Name ____________________

Date ____________________

EXPLORATIONS

ACTIVITY 7

Walk the Line

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

Objectives

In this activity you will:

- Create constant-speed motion plots.
- Develop *linear equations* to describe these plots mathematically.

You'll Need

- CBR unit
- TI-82 or TI-83 and calculator-to-CBR cable

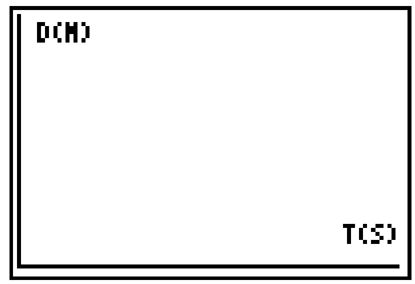
CBR Setup

1. Connect the CBR to the calculator using the link cable.
2. Turn on your calculator. If you have not already loaded the **RANGER** program into your calculator, follow these steps:
   - **a.** Press [2nd] [LINK] [▶] [ENTER]. The calculator displays **Waiting** ....
   - **b.** Press the (82/83) transfer button on the CBR.
3. Run the **RANGER** program on your calculator:
   - **a.** Press [PRGM].
   - **b.** Choose **RANGER**.
   - **c.** Press [ENTER].
4. From the **MAIN MENU** select **2: SET DEFAULTS**.
5. With the selector arrow (▶) at **START NOW**, press [ENTER].

Collecting the Data

In this activity, you will walk in front of the CBR at a constant speed.

1. To start, place the CBR on a table or desk. Stand at least 0.5 meters away from the CBR.
2. Prepare to walk away from the CBR at a slow and steady pace. When you are ready to begin collecting data, press [ENTER] and begin. You will have a total of 15 seconds to collect the data.
3. If you are satisfied with your plot, sketch your plot to the right, and go to the next section. Your plot should show a straight-line plot. The entire plot should fit within the boundaries of your calculator screen. If not, press [ENTER], select **3: REPEAT SAMPLE** from the **PLOT MENU**, and try again.



Looking at the Results

The *slope-intercept* form of a linear equation is

Y = MX + B

where M is the slope or steepness of the line and B is the intercept or starting value. In this activity, the control variable, X, represents time and Y represents distance.

1. Use the arrow keys on the calculator to move the cursor along the Distance-Time plot. Identify the starting value (the Y-value when X = 0) and record this below as the intercept, B.

   B = ____________

2. When you've finished tracing on the data, press [ENTER]. From the **PLOT MENU**, select **5: QUIT**. Press [CLEAR].
3. Enter the intercept value from above, then press [STO▸] [ALPHA] [B] [ENTER] to store this value to the variable B on your calculator.
4. Press [Y=] and enter the expression MX + B. Press [2nd] [QUIT] to return to the home screen.

   To find the equation of the line that fits your data, use a guess-and-check method to find the value of M.

5. Start with an initial guess of M = 1. Store this value to M by pressing 1 [STO▸] [ALPHA] [M] [ENTER].
6. Press [GRAPH] to view the equation Y = MX + B. If the line doesn't fit the data well, press [2nd] [QUIT] to return to the home screen and store a different value to M using the method described above.

7. For each new value of M that you test, press [GRAPH] to view your adjusted equation. Experiment until you find one that provides a good fit for the data. Record the value of M that works best in the space below.

M = ____________

8. Using this value of M and the B-value determined in question 1, complete the slope-intercept form of the equation and record it below.

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9. Press [TRACE]. Move along the data plot with the arrow keys, to identify two points (x_1, y_1) and (x_2, y_2) and then record them below. Try to pick the points so that they are not close together.

x_1	y_1	x_2	y_2

When the coordinates of two points on a line are known, the slope of the line can be computed by finding the difference in y-values divided by the difference in x-values:

slope = $(y_2 - y_1) / (x_2 - x_1)$

Use this formula to compute the slope for your linear plot and record the result below.

Slope = ____________

How does this value compare to the value of M you found experimentally in question 2?

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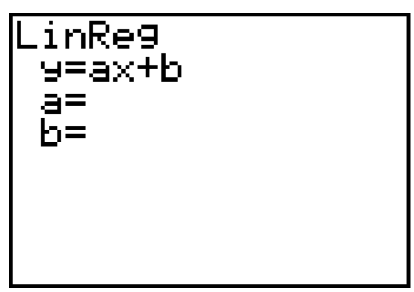
10. The values you found for M and B can be tested using a built-in feature of your calculator that allows it to compute the best-fitting line through a set of data. This procedure is called *linear regression*.

To perform a linear regression on the data you collected:

a. Press [STAT] [▸] and select **4: LinReg(ax+b)** to copy the command to the home screen.

b. Press [ENTER] to compute the regression equation.

c. Copy the values that appear on your calculator screen into the matching table to the right.



How do the values of **a** and **b** in the regression model compare to the values of M and B you found earlier?

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11. Remember, 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 ____________________.

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

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12. As mentioned earlier, the intercept value, B, can be interpreted as the starting position or the starting distance from the CBR. What does the value of M represent physically?
Hint: Think about the units of measurement for slope you described in question 11.

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Going Further

Answer these questions on a separate piece of paper. Show all work.

1. Repeat the activity, this time walking away from the CBR at a slower rate than before. Find the linear equation associated with this data set. How does the slope of this equation compare with the slope of your original equation? How do you think the slope would compare if you walked away from the CBR at a much faster pace? Generally, how is the magnitude (steepness) of a linear plot related to the speed of the walker?

2. Repeat the activity again, this time starting several meters from the CBR and walking toward it at a slow and steady pace. Find the linear equation associated with this data set. How does the slope of this equation compare with the slope of your original equation? Generally, how is the sign (positive or negative) of the slope related to the direction in which you are moving?