72
6	4.52
8	4.34



Trial 4

List L1	List L2
2	5.67
4	4.81
6	3.93
8	3.07
10	2.17



Trial	Starting Distance	Type of Motion	*x*-coord. (sec)	*y*-coord. (m)	Slope (m/s)
1	0.5 m	Slow, steady away from CBR 2	$x_1 = 2$ $x_2 = 6$	$y_1 = 0.92$ $y_2 = 1.75$	0.21
2	0.5 m	Moderate, steady away from CBR 2	$x_1 = 4$ $x_2 = 6$	$y_1 = 3.06$ $y_2 = 4.34$	0.64
3	4.5 m	Slow, steady toward CBR 2	$x_1 = 0$ $x_2 = 6$	$y_1 = 5.06$ $y_2 = 4.52$	– 0.09
4	4.5 m	Moderate, steady toward CBR 2	$x_1 = 2$ $x_2 = 10$	$y_1 = 5.67$ $y_2 = 2.17$	– 0.44

3. The slope in Trial 2 is larger than the one in Trial 1. The signs of the slopes are both positive.
4. The slope in Trial 4 is larger than the one in Trial 3. The signs of both slopes are negative.
5. The slopes in Trials 1 and 2 are positive and the slopes in Trials 3 and 4 are negative.
6. Changing the speed of the walker changes the size of the slope.
7. Changing the direction of the walker changes the sign of the slope.
8. a. greater
   b. positive; negative

Extension

1. Slope = 0.63
2. 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. The value of the slope would not change since the *y*- and *x*- coordinates are both being subtracted in reverse order.
4. The plot should look like a flat line. The slope should be 0 m/s. **See Figure 7**.
5. The first section would be a steep linear segment with a positive slope. The second would be a flat line with a slope of zero, and the third would be a gradually-sloped line with a negative slope value. **See Figure 8**.

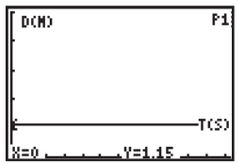


Figure 7

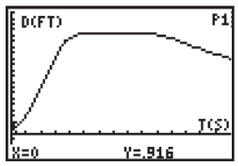


Figure 8

TI-NAVIGATOR™ EXTENSION ACTIVITY

1. If needed, show students that in a line written in the form $y = mx$, that m equals slope. So if they wanted to draw a line with a slope of 3, their equation would be $y = 3x$.
2. Enter Activity Center and turn off the axes. Have one student submit a line in the form $y = mx$. Challenge another student to submit a line that would represent another situation, such as walking faster, walking much faster, walking slower, walking much slower (you may need to tell students slope can be less than 1), walking the same pace in the opposite direction, or walking slower in the opposite direction.
3. Repeat with another student submitting a new line to Activity Center.

Name _____

ADVENTURE 3

A Steep Hike Worksheet

Math Objectives:

Calculate slope, Relate rate of change to slope, Graph distance as a function of time, Interpret and analyze graphs

Science Objectives:

Represent motion graphically, Represent the changes in motion graphically

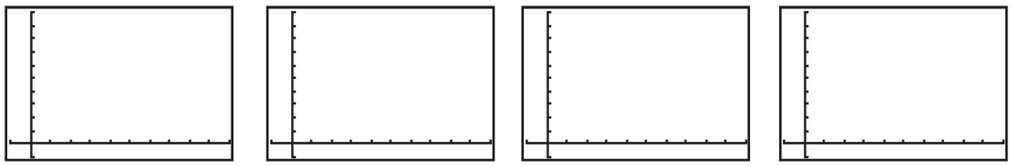
Materials:

TI-73 Explorer™, Calculator-Based Ranger™ (CBR 2™), CBL/CBR™ Application
Metric stick, Masking tape

In this adventure, you will observe the effect of two factors on a motion plot. You will walk at two different speeds and walk in two different directions.

1. Sketch the plots of each of the four trials on the axes provided.

Trial 1 **Trial 2** **Trial 3** **Trial 4**



2. Fill in the table below with two coordinates and the slope for each trial.

Trial	Starting Distance	Type of Motion	*x*-coord. (sec)	*y*-coord. (m)	Slope (m/s)
1	0.5 m	Slow, steady away from CBR 2	x_1 = x_2 =	y_1 = y_2 =	
2	0.5 m	Moderate, steady away from CBR 2	x_1 = x_2 =	y_1 = y_2 =	
3	4.5 m	Slow, steady toward CBR 2	x_1 = x_2 =	y_1 = y_2 =	
4	4.5 m	Moderate, steady toward CBR 2	x_1 = x_2 =	y_1 = y_2 =	

3. For Trials 1 and 2, how do the sizes of the slopes compare? How do their signs (positive and negative) compare?

4. For Trials 3 and 4, how do the sizes of the slopes compare? How do their signs compare?

5. How do the slopes from Trials 1 and 2 differ from the slopes for Trials 3 and 4?

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

7. What effect does changing direction have on the plot?

8. Complete the statements to summarize the relationship between motion and the characteristics of the slope value.

a. The faster the speed, the _____ the size of the slope.

b. Moving away from the CBR 2 makes a plot with a _____ slope, and moving toward the CBR 2 makes a plot with a _____slope.

EXTENSION

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

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

3. Would the value of the slope change if the formula was changed to $\frac{y_1 - y_2}{x_1 - x_2}$? Explain why or why not.

4. Suppose motion data were collected for a person standing still, 1 meter in front of the CBR 2. Predict what the Distance-Time plot would look like. Repeat the data collection for this situation. Was your prediction accurate? If not, describe the plot that was made. Calculate and record the slope.

5. Sketch the plot of a walker starting 0.5 meter from the CBR 2 and moving away quickly for a few seconds, stopping for a few seconds, then moving toward the CBR 2 slowly. What is the sign of the slope for each section?