ACTIVITY 6

Step by Step

Math Objectives:

- Graph scatter plots
- Graph linear functions
- Calculate slope

Materials: (Per Group)

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application

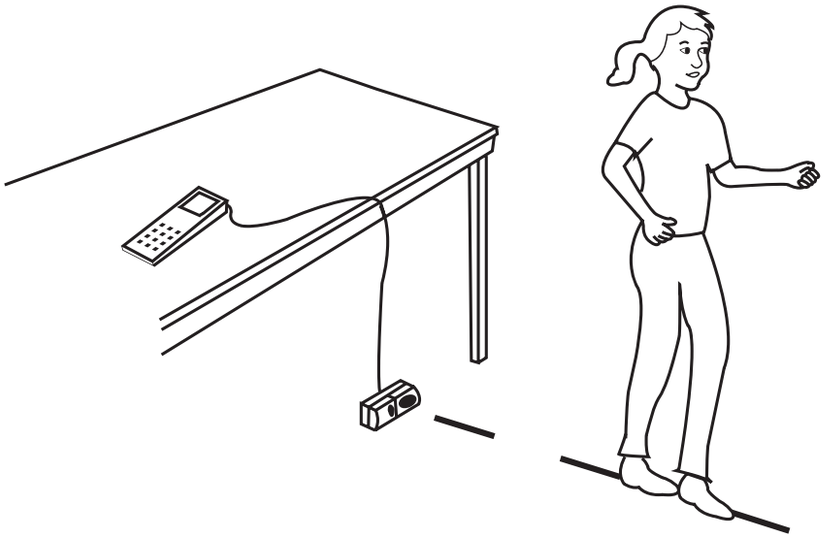
OVERVIEW

Many situations in every day life exhibit linear behavior. Linear behavior can be defined as a situation in which equal changes in the independent variable produce approximately equal changes in the dependent variable. For example, if data is collected for pressure versus depth underwater, each meter descended produces an approximately equal change in the pressure. This activity will help your students gain a better understanding of this concept and apply it to the slope of a line.

In this activity, you will create a situation that produces linear behavior by taking distance readings as you step heel to toe. You will then apply the properties of a linear function to develop a model for your motion. Finally, you will interpret the values used in your model.

NOTE Demo the activity using the overhead calculator so the entire class can see the process. If you only have one CBR 2, link the data lists after running the activity. If you have enough CBR 2 units, have students work in small groups.

NOTE *For help linking lists, see Appendix J.*



SETUP

1. Set up the activity as shown in the picture above. You may place the CBR 2 on the floor or set it on a stack of books to align with the calf of the walker.
2. Link the CBR 2 directly to the TI-84 Plus. You can use either the I/O unit-to-unit cable or the mini-USB cable.

3. The EasyData App will launch automatically if you are using the mini-USB cable. If you are using the I/O unit-to-unit cable, press the [APPS] key, scroll down to highlight the EasyData App, and then press [ENTER] to launch the App.

4. Press [Y=] to access the **File** menu and select **1:New**. This resets the program and clears out old data. **See Figure 1.**

Figure 1

5. The default unit of measurement on the EasyData App is meters. This activity will be done in feet. To change the units of measurement, select the **Setup** menu soft key by pressing the [WINDOW] key on the top row of the calculator. From the **Setup** menu, choose **1:Dist** by pressing [1] or [ENTER] since **1** is highlighted. **See Figure 2.**

Figure 2

6. From the **Units** menu, select **2:(ft)** by pressing [2] or by scrolling down until the **2** is highlighted and pressing [ENTER]. Then select **OK. See Figure 3.**

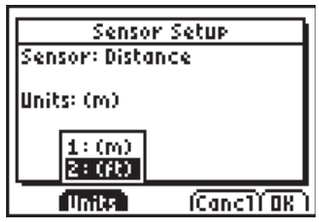


Figure 3

7. You will be returned to the main screen of the EasyData App. Select the **Setup** menu again and select **6: Events with Entry**. This will allow you to control when data is recorded by pressing a key on the calculator. **See Figure 4.**

Figure 4

DATA COLLECTION

1. You will be taken to a screen that displays the distance being recorded by the CBR 2 in real time. The distance to the nearest object in its path is displayed at the top of the screen. You will hear the CBR 2 clicking. Position the walker in front of the CBR 2. To record the distance for this position, select **Keep**. **See Figure 5.**

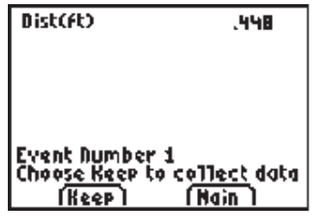


Figure 5

2. The next screen that appears allows you to match a value with the distance you just recorded. Since this value was the first position, press [1] and then select **OK. See Figure 6.**

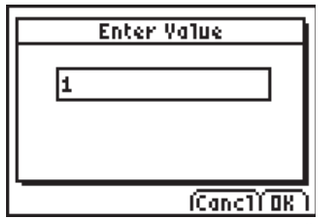


Figure 6

3. Have the walker take a step. Repeat steps 1 and 2 until you have collected at least 6 steps. When the **Enter Value** screen appears, increase the value each time to represent which step you are recording. With each recorded value, a new data point will be displayed on the graph. When finished, select the **Stop** key. **See Figure 7.** Attention should be paid to how the walker shifts his/her weight after each step and **Keep** should not be selected until this position is the same after each step. Inconsistent shifting of weight can introduce significant error.

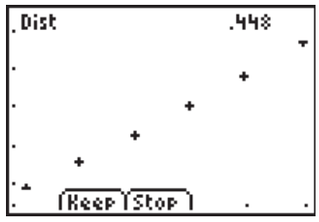


Figure 7

4. The graph of all the data points will be displayed. You can use the right and left arrow keys to view the coordinates of the points. **See Figure 8.**

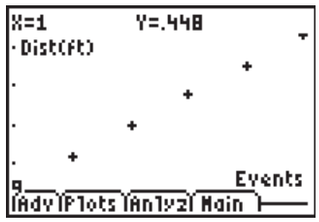


Figure 8

5. To confirm a description of the plots, select the **Plots** soft key. This confirmation screen will help to reinforce some of the mathematical vocabulary used routinely in the study of algebra. Identify the **Events** as the independent variable and the **Distance** as the dependent variable. **See Figure 9.**

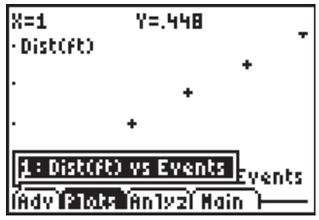


Figure 9

6. When you select the **Anlyz** menu, the EasyData App will allow you to select from a variety of possible regression equations. Choose **2:Linear Fit. See Figure 10.**

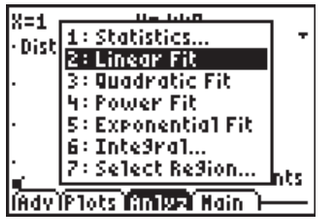


Figure 10

7. When **2:Linear Fit** is chosen, the App displays the regression equation. Select **OK. See Figure 11.**

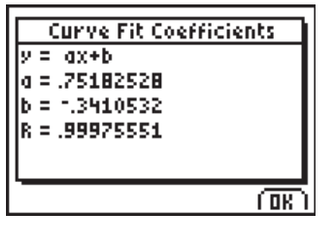


Figure 11

8. You will see the line of best fit being drawn on the screen along with the data points. **See Figure 12.**

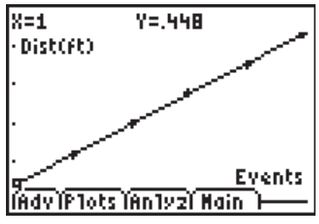


Figure 12

You can still use the right and left arrow keys to scroll through the data points. To trace along the line, use either the up or down arrow key. **See Figure 13.**

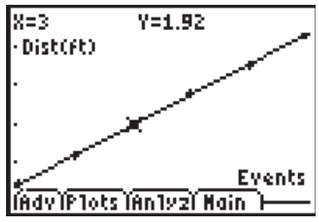


Figure 13

9. Select **Main** and then **Quit**. The confirmation screen will be displayed so you can note the lists where your data is stored. Select **OK** to exit the App. **See Figure 14.**

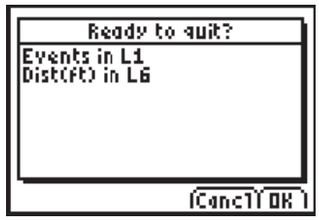


Figure 14

DATA ANALYSIS

1. Rather than having the calculator do all the work of finding the regression equation, have the students use the definition of slope and their understanding of linear equations to write their own equation for the line of best fit. The following directions use a combination of the knowledge of formulas and calculator computations to graph an equation of a line. The students need to know the formula for deriving the slope when given the coordinates of two points and how to use the calculator for quicker and more accurate computations. This activity is meant to build the students' understanding of slope while showing them some lesser used features of the calculator.

2. When you exit the App, the data values are stored in lists **L1** and **L6**. Under the [STAT PLOT] menu, **Plot 1** is still turned on with the window set to display all the points collected. **Y1** is turned off but the regression equation found by the App is still displayed there. You can tell that **Y1** is off because the equals sign is not highlighted. This will prevent **Y1** from being displayed in the graph window. **See Figure 15.**

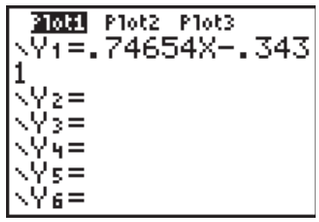


Figure 15

3. A good activity is to have the students find their own regression equation and see how closely it matches the one found by the calculator. This is also a great opportunity to explore some different features of the calculator. For the calculator portion of the activity, press [2nd] [Y=] to access the [STAT PLOT] menu and be sure the **Plot 1** is still turned on with **L1** and **L6** entered as the coordinates of the plot. **See Figure 16.**

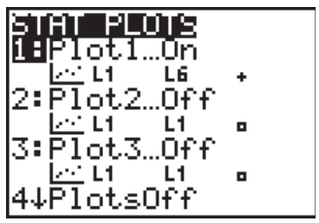


Figure 16

4. Press [GRAPH] to see the plots. Rather than using a paper and pencil to find the slope, let the calculator do the work for you. **See Figure 17.**

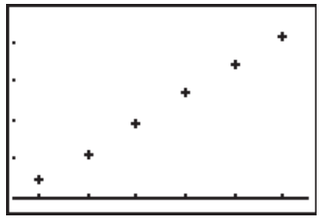


Figure 17

5. Press [TRACE] and use the right and left arrow keys to scroll through the points. Trace to the first point and notice the **X**- and **Y**-values. **See Figure 18.**

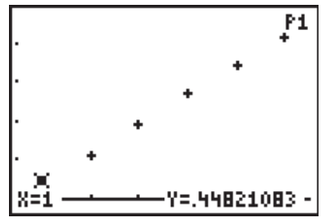


Figure 18

6. Press [2nd] [MODE] to access [QUIT]. This will take you to the home screen. Press [X,T,Θ,n] [STO▸] [ALPHA] **A** [ENTER]. This will store the **X**-value from the point you last traced on the graph screen to the variable **A**. Repeat this procedure to store the **Y**-value in **B**. Press [ALPHA] **Y** [STO▸] [ALPHA] **B** [ENTER].
See Figure 19.

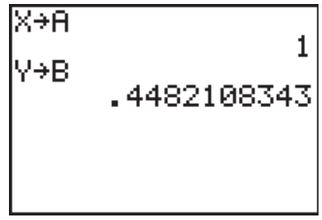


Figure 19

7. Press [GRAPH] and then [TRACE]. Use the right arrow key to move to the last point on the right. Once again, notice the **X**- and **Y**-values displayed at the bottom of the screen. **See Figure 20.**

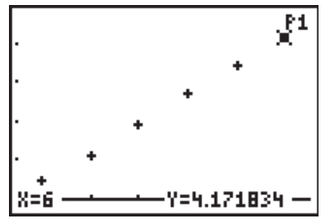


Figure 20

8. Repeat the procedure from above to store these values in **C** and **D**. Press [2nd] [MODE] to access [QUIT]. This will take you to the home screen. Press [X,T,Θ,n] [STO▸] [ALPHA] **C** [ENTER]. This will store the **X**-value from the last point to the variable **C**. Next, press [ALPHA] **Y** [STO▸] [ALPHA] **D** [ENTER]. **See Figure 21.**

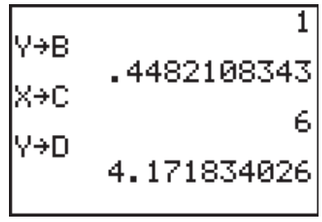


Figure 21

9. Using the slope definition, have the calculator find the slope and store the value in **M.** Be sure to enclose both the numerator and denominator in parentheses. The keystroke sequence is
[(] [ALPHA] **D –** [ALPHA] **B** [)] **/** [(] [ALPHA] **C –** [ALPHA] **A** [)] [STO▸] [ALPHA] **M** [ENTER].
See Figure 22.

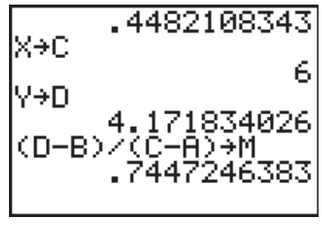


Figure 22

10. Go to the [Y=] window and press [ALPHA] **M** [X,T,Θ,n] to type in **MX** beside **Y2.**
See Figure 23.

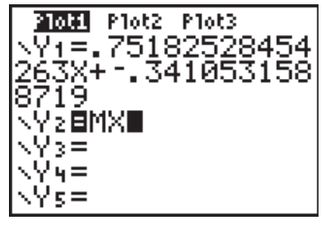


Figure 23

11. Press GRAPH to see how closely this graph fits the points. In the example shown, it looks like the slope is correct since the line is parallel to an imaginary line through the points. The horizontal position of the line needs to be moved by adjusting the **Y**-intercept. **See Figure 24.**

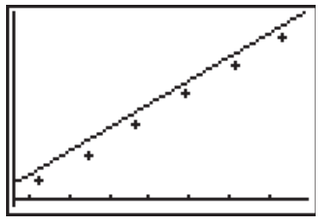


Figure 24

12. Determine how far your line is *above* where the line should be. Press TRACE. You will be on the first point where **X=1**. Round the **Y**-value to the nearest hundredth and keep it in your memory. For this example, remember 0.45. **See Figure 25.**

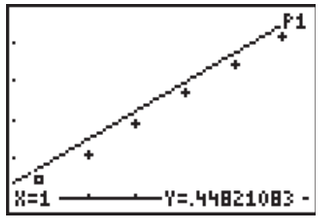


Figure 25

13. Next, press the up arrow key. Your cursor will jump to the middle of the line and will begin tracing along the line instead of from point to point. **See Figure 26.**

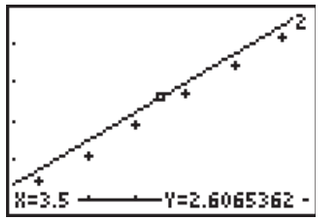


Figure 26

14. Use the left arrow key to scroll to the point whose **X**-value is as close to 1 as you can get. Round the associated **Y**-value to the nearest hundredth and subtract the previous **Y**-value from it. For this set of data, the difference would be 0.75 – 0.45 = 0.3. **See Figure 27.**

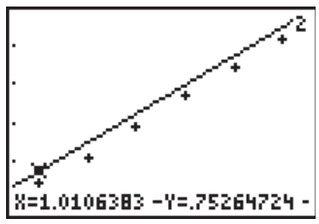


Figure 27

15. The line needs to move down, so the **Y**-intercept should be negative. Enter –.3 as the **Y**-intercept in **Y2**. Press GRAPH. **See Figure 28.**

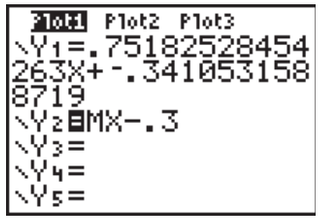


Figure 28

16. You will see the line being drawn between the points. **See Figure 29.**

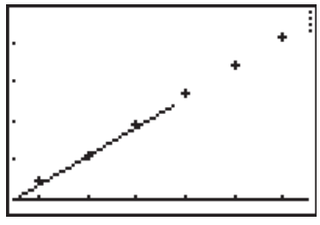


Figure 29

17. Go back to the [Y=] window and turn on **Y1**. If you graph both lines at the same time it is hard to tell one line from the other. **See Figure 30.**

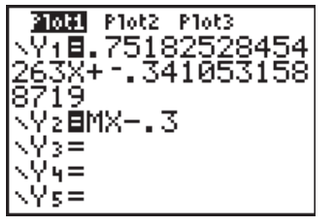


Figure 30

18. A nice feature of the TI-84 Plus is the ability to change the appearance of a line. Leave **Y1** with the default line but use the left arrow key to highlight the slash icon in front of **Y2**. Press [ENTER] repeatedly until you see the symbol shown in **Figure 31.** The symbol looks like a ball with a line to its left.

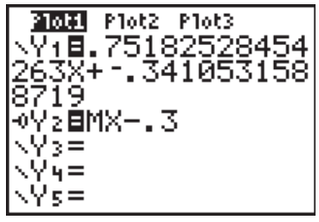


Figure 31

19. Press [GRAPH]. You will see **Y1** graphed with the default setting. **See Figure 32.**

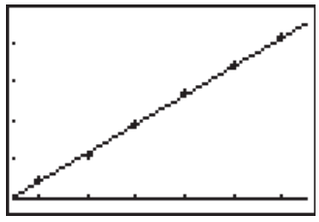


Figure 32

20. After **Y1** is completely graphed, you will see a small ball marking the trail as **Y2** is graphed. You will easily be able to see how closely your graph matches the graph the calculator found. **See Figure 33.**

NOTE You could also use the **Manual-Fit** feature to find the regression equation.

NOTE *For help with the Manual-Fit feature, see Appendix H.*

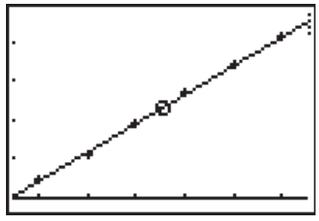


Figure 33

WORKSHEET ANSWERS

1. Number of steps

2. Number of steps; one step

3. Distance

4. Feet or meters; One foot or one meter

5–8. Answers will vary.

9. Answers will vary, but should match the slope in question 7 or 8.

10. The slope of a line is the ratio of the difference in the **Y**-values and the difference in the **X**-values. You could also accept rise/run.

11. The slope in this activity represents the change in distance per step taken.

12. Answers will vary, but should be 20 times the answer of question 9.

ACTIVITY 6

Name: _____

Step by Step

Math Objectives:

- Graph scatter plots
- Graph linear functions
- Calculate slope

Materials: (Per Group)

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application

Use the **Events with Entry** feature with the EasyData App to create a situation that produces linear behavior by taking distance readings as you step heel–to–toe. Then, apply the properties of a linear function to develop a model for your motion. Finally, interpret the values used in your model. Your teacher will outline the procedure for you. It is suggested that you set the App to take measurements in feet rather than meters.

Round all decimals to the nearest hundredth.

1. What physical property is represented along the **X**-axis? _____
2. What are the units? How far apart are the tick marks? _____
3. What physical property is represented along the **Y**-axis? _____
4. What are the units? _____ How far apart are the tick marks? _____
5. Record the coordinates of the first data point. **X** = _____ **Y** = _____
6. Record the coordinates of the last data point. **X** = _____ **Y** = _____
7. What is the regression equation you found to fit the data? _____
8. What is the regression equation found by the calculator? _____
9. For every step taken, the distance from the CBR 2 increased by _____.
10. What is the mathematical definition of slope? _____

    _____
11. Describe in your own words the meaning of slope in relation to this activity. _____

    _____
12. If 20 steps were taken, how far would the walker be from the CBR 2? _____