EXPLORATIONS

Activity 10

Step Up

Objective

- To explore the concept of slope

Materials

- TI-73 calculator
- A ruler that measures in inches and centimeters
- String and tape
- Student Worksheet

In this activity you will:

- measure the vertical height (rise) and horizontal length (run) of a set of stairs
- find a ratio to describe how steep the stairs are
- create a graph to show the relationship

You will need to know this math vocabulary:

- ratio
- slope
- origin
- coefficient
- rise
- run

How steep are the stairs in your school? Are they all the same degree of steepness? Architects know that they cannot be too steep. They also know that if they are not steep enough they would be too long to fit in the space they need to. How can you numerically describe how steep something is like stairs, a mountain, or a ramp ?

Problem

In this activity, you will measure the height (rise) and depth (run) of stairs in centimeters and inches. Your teacher will tape a piece of string from the third stair to the bottom stair to represent the slope of the stairs. You will find the **ratio** of the vertical height (rise) to the horizontal height (run) or rise divided by run. This ratio is known as the **slope** of the line made by the string.

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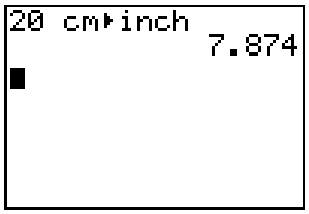
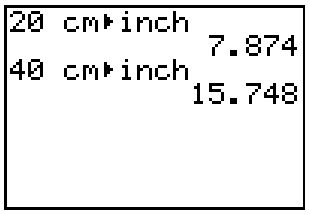
Activity

1. Type in the rise measurement in centimeters. Press [2nd] [CONVERT] and select **1:Length**, press [ENTER] and select **2:cm**, and then **4: inch**. You will use this to verify the accuracy of your measurements. Follow the same procedure with the run measurements.

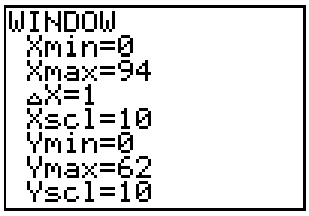




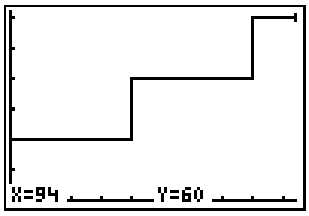
✎ Record these measurements in Table 1 on the Student Worksheet.

2. Use the Draw function of the calculator to draw a model of the stairs.

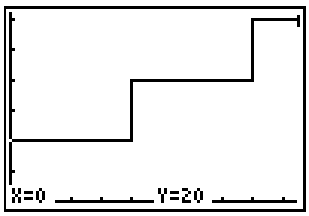
a. Press [WINDOW] to set a friendly window as shown at the right. Make sure stat plots are off and there are no equations on in the [Y=] editor.



b. Press [GRAPH] [DRAW] and select **8:Pen.** Use the cursor to move to the **origin** coordinates (0,0). Press [ENTER] to turn the pen on. Move the cursor up [▲] the vertical height of the stairs. To do this, press [▲] the number of times or the rise of the stairs. For example, if they are 20 cm tall, press [▲] 20 times. Then move the pen right [▶] the depth (horizontal length) of stairs. Continue this until you are about to leave the window. Do not go past your **Xmax** or **Ymax**. For example, in the screen shot at the right, do not go greater than **X**=94 or **Y**=62 or your window will change. Do this until you have at least 2 stairs. Press [ENTER] to turn the pen off.



3. Store your picture by pressing [DRAW] [◀] **1:StorePic** then **1** [ENTER]. If your stairs reappear, then the picture has been successfully stored.



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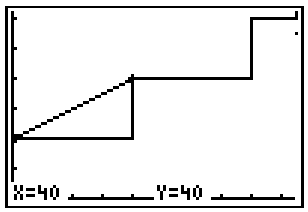
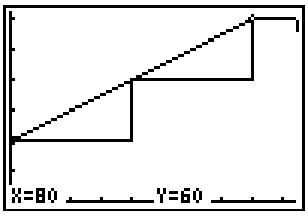
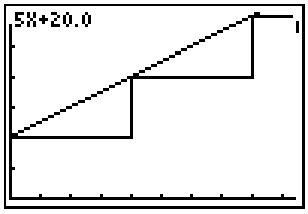
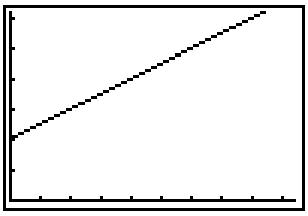
4. Use the Manual-Fit to place a line like the piece of string on your steps. On the Home screen, press 2nd [STAT] ◀ **3:Manual-Fit**, then 2nd [VARS] **2: Y-Vars** ENTER. Position the cursor at the top tip of stair 1. For example, at coordinates (0,20) in the screen shot shown in step 3 above. Press ENTER to set the endpoint of a segment that will contain the line that represents the string. Rise up the vertical height of the stairs (press ▲ the number of times of the height in cm) and run right the horizontal length (press ▶ the number of times of the depth in cm) until you arrive at the tip of stair 2. Repeat the process until you arrive at the tip of step 3.



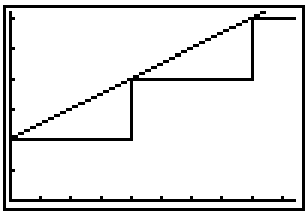


5. Press ENTER again. You should have an algebraic expression in the upper left corner of the screen. Press ENTER a third time to paste this expression into the Y= editor. Your stairs have disappeared and the string or line is all that is left.

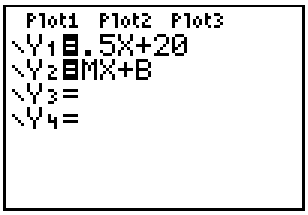




To recall your stairs, go to the Home screen and press DRAW ◀ **2:RecallPic** then **1** ENTER. Do this every time after you graph a line so you will have the string as your reference line. Remember to use the calculators scroll up and select feature to execute the command.

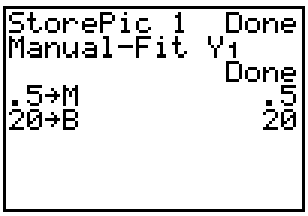


6. Look at the Y= editor and see the expression pasted on the right side of the equal sign. This is now an equation. In **Y2**, type the equation as shown at the right. In the example, **M**= .5 and **B**=20.



✎ Answer questions 1 through 4 on the Student Worksheet.

7. Go to the Home screen and store the values you found for **M** and **B** to those variables as shown at the right. Make sure you use *your* values and not the example at the right. Then press GRAPH again and you should see the same line because **Y2** is on top of **Y1**. Use the Recall Picture command to get the stairs back.



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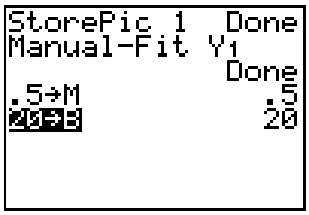
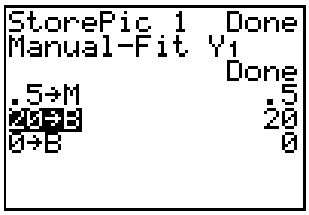
8. Go back to the Home screen and change the value of **B** to 0. To do this, use ▲ until you are on the command where you stored a value to **B**. Then press ENTER and edit it to change the value to 0.

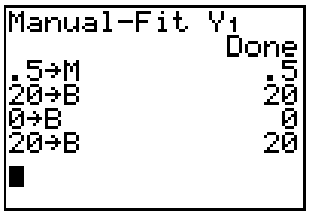


9. Press GRAPH. Remember to recall picture 1 to get your stairs back.

✎ Answer question 5 on the Student Worksheet.

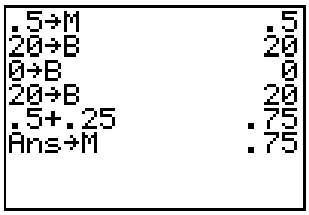


10. Now go back to the Home screen and change **B** back to the original value. Remember to use your scroll up and select feature to get the earlier command and don't forget to press ENTER to execute the command.



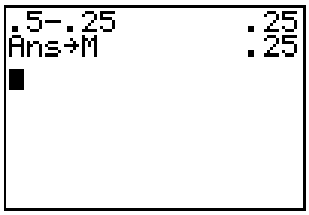
11. Change **M** to a greater decimal value. For example, add 0.25 to your original value of **M** and store the new value to **M**. Press GRAPH.

✎ Answer questions 7 through 8 on the Student Worksheet.



12. Change **M** to a smaller decimal value. For example, subtract .25 from your original value of **M** and store this value to **M**. Then press GRAPH.

✎ Answer questions 9 through 10 on the Student Worksheet.



The number in front of the **X** is called a **coefficient**. In the equation **Y=.5X+20**, the coefficient of .5 is called the **slope**, and 20 is the **y-intercept**. (It tells where the line crosses the y axis.)

Y=MX + B is known as the **slope intercept form** of a linear equation where **M** is the slope and **B** is the y-intercept.

Recall the definition of slope from the beginning of this activity:

$$\text{Slope} = \mathbf{M} \qquad \mathbf{M} = \frac{\text{rise}}{\text{run}}$$

✎ Answer questions 11 and 12 on the Student Worksheet.

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Student Worksheet

Name _____

Date _____

Activity 10

Step Up

Record your results on the table below. Then answer the questions about the activity.

Table 1

	Centimeters (to the nearest tenth)	Inches (to the nearest eighth of an inch)	convert cm to inches using convert function
Rise			
Run			

1. What was the rise of the stair you measured in centimeters?

_____

_____

2. What was the run of the stair you measured in centimeters?

_____

_____

3. Find the ratio of the rise to the run.

_____

_____

4. Record the values of M= ____ B= _____

5. Record the new value of B= ____ How does the slope of this new line compare to the slope of the stairs (the string)?

_____

_____

6. How are the lines different?

_____

_____

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7. Record the new value of M= ____. How does the slope of this new line compare to the original line (the string)?

_____

_____

8. How are the lines the same?

_____

_____

9. Record the new value of M= ____. How does the slope of this new line compare to the original line (the string)?

_____

_____

10. Explain what you think the values of M and B stand for in the graphs of the equations Y=MX+B.

_____

_____

11. Calculate the slope ratio first using your centimeter measurements. Now calculate the slope ratio using your inches measurements.

_____

_____

12. How did the two ratios in question 11 compare?

_____

_____

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Teacher Notes

Activity 10

Step Up

Math Strand

- Geometry and measurement
- Patterns and functions
- Algebraic reasoning

Materials

- TI-73 calculator
- Student Worksheets (page 93)
- A set of stairs with at least 3 stairs, or 6 congruent shoe boxes
- A ruler for each group with centimeters and inches
- String and tape

Students will use measurements on a real model to develop the concept of slope and linear functions. They will use the calculator to explore changing the slopes and Y intercepts in the slope intercept form of Y= MX+B.

Vocabulary

ratio	a comparison of two numbers by division
slope	the ratio of the rise to the run; the change in "y" divided by the change in "x"
origin	the coordinates (0,0) on a coordinate plane
coefficient	the number in front of the variable; for example, in 5A, "5" is the coefficient
rise	a vertical move on a coordinate plane that describes the change in "y" coordinates
run	a horizontal move on a coordinate plane that describe the change in "x" coordinates

Classroom Management

Students should work in small groups. When measuring the rise and run of the stairs make sure the groups can come to a consensus on a precise measurement. They should record the measurements in centimeters to the nearest tenth and inches to the nearest eighth of an inch. You should tape the string from the tip of the third stair to the tip of the first stair.

If stairs are not available, you could construct a model of stairs using six congruent shoe boxes arranged in three rows.

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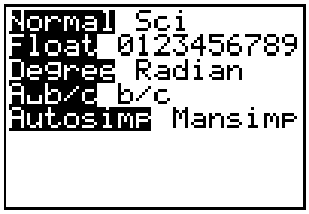
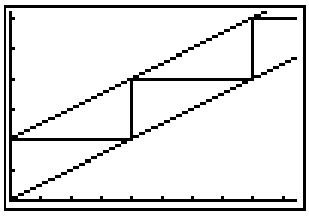
Activity

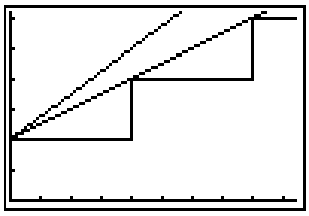
Depending on the calculator experience of your students, you may want to help with setup. Make sure that the stat plots are off and equations are cleared out of [Y=]. Press [MODE] and [2nd] [FORMAT] and use the setups shown at the right.

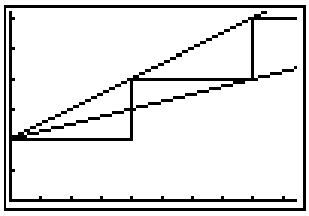


Sample data where **M** is the same and **B**=0



Sample data when **B** is the same and **M** increases and then decreases





Answers to Student Worksheet

1. Answers will vary.
2. Answers will vary.
3. Answers will vary.
4. Answers will vary.
5. Answers will vary. The slope of the new line is the same as the original line.
6. Answers will vary. The new line passes through the origin and the original line passes through higher up on the y-axis.
7. Answers will vary. The slope is steeper.

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8. Answers will vary. They start at the same place or intersect the y-axis at the same place.

9. Answers will vary. The slope is not as steep.

10. Answers will vary. M is the ratio of the rise to the run also known as the slope and B is where the line intersects the y-axis.

11. Answers will vary but the slope ratios should be the same for centimeters and inches.

12. The ratio of the rise to the run should be very close to the same.

Going Further

- Have the students start at different locations on the y-axis and use the **Manual-Fit** function to create different lines.
- Explore lines with negative slopes.

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