

Activity 1

Step by Step

Many different situations in the real world 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 you collected data for pressure versus your depth underwater, each meter you descended would produce an approximately equal change in the pressure.

Introduction

In this experiment, you will create a situation that produces linear behavior by stepping heel to toe and taking distance readings as you step. 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.

Equipment Required

- ◆ Computer
- ◆ TI InterActive!™ software
- ◆ CBL™ unit or CBL 2™ unit with a compatible TI calculator
- ◆ Motion detector
- ◆ TI-GRAPH LINK™ cable

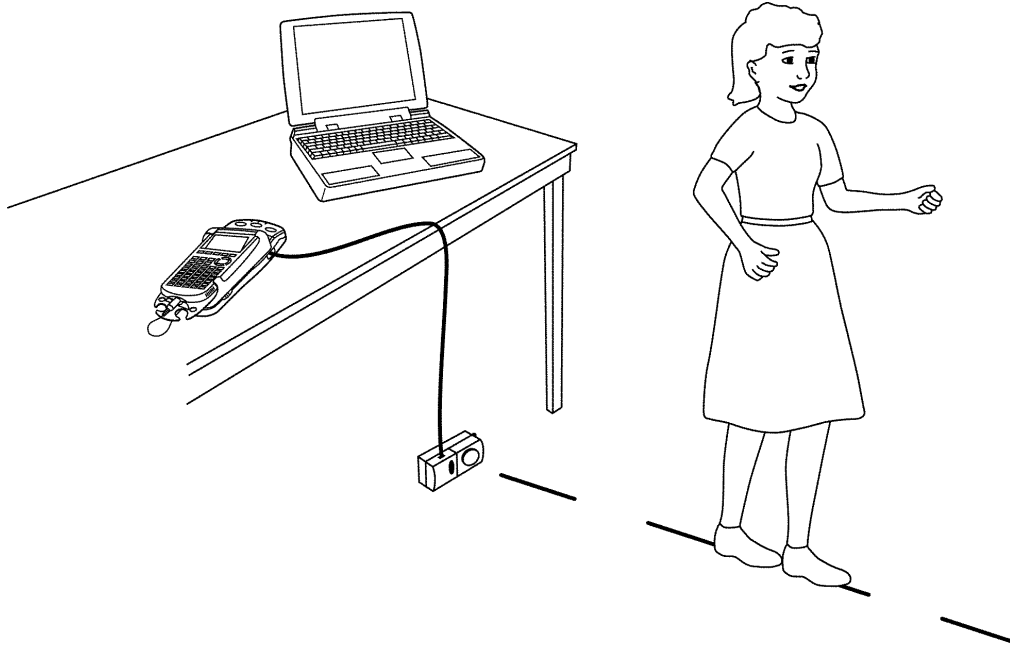
Setup




| CBL | CBL 2 |
|--|---|
| <ol style="list-style-type: none"> 1. Plug the motion detector into the SONIC port of the CBL, and connect the CBL to a compatible TI calculator. 2. Press the ON/HALT button, then press the MODE key to put the CBL in multimeter mode. 3. Press the CH VIEW button repeatedly until the SONIC channel, with Ft appears. The detector will begin to click and distance readings will appear on the screen of the CBL. | <ol style="list-style-type: none"> 1. Plug the motion detector into the DIG/SONIC port of the CBL 2. 2. Connect the CBL 2 to a compatible TI calculator. Clear the lists so your data will automatically load to L1 and L2. 3. Run the DATAMATE program on the calculator. Choose 1:SETUP. Press (down arrow) to move to DIG: and press Enter. Press 2 to select MOVEMENT(FT). Finally, choose 1:OK to return to the main screen and begin collecting data. |

- Place the motion detector on the floor with the front of the unit facing forward. Be sure that you have a clear path in front of the detector.

Collecting the Data


- Have a student stand approximately two feet in front of the motion detector with the heel of one foot directly in line with the detector and the heel of the other against the toe of the first foot, as shown in the illustration below.

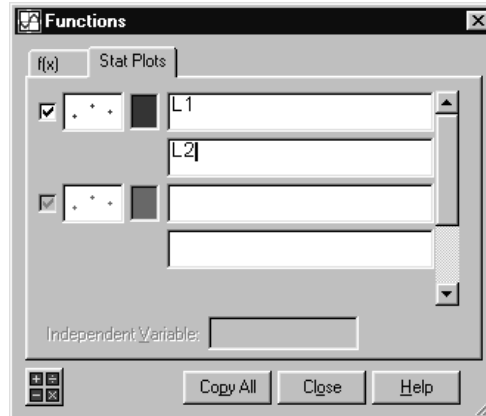


- Have the student who is walking place the heel of the back foot in front of the toe of the front foot. Continue stepping away from the motion detector until you have a good sample collected. The data is stored into **L1** and **L2** of your calculator. **L1** is the step number, and **L2** is the distance reading.
- Connect the calculator to your computer, using the TI-GRAPH LINK™ cable.
- Start TI InterActive!™ The software opens to a new, blank document.
- Title your new document *Step by Step* and add your name and the date. Press the Save button  to save and name your document.
- Click the List button  to open the Data Editor.
- Press the Import Calculator Data button  in the Data Editor.
- Choose the appropriate calculator from the Import Calculator Data dialog box.
- Highlight the lists containing your data (**L1** and **L2**), and click **Import**. TI InterActive! automatically inputs your data into **L1** and **L2** in the Data Editor.

Recording the Data




1. Press the Graph button  and then click the Stat Plots tab. In the uppermost text box, type **L1** to specify it as the list containing the x coordinates. Press the Tab key and move to the second text box. Type **L2** to specify the list containing the y coordinates.




2. Press Enter, then click the Zoom Statistics button. The viewing boundaries are adjusted automatically to show all the plotted data.
3. Your segment length versus step plot should appear to be linear. If you are not satisfied with your data, return to the *Collecting the Data* section and collect a new set of data. If you are satisfied with your plot, move to the box below the graph and enter **0**, then press Enter. This will change the minimum value of y to 0 and allow you to see the x axis.



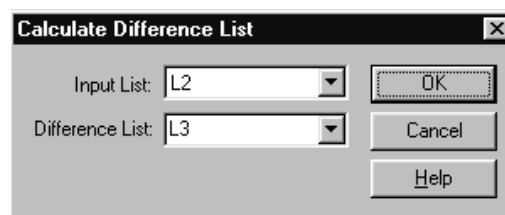
4. Click the Save to Document button  to place the graph in your TI InterActive!™ document.



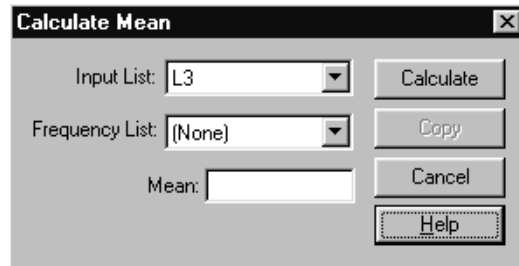
5. Click the Save to Document button  on the Data Editor to place the lists in your document.

Analysis and Questions

1. To find a formula for the distance of the walker from the motion detector with respect to the number of steps taken, you need to know two things: the starting position, and the distance traveled per step. Refer to Data Editor to find the initial position of the walker and record it in your TI InterActive! document.
2. Linear data is characterized by the property that equal changes in the x values result in approximately equal changes in the y values. The graph you created already has equal changes of one for the x values. To find the changes in the y values, return to the Data Editor by double-clicking on the lists in your document. Choose **List**, then **Operations**, and finally **Calculate Difference List** to bring up the Calculate Difference List dialog box. Enter **L2** for the Input List and **L3** for the Difference List. Click **OK** to calculate the difference list.



- The differences you stored in **L3** represent changes in distance per step. For the formula, you will need one value that is representative of all these changes in distance. One measure that does this is the mean of the differences. To find the mean of your difference list, from the Data Editor choose **List**, **Calculate**, and **Calculate Mean**. Enter **L3** as your Input List and click **Calculate**. Click **Copy** to copy this value onto the clipboard.



- Your formula can be written in the form $f(x) = IP + Sx$, where IP is the initial position of the walker, S is the average distance per step, and x is the number of steps taken. Open a Math Box, and using the values you found above, write out your formula for distance from the motion detector with respect to the number of steps taken. Use **Edit**, **Paste** to paste the value of the mean from the clipboard into the math box. Make sure you place the math box above the graph in the document.
- Close the Math Palette and double-click on the graph in the TI InterActive!™ document to refresh the Graph window. How well does your formula fit the data?
- What is the physical interpretation of the value of IP that you found in your model?
- What is the physical interpretation of the slope S in the model you found?
- Place a yardstick on the floor and have the walker stand on it. How does the length of the walker's foot compare to the value of S ?
- Use the model you found to predict where the walker would be if he took 100 steps. Record your prediction in your TI InterActive! document.
- If you were standing at the back of a 20-foot diving board, how many steps would it take before you fell in the water? Be careful with respect to the initial value. Record your answer in your TI InterActive! document.
- Save and print your TI InterActive! document.

Extensions

- ◆ Find a formula to model this data by the traditional method of selecting two points and finding a linear model containing those points. Was this model better or worse than the one you found in the activity?
- ◆ Have TI InterActive!™ find a model for this activity by performing a linear regression on the data. How does this model compare to the one you found in this activity?
- ◆ Reverse the order of this experiment. Measure your foot and the distance to the starting point of the data collection. Use these values to predict the model for the data before you collect it.
- ◆ Connect the TI-GRAPH LINK™ cable to your calculator and use TI InterActive! to send the data you collected from the computer to the calculator. Analyze the data on your calculator using the same methods applied in this activity.

Teacher Notes

Activity 1: Step by Step



Math Concepts

- ◆ CBL™/CBL 2™
- ◆ List Manipulation
- ◆ Linear Function

Activity Notes

- ◆ Make sure the student doing the stepping has his/her foot lined up directly in front of the motion detector, a minimum of two feet away.
- ◆ For some students, maintaining balance may be a problem. Take appropriate precautions to prevent injuries in case of a fall.

Sample Data

| STEP# | DISTANCE (feet) |
|-------|-----------------|
| 0 | 2.015 |
| 1 | 3.160 |
| 2 | 4.308 |
| 3 | 5.457 |
| 4 | 6.601 |
| 5 | 7.747 |
| 6 | 8.897 |

Analysis and Questions - Answer Key

1. The initial position was 2.015 feet.
2. The difference list table is shown below.

| L3 |
|-------|
| 1.145 |
| 1.148 |
| 1.149 |
| 1.144 |
| 1.146 |
| 1.150 |

3. The mean is 1.147 feet.
4. $f(x) = 2.015 + 1.47x$
5. The formula is an almost perfect model for the data.

6. The value IP represents how far the person walking was from the motion detector when data collection began.
7. The value S represents the length of the shoe of the person stepping.
8. The values should be very close.
9. The person walking would be 116.715 feet from the motion detector.
10. You would fall into the water on the 18th step. (Remember, the initial value is zero in this problem while the length of the step remains the same.)