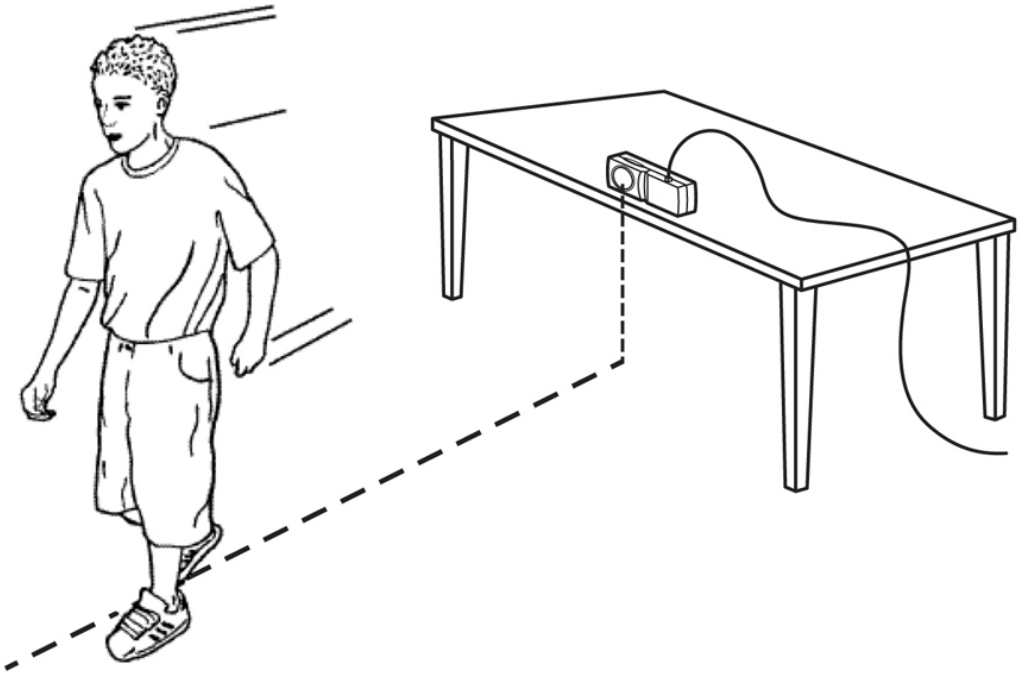
Walk the Line:
Straight Line Distance Graphs

When one quantity changes at a constant rate with respect to another, we say they are *linearly related*. Mathematically, we describe this relationship by defining a linear equation. In real-world applications, some quantities are linearly related and can be represented by using a straight-line graph.

In this activity, you will create straight-line, or constant-speed, position versus time plots using a Motion Detector, and then develop linear equations to describe these plots mathematically.



OBJECTIVES

- Record distance versus time data for a person walking at a uniform rate.
- Analyze the data to extract slope and intercept information.
- Interpret the slope and intercept information for physical meaning.

MATERIALS

TI-Nspire handheld **or**
computer and TI-Nspire software
CBR 2 **or** Go! Motion, **or**
Motion Detector and data-collection interface

PROCEDURE

1. If your Motion Detector has a switch, set it to Normal, as shown. Connect the Motion Detector to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer. (If you are using a CBR 2 or Go! Motion, you do not need a data-collection interface.)

2. Position the Motion Detector on a table or chair so that the head is pointing horizontally out into an open area where you can walk. There should be no chairs or tables nearby.

3. Choose New Experiment from the Experiment menu. For this experiment, the default data-collection parameters for a Motion Detector will be used (Rate: 20 samples per second; Duration: 5 seconds). The number of points collected should be 101.

4. Stand about a meter from the Motion Detector. When you are ready to collect data, walk away from the Motion Detector at a slow and steady pace and start data collection (). You will have five seconds to collect data.

5. When data collection is complete, choose Show Graph ► Graph 1 from the Graph menu, a graph of distance *vs*. time will be displayed. Examine the graph. It should show a nearly linearly increasing function with no spikes or flat regions. If you need to repeat data collection, repeat Step 4.

6. Once you are satisfied with the graph, sketch or print copies of the graph as directed by your teacher.

DATA TABLE

y-intercept, *b*	
optimized slope, *m*	
optimized line equation	
x_1, y_1	
x_2, y_2	
regression line equation	

ANALYSIS

1. Click any data point and use ► and ◄ to read the values from the graph.

2. The slope-intercept form of a linear equation is $y = mx + b$, where m is the slope of the line and b is the y-intercept value. The independent variable is x, which represents time, and the dependent variable is y, which represents position in this activity. Trace across your graph to the left edge to read the y-intercept. Record this value as b in your data table.

3. One way to determine the slope of your position *vs.* time graph is to guess a value and then check it by viewing a graph of the line. To do this, use the movable line feature of Data & Statistics.
   a. Add a new Data & Statistics page to your document (handheld – Select Insert ► Data & Statistics from the Documents menu; computer – Select Data & Statistics from the Insert menu.)
   b. Add **time** as the variable for the horizontal axis.
   c. Add **position** as the variable for the vertical axis.
   d. Choose Add Movable Line from the Data & Stats Analyze Menu.
   e. Move the cursor over the movable line. Near the center of the movable line, the cursor will appear as a four-directional icon. Away from the center of the movable line, the cursor appears as two arrows in a circular arrangement. Grasp the movable line to translate and rotate it.
   f. Experiment with your movable line to find the best value for *m* and record the optimized value in the data table.

4. Use the values of the slope and intercept to record in your data table the equation of the line that best fits your position *vs.* time data.

5. Another way to determine the slope of a line to fit your data is to use two well-separated data points. Choose two points (x_1, y_1) and (x_2, y_2) that are not close to each other and record them in the data table.

6. Use the points in the table to compute the slope, *m*, of the position *vs.* time graph.

$$m = \frac{y_2 - y_1}{x_2 - x_1} =$$

   Answer Analysis Question 1.

7. You can also use Data & Statistics to automatically determine an optimized slope and intercept.
   a. Choose Remove Movable Line from the Analyze Menu.
   b. Choose Regression ► Show Linear (mx+b) from the Analyze Menu.
   c. Use the parameters *m* and *b* to record the equation of the best-fit regression line in your data table.
   d. (optional) Print your graph.

8. Answer Analysis Questions 2–5.

ANALYSIS QUESTIONS

1. How does this value compare with the slope you found by trial and error?

2. How do the values of the slope and intercept as determined by the calculator compare to your earlier values? Would you expect them to be exactly the same?

3. Slope is defined as change in *y*-values divided by change in *x*-values. Complete the following statement about slope for the linear data set you collected.

   In this activity, slope represents a change in _____ divided by a change in _____.

4. Based on this statement, what are the units of measurement for slope in this activity?

5. The *y*-intercept can be interpreted as the starting position or the starting distance from the Motion Detector. What does the slope represent physically? **Hint**: Consider the units of measurement for the slope you described in the previous question.