Step by Step

About the Lesson

In this activity, students 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.

As a result, students will:

- Model data with a linear equation

Vocabulary

- slope
- line of best fit
- y-intercept
- regression

Teacher Preparation and Notes

- Students should know how to graph linear equations.
- Students will be using the Vernier EasyData® App in this activity.

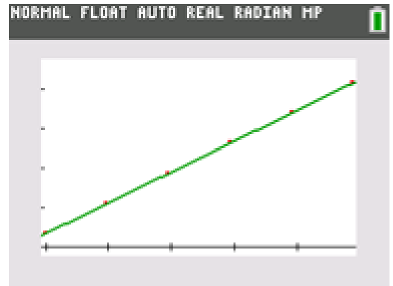
Activity Materials

- 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:

- Step_by_Step_Student.pdf
- Step_by_Step _Student.doc

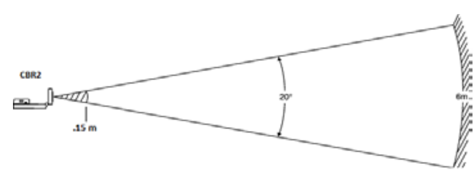
Tech Tip: Demo the activity using the overhead calculator so the entire class can see the process. If you only have one CBR 2™, link the data lists after running the activity. If you have enough CBR 2™ units, have students work in small groups. You could also have students use the **Manual-Fit** feature to find the regression equation.

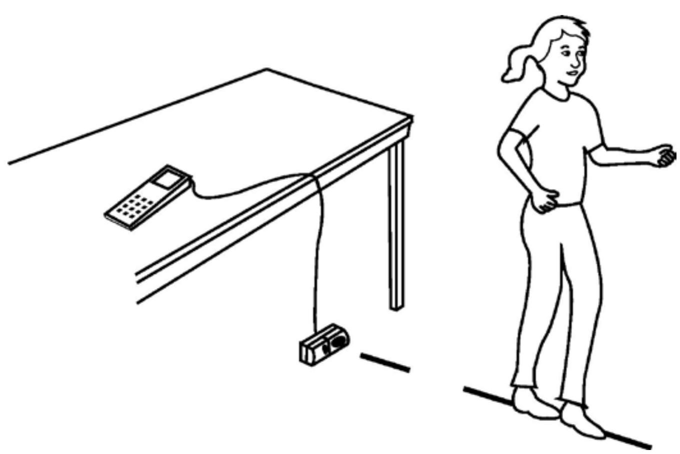
Introduction

Many situations in everyday 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, students will create a situation that produces linear behavior by taking distance readings as they step heel to toe. They will then apply the properties of a linear function to develop a model for their motion. Finally, they will interpret the values used in their model.

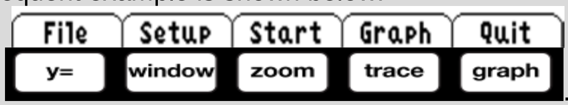
Teaching Notes

- 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.
- 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.



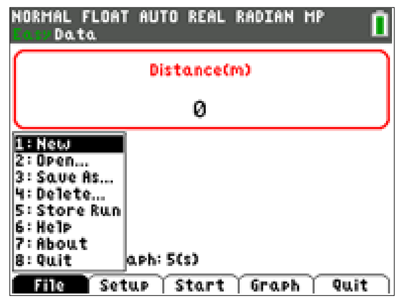


Tech Tip: While using the EasyData app, the tabs at the bottom of the screen indicate menus that are accessed by pressing the key directly below it. A frequent example is shown below:

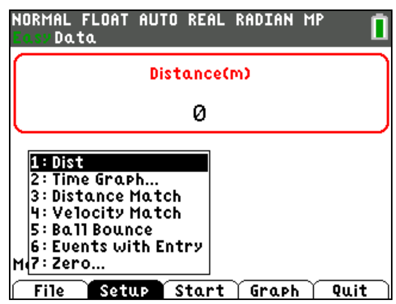


Collecting the Data

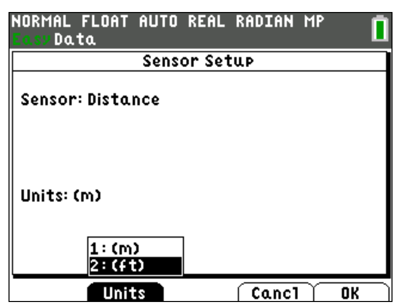
1. Set up the activity as shown in the picture above. You may place the CBR 2™ on the floor or set it on a stack of books to align with the calf of the walker.
2. Link the CBR 2™ directly to the TI-84 Plus CE using the mini-USB cable.
3. The **EasyData App** will launch automatically if you are using the mini-USB cable.
4. Press [y=] to access the File menu and select **1:New**. This resets the program and clears out old data.



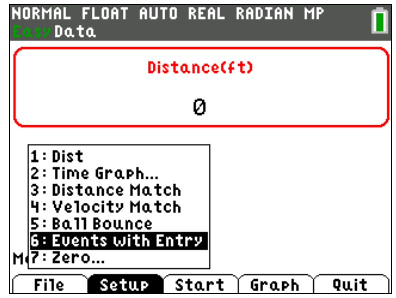
5. The default unit of measurement on the **EasyData App** is meters. This activity will be done in feet. To change the units of measurement, select the **Setup** menu soft key by pressing the [window] key on the top row of the calculator. From the **Setup** menu, choose **1:Dist** by pressing [1] or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



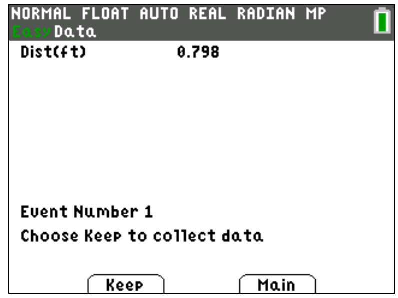
6. From the **Units** menu, select **2:(ft)** by pressing [2] or by scrolling down until the **2** is highlighted and pressing [enter]. Then select **OK**.



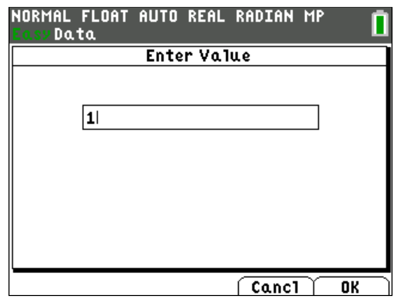
7. You will be returned to the main screen of the **EasyData App**. Select the **Setup** menu again and select **6: Events with Entry**. This will allow you to control when data is recorded by pressing a key on the calculator.



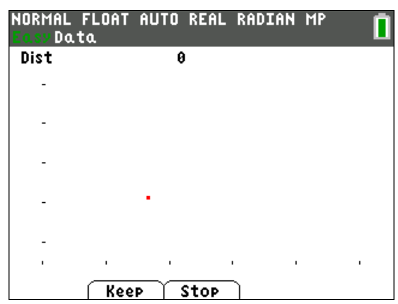
8. You will be taken to a screen that displays the distance being recorded by the CBR 2 in real time. The distance to the nearest object in its path is displayed at the top of the screen. You will hear the CBR 2 clicking. Position the walker in front of the CBR 2. To record the distance for this position,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



9. 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**.

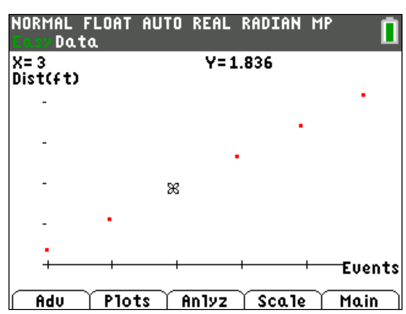


10. Have the walker take a step. Repeat steps 1 and 2 until you have collected at least 6 steps. When the **Enter Value** screen appears, increase the value each time to represent which step you are recording. With each recorded value, a new data point will be displayed on the graph. When finished, select the **Stop** key. 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.

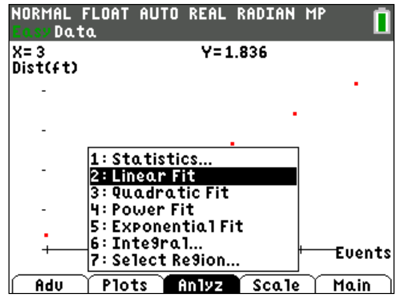


11. The graph of all the data points will be displayed. You can use the right and left arrow keys to view the coordinates of the points.

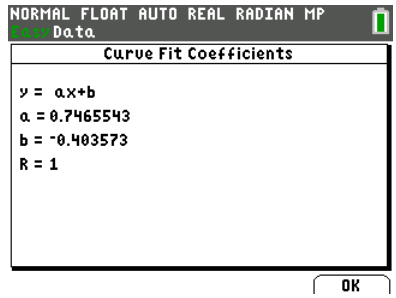
12. To confirm a description of the plots, select the **Plots** soft key. This confirmation screen will help to reinforce some of the mathematical vocabulary used routinely in the study of algebra. Identify the **Events** as the independent variable and the **Distance** as the dependent variable.



13. 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**.

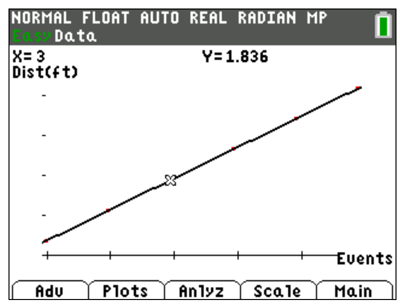


14. When **2:Linear Fit** is chosen, the App displays the regression equation. Select **OK**.

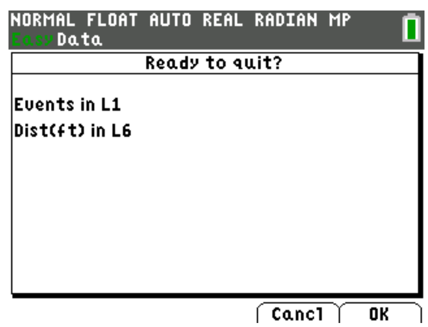


15. You will see the line of best fit being drawn on the screen along with the data points.

    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.

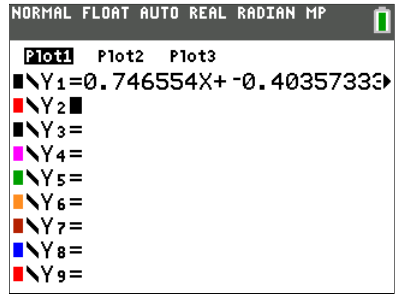


16. Select **Main** and then **Quit**. The confirmation screen will be displayed so you can note the lists where your data is stored. Select **OK** to exit the **App**.

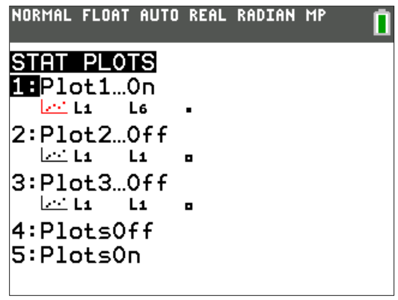


Data Analysis

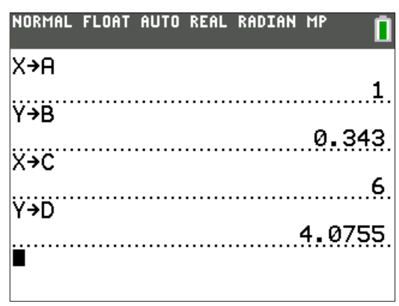
1. When you exit the App, the data values are stored in lists **L1** and **L6**. Under the **STAT PLOT** menu, **Plot1** is still turned on with the window set to display all the points collected. **Y1** is turned off but the regression equation found by the App is still displayed there. You can tell that **Y1** is off because the equals sign is not highlighted. This will prevent **Y1** from being displayed in the graph window.



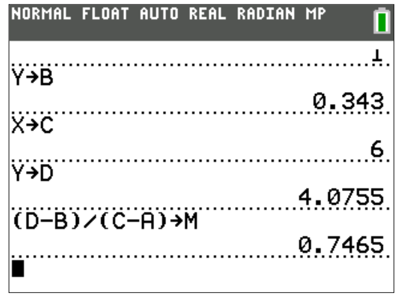
2. For the calculator portion of the activity, press [2nd] [y=] to access the **STAT PLOT** menu and be sure the **Plot 1** is still turned on with **L1** and **L6** entered as the coordinates of the plot.



3. 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.
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.
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.
6. Press [2nd] [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**.
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.

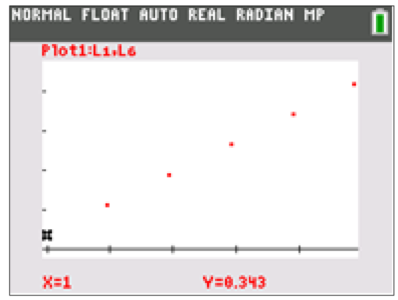


8. Repeat the procedure from above to store these values in **C** and **D**. Press [2nd] [quit]. This will take you to the home screen. Press [X,T,θ,n] [sto→][alpha] **C** [enter] . This will store the **X**-value from the last point to the variable **C**. Next, press [alpha] **Y** [sto→] [alpha] **D.**

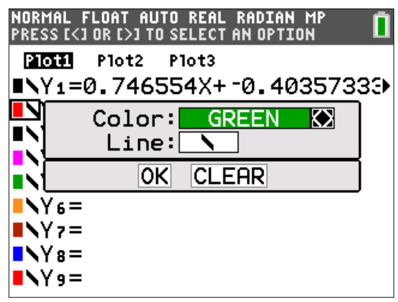


9. Using the slope definition, have the calculator find the slope and store the value in **M**. Be sure to enclose both the numerator and denominator in parentheses. The keystroke sequence is

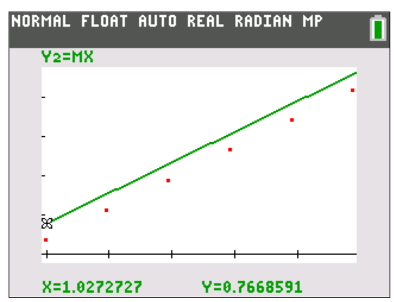
   [(] [alpha] D [−] [alpha] B [)] [÷] [(] [alpha] C [−] [alpha] A [)] [sto→] [alpha] M [enter].



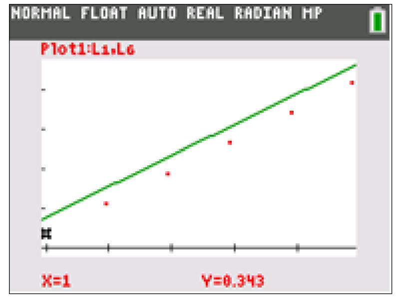
10. Go to the [y=] window and press [alpha] **M** [X,T,θ,n] to type in **MX** beside **Y2**. Change the color of the line being graphed if you desire by pressing the [◄] until you get to the two piece icon to the left of the equal sign and press [enter]. Use the [◄][►] to select the desired color. Then press [▼] to highlight **OK** and press [enter].



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.



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 0.34.

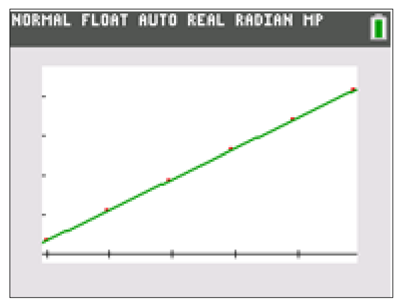


13. Next, press the [▲] key. Your cursor will jump to the middle of the line and will begin tracing along the line instead of from point to point.

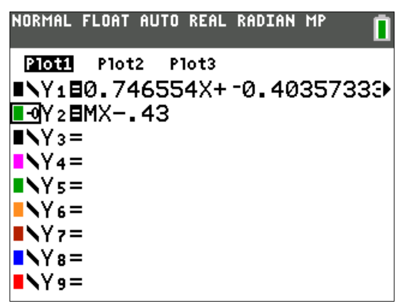
14. Use the [◄] key to scroll to the point whose **X-**value is as close to 1 as you can get. Round the associated **Y-**value to the nearest hundredth and subtract the previous **Y-**value from it. For this set of data, the difference would be 0.77 — 0.34 = 0.43

15. The line needs to move down, so the Y-intercept should be negative. Enter [(−)]**.43** as the **Y-**intercept in **Y2**. Press [graph]

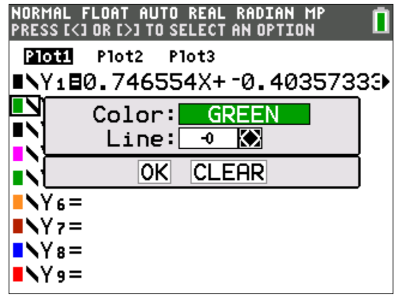
    You will see the line being drawn between the points.



16. 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



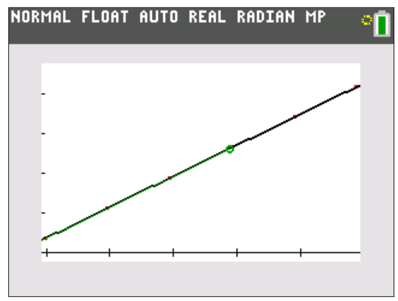
17. A nice feature of the TI-84 Plus CE is the ability to change the appearance of a line. Leave **Y1** with the default line but use the [◄] key to highlight the slash icon in front of **Y2**. Press [enter] repeatedly until you see the symbol shown. The symbol looks like a ball with a line to its left. You can also change the color of the line if you desire. Highlight **OK** and press [enter].



18. 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.

19. Press [graph]. You will see **Y1** graphed with the default setting.

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.



Looking at the Results

1. What physical property is represented along the X-axis?

   Answer: Number of steps

2. What are the units? How far apart are the tick marks?

   Answer: Number of steps; one step

3. What physical property is represented along the Y-axis?

   Answer: Distance

4. What are the units? How far apart are the tick marks?

   Answer: Feet or meters; One foot or one meter

5. Record the coordinates of the first data point. X =__________ Y=__________

   Student answers will vary.

6. Record the coordinates of the last data point. X =__________ Y=__________

   Student answers will vary.

7. What is the regression equation you found to fit the data?

   Student answers will vary.

8. What is the regression equation found by the calculator?

   Student answers will vary.

9. For every step taken, the distance from the CBR 2 increased by _____________.

   Student Answers will vary.

   Sample Response: Student answers should match the slope in question 7 or 8.

10. What is the mathematical definition of slope?

    Answer: 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. Describe in your own words the meaning of slope in relation to this activity.

    Student Answers will vary.

    Sample Response: The slope in this activity represents the change in distance per step taken.

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

    Student Answers will vary.

    Sample Response: Student answers should be 20 times the answer of question 9.