# Getting Started with TI-Nspire™ CAS High School Mathematics

| | | |
|---|---|---|
| 8. | Walk a Line<br><u>Reflective Questions:</u><br>How can this type of activity help students make connections between their actions and the graphs generated on the handheld?<br>How can data collection increase student engagement?<br>What mathematics and science concepts can we explore in this activity? | 41 |
| 9. | You Are What You Eat!<br><u>Reflective Questions:</u><br>How can the use of real world data related to students' interests be used to engage students?<br>As a teacher, what strategies could you use if this activity is not completed in class?<br>How can the use of the Add Movable Line tool help better understand modeling data? | 53 |
| 10. | Graphing a Scatter Plot<br><u>Reflective Questions:</u><br>What are the advantages of graphing a scatter plot on the same page as the data?<br>How could the ease of graphing with Quick Graph and the *Data & Statistics* application facilitate the use of "real-world" data? | 63 |
| 11. | Getting Started with TI-Nspire™ CAS Teacher Software<br><u>Reflective Questions:</u><br>How can the TI-Nspire Teacher Software be integrated into your planning and instruction?<br>When would you use the different options in the Documents Toolbox? | 67 |
| 12. | Transferring Documents Using the TI-Nspire™ CAS Teacher Software<br><u>Reflective Questions:</u><br>Why might you wish to transfer a TI-Nspire document from a handheld to the TI-Nspire™ Teacher Software?<br>Why might you wish to transfer a TI-Nspire document from the computer to a handheld? | 73 |
| 13. | Opening and Exploring a TI-Nspire document with TI-Nspire™ CAS Teacher Software<br><u>Reflective Questions:</u><br>When might you wish to open and display a TI-Nspire document with the Teacher Software in your class?<br>What should you be aware of as a teacher when using the Teacher Software to introduce or guide an activity? | |
| 14. | Wrap Up Day One (Exit Ticket) | |
| | **Day Two** | **Page #** |
| 1. | Overview of Day Two<br><u>Reflective Questions:</u><br>How have you used technology in the past for formative assessment?<br>How have your students used technology in the past to assess their own learning? | |

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| 2. | The Graphs Application - Part Two<br>Reflective Questions:<br>Are there strategies for finding the point of intersection that might be more appropriate for students at different grade levels?<br>What other representations could be used to enhance student understanding of the solution of a system of equations? | 77 |
| 3. | Modeling with a Quadratic Function (CAS Extension)<br>Reflective Questions:<br>How can images be used to explore characteristics of various functions?<br>How can the transformation tools (dilating or translating the function) be used to understand transformations of quadratic functions? | 83 |
| 4. | Maximizing the Area of the Garden (CAS Extension)<br>Reflective Questions:<br>Why might it be important to have students use manipulatives and/or graph paper to model this problem before they explore the TI-Nspire document file?<br>How do the multiple representations of the TI-Nspire™ enhance the learning in this activity?<br>When are the various solution methods appropriate? Is one more appropriate than another? | 91 |
| 5. | Solving Equations with CAS<br>Reflective Questions:<br>What advantages are there to solving equations using the approach outlined in the activity?<br>When would you use the solve command? When wouldn't you use the solve command?<br>What would you want students to record in their notes or on assessments if they were allowed to use the TI-Nspire™ CAS? | 107 |
| 6. | Solving by Elimination with CAS<br>Reflective Questions:<br>How would you use this activity in the classroom?<br>What would you want students to record in their notes or on assessments if they were allowed to use the activity? | 111 |
| 7. | Creating a Slider<br>Reflective Questions:<br>How can the document be modified to address other derivatives of other functions?<br>How can the document be modified to address transformations of functions?<br>How might a slider for the parameter b in the function $f(x) = b^x$ help students understand why b cannot equal 1 in an exponential function? | 113 |
| | **LUNCH** | |
| 8. | Match Me<br>Reflective Questions:<br>How does this activity help students make connections between mathematics and science?<br>What student misconceptions could be addressed by the use of this activity?<br>How does the physical model of walking a graph relate to the slope of a line? | 117 |

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| 3. | Aggregating Data with TI-Nspire™ CAS Navigator™ Teacher Software<br><u>Reflective Questions:</u><br>How have you taught modeling data in your classroom?<br>Do you use data sets from sources other than your text?<br>What types of data do your students typically collect in your classroom? | 165 |
| 4. | The Painted Cube<br><u>Reflective Questions:</u><br>Would this activity be more appropriate at the beginning of a unit on polynomial functions or at the end? Why?<br>How can this activity/investigation better assist students to understand the mathematics at a higher cognitive level? | 169 |
| 5. | The Box Problem (CAS Extension)<br><u>Reflective Questions:</u><br>How have you taught modeling data in your classroom?<br>Do you use data sets from sources other than your text?<br>What types of data do your students typically collect in your classroom? | |
| 6. | Trigonometric Transformations<br><u>Reflective Questions:</u><br>How does the use of animation enhance this activity and how could it help to engage students?<br>If a student doesn't understand why the graph generated didn’t form a circle, how do you help that student understand the resulting graph? | 183 |
| | **LUNCH** | |
| 7. | Graphs of Trigonometric Functions<br><u>Reflective Questions:</u><br>What types of questions could be asked if you used this activity in the classroom?<br>What types of extensions could be provided for this activity?<br>What difficulties do students have in solving trigonometric equations?<br>How do the strategies provided in the activity help students solve trigonometric equations? | 191 |
| 8. | Area Formulas<br><u>Reflective Questions:</u><br>How could an activity like this help our students provide informal arguments for formulas?<br>How does color help students “see the mathematics” in this activity? | 195 |
| 9. | Parallel Lines and Transversals<br><u>Reflective Questions:</u><br>How does the exploration of a geometric construction with which students can interact help them learn geometric relationships and properties?<br>Some teachers may ask students to create their own document. How could this process help students better understand the mathematics involved at a higher cognitive level? | 207 |

 

# Interactive Math and Science Classrooms…

## I.C.E.R

Interaction
Communication
Engagement
Reasoning & Sense-Making

## 5 E's Learning Cycle for Science

Engagement
Exploration
Explanation
Elaboration
Evaluation

## CCSS Mathematical Practices

Make sense of problems & persevere in solving them

Reason abstractly & quantitatively

Construct viable arguments & critique others' reasoning

Model with mathematics

Use appropriate tools strategically

Attend to precision

Look for & make use of structure

Look for & express regularity in repeated reasoning

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## Activity Overview

In this activity, you will become familiar with the layout of the TI-Nspire™ CX CAS.

**Step 1:**

Locate the Touchpad. The Touchpad is used to navigate the cursor around the screen. What appears in the center of the Touchpad?

**Step 2:**

Locate the keys to the left of the Touchpad. How do some of these keys compare in name and location to keys on a computer keyboard?

**Step 3:**

Note the light blue color of the commands that appear above many of the keys. Which key do you push to access the light blue options on the keypad?

**Step 4:**

Many of the traditional shortcut keys used with computer software are available on a TI-Nspire™ CAS handheld. For example, [ctrl] [C] and [ctrl] [V] are shortcuts for **Copy** and **Paste**, respectively.

**Step 5:**

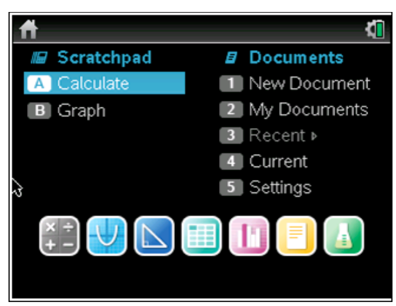
Note the colors of various keys and the location of the alphabet keys. What do you notice about the arrangement of the keys?

**Step 6:**

Where are the buttons for adding, subtracting, multiplying, and dividing located?

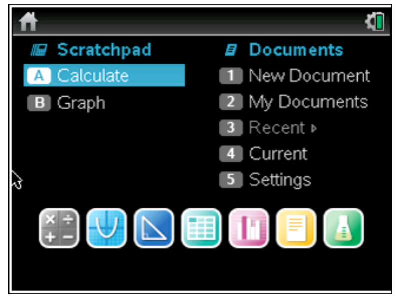
**Step 7:**

Press [⌂on] to turn on the handheld. If the Home Screen is not displayed, press [⌂on] again. Look at the available options. Use the [tab] key to move to each of the Home Screen options. Note the applications available on the bottom row of the Home Screen.



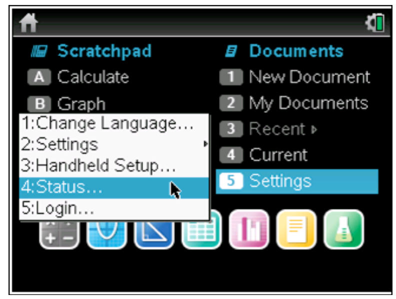
**Step 8:**

Note the **Scratchpad** options available on the left hand side of the screen and the icon in front of the **Scratchpad**. Locate the **Scratchpad** key on the handheld.



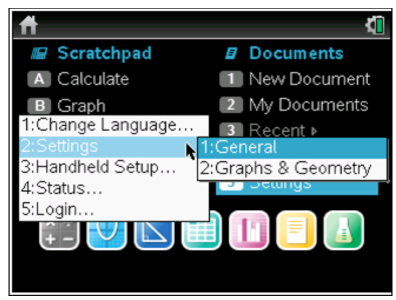

**Step 9:**

Select **Settings** and choose **4: Status**. You will find the available memory and battery status noted on the following screen. Press esc or press to choose **OK** to exit the **Status** menu.



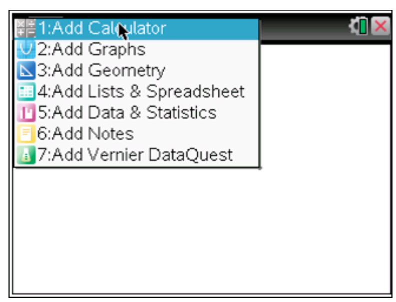

**Step 10:**

Select **Settings** again. Note the other options and explore the various **General** settings and the **Graphs & Geometry** settings. Press esc or press to choose OK to exit the Settings menu.



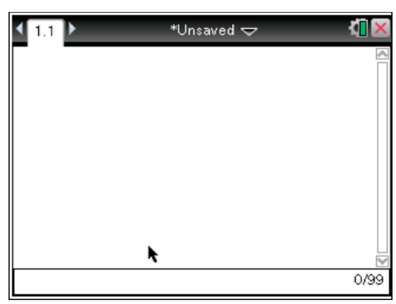

**Step 11:**

From the Home Screen, select **New Document** to start a new document. If prompted to save the current document, select **No**. Select **1:Add Calculator**. A blank *Calculator* page appears on the screen and a tab labeled **1.1** is displayed in the top-left corner of the screen.




**Step 12:**

Using the Touchpad, move the cursor to the icon to the left of the red **x** in the upper-right corner of the screen. What information is provided?

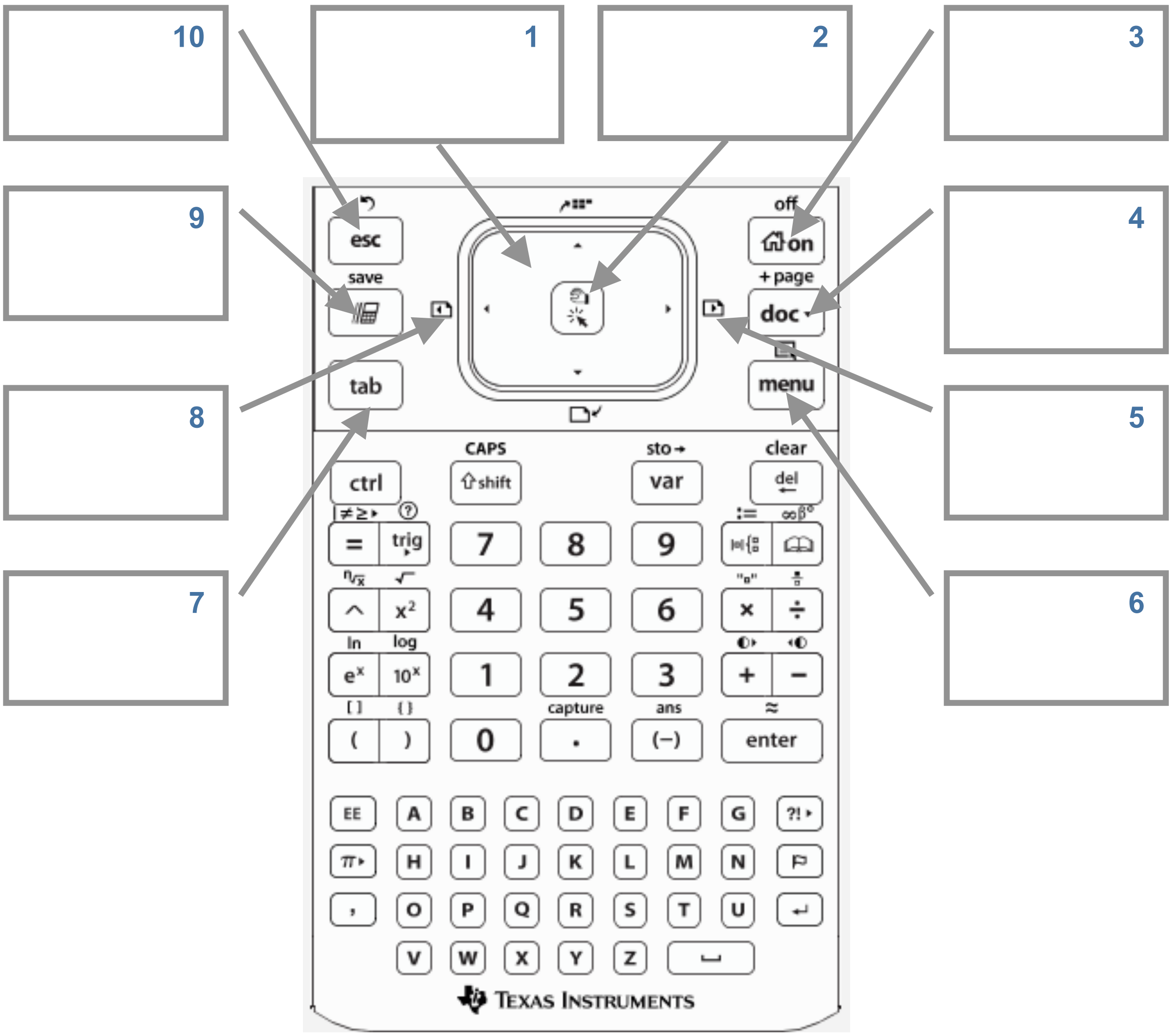


# TI-Nspire™ CX Family Touchpad Overview

**TI PROFESSIONAL DEVELOPMENT**

**Activity Overview:**

*In this activity you will become familiar with the most commonly used keys on the TI-Nspire™ CX and TI-Nspire™ CX CAS handhelds.*



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# The *Calculator* Application

**TI PROFESSIONAL DEVELOPMENT**



## Activity Overview

This activity explores various menus and templates available in the *Calculator* application.

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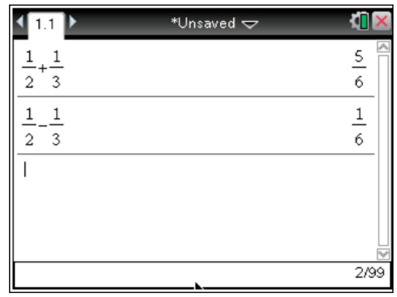
**Step 1:**

Choose **New Document** and add a *Calculator* application. If you are on the Home screen, select **Current** to return to the document with the *Calculator* application.

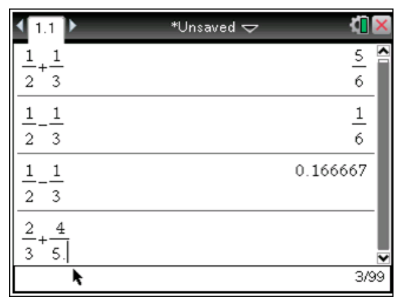



**Step 2:**

Press the templates key to access the templates. Select the first option on the first row for the fraction template. Practice adding and subtracting fractions.

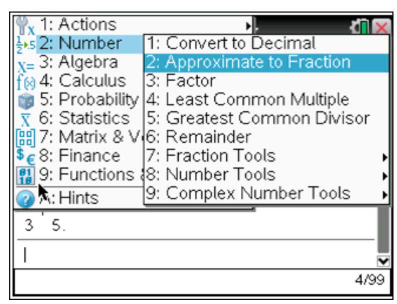
**<u>Note</u>:** You can also press `ctrl` `÷` to access the fraction template. Use the Touchpad arrow keys or press `tab` to move from numerator to denominator.

**<u>Note</u>:** To find the decimal value (usually displayed at a maximum of 6 digits), press `ctrl` `enter`.




**Step 3:**

Enter another fraction problem and add a decimal after any numerator or denominator. Press `enter`.




**Step 4:**

To convert the last answer from a decimal back into a fraction, select **Menu > Number > Approximate to Fraction**, and press `enter`.

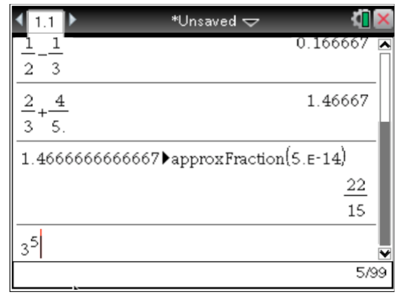
**<u>Note</u>:** The value within the parentheses is the tolerance for this command.

**Step 5:**

To raise a number to a power, first enter the base. Press [^], and enter the exponent. Press [enter].

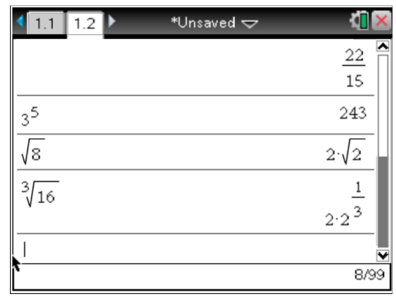
<u>**Note**</u>: The cursor is still in the exponent box after entering the exponent. If a further calculation is needed, press ▶ to exit the exponent box.

<u>**Note**</u>: Pressing  and selecting the second option in the first row will also access the exponent template.




**Step 6:**

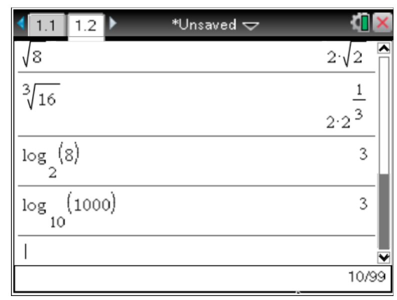
To determine a root, press [ctrl] [$x^2$] for the square root or [ctrl] [^] for the *n*th root. Use the root template and evaluate different problems.




**Step 7:**

To calculate a logarithm to any base, press [ctrl] [$10^x$].

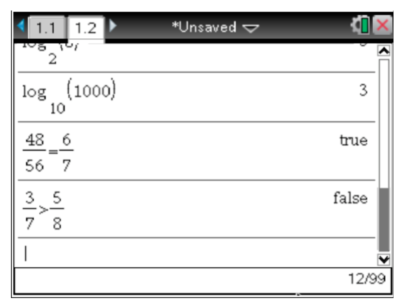
<u>**Note**</u>: If the base is not specified, then the logarithm will be evaluated as base 10. The logarithm template can also be accessed by pressing .




**Step 8:**

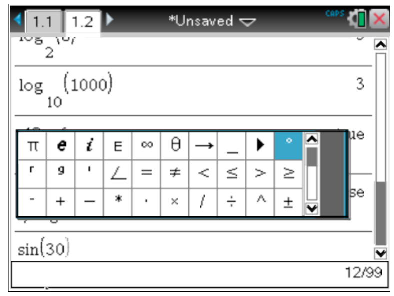
To check the truth value of a statement, enter the statement, and then press [enter].

<u>**Note**</u>: To access the inequality symbols, press [ctrl] [=].



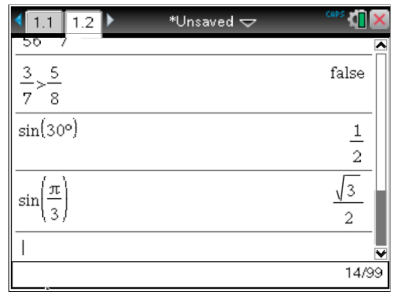
**Step 9:** To evaluate a trigonometric ratio in degrees without changing to degree mode:

- Press [trig] to access the trigonometric ratios, and then select the required ratio.
- After entering the angle to be evaluated, press [ctrl] [📖] to access the symbol palette.
- Select the degree symbol and press [enter]. Press [enter] to evaluate the trigonometric ratio.



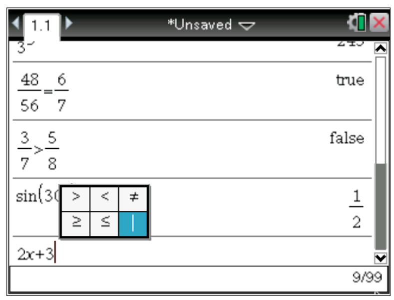

**Step 10:** To copy and paste a previous line that you would like to edit, press ▲ until the line is highlighted, and press [enter] to paste the desired line into the current line. Edit the line as needed and press [enter] to execute the line.

**Note:** To access the π symbol, press [π▸].

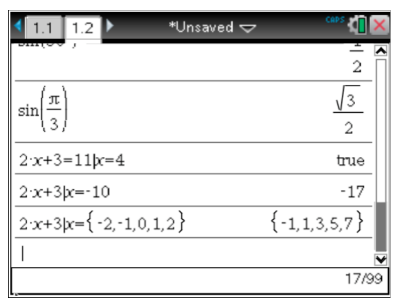



**Step 11:**

To check an equation or to evaluate an expression, use the **such that** command by pressing [ctrl] [=].




**Note:** To access the braces, press [ctrl] [ ) ].

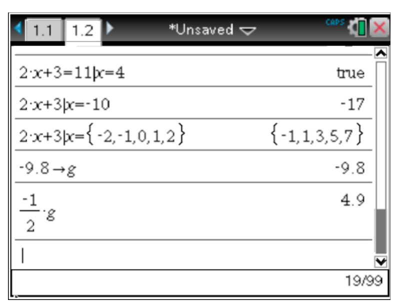



**Step 12:**

To store a value to a variable, enter the value and press [ctrl] [var] and then the name of the variable; then, press [enter].

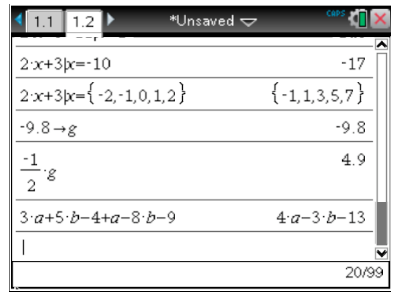
**Step 13:**

You can use the stored value by typing the name of the variable when you are performing a calculation.



**Step 14:**

Simplify an algebraic expression using the alpha and numeric keys to enter the expression.

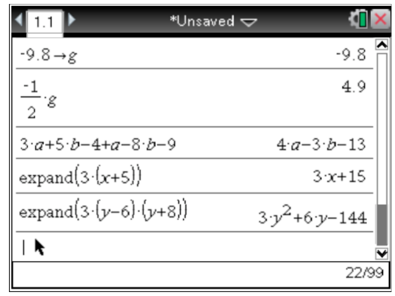



**Step 15:**

To expand an expression, press **Menu > Algebra > Expand** and enter the expression within the set of parentheses. Press [enter].

<u>**Note**</u>**:** You can also type the word **expand** and then the expression.

<u>**Note**</u>**:** It is a good habit to press [×] between sets of parentheses or wherever implied multiplication is needed. If it is omitted, the command will still be executed, but other commands require the multiplication symbol.



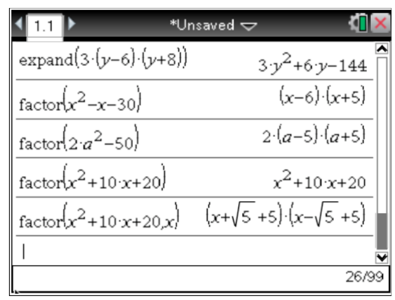

**Step 16:**

To factor an expression, press **Menu > Algebra > Factor** and enter the expression within the set of parentheses. Press [enter].

<u>**Note**</u>**:** There is a **Factor** command available in the **Number** menu as well. The **Factor** command in the **Algebra** menu and the **Factor** command in the **Number** menu are identical.

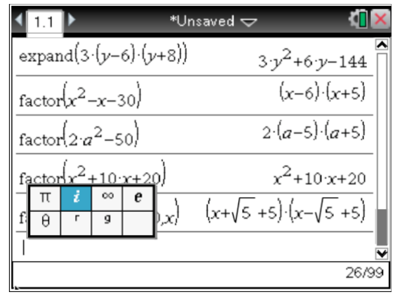
<u>**Note**</u>**:** The default for the **Factor** command is to factor over the integers. Therefore, an expression that is not factorable (e.g., $x^2$ + 10$x$ + 20) will be returned as the result if you try to factor it with the **Factor** command.

However, if you press [,] [X] after the expression within the parentheses, the expression will be factored over the real numbers.

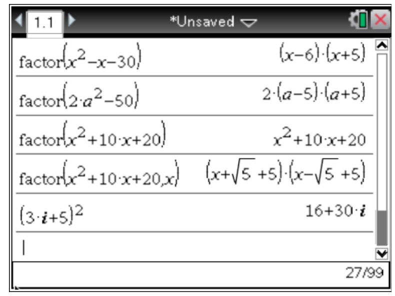


**Step 17:**

To evaluate an expression using the imaginary unit, press [π▸] and select it from the template.

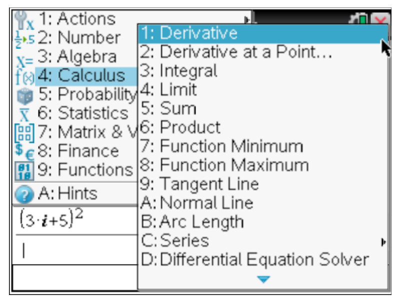



**Note:** There is a difference between the letter/variable [I] and the imaginary unit accessed through the templates.

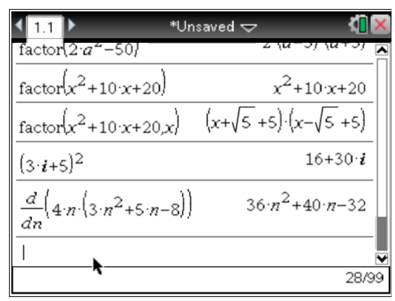



**Step 18:**

Press **Menu > Calculus > Derivative** to paste the derivative template into the current line. You must enter the expression and the variable for the derivative.

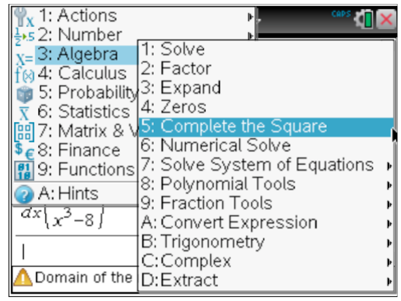


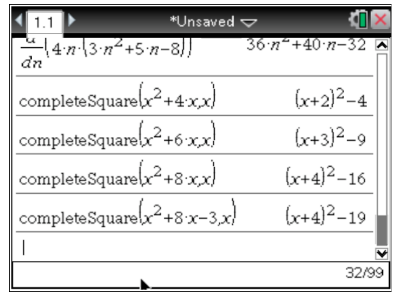

**Note:** Omitting the multiplication symbol before the parentheses in this example will result in an error. Please see note above in Step 15 regarding implied multiplication.



**Step 19:**

Press **Menu > Algebra > Complete the Square**. You must enter the expression, press [,], and then the enter variable within the parentheses in the expression.

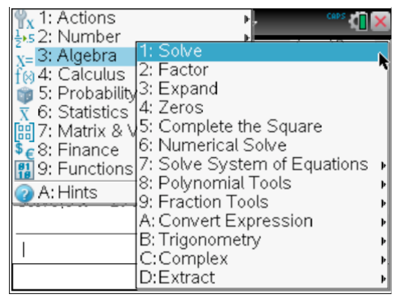


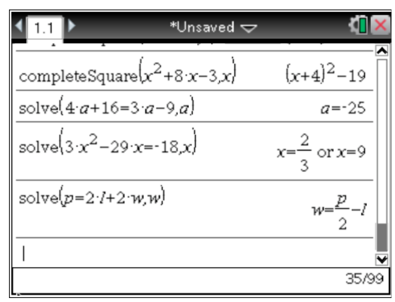




**Note:** The copy-and-paste sequence was used in the examples at right provided to quickly edit the expression.

**Step 20:**

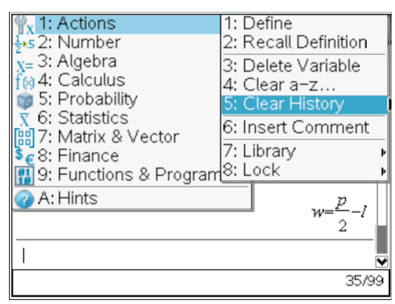
To solve an equation, press **Menu > Algebra > Solve**. You must enter the equation, press [,], and then the enter variable within the parentheses in the expression that you wish to solve for.




**Step 21:**

The **xx/99** in the lower-right corner of the screen is the number of lines in the history of the *Calculator* application that have been executed. To clear the *Calculator* screen, select **Menu > Actions > Clear History**.




**Note:** You can also clear the history by pressing [ctrl] [menu] on any *Calculator* line. This is the equivalent to the right-click on a computer mouse. Note the other options available when you press [ctrl] [menu].

# Factoring with CAS

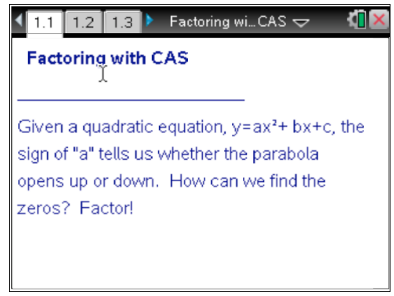
## Student Activity

**Name** ____________

**Class** ____________

**Open the TI-Nspire™ document Factoring_with_CAS.tns.**

You will investigate what types of quadratic equations can be factored by changing the values of the parameters in the quadratic equation. You will then explore how the value of the discriminant is related to the quadratic equations.




**Move to page 1.2.**

Read the instructions on page 1.2.

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

**Move to page 1.3.**

1. Record the standard form and factored form of three equations that have two zeros.

| | **Equation 1** | **Equation 2** | **Equation 3** |
|---|---|---|---|
| **Standard form** | | | |
| **Factored form** | | | |

2. What should the value of the discriminant be for a quadratic equation that has two zeros that are integer values?

3. What is the relationship between the two zeros and the factored form of the quadratic equation?

4. Record the standard form and factored form of three equations that have one zero.

| | **Equation 1** | **Equation 2** | **Equation 3** |
|---|---|---|---|
| **Standard form** | | | |
| **Factored form** | | | |

# Factoring with CAS

**Student Activity**

**Name** ________________

**Class** ________________

5. What will be the value of the discriminant for a quadratic equation that has one zero that is an integer value?

6. What is the relationship between the one zero and the factored form of the quadratic equation?

7. Record the standard form of three equations that have no zeros.

| | **Equation 1** | **Equation 2** | **Equation 3** |
|---|---|---|---|
| **Standard form** | | | |

8. What will be the value of the discriminant for a quadratic equation that has no zeros?

**Move to page 1.4.**
Answer the questions on page 1.4.

**Move to page 2.1.**
Read the instructions on page 2.1.

**Move to page 2.2.**

9. Record the standard form and factored form of three equations that have two zeros.

| | **Equation 1** | **Equation 2** | **Equation 3** |
|---|---|---|---|
| **Standard form** | | | |
| **Factored form** | | | |

10. What will be the value of the discriminant for a quadratic equation that has two zeros that are integer values?

Name ________________
Class ________________

11. What is the relationship between the two zeros and the factored form of the quadratic equation?

**Move to page 3.1**

Read the instructions on page 3.1.

**Move to page 3.2.**

12. Record the standard form and factored form of three equations that have two zeros.

| | **Equation 1** | **Equation 2** | **Equation 3** |
|---|---|---|---|
| **Standard form** | | | |
| **Factored form** | | | |

13. What do you notice about the zeros?

14. What must be true of the value of *c* for you to factor a difference of squares?

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# Factoring with CAS



## Math Objectives

- Students will connect the zeros of a quadratic graph with the equation in factored form.
- Students will identify the number of zeros of a quadratic based on the value of the discriminant.

## Vocabulary

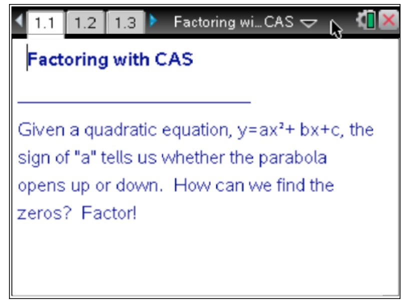
- standard form
- factored form
- zero
- discriminant

## About the Lesson

- This lesson involves changing the values of the parameters of a quadratic equation to connect the zeros of the graph with the equation in factored form.
- As a result, students will:
  - Change the values of sliders and associate the values of the zeros with the corresponding values in the equation in factored form
  - Make and confirm a conjecture describing the relationship between the number of zeros and the sign of the discriminant

## TI-Nspire™ Navigator™ System

- Use **Screen Capture** to examine patterns that emerge.
- Use **Live Presenter** to allow students to explain their findings.




**TI-Nspire™ Technology Skills:**

- Download a TI-Nspire™ document
- Open a document
- Move between pages
- Change the values of sliders

**Tech Tips:**

- Make sure the font size on your TI-Nspire™ handhelds is set to Medium.

**Lesson Files:**

*Student Activity*

Factoring_with_CAS_Student.pdf

Factoring_with_CAS_Student.doc

*TI-Nspire™ document*

Factoring with CAS.tns

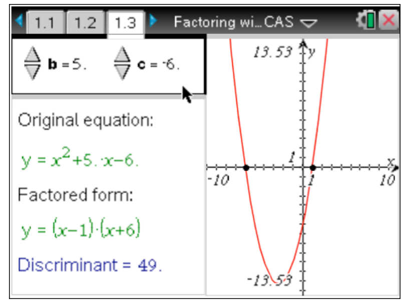
## Discussion Points and Possible Answers

**Tech Tip:** If students experience difficulty changing the value of a slider, they can use the [tab] key to move between objects.

**Move to page 1.2.**

Read the instructions on page 1.2.

**Move to page 1.3.**




1. Record the standard form and factored form of three equations that have two zeros.

**Teacher Tip:** Students should change one parameter at a time. They should look at positive and negative values of *b* and *c*.

**Sample answers**:

| | Equation 1 | Equation 2 | Equation 3 |
|---|---|---|---|
| **Standard form** | $y = x^2 + 5x - 6$ | $y = x^2 + 4x - 12$ | $y = x^2 - 2x - 3$ |
| **Factored form** | $y = (x - 1)(x + 6)$ | $y = (x - 2)(x + 6)$ | $y = (x - 3)(x + 1)$ |

2. What should the value of the discriminant be for a quadratic equation that has two zeros that are integer values?

**Sample answer**: The discriminant should be a perfect square.

3. What is the relationship between the two zeros and the factored form of the quadratic equation?

**Sample answer**: The zeros of the graph, *s* and *t*, match the values in the equation written in factored form $y = (x - s)(x - t)$.

4. Record the standard form and factored form of three equations that have one zero.

**Sample answers**:

| | Equation 1 | Equation 2 | Equation 3 |
|---|---|---|---|
| **Standard form** | $y = x^2 + 6x + 9$ | $y = x^2 + 2x + 1$ | $y = x^2 - 4x + 4$ |
| **Factored form** | $y = (x + 3)^2$ | $y = (x + 1)^2$ | $y = (x - 2)^2$ |

5. What will be the value of the discriminant for a quadratic equation that has one zero that is an integer value?

   **Sample answer:** The discriminant will be 0.

6. What is the relationship between the one zero and the factored form of the quadratic equation?

   **Sample answer:** The one zero is the root of the equation.

7. Record the standard form of three equations that have no zeros.

   **Sample answers**:

| | Equation 1 | Equation 2 | Equation 3 |
|---|---|---|---|
| **Standard form** | $y = x^2 + 6x + 12$ | $y = x^2 - 2x + 2$ | $y = x^2 + 9x + 25$ |

8. What will be the value of the discriminant for a quadratic equation that has no zeros?

   **Sample answer**: The discriminant will be negative.

**Move to page 1.4.**
Answer the questions on page 1.4.

**Sample answers:** $b = s + t$ and $c = (s)(t)$; the discriminant was greater than or equal to zero for each quadratic that factored.

**Move to page 2.1**
Read the instructions on page 2.1.

**Move to page 2.2.**
9. Record the standard form and factored form of three equations that have two zeros.

   **Sample answers**:

| | Equation 1 | Equation 2 | Equation 3 |
|---|---|---|---|
| **Standard form** | $y = 2x^2 + 2x - 4$ | $y = 5x^2 - 3x - 2$ | $y = 4x^2 - 8x - 5$ |
| **Factored form** | $y = 2(x - 1)(x + 2)$ | $y = (x - 1)(5x - 2)$ | $y = (2x - 5)(2x + 1)$ |

10. What will be the value of the discriminant for a quadratic equation that has two zeros that are integer values?

    **Sample answer**: The discriminant will be positive.

11. What is the relationship between the two zeros and the factored form of the quadratic equation?

    **Sample answer**: The two zeros are the roots of the equation.

**Move to page 3.1**

Read the instructions on page 3.1.

**Move to page 3.2.**

12. Record the standard form and factored form of three equations that have two zeros.

    **Sample answers**:

| | **Equation 1** | **Equation 2** | **Equation 3** |
|---|---|---|---|
| **Standard form** | $y = x^2 – 4$ | $y = x^2 – 1$ | $y = x^2 – 9$ |
| **Factored form** | $y = (x – 2)(x + 2)$ | $y = (x – 1)(x + 1)$ | $y = (x – 3)(x + 3)$ |

13. What do you notice about the zeros?

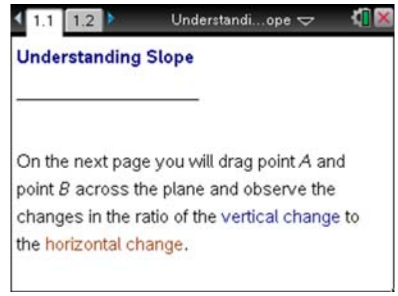
    **Sample answer**: The zeros are symmetrical about the origin and match the roots of the equation.

14. What must be true of the value of *c* for you to factor a difference of squares?

    **Sample answer:** The value of *c* must be a perfect square.

# Understanding Slope
## Student Activity

**Name** ________________
**Class** ________________




**Open the TI-Nspire™ document Understanding_Slope.**

The slope of a line can be determined using two points on the line. Does it matter which two points you choose? This activity introduces the idea of slope with movable points on a line.

**Move to page 1.2.**

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

1. Following the arrows from point *A* to point *B*, what is the value of the vertical change? Of the horizontal change?

2. Move one or both points until the values for both the vertical and horizontal changes are positive. Describe the line.

3. Write your answer to question 2 in the first row of the table below. Move your points to match each pair of remaining conditions. For each case, describe what the line looks like.

| Vertical Change | Horizontal Change | Does the line rise or fall from left to right? |
|---|---|---|
| Positive | Positive | |
| Positive | Negative | |
| Negative | Positive | |
| Negative | Negative | |

4. What patterns do you observe in your descriptions in the previous table?

5. Set point *A* to (–4, 1).

   a. Where must you place point *B* for the line to rise from left to right?

   b. Where must you place point *B* for the line to fall from left to right?

# Understanding Slope
## Student Activity

6. Set point *A* to coordinates of your choice.

   a. Where must you place point *B* for the line to rise from left to right?

   b. Where must you place point *B* for the line to fall from left to right?

7. Ann says that her point *B* is above and to the right of point *A*. Elizabeth says that her point *B* is below and to the left of point *A*. Jessica says her point *B* is to the right of point *A*. Whose line must rise from left to right? Explain.

8. The slope of a line is defined as the ratio of the vertical change to the horizontal change for any two distinct points on the line.

   a. What relationships must exist between the vertical and horizontal changes to produce a positive slope?

   b. To produce a negative slope?

9. In each question so far, you have been following the arrows from point *A* to point *B*. If you started at point *B* and moved to point *A*, how would that change your previous answers?

## Math Objectives

- Students will identify positive and negative slope.
- Students will know that the sign of the ratio of the vertical and horizontal changes determines the sign of the slope.
- Students will recognize that a positive slope indicates a line is rising from left to right and a negative slope indicates a line is falling from left to right.
- Students will reason abstractly and quantitatively (CCSS Mathematical Practice).
- Students will construct viable arguments and critique the reasoning of others (CCSS Mathematical Practice).

## Vocabulary

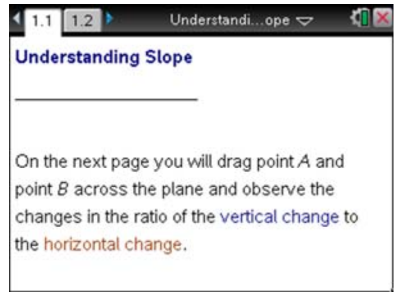
- slope
- vertical change
- horizontal change

## About the Lesson

- This lesson is designed to help students see the connections between the sign of the ratio of the vertical and horizontal change as they relate to the sign of the slope of a line.
- As a result, students will:
  - Move points in the coordinate plane
  - Observe how a line moves
  - Observe the relationships between the signs of the vertical and horizontal change

## TI-Nspire™ Navigator™ System

- Use **Quick Poll** to assess students' understanding.
- Use **Screen Capture** to compare students' lines.
- Collect student documents and analyze the results.
- Use the **Review** and **Portfolio** workspaces to display students' answers.




**TI-Nspire™ Technology Skills:**

- Download a TI-Nspire™ document
- Open a document
- Move between pages
- Grab and drag a point on a line

**Tech Tips:**

- Make sure the font size on your TI-Nspire™ handheld is set to Medium.
- You can hide the function entry line by pressing ctrl G.

**Lesson Files:**

*Student Activity*
Understanding_Slope_
Student.doc

*TI-Nspire document*
Understanding_Slope.tns

Visit www.mathnspired.com for lesson updates and tech tip videos.

## Discussion Points and Possible Answers

**Tech Tip:** If students experience difficulty dragging the point, check to make sure that they have moved the arrow until it becomes a hand (👆) getting ready to grab the point. Then press ctrl 👆 to grab the point and close the hand (✊).

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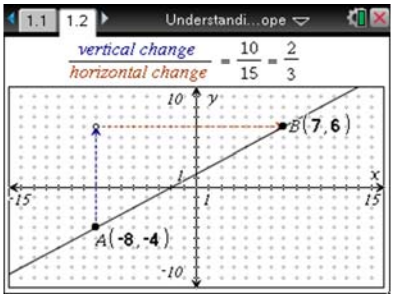
**Move to page 1.2.**




1. Following the arrows from point *A* to point *B*, what is the value of the vertical change? Of the horizontal change?

   **<u>Answer:</u>** The vertical change is the number of units counted up/down on the triangle (height of the slope triangle). The horizontal change is the number of units counted left/right on the triangle (length of the slope triangle).

**Teacher Tip:** The main point here is to focus on the amount of the vertical and horizontal changes. Students can determine this by simply counting the number of units. Some students might say something about subtracting the coordinates. If so, this would be a good opportunity to discuss the slope formula. If students want to talk only about looking at the fraction at the top of the graph screen, emphasize counting to determine each change.

2. Move one or both points until the values for both the vertical and horizontal changes are positive. Describe the line.

   **<u>Answer:</u>** The graph rises (goes up) from left to right.

**TI-Nspire™ Navigator™ Opportunity: Quick Poll and/or Screen Capture**
**See Note 1 at the end of this lesson.**

**Teacher Tip:** The main point of this question is to identify the characteristics of a positive slope. If any students want to talk about steepness, encourage the discussion, and then focus on the idea that no matter how steep the line is, it will rise from left to right.

**Tech Tip:** It is possible to move point *A* or point *B* outside of the grid of the coordinate plane. If this happens, simply move the point(s) back to the coordinate plane.

3. Write your answer to question 2 in the first row of the table below. Move your points to match each pair of remaining conditions. For each case, describe what the line looks like.

**Answer:** The completed table is below.

| Vertical Change | Horizontal Change | Does the line rise or fall from left to right? |
|---|---|---|
| Positive | Positive | **Rise** |
| Positive | Negative | **Fall** |
| Negative | Positive | **Fall** |
| Negative | Negative | **Rise** |

4. What patterns do you observe in your descriptions in the previous table?

**Answer:** When the ratio is positive (same signs), the line rises from left to right. When the ratio is negative (opposite signs), the line falls from left to right.

**Teacher Tip:** Students might observe patterns in steepness. Direct discussion toward identifying whether the line is rising or falling from left to right.

5. Set point *A* to (–4, 1).

   a. Where must you place point *B* for the line to rise from left to right?

   **Answer:** Point *B* must be above and to the right of point *A* or below and to the left of point *A*.

   b. Where must you place point *B* for the line to fall from left to right?

   **Answer:** Point *B* must be below and to the right of point *A* or above and to the left of point *A*.

**Teacher Tip:** You might also ask students to write inequalities for the conditions of the coordinates. For example, in the first question, in order for the line to rise, $x > -4$ and $y > 1$ (or $x < -4$ and $y < 1$) must be true for point *B*. Similarly, in order for the line to fall, $x > -4$ and $y < 1$ (or $x < -4$ and $y > 1$) must be true for point *B*.

6. Set point *A* to coordinates of your choice.

   a. Where must you place point *B* for the line to rise from left to right?

      **Answer:** Point *B* must be above and to the right of point *A* or below and to the left of point *A*.

   b. Where must you place point *B* for the line to fall from left to right?

      **Answer:** Point *B* must be below and to the right of point *A* or above and to the left of point *A*.

7. Ann says that her point *B* is above and to the right of point *A*. Elizabeth says that her point *B* is below and to the left of point *A*. Jessica says her point *B* is to the right of point *A*. Whose line must rise from left to right? Explain.

   **Answer:** Both Ann's and Elizabeth's lines rise from left to right. Jessica's line will sometimes rise from left to right, but not always (depending on whether point *B* is above point *A*).

   > **Teacher Tip:** Although students might think point *B* being to the right of point *A* is sufficient to ensure a positive slope, it is important for them to understand it is not.

8. The slope of a line is defined as the ratio of the vertical change to the horizontal change for any two distinct points on the line.

   a. What relationships must exist between the vertical and horizontal changes to produce a positive slope?

      **Answer:** Same signs produce a positive slope (rising from left to right).

   b. To produce a negative slope?

      **Answer:** Different signs produce a negative slope (falling from left to right).

   > **Teacher Tip:** This is the main point of the lesson. Guide the discussion toward the ratio of the signs of horizontal and vertical change. Some students might still have trouble remembering the rules for division with two signed numbers. Remind them that when the signs are the same, the quotient is positive, and when they are opposite, the quotient is negative.

9. In each question so far, you have been following the arrows from point *A* to point *B.* If you started at point *B* and moved to point *A*, how would that change your previous answers?

**Answer:** Each sign for the horizontal and vertical change would be the opposite, but the ratio of signs would still be the same (meaning the slope would still be the same whether you move from point *A* to point *B* or from point *B* to point *A*).

> **Teacher Tip:** Have students explain this in their own words. This is an important point for the students to realize, and many might not immediately make the connection.

## Extension

10. What relationships exist between the coordinates of points *A* and *B* and the slope of the line passing through them?

**Answer:** The coordinates can be used to determine the signs of the vertical and horizontal changes, and the ratio of the signs determines whether the slope will be positive or negative.

> **Teacher Tip:** This question is designed to look ahead at the formula for slope. Not all students will be able to see how the values for change were calculated using the coordinates (for example, change in *y* over change in *x*).

**TI-Nspire™ Navigator Opportunity: Quick Poll**
**See Note 2 at the end of this lesson.**

## Wrap Up

Upon completion of the discussion, the teacher should ensure that students understand:

- That the ratio of the signs of the vertical and horizontal changes determines the sign of slope of a line
- How to use the ratio of the vertical change to the horizontal change to determine whether the slope of a line is positive or negative
- That a positive slope indicates that a line rises from left to right and a negative slope indicates that a line falls from left to right

## TI-Nspire™ Navigator

**Note 1**

**Question 2, Quick Poll and/or Screen Capture:** You may want to take **Screen Captures** of student work to show the different possible lines with positive slopes.

**Note 2**

**Questions 8, 9, and 10, Quick Poll:** You may want to send a **Quick Poll** to determine whether students have reached the proper conclusions about lines with positive and negative slopes.

# The *Graphs* Application—Part One

**TI Professional Development**

**Teacher Notes**

## Activity Overview:

In this activity, you will graph a function, display a table of values for a function, and transform a function.

## Part One—Graphing a Linear Function and Displaying a Table

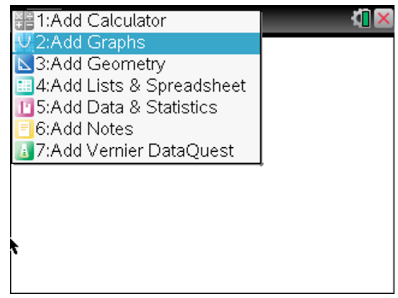
**Step 1:**

Press [on], and select **New Document** to start a new document.

**Step 2:**

Choose **Add Graphs**.

**Note:** To add a new *Graphs* page to an existing document, press [ctrl] [doc▾] and choose **Add Graphs**. Alternatively, press [on] and select .

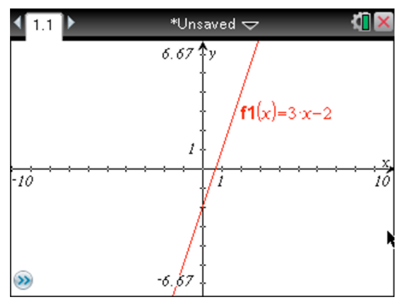



**Step 3:**

The cursor will be in the entry line at the bottom of the screen, to the right of "**f1**(*x*) =". To graph **f1**(*x*) = 3*x* – 2, type in **3*x* – 2** by pressing [3] [X] [–] [2].

> **Teacher Tip**: Before they press [enter], ask students to predict the shape of the graph.

Press [enter] to graph.

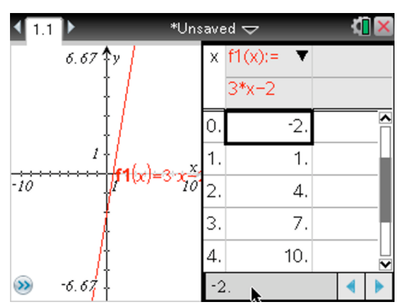



<u>**Note**</u>: If desired, the function definition (label) may be moved to another location on the screen. Move the cursor to hover over the function label. When the word **label** appears, you may use the Touchpad to move the label. Press [click] or [enter] to "drop" the label.

**Step 4:**

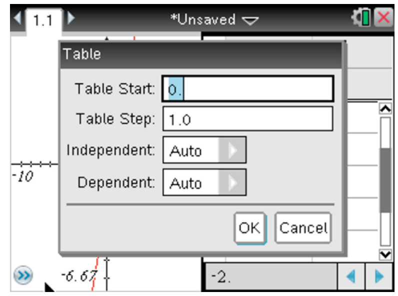
To insert a table of values, press [ctrl] [T]. The table will be inserted to the right of the graph. You can navigate within the table to view the values of each function for a specific *x*-value.

**Note:** The dark rectangle around the table indicates that the application is active. To move from one application work area to another, press [ctrl] [tab] or use the Touchpad and press [click] to select the desired application.



**Step 5:**

To change the table settings, press **Menu > Table > Edit Table Settings**. Edit the settings, as desired, and press enter or click **OK** when done.




**Step 6:**

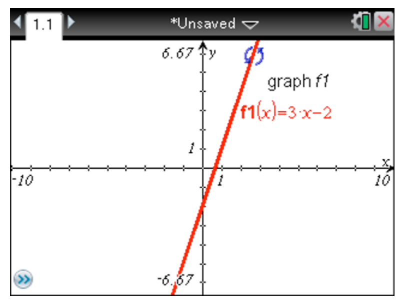
To hide the table, first click on the *Graphs* application side of the page to select that application. Then, press ctrl T to hide the table. Alternatively, in the *Graphs* application, press **Menu > View > Hide Table**.

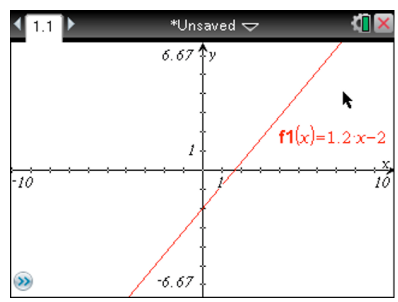
## Part Two – Transforming a Linear Function

**Step 1:**

Using the Touchpad, move the cursor near the graph of the function. As the cursor moves toward certain regions of the graph of a linear function, two different tools—the **Rotation** tool and the **Translation** tool—may be displayed.

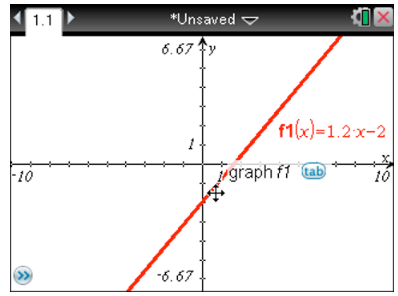
To rotate the line, move the cursor to the graph of the line near the edge of the graph screen. When the rotation symbol ( ) appears, press ctrl to grab the line. Use the Touchpad to rotate the graph. When finished, press or esc.

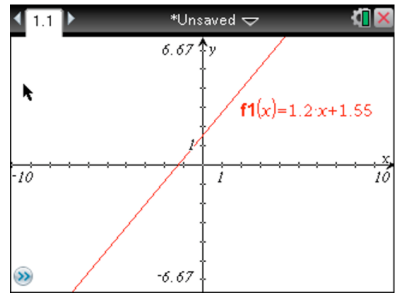


**Step 2:**

To translate the line, move the cursor to the graph of the line in the center of the screen. When the translation symbol (✥) appears, press ctrl [click] to grab the line. Use the Touchpad to translate the graph. When finished, press [click] or esc.



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# Walk a Line
## Student Activity

Name ____________

Class ____________

### Activity Overview

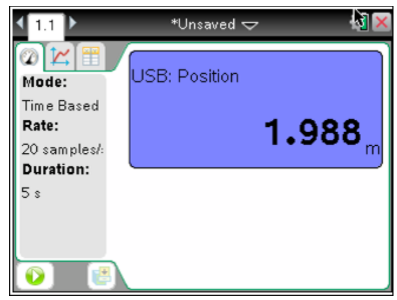
This activity will introduce the CBR 2™ and the *Vernier DataQuest*™ application. You will collect and analyze linear data.

### Materials

- CBR 2™
- USB Connection Cable for CBR 2™

**Step 1:**

Connect the CBR 2™ to the handheld with the USB cable. A *Vernier DataQuest*™ application page will automatically open and the CBR 2™ will begin measuring the position of the closest object.

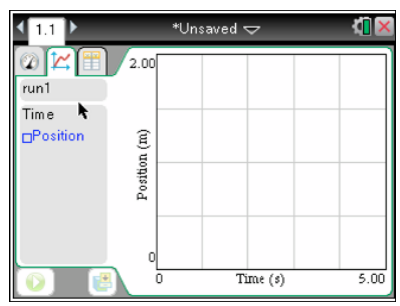



**Step 2:**

Work in groups of two. One person will operate the TI-Nspire™ and point the CBR 2™ toward the other partner, the "walker." The walker should be standing approximately two meters from the motion detector. The walker will walk slowly toward the motion detector at a constant velocity.

**Step 3:**

Before collecting the data, make a prediction of what the graph of position versus time should look like. Sketch your prediction on the grid to the right.




**Step 4:**

The calculator operator should click the green **Start** button in the lower left corner of the screen. The walker should walk SLOWLY toward the CBR 2™ at a constant velocity to close the gap in approximately 5 seconds. Don't go too fast or you will run out of room and need to try again. You must walk at the same velocity the entire time.

# Walk a Line
**Student Activity**

**Name** ____________
**Class** ____________

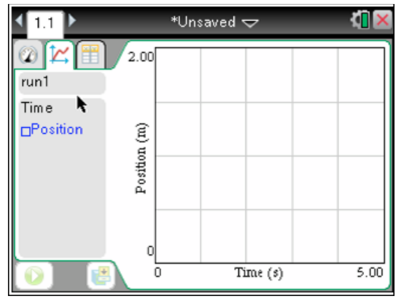
**Step 5:**

Graphs for position versus time and velocity versus time are created and displayed on the same screen. Repeat as necessary until you generate a graph for position versus time that is roughly linear. How does the graph compare with your prediction?

**Step 6:**

To display only the position versus time graph, press **Menu > Graph Settings > Show Graph > Graph 1**.

Sketch the actual graph of your position versus time graph on the grid shown to the right.




**Step 7:**

**Manual Analysis of Data**

a. How can you estimate the average velocity of the walker?

b. What was the position of the walker at time $t$ = 0 seconds? At time $t$ = 5 seconds?

c. Show your work to calculate the slope of the graph using your positions at time $t$ = 0 seconds and $t$ = 5 seconds.

d. What does the slope of the graph represent physically?

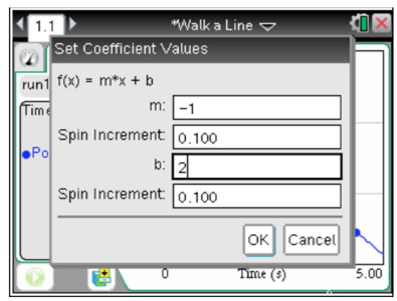
e. Why is the velocity negative?

f. Linear functions are usually written in the form **f**($x$) = $mx + b$. Determine the $y$-intercept of your line and write an equation that you think will model the data.

g. What does the $y$-intercept represent?

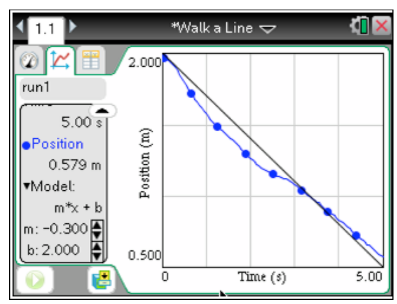
**Step 8:**

Press **Menu > Analyze > Model**. Select **m*x + b** to create a linear model by clicking **OK**. Type your values calculated manually from above in the fields for $m$ and $b$ and click **OK**.



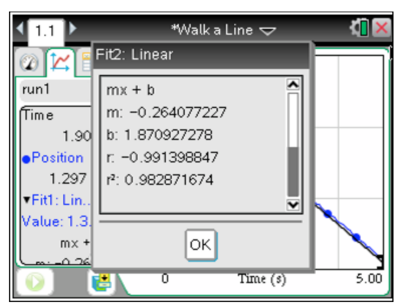

**Step 9:**

The model can be adjusted by clicking the slider arrows on the left side of the screen or by changing the values of $m$ and $b$ manually. See the sample shown to the right. If you made adjustments, record the new values below.




**Step 10:**

To analyze the data with a regression, a linear curve fit can be performed within the *Vernier DataQuest*™ application. Press **Menu > Analyze >Curve Fit > Linear**. This will give the equation of the linear regression model. You will have to scroll down the dialog box to see the values of $m$ and $b$ for the linear model. Record the values for $m$ and $b$ below.

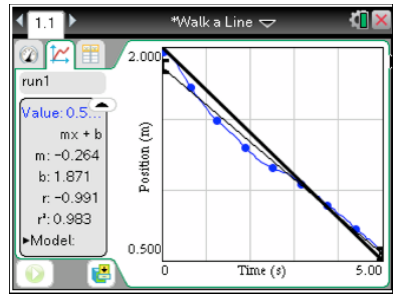


# Walk a Line
## Student Activity

Name ___________
Class ___________

**Step 11:**

Click **OK** to see the graphical results of the regression. How does your linear regression compare with the equation you found in Step 9? How do the values for *m* and *b* compare?




**Discussions/Explorations**

1. As you may have gathered from your practice trials, the CBR 2™ collects data measuring how far an object is located from the sensor. By walking in front of the CBR 2™, collect a set of data which appears linear and has a positive slope. Provide a detailed description of your walk. Be sure to discuss the real-world connections for the slope and *y*-intercept of the model.

2. By walking in front of the CBR 2™, collect a set of data that appears linear and has a slope that is approximately zero. Provide a detailed description of your walk, including the connection between slope and *y*-intercept and the physical actions.

3. By walking in front of the CBR 2™, collect a set of data that represents a piecewise function with two parts, both of which are linear—one with a positive slope and one with a negative slope. Provide a detailed description of your walk, including the connections between slope and *y*-intercept and the physical actions.

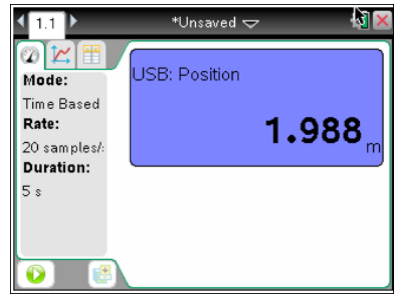
# Walk a Line

**TI PROFESSIONAL DEVELOPMENT**



## Math and Science Objectives

- Students will find the slope and *y*-intercept of a linear equation to model position versus time data.
- Students will explain the relationship between a position-time graph and the physical motion used to create it.
- Students will model with mathematics. (CCSS Mathematical Practice)




**TI-Nspire™ Technology Skills:**

- Collect motion data with the *Vernier DataQuest™* application.
- Run a linear regression in the *Vernier DataQuest™* application.

## Vocabulary

- linear equation
- position
- speed
- velocity
- average velocity

## About the Lesson

- In this lesson, students collect data by moving at a constant velocity in front of a CBR 2™.
- As a result, students will:
  - Develop a linear model for a scatter plot of position versus time data
  - Make a real-world connection between a linear equation used to model the data and the physical motion involved in the data collection process

## Materials Note

- CBR 2™ with USB CBR 2–to–calculator cable.
- Using the CBR 2™ with a computer requires the use the mini-standard USB adaptor to plug the CBR 2™ into a computer with TI-Nspire™ Teacher or Student Software. This adapter will convert the CBR 2™ USB cable to a standard USB connection so that it can be connected to the computer.
- **New option**: Use the legacy CBR™ with the new TI-Nspire™ Lab Cradle. You will need the MDC-BTD cord to connect a motion detector to the TI-Nspire™ Lab Cradle. With the Lab Cradle, you can even connect multiple motion detectors to extend your exploration.

**Tech Tips:**

1. Flip the motion detector open. Set the switch to normal.
2. Check that the four AA batteries in the motion detector are good.
3. Unplug and plug the CBR 2 back in.
4. When using an older CBR or motion detector with the Lab Cradle, you may need to launch *Vernier LabQuest™*. Then select **Menu > Experiment > Advanced Setup > Configure Sensor > TI-Nspire Lab Cradle: dig1 > Motion Detector**.

**Lesson Files:**

*Student Activity*
Walk_a_Line_Student.pdf
Walk_a_Line_Student.doc

## TI-Nspire™ Navigator™ System

- Use **Screen Capture** to monitor student progress and compare students' mathematical models.
- Use **Live Presenter** so that a student may demonstrate various steps in the modeling process.
- Share data via **File Transfer**, if desired.

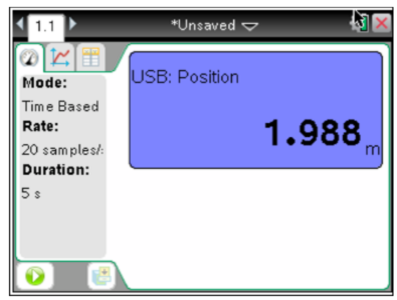
Visit www.mathnspired.com for lesson updates and tech tip videos.

## Discussion Points and Possible Answers

**Tech Tip:** The *Vernier DataQuest*™ application is user friendly. It should launch when the CBR 2™ is connected. To begin the data collection, click the green Play button ( ) in the lower-left corner of the screen.

**Step 1:**

Connect the CBR 2™ to the handheld with the USB cable. A *Vernier DataQuest*™ application page will automatically open and the CBR 2™ will begin measuring the position of the closest object.



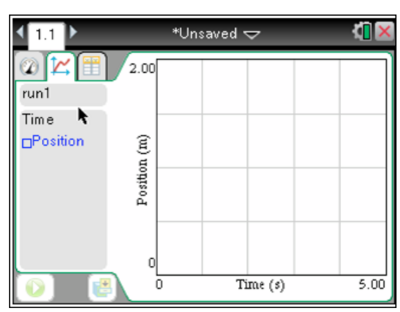

**Teacher Tip:** When the CBR 2™ is first connected, it begins clicking and recording measurements. Have the students move the CBR 2™ and point it at different objects. Ask them what the motion detector is doing. It should be measuring the distance from the CBR 2™ to the object directly in front of it. We call this the position of the object with respect to the CBR 2™. Be aware that it reads the position of the closest object in its path, so students should have an open area between the CBR 2 and the student whose position they will measure.

**Step 2:**

Work in groups of two. One person will operate the TI-Nspire™ and point the CBR 2™ toward the other partner, the "walker." The walker should be standing approximately two meters from the motion detector. The walker will walk slowly toward the motion detector at a constant velocity.

**Step 3:**

Before collecting the data, make a prediction of what the graph of position versus time should look like. Sketch your prediction on the grid to the right.




**Answer:** Predictions will vary.

> **Teacher Tip:** It is important for students to make a prediction before simply pressing the **Play** button. Making predictions and testing those predictions supports higher-level thinking.

**Step 4:**

The calculator operator should click the green Start button in the lower left corner of the screen. The walker should walk SLOWLY toward the CBR 2™ at a constant velocity to close the gap in approximately 5 seconds. Don't go too fast or you will run out of room and need to try again. You must walk at the same velocity the entire time.

> **Teacher Tip:** Students often cannot get the timing right at the beginning of this activity. You may want to suggest that the recording partner press the enter key to begin data collection after the walker starts walking. This gives students a better opportunity to collect linear data for the entire collection time period. You may also want to remind students that they must walk slowly at a constant velocity.

**Step 5:**

Graphs for position versus time and velocity versus time are created and displayed on the same screen. Repeat as necessary until you generate a graph for position versus time that is roughly linear. How does the graph compare with your prediction?

__**Sample answer:**__ Comparisons can include function type (linear, quadratic, etc.), *y*-intercept, and whether the graph is increasing or decreasing.

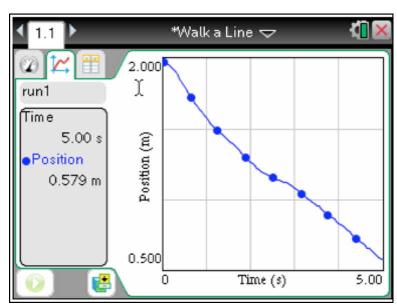
> **Tech Tip:** If the students are not satisfied with their results, they can repeat the data collection by clicking the **Play** button again. This will overwrite the previous trial.

**Step 6:**

To display only the position versus time graph, press **Menu > Graph Settings > Show Graph > Graph 1**.

Sketch the actual graph of your position versus time graph on the grid shown to the right.

__**Sample answer:**__ A sample graph is shown to the right. Since students are all walking toward the CBR 2™, all graphs should show a negative slope.



**Step 7:**

**Manual Analysis of Data**

a. How can you estimate the average velocity of the walker?

**Answer:** Find the change in the position (final – initial) and divide that change in position by the elapsed time.

b. What was the position of the walker at time *t* = 0 seconds? At time *t* = 5 seconds?

**Sample answer:** At time *t* = 0, the position was 2 meters. At time *t* = 5, the position was 0.579 meters. Answers for *t* = 5 will vary but should be a positive value less than 5 given in meters.

c. Show your work to calculate the approximate slope of your line using your positions at time *t* = 0 seconds and *t* = 5 seconds.

**Sample answer:** $\frac{0.579-2}{5-0} = \frac{-1.421}{5} = -0.2842$

Answers will vary, but the slope should be negative.

d. What does the slope of the graph represent physically?

**Answer:** The slope represents the velocity of the walker.

**Teacher Tip:** Some students may answer "speed." This is a great opportunity to explain the difference between speed and velocity. Speed indicates how fast the walker is moving but does not include direction. Since speed has magnitude only, it is referred to as a scalar quantity. Speed is always positive. Velocity is called a vector quantity. It includes both speed and direction. Velocity can be positive or negative for a person moving back and forth along a line. Velocity is positive when the walker moves away from the motion detector, increasing the position, and negative when the walker moves toward the motion detector, decreasing the position.

e. Why is the velocity negative?

**Answer:** The velocity is negative because the position between the walker and the CBR 2™ is decreasing.

f. Linear functions are usually written in the form **f**(*x*) = *mx* + *b.* Determine the *y*-intercept of your line and write an equation that you think will model the data.

**Sample answer:** The *y*-intercept is 2; *y* = –0.2842*x* + 2. Equations will vary but should have *b* = 2 and *y* = the slope from part c in Step 7.

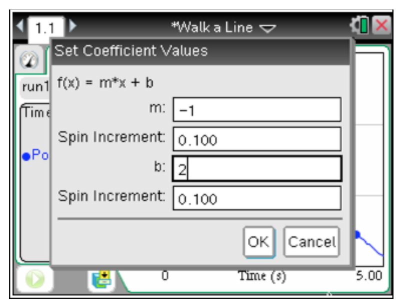
g. What does the *y*-intercept represent?

**Answer:** The *y*-intercept represents the initial or starting position—the distance, in meters, of the walker from the motion detector at time *t* = 0 seconds.

**Teacher Tip:** Students should determine an equation by hand first to practice finding slope and to help make the connections between the physical actions and the mathematical equation. Students will better understand the meaning and physical representations of the slope and *y*-intercept if they write their own model rather than simply run a linear regression.

**Step 8:**

Press **Menu > Analyze > Model**. Select **m*x + b** to create a linear model and click **OK**. Type your values calculated manually from above in the fields for *m* and *b* and click **OK**.

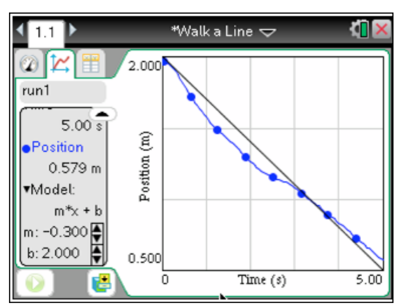



**TI-Nspire™ Navigator™ Opportunity: Live Presenter**
**See Note 1 at the end of this lesson.**

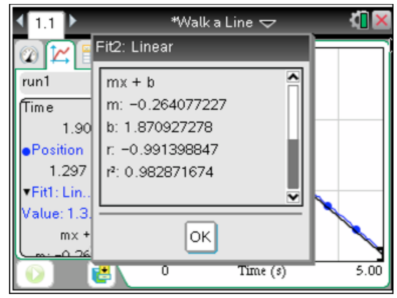
**Step 9:**

The model can be adjusted by clicking the slider arrows on the left side of the screen or by changing the values of *m* and *b* manually. See the sample shown at the right. If you made adjustments, record the new values below.

**Sample answer:** *m* = –0.3, *b* = 2; *y* = –0.3*x* + 2



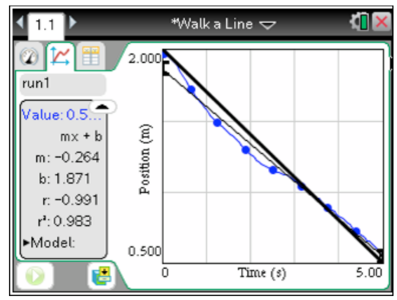
**Step 10:**




To analyze the data with a regression, a linear curve fit can be performed within the *Vernier DataQuest*™ application. Press **Menu > Analyze > Curve Fit > Linear**. This will give the equation of the linear regression model. You will have to scroll down the dialog box to see the values of *m* and *b* for the linear model. Record the values for *m* and *b* below.

**Sample Answer:** $m$ = –0.264077227; $b$ = 1.870927278

**Step 11:**




Click **OK** to see the graphical results of the regression. How does your linear regression compare with the equation you found in Step 9? How do the values for *m* and *b* compare?

**Sample answer:** The linear regression is similar to the equation from Step 9 but not exactly the same. The value of *m* in the linear regression is slightly greater (less negative) than in Step 9. The value of *b* is less than in Step 9. Answers will vary.

> **Teacher Tip:** The regression equation should be similar to the students' equations. In some ways a student's equation may appear to be a better fit because the regression equation may not go through the actual starting position.

**Discussions/Explorations**

1. As you may have gathered from your practice trials, the CBR 2™ collects data measuring how far an object is located from the sensor. By walking in front of the CBR 2™, collect a set of data that appears linear and has a positive slope. Provide a detailed description of your walk. Be sure to discuss the real-world connections for the slope and *y*-intercept of the model.

   **Sample answer:** The walker stands close to the CBR 2™ and slowly walks away at a steady rate. The *y*-intercept is the walker's distance from the CBR 2™ at time $t = 0$ seconds. The slope is the walker's average velocity.

2. By walking in front of the CBR 2™, collect a set of data that appears linear and has a slope that is approximately zero. Provide a detailed description of your walk, including the connection between slope and *y*-intercept and the physical actions.

   **Answer:** The walker stands still in front of the CBR 2™ and does not move for the entire experiment. The *y*-intercept is the walker's distance from the CBR 2™. Since there is no movement toward or away from the CBR 2™, the slope is 0.

3. By walking in front of the CBR 2™, collect a set of data that represents a piecewise function with two parts, both of which are linear—one with a positive slope and one with a negative slope. Provide a detailed description of your walk, including the connections between slope and *y*-intercept and the physical actions.

   **Sample answer:** The walker starts close to the CBR 2™ and slowly walks away at a steady velocity, then changes direction and heads back toward the CBR 2™ at a steady velocity. This could be reversed so that the walker started walking toward the CBR 2™ and then walked away. The *y*-intercept is the walker's distance from the CBR 2™ at time $t = 0$ seconds. The slopes are the walker's average velocities—positive when walking away from the CBR 2™ and negative when walking toward it. During the change in direction, the graph will not be linear.

## Wrap Up

Upon completion of the discussion, the teacher should ensure that students understand:

- That the *y*-intercept of a graph of position versus time shows starting position
- That the slope of a position-versus-time graph shows velocity
- How negative, zero, and positive slopes relate to motion in a graph of position versus time

## Assessment

Explain why the *y*-intercept on a position-versus-time graph can never be negative.

## TI-Nspire™ Navigator™

**Note 1**

**Step 8, Live Presenter:** You may wish to use **Live Presenter** here to allow students to share how well their equations fit the data points.

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# You Are What You Eat!
## Student Activity

**Name** ____________
**Class** ____________

**Open the TI-Nspire™ document You_Are_What_You_Eat.tns.**

In this activity, you will explore the relationship between the number of fat grams and the number of calories in hamburgers from three different fast food restaurants.


Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

**Move to page 1.2.**

1. How many fast food hamburgers do you eat in a week?

**Move to page 1.3**.

2. How do you think the number of grams of fat and number of calories in a fast food hamburger are related?

**Move to page 1.4**.

The spreadsheet on this page contains the numbers of fat grams and calories for 29 hamburgers from three different fast food restaurants.

3. Look at the data. What patterns or relationships do you see?

**Move to page 1.5.**

Move the cursor to the center of the lower part of the screen. Press or enter and select the list **fat**. Next, move the cursor to the center of the left side of the screen. Press or enter and select the list **cal**. A scatter plot of the data from page 1.4 is graphed.

To add a movable line, press **Menu > Analyze > Add Movable Line**. Rotate and translate the line until you have a good fit for the data.

 

4. What is the equation of your line?

5. Why does it make sense that the number of grams of fat is used as the independent variable?

6. What does the slope mean in terms of the fat grams and calories of these hamburgers?

7. What does the *y*-intercept mean in the context of this problem?

**Move to page 1.6.**

Another scatter plot of the hamburger data has been graphed on this page. Graph a linear regression equation by pressing **Menu > Analyze > Regression > Show Linear (mx+b)**.

8. What is the regression equation? Round the slope and *y*-intercept to the nearest hundredth.

9. Compare the equation of your movable line to the regression equation. How are the equations alike? How are they different?

**Move to page 1.7.**

10. Based on the regression equation, how many calories are in a hamburger that has 22 grams of fat? (Round your answer to the nearest integer.)

**Move to page 1.8.**

11. Based on the regression equation, if a fast food chain created a triple burger with 1,243 calories, how many grams of fat would it contain? (Round your answer to the nearest integer.)

**Move to page 1.9.**

12. Which of these statements about the relationship between the number of grams of fat and the number of calories are true? Explain your reasoning.
    a. As the number of fat grams increases, the number of calories decreases.
    b. As the number of fat grams increases, the number of calories increases.
    c. As the number of fat grams decreases, the number of calories decreases.
    d. As the number of fat grams decreases, the number of calories increases.

A relationship where one variable is increases when the other variable increases is called a **positive correlation**. If one variable decreases when the other variable decreases, that too is a **positive correlation**.

A relationship where one variable increases when the other variable decreases is called a **negative correlation**.

13. Is the relationship between grams of fat and calories a positive correlation or a negative correlation? Explain your reasoning.

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# You Are What You Eat!

TI PROFESSIONAL DEVELOPMENT

TEACHER NOTES

## Math Objectives

- Students will develop a linear model to predict the number of calories in fast food hamburgers when given the number of grams of fat.
- Students will interpret the slope of a line in the context of calories per fat gram.
- Students will make sense of problems and persevere in solving them. (CCSS Mathematical Practice)
- Students will model with mathematics. (CCSS Mathematical Practice)

## Vocabulary

- slope
- *y*-intercept
- linear model
- regression equation

## About the Lesson

- In this activity, students explore the relationship between the number of fat grams and the number of calories in hamburgers from three different fast food restaurants.
- Students are introduced to developing a mathematical model for a set of linear data. Students will use both a movable line and a regression equation to determine a relationship between the number of fat grams and the number of calories in fast food hamburgers.
- As a result students will:
    - Model data with linear functions
    - Interpret the parameters in a linear model in a real-world context
    - Use a mathematical model to make predictions

## TI-Nspire™ Navigator™ System

- Use **Screen Capture** to compare students' graphs when they fit a movable line.
- Use **Live Presenter** and have a student demonstrate how to rotate and translate a movable line.
- Use Teacher Software to review student documents.


**TI-Nspire™ Technology Skills:**

- Download a TI-Nspire™ document
- Open a document
- Move between pages
- Grab and drag a movable line

**Tech Tips:**

- Make sure the font size on your TI-Nspire™ handhelds is set to Medium.
- You can hide the function entry line by pressing ctrl G.

**Lesson Files:**

*Student Activity*

You_Are_What_You_Eat_Student.pdf

You_Are_What_You_Eat_Student.doc

*TI-Nspire document*

You_Are_What_You_Eat_.tns

## Discussion Points and Possible Answers

> **Tech Tip:** If students experience difficulty rotating or translating the movable line, check to make sure that they have moved the cursor near the line until the cursor becomes a rotation symbol (⟲) or a translation symbol (✥). They should then press ctrl to grab the line and use the Touchpad to rotate or translate the line.

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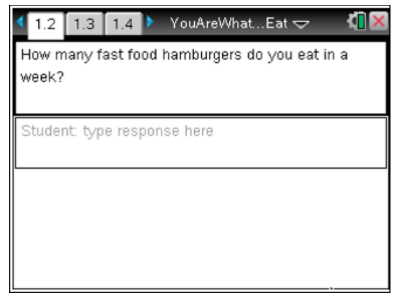
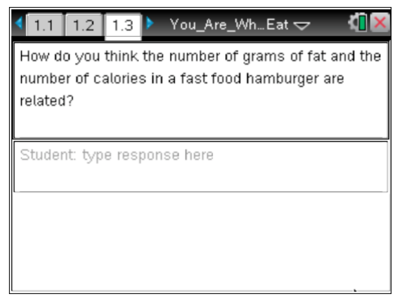
**Move to page 1.2.**




1. How many fast food hamburgers do you eat in a week?

   **<u>Sample answers:</u>** Answers will vary.

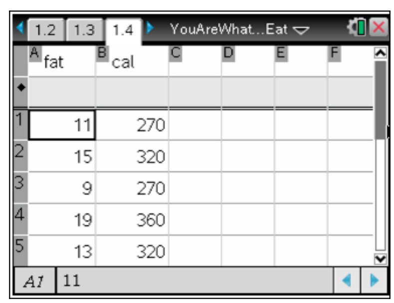
**Move to page 1.3.**




2. How do you think the number of grams of fat and the number of calories in a fast food hamburger are related?

   **<u>Sample answers:</u>** If the number of fat grams increases, the number of calories will increase. If the number of fat grams decreases, the number of calories will decrease.

**Move to page 1.4.**

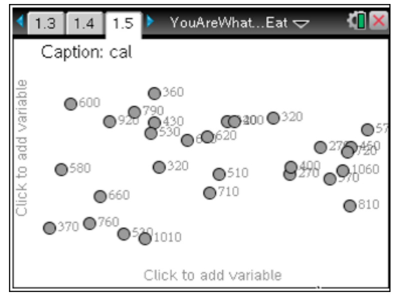



The spreadsheet on this page contains the numbers of fat grams and calories for 29 hamburgers from three different fast food restaurants.

3. Look at the data. What patterns or relationships do you see?

   **<u>Sample answers:</u>** When the number of fat grams increases, the number of calories increases. When the number of fat grams decreases, the number of calories decreases.

**Move to page 1.5.**




Move the cursor to the center of the lower part of the screen. Press or enter and select the list **fat**. Next, move the cursor to the center of the left side of the screen. Press or enter and select the list **cal**. A scatter plot of the data from page 1.4 is graphed.

To add a movable line, press **Menu > Analyze > Add Movable Line**. Rotate and translate the line until you have a good fit for the data.

4. What is the equation of your line?

   **<u>Sample answer:</u>** m1($x$) = 12$x$ + 151

5. Why does it make sense that the number of grams of fat is used as the independent variable?

   **<u>Sample answer:</u>** The number of calories in a hamburger depends on the number of grams of fat.

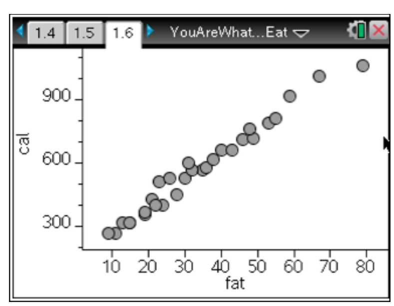
6. What does the slope mean in terms of the fat grams and calories of these hamburgers?

   **<u>Sample answer:</u>** As the number of fat grams increases by 1, the number of calories increases by 12.

7. What does the $y$-intercept mean in the context of this problem?

   **<u>Sample answer:</u>** When the number of fat grams is zero, the number of calories is 151.

**Move to page 1.6.**




Another scatter plot of the hamburger data has been graphed on this page. Graph a linear regression equation by pressing **Menu > Analyze > Regression > Show Linear (mx+b)**.

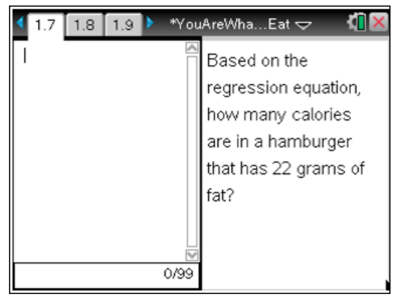
8. What is the regression equation? Round the slope and $y$-intercept to the nearest hundredth.

**Sample answer:** $y = 12.14x + 156.79$

9. Compare the equation of your movable line to the regression equation. How are the equations alike? How are they different?

   **Sample answers:** The slope of the regression equation is close to the slope of the movable line. The *y*-intercept of the regression equation is greater than the *y*-intercept of the movable line.

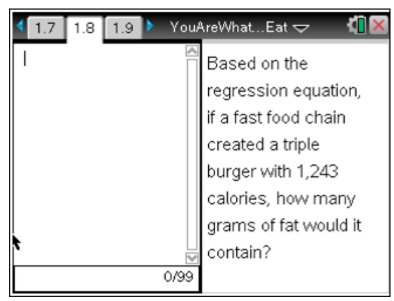
**Move to page 1.7.**




10. Based on the regression equation, how many calories are in a hamburger that has 22 grams of fat? (Round your answer to the nearest integer.)

    **Sample answer:** 424 calories; calories = 12.14(fat) + 156.79; $y = 12.14(22) + 156.79$

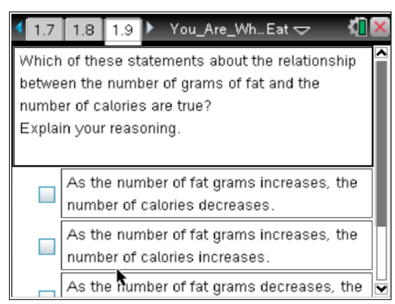
**Move to page 1.8.**




11. Based on the regression equation, if a fast food chain created a triple burger with 1,243 calories, how many grams of fat would it contain? (Round your answer to the nearest integer.)

    **Sample answers:** 89 grams of fat; calories = 12.14(fat) + 156.79; $1243 = 12.14x + 156.79$

**Move to page 1.9.**




12. Which of these statements about the relationship between the number of grams of fat and the number of calories are true? Explain your reasoning.

    a. As the number of fat grams increases, the number of calories decreases.

    b. As the number of fat grams increases, the number of calories increases.

    c. As the number of fat grams decreases, the number of calories decreases.

    d. As the number of fat grams decreases, the number of calories increases.

**<u>Sample answers:</u>** Answers b and c are correct. The slope of the line of fit is positive. If the number of fat grams increases, the number of calories increases. If the number of fat grams decreases, the number of calories decreases.

A relationship where one variable is increases when the other variable increases is called a **positive correlation**. If one variable decreases when the other variable decreases, that too is a **positive correlation**.

A relationship where one variable increases when the other variable decreases is called a **negative correlation**.

13. Is the relationship between grams of fat and calories a positive correlation or a negative correlation? Explain your reasoning.

    **<u>Sample answers:</u>** The relationship is a positive correlation. When the number of fat grams increases, the number of calories increases. When the number of fat grams decreases, the number of calories decreases.

**Extensions**

- Ask students to obtain nutritional data on fast food hamburgers from three fast food restaurants and compare the analysis of that data set to the results they obtained in this activity.
- Ask students to obtain nutritional data on another type of food (e.g., ice cream, candy, chips) and determine the relationship between the number of calories and the number of grams of fat.
- Ask students to obtain nutritional data on another type of food (e.g., ice cream, candy, chips) and determine the relationship between the number of calories and the number of grams of sugar.

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# Graphing a Scatter Plot

**TI PROFESSIONAL DEVELOPMENT** **TEACHER NOTES**

## Activity Overview

This activity describes how to enter data into a *Lists & Spreadsheet* application and then generate a scatter plot of the data using **Quick Graph**. Information is also provided on graphing the data on a separate page using the *Data & Statistics* application.

### Step 1: Entering Data in a Spreadsheet and Using Quick Graph

1. Press [on], and select **New Document** to start a new document.

2. Choose **Add Lists & Spreadsheet**.

**Note**: To add a *Lists & Spreadsheet* page to an existing document, press [ctrl] [doc▾] and choose **Add Lists & Spreadsheet**.

Alternatively, you may press [on] and select the Lists & Spreadsheet icon using the Touchpad.

3. In Column A, press ` on the Touchpad to move to the top of Column A. Be sure to move to the top of the column.


4. Type the list name **folds** next to the letter *A*, and press [enter].

5. Move to the top of column B, enter the list name **layers**, and press [enter].

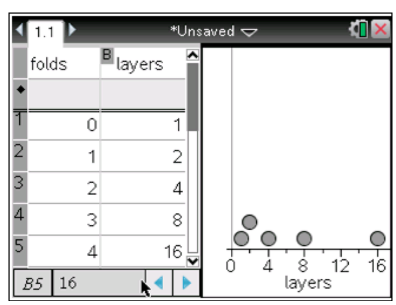
6. Enter data, as shown, into the two lists.


Place the cursor in cell A1 for Column A or in cell B1 for Column B, and enter the first number.

**Note:** Pressing [enter] or ▼ will move the cursor to the next cell in the column.

7. To create a graph, press [menu] and select **Data > Quick Graph**.

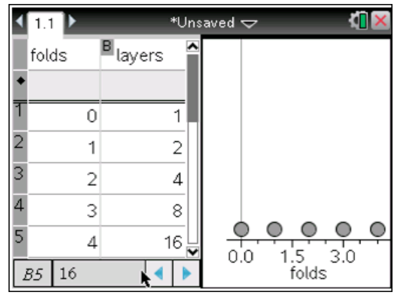
   The screen will automatically split vertically—the *Lists & Spreadsheet* application remains in the left work area while a *Data & Statistics* application is inserted into the right work area. A dot plot appears. The values graphed are from the list in which the cursor was located when **Quick Graph** was selected.



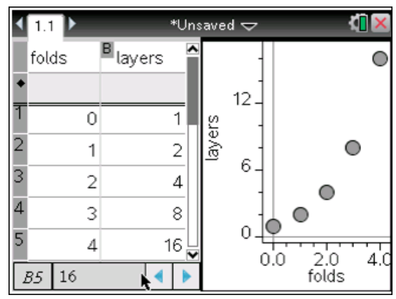
**Note**: The dark rectangle around the *Data & Statistics* application work area indicates that the application is active. To move from one work area to another, press ctrl tab or use the Touchpad and press to select the desired application.

8. To change the list graphed, move the cursor over the horizontal axis label. The message **Click or Enter to change variable** will appear.

9. Press to display the variables—in this case, the names of the lists entered in the spreadsheet. Press or enter to select the variable **folds**. A dot plot of the **folds** data is graphed.

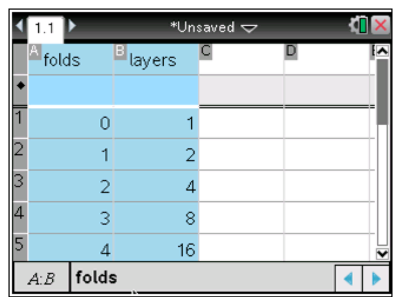


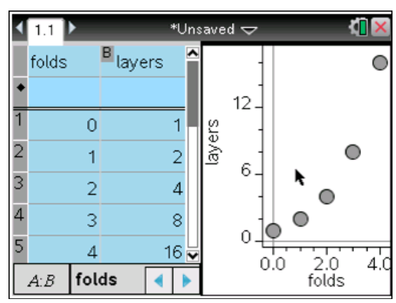

10. Move the cursor to the middle of the left side of the graph screen. The message **Click or Enter to add variable** will appear. Press to display the variables and then press ▼ to highlight the variable **layers**. Press or enter to select the variable **layers**.




**Note**: Had both lists been selected before the **Quick Graph** menu option was selected, a scatter plot would have been graphed rather than a dot plot.

- To select multiple lists, place the cursor in a cell in the **folds** column, and continue to press ` until the entire list is highlighted.
- Press and hold ⇧shift, and press ▶ to highlight both lists.
- Release the ⇧shift key.
- Press menu and select **Data > Quick Graph**.
- A scatter plot will be created with the list to the left as the independent variable list.

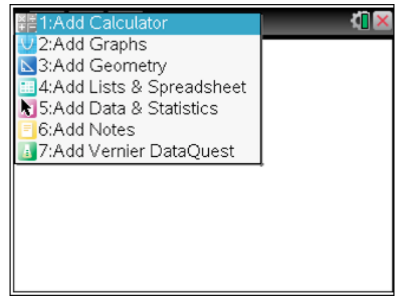


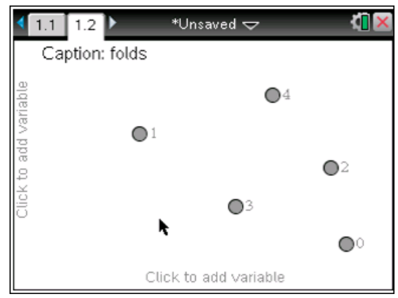

**Note**: To clear all data in one or more lists, first select the list(s) as described above. Then, press menu and select **Data > Clear Data**.

## Step 2: Graphing Data on a Separate Page Using the *Data & Statistics* Application

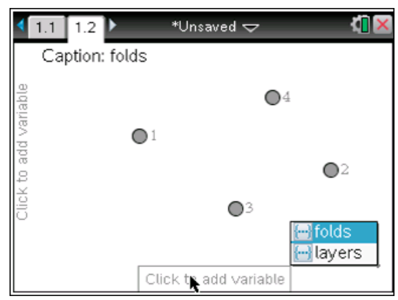
1. To display the graph on a separate page, first add a *Data & Statistics* page by pressing ctrl doc▾ and selecting **Add Data & Statistics**.



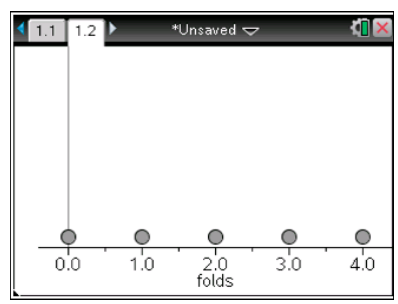

**Note**: The list name displayed next to the word **Caption** is the first list in the spreadsheet, alphabetically.



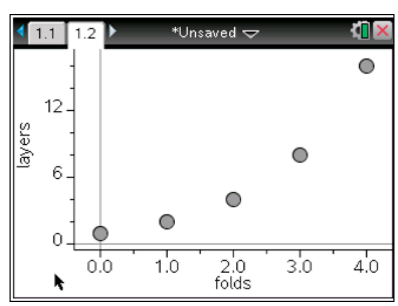

2. To choose the variable for the horizontal axis, move the cursor to the **Click to add variable** message at the bottom of the screen. Press to display the variables.




3. Select the variable **folds**.




4. Move the cursor to the middle of the left side of the screen. When the message **Click or Enter to add variable** appears, press to display the variables. Select the variable **layers**.



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# Getting Started with TI-Nspire™ Teacher Software

**TI PROFESSIONAL DEVELOPMENT**

## Activity Overview:

In this activity, you will explore basic features of the TI-Nspire™ Teacher Software. You will explore the **Welcome Screen**, add pages with *Calculator* and *Graphs* applications, and explore the menus and submenus of each application. You will explore the five tabs within the **Documents Toolbox**, as well as the options available in the **Documents** toolbar and the **Status** bar.

## Materials

- TI-Nspire™ Teacher Software

**Step 1:**

Open the TI-Nspire™ Teacher Software. The **Welcome Screen** displays an icon for each of the seven applications: *Calculator*, *Graphs*, *Geometry*, *Lists & Spreadsheet*, *Data & Statistics*, *Notes*, *Vernier DataQuest™*, and *Question*. To see a brief description of each application, hover the cursor over each icon.

The **Welcome Screen** also allows you to view content, manage handhelds, transfer documents, and open documents. To see a brief description of each option, hover the cursor over each icon on the right. To view the **Welcome Screen** at any time, go to **Help > Welcome Screen**

To create a new document with a *Calculator* application as the first page, click .

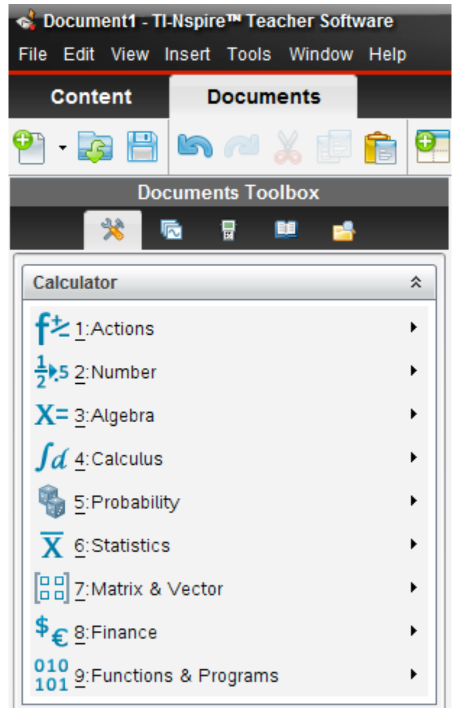
**Step 2:**

The *Calculator* application allows you to enter and evaluate mathematical expressions as well as create functions and programs.

In most cases, each application has a unique menu of commands and tools. To view the *Calculator* menu, go to the **Documents Toolbox** and select the **Document Tools** tab.

Each item in the *Calculator* menu has a submenu. Explore the various menus and submenus by entering and evaluating your own expressions.

**Note:** To access the *Calculator* menu on the handheld, press menu.

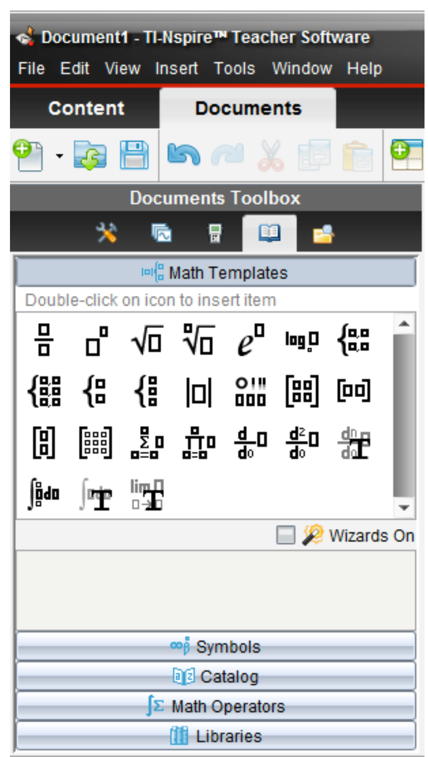



**Step 3:**

The **Utilities** tab contains **Math Templates**, **Symbols**, **Catalog**, **Math Operators**, and **Libraries** panes. Only one pane is displayed at a time, and the **Math Templates** pane is the default pane. Explore each of the other panes by clicking them.

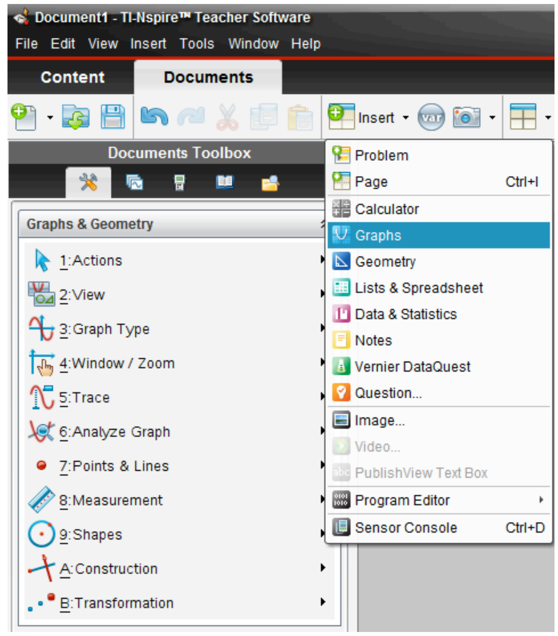
To insert a **Math Template** into the *Calculator* application, double-click it. Explore various **Math Templates** by evaluating your own expressions involving fractions, exponents, square roots, logarithms, and absolute value expressions.

**Note:** When evaluating expressions, the *Calculator* application displays rational expressions by default. To display a decimal approximation when evaluating an expression, press **CTRL + Enter**.



**Step 4:**

The **Insert** menu allows you to insert problems and pages, along with each of the eight applications. A problem can contain multiple pages, and variables that are linked within a problem are linked across pages.

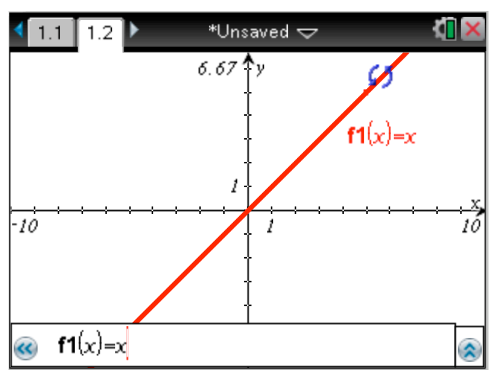



Insert a *Graphs* application by selecting **Insert > Graphs**.

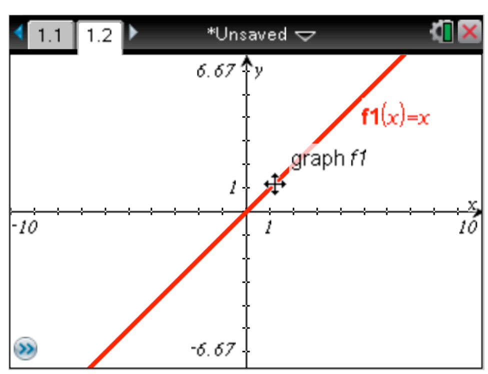
The *Graphs* application allows you to graph and analyze relations and functions. Explore the various menus and submenus available in the *Graphs* application.

**Step 5:**

Graph the function **f**($x$) = $x$ by typing $\boldsymbol{x}$ into the function entry line and pressing **Enter**.



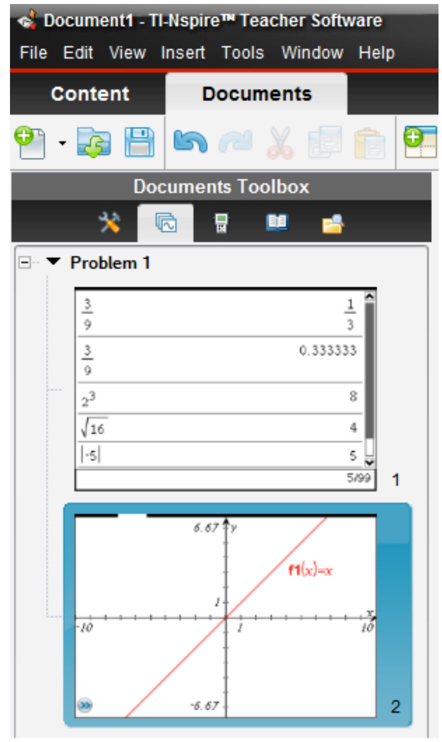

Rotate the line by hovering the cursor over the upper-right corner of the graph. When the rotational cursor appears, rotate the line by clicking and dragging it.




Translate the line by hovering the cursor over the line near the origin. When the translational cursor appears, translate the line up and down by clicking and dragging it.

**Step 6:**

Since you have inserted a *Calculator* application and a *Graphs* application, your TI-Nspire™ document now has two pages. The **Page Sorter** view allows you to view thumbnail images of all pages in the current TI-Nspire™ document.



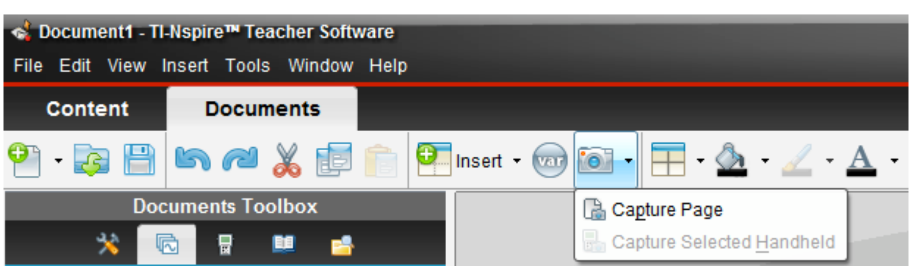

Access the **Page Sorter** by going to the **Documents Toolbox** and clicking the **Page Sorter** tab. Pages can be rearranged by grabbing and moving them. Right-clicking allows for pages to be cut, copied, and pasted.

**<u>Note</u>:** To access **Page Sorter** in the handheld, press ctrl ▲. To right-click in the handheld, press ctrl menu.

**Step 7:**

The **Documents** toolbar allows you to create, open, and save a TI-Nspire™ document. Commands such as **Undo**, **Redo**, **Cut**, **Copy**, and **Paste** are also available. Explore these options by hovering the cursor over each icon. Pages, problems, and applications can be inserted and variables can be stored.

Take a **Screen Capture** of the current page by selecting **Take Screen Capture > Capture Page**. This **Screen Capture** can be saved as an image. Page layouts allow multiple applications to appear on one screen. Explore the various page layouts that are available by clicking **Page Layout**. Fill color, line color, and text color can also be changed.



**Step 8:**

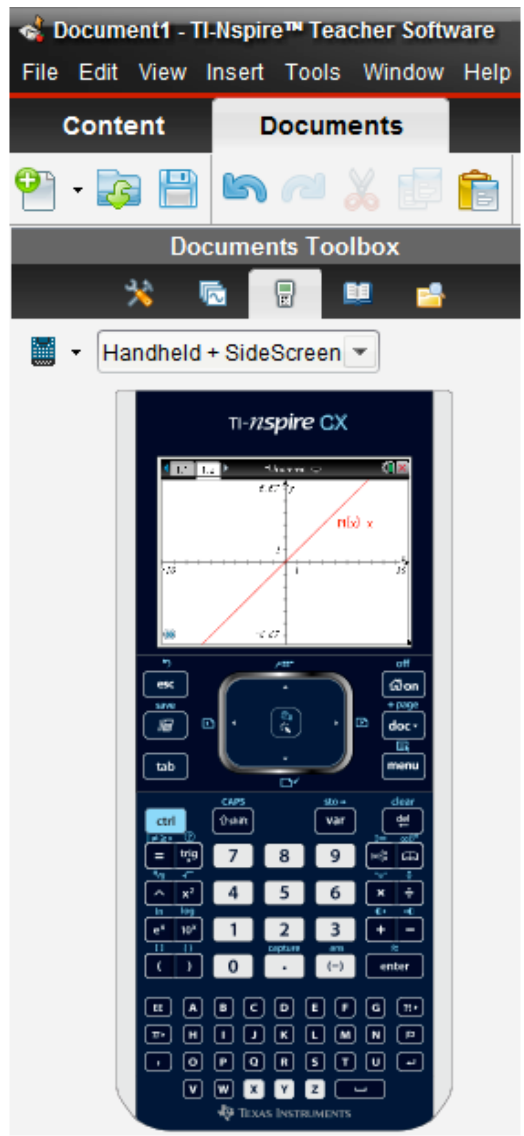
The **Status Bar** allows the user to access settings, change the Document View from Handheld mode to Computer mode, and adjust the scale of the screen. Change the Document View to Computer mode by clicking **Computer mode**. Change the Document View back to Computer mode by clicking **Handheld mode**.


**Step 9:**

To access the **TI-SmartView** emulator, go to the **Documents Toolbox** and select the **TI-SmartView** tab.

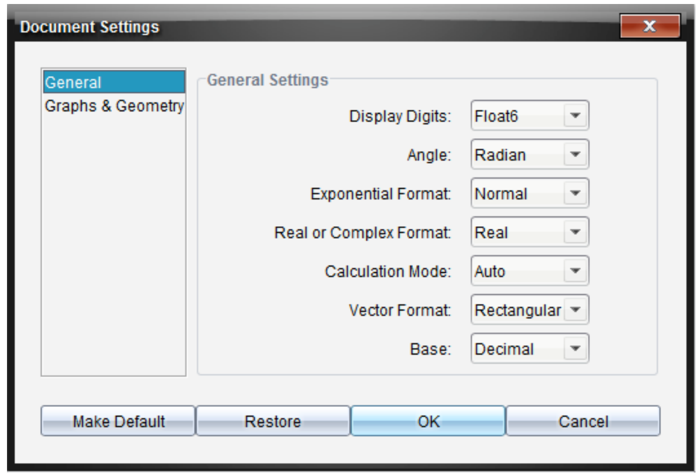
**TI-SmartView** has three available views: **Handheld** only, **Keypad + SideScreen**, and **Handheld + Side Screen**. Explore each of these views.

**TI-SmartView** has three available keypads: TI-Nspire CX™, TI-Nspire™ with Touchpad, and TI-Nspire™ with Clickpad. Each keypad has three available views: Normal, High Contrast, and Outline. Click the **Keypad** menu and explore each keypad and view.



**Step 10:**

View the **Document Settings** by going to **File > Document Settings**. The **Document Settings** can also be viewed by going to the **Status Bar** and clicking **Settings**.

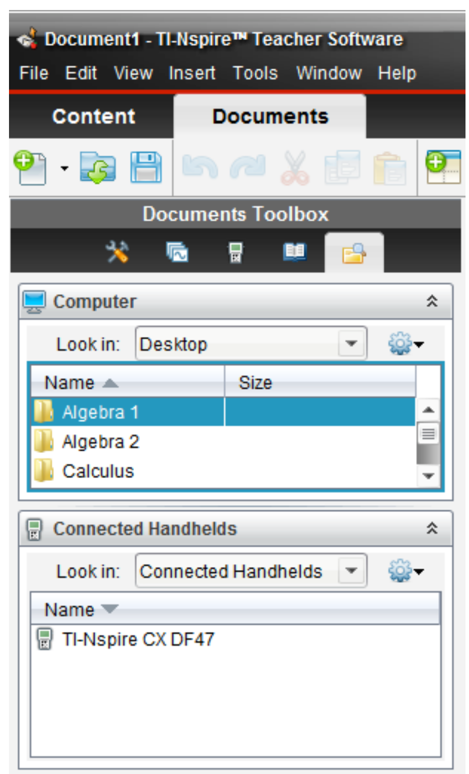



**General** settings apply to the entire TI-Nspire™ document, while **Graphs & Geometry** settings apply only to the *Graphs* and *Geometry* applications.

<u>**Note**</u>: To move across fields in the **Document Settings** window, press tab. To change the setting in a given field, press ▼, select the desired setting, and press enter. To exit the window, press tab until **OK** is highlighted and press enter.

**Step 11:**

The **Content Explorer** allows you to access local content on your computer and manage content on connected handhelds. Explore the **Content Explorer** by clicking the **Content Explorer** tab.



# Transferring Documents Using the TI-Nspire™ Teacher Software

TEACHER NOTES

**TI PROFESSIONAL DEVELOPMENT**

## Activity Overview:

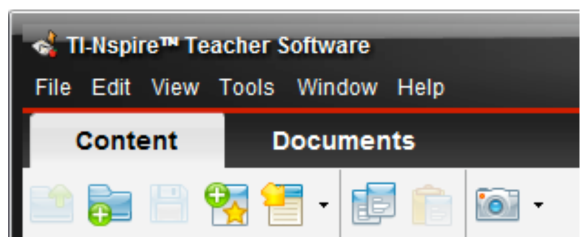
In this activity, you will use the **Content** and **Documents** Workspaces of the TI-Nspire™ Teacher Software to transfer files between the computer and the handheld. You will view information about a connected handheld, send a document from the computer to the handheld, and preview the contents of a document. You will also learn how to transfer files using the **Content Explorer** in the **Documents Workspace**.

## Materials

- TI-Nspire™ Teacher Software
- TI-Nspire™ handheld
- TI-Nspire™ USB connection cable

**Step 1:**

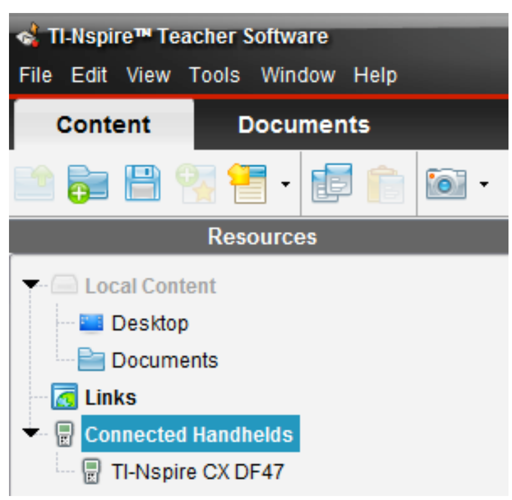
Open the TI-Nspire™ Teacher Software. If the **Welcome Screen** appears when the software is opened, go to the **Content Workspace** by clicking **View Content.** Otherwise, go to the **Content Workspace** by clicking the **Content** tab.




**Step 2:**

Connect a TI-Nspire™ handheld to the computer using the USB connection cable. In the **Resources** panel, click **Connected Handhelds**.

**<u>Note</u>:** Multiple handhelds can be connected to the computer using multiple USB ports, USB hubs, or the TI-Nspire™ Docking Station. If multiple handhelds are connected to the computer, then multiple handhelds appear in the list of **Connected Handhelds**.



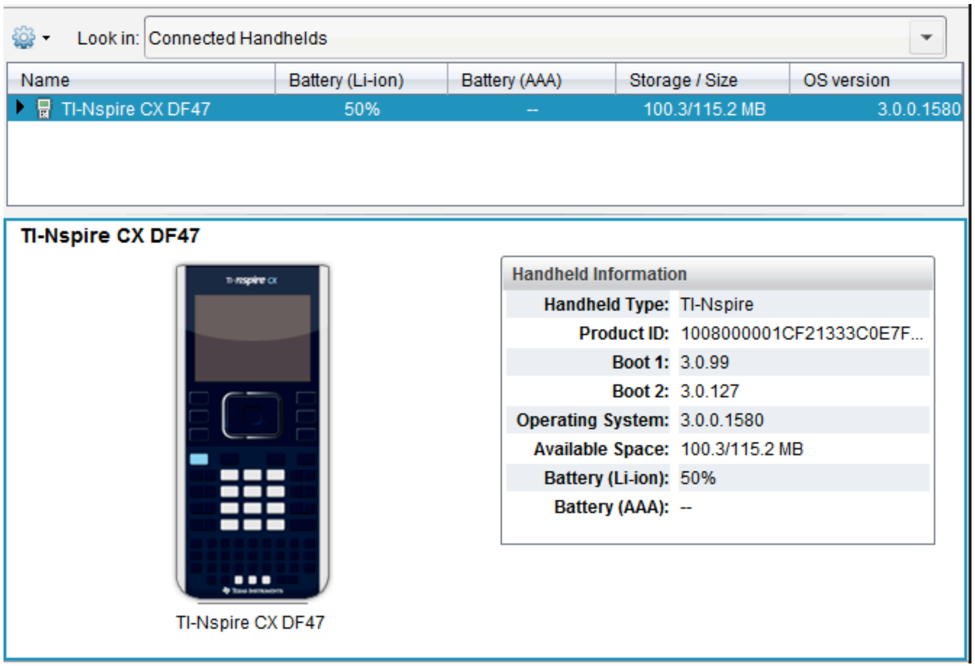
# Transferring Documents Using the TI-Nspire™ Teacher Software



**TI PROFESSIONAL DEVELOPMENT**

**Step 3:**

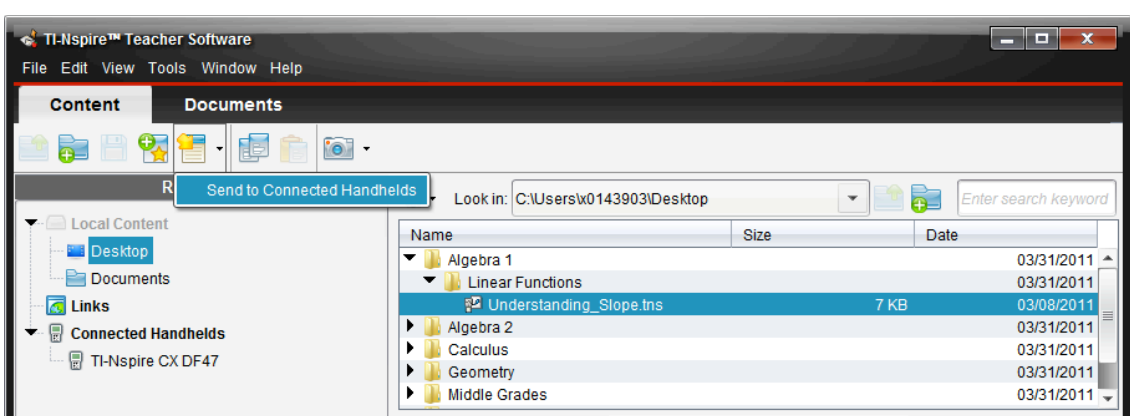
The connected handheld appears in the **Content Window**, along with battery, storage, and OS information. More detailed information appears in the **Handheld Information** window.




**Step 4:**

Locate a TI-Nspire™ document on your computer by going to the **Resources** panel and accessing **Local Content**. To locate a file on the desktop, click **Desktop**. To locate a file in the **My Documents** folder, click **Documents**. Send the TI-Nspire™ document to the connected handheld by clicking the file and selecting **Send to Connected Handhelds**.

__Note__: The TI-Nspire document can also be sent to the connected handheld by right-clicking the file and selecting **Send to Connected Handhelds**.



# Transferring Documents Using the TI-Nspire™ Teacher Software

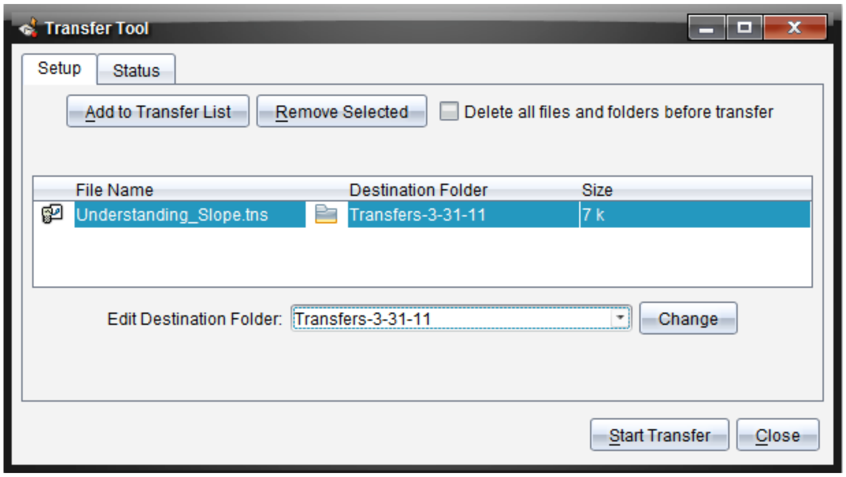




**Step 5:**

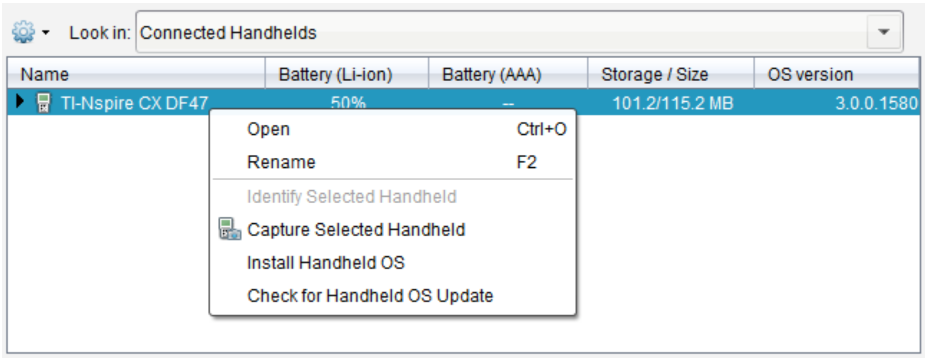
Upon selecting **Send to Connected Handhelds**, the **Transfer Tool** window appears, the **Setup** tab is active, and the current TI-Nspire™ document is listed. To add an additional file to the transfer list, select **Add to Transfer List** and locate the additional file. To remove a file from the transfer list, select the file and click **Remove Selected**.

The **Destination Folder** is the folder on the handheld where the file will be placed. To change the **Destination Folder**, select the file and go to the **Edit Destination Folder** field. To select an existing folder, select it from the drop-down menu and click **Change**. To create a new folder, type its name into the field and click **Change**. To send the file to the handheld, click **Start Transfer**. Once the **Status** tab indicates that the transfer is complete, click **Stop Transfer**



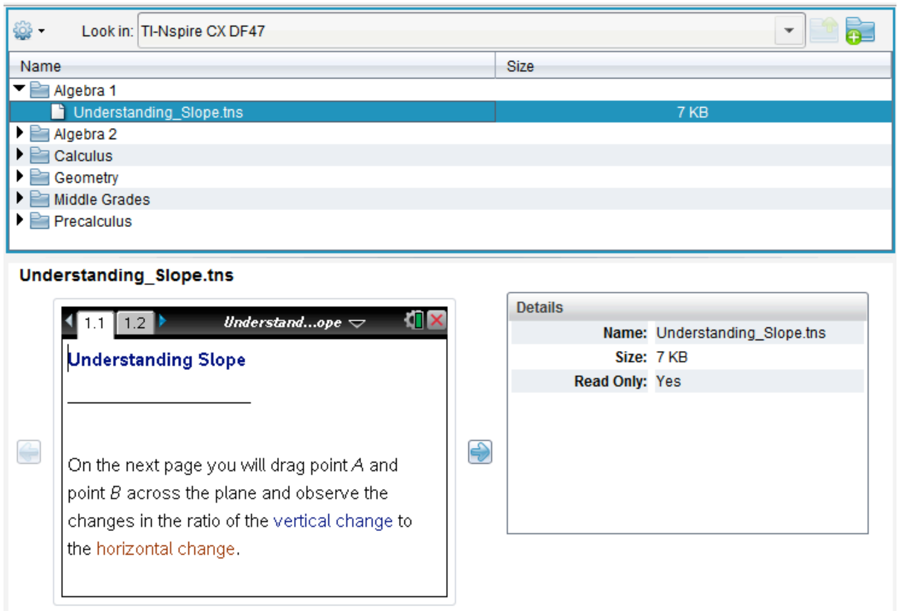

**Step 6:**

To view the files and folders on a connected handheld, right-click the handheld and select **Open**. From the right-click menu, the selected handheld can be renamed, its current screen can be captured, the OS can be checked, and an updated OS can be installed.



**Step 7:**

The files and folders on a connected handheld can also be viewed by going to the **Resources** panel and selecting from the list of **Connected Handhelds**. When a TI-Nspire™ document is selected, an icon appears labeled **Click here to preview document**. Click the icon to preview the first page of the TI-Nspire™ document. Double-click the file to open it in the **Documents Workspace**.

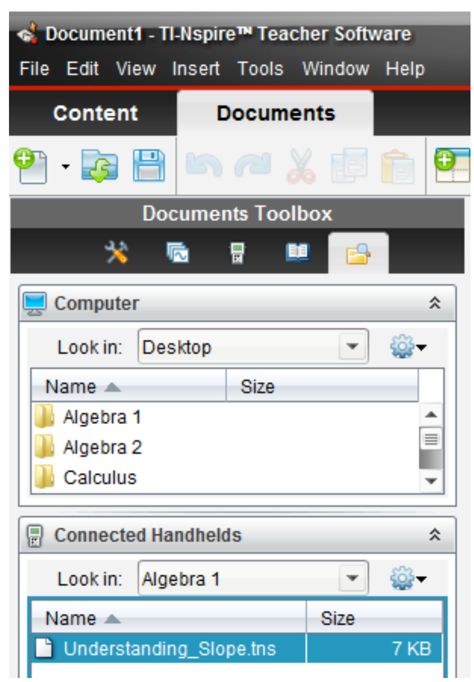



**Step 8:**

Files can also be transferred between the computer and connected handhelds using the **Content Explorer** in the **Documents Workspace**.

To transfer a TI-Nspire™ document from the computer to the connected handheld, locate the file in the **Computer** panel. Click, drag, and drop it into the desired handheld or folder in the **Connected Handhelds** panel.

To transfer a TI-Nspire™ document from the connected handheld to the computer, locate the file in the **Connected Handhelds** panel. Click, drag, and drop it into the desired folder in the **Computer** panel.



## Activity Overview:

In this activity, you will graph two functions and explore various methods for finding points of intersection.

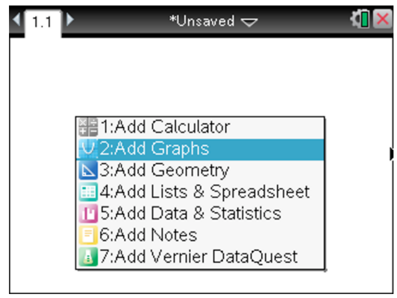
### Part One: Graphing Two Linear Functions and Finding the Point of Intersection by Tracing on the Graph of the Functions

**Step 1:**

Press [on] and select **New Document** to start a new document.

**Step 2:**

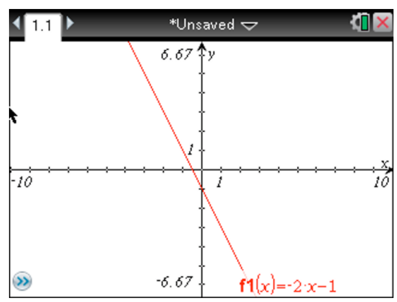
Choose **Add Graphs.**




__Note__: To add a new *Graphs* page to an existing document, press [ctrl] [doc▾] and choose **Add Graphs***.* Alternatively, you can press [on] and select the Graphs icon.

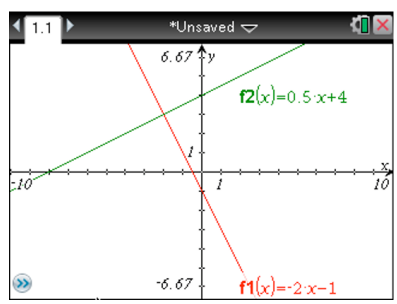
**Step 3:**

The cursor will be in the entry line at the bottom of the screen to the right of **f1(*x*) =**. To graph **f1**(*x*) = –2*x* – 1, press [(–)] [2] [X] [–] [1], and then press [enter].




**Step 4:**

To graph **f2**(*x*) = 0.5*x* + 4, first press [tab] to view the entry line. (Alternatively, press [ctrl] [G] or click on the chevron to display the entry line.)



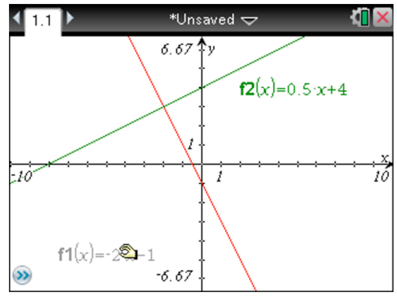

The cursor will now be to the right of **f2(*x*) =**. Press [.] [5] [X] [+] [4], and then press [enter] to graph the function.

__Note__: To graph multiple functions without closing the entry line, press ▼ after entering a function definition. After entering the last function definition, press [enter].

**Step 5:**

Drag the function label for **f1**(*x*) to the lower-left side of the screen.

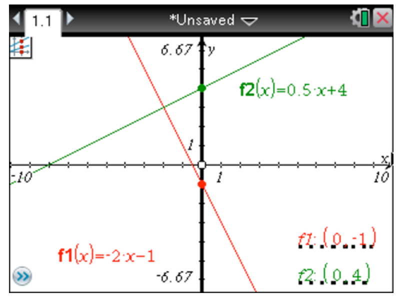
**<u>Note</u>:** This function label is moved to prepare for Step 6. When **Trace** is selected, the coordinates of the trace point(s) will be displayed in the lower right corner of the screen.




**Step 6:**

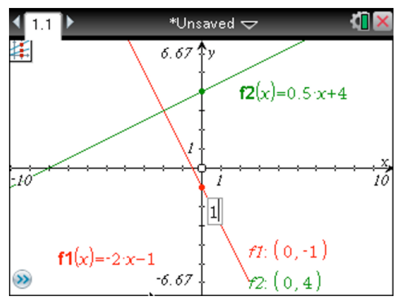
To trace and display function values for multiple graphed functions, press **Menu > Trace >Trace All**.

To trace on the functions, press the left or right arrow key on the Touchpad.

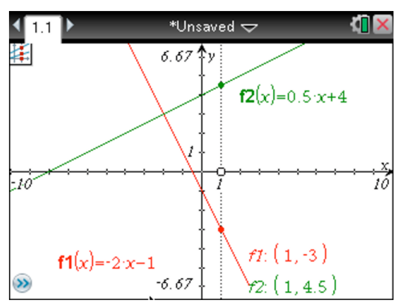



**Step 7:**

When the **Trace** tool is active, function values for a particular value of *x* may be displayed. Type a value for *x* (the number 1 was chosen for this example) and then press [enter] to display the function values at that value of *x*.

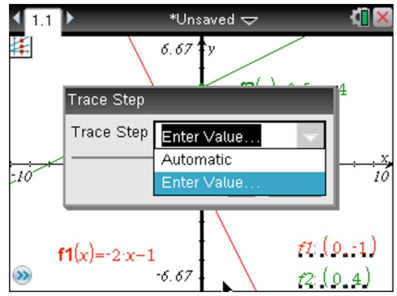



**<u>Note</u>:** If a value for *x* outside of the window settings is entered while tracing, the window will readjust for that particular *x*-value. The minimum and maximum *y*-values for the window may need to be adjusted.



### Step 8:

To change the trace step, press **Menu > Trace >Trace Step**. Press the arrow to the right of the word **Automatic** and select **Enter Value**. Enter a value for **Trace Step** (0.25 for this example) and then press [enter].

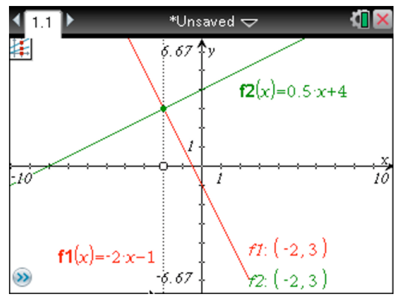



**<u>Note</u>:** When tracing after the trace step has been changed, the first value displayed for *x* will be the current *x*-value plus or minus the trace step. To change the *x*-value, follow the steps described in Step 7. Then, continue to trace.

### Step 9:

Trace until the point of intersection is located.

To exit the **Trace** tool, press [esc].



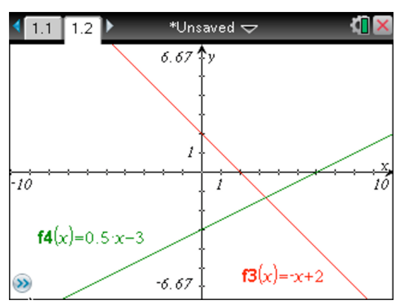

### Part Two Finding Points of Intersection Using the Intersection Point(s) Tool

### Step 10:

Press [ctrl] [I] or [ctrl] [doc▾] to insert a new page in the document. Select **Add Graphs**. Note that this is page 1.2—problem 1, page 2.

### Step 11:

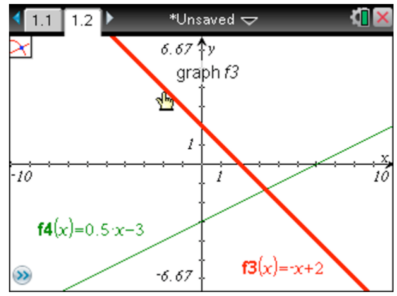
Graph any two linear functions whose point of intersection will be displayed in the current window. Move the function labels, as needed.




**<u>Note</u>:** The entry line displays **f3(*x*) =** since **f3** is the next available function in this problem.

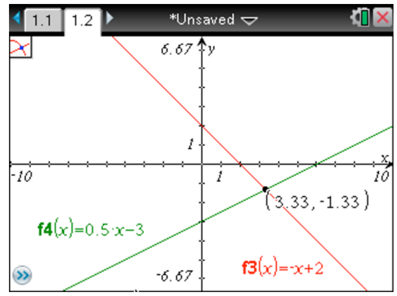
**Step 12:**

Press **Menu > Points & Lines > Intersection Point(s)**. Using the Touchpad, move the **Pointer** tool to the graph of one of the functions, and press to select the function. Move the **Pointer** tool to the second function and press to select the second function.

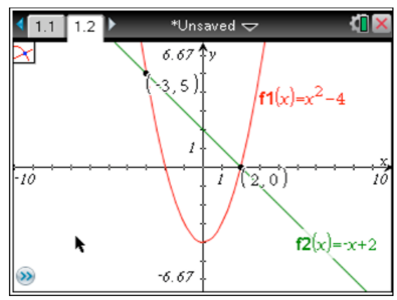



The point of intersection and its coordinates are displayed.

To exit the **Intersection Point(s)** tool, press esc.




<u>**Note**</u>: Use **Points & Lines > Intersection Point(s)** to determine multiple intersection points. After the functions are graphed, press **Menu > Points & Lines > Intersection Point(s)**. Press to select the graph of one of the functions. Move the **Pointer** tool to the second graph and press to select the second function. Both intersection points as well as the coordinates are displayed.



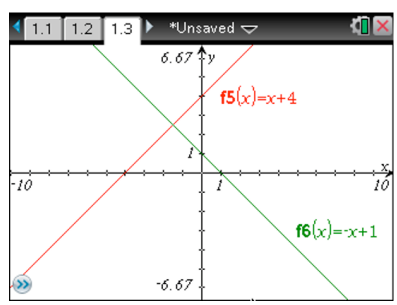

**Part Three: Finding a Point of Intersection Using the Analyze Graph Menu**

**Step 13:**

Press ctrl I or ctrl doc▾ to insert a new page in the document. Select **Add Graphs**.

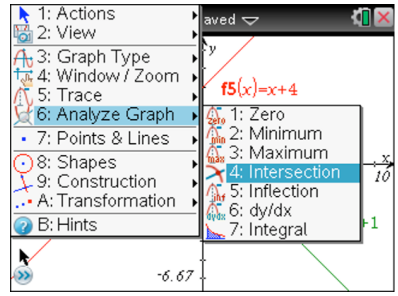
**Step 14:**

Graph any two functions whose point of intersection will be displayed in the current window. Move the function labels, as needed.



**Step 15:**

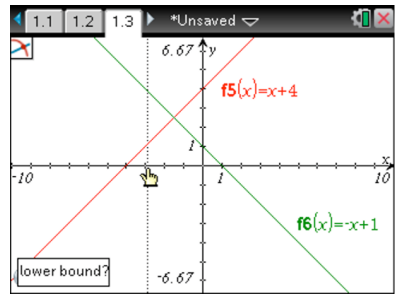
Press **Menu > Analyze Graph > Intersection**.




**Step 16:**

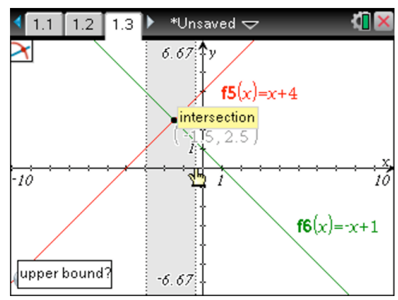
Set the lower bound by moving the **Pointer** tool to the left of the point of intersection. The message “**lower bound?**” is displayed.

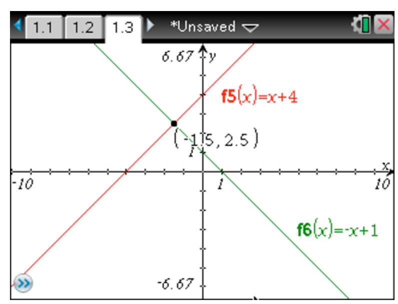
Press to set the lower bound.




To set the upper bound, first move the pointer to the right of the intersection point. The point of intersection will appear if the upper bound is to the right of the intersection point.

Press to set the upper bound.



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# Modeling with a Quadratic Function
## Student Activity

**Name** ____________________

**Class** ____________________

**Open the TI-Nspire™ document Modeling_with_a_Quadratic_Function.tns.**

You will determine the equation of a quadratic function that models the path of a basketball. Based on your equation, you will solve problems related to the path of the basketball.


**Move to page 1.2.**

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

**Note**: Two tick marks represent 1 meter.

1. Graph the parent quadratic function, $\mathbf{f}(x) = x^2$, on page 1.2. Transform the parent function so that it matches the path of the basketball. What is the equation of the quadratic function that matches the path of the basketball?

**Note**: You may need to drag the function definition away from the graph in order to transform the parabola.

2. In this activity, the horizontal distance traveled by the basketball is the independent variable. What is the dependent variable?

3. Determine the maximum height of the basketball in meters. Explain your reasoning.

4. Visualize a point on the ground directly beneath the ball when it reaches its maximum height. How far is this point from the person shooting the basketball? Explain your reasoning.

5. How high was the ball when it was a horizontal distance of 2 m from the person shooting the basketball? Explain your reasoning.

Name ________________
Class ________________

6. If the ball followed the path modeled by your quadratic function and the basket was not there, how far would it have landed from the person on the left? Explain your reasoning.

7. Insert a *Calculator* page. Type **f1(*x*)** to recall the function you used to model the path of the basketball. Record the equation here. What information does this form of the equation tell us about the path of the basketball?

8. Press **Menu > Algebra > Factor** and enter the following command: factor **(f1(*x*), *x*)**. Record the answer here. What information does this form of the equation tell us about the path of the basketball?

# Modeling with a Quadratic Function




## Math Objectives

- Students will model a basketball's flight through the air using a quadratic function.
- Students will analyze their quadratic function and interpret the parameters of the function in relation to the flight path of the basketball.
- Students will reason abstractly and quantitatively. (CCSS Mathematical Practice)

## Vocabulary

- parent quadratic function
- maximum value of a quadratic function
- zero of a quadratic function

## About the Lesson

- In this lesson, students use a quadratic function to model the flight path of a basketball. Students will interpret the parameters of the quadratic model to answer questions related to the path of the basketball.
- As a result, students will:
  - Model data with quadratic functions
  - Interpret the vertex of a quadratic function in a real-world context
  - Determine a zero of a quadratic equation
  - Use a mathematical model to make predictions

## TI-Nspire™ Navigator™ System

- Use **Screen Capture** to compare students' graphs when they fit a quadratic function.
- Use **Live Presenter** and have a student demonstrate how to grab and drag the quadratic function to fit the flight path of the ball.

**TI-Nspire™ Technology Skills:**

- Download a TI-Nspire™ document
- Open a document
- Move between pages
- Grab and drag a point

**Tech Tips:**

- Make sure the font size on your TI-Nspire™ handhelds is set to Medium.
- You can hide the function entry line by pressing ctrl G.

**Lesson Files:**

*Student Activity*
Modeling_with_a_Quadratic_Function.pdf
Modeling_with_a_Quadratic_Function.doc

*TI-Nspire™ document*
Modeling_with_a_Quadratic_Function.tns

## Discussion Points and Possible Answers

> **Tech Tip:** If students experience difficulty dilating or translating the parabola, check to make sure that they have moved the cursor near the parabola until the cursor becomes a dilation symbol (⤡) or a translation symbol (✥). They should then press ctrl [click] to grab the parabola and use the Touchpad to dilate or translate the parabola.

**Move to page 1.2.**

> Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

**Note**: Two tick marks represent 1 meter.

1. Graph the parent quadratic function, **f**$(x) = x^2$, on page 1.2. Transform the parent function so that it matches the path of the basketball. What is the equation of the quadratic function that matches the path of the basketball?

**Note**: You may need to drag the function definition away from the graph in order to transform the parabola.

**Sample answer**: Student models will vary slightly. A possible equation is **f**$(x) = \square 0.1(x - 6.65)^2 + 8.66$.

2. In this activity, the horizontal distance traveled by the basketball is the independent variable. What is the dependent variable?

**Answer**: The dependent variable represents the vertical height of the basketball.

> **Tech Tip:** To determine the maximum height, students can use the **Trace** command by pressing **Menu > Trace > Graph Trace** and can then move the cursor to the maximum function value on the parabola. Another method of determining the maximum value is by pressing **Menu > Analyze Graph > Maximum**. Students will need to move to the left of the maximum and press enter or [click] to set the lower bound. They should then move to the right of the maximum and press enter or [click] to set the upper bound. As they move the cursor, the coordinates of the maximum will be ghosted. The coordinates of the maximum will remain on the screen once the upper bound is set.

 

3. Determine the maximum height of the basketball in meters. Explain your reasoning.

   **Sample answer**: The maximum height of the basketball is 4.33 m. The *y*-coordinate of the vertex is 8.66. Using the scale provided, this value must be divided by 2 to determine the height of the ball.

**Note**: Students can justify their reasoning by using strategies such as reading the value from the graph, using the **Trace** command, or using the **Maximum** command.

4. Visualize a point on the ground directly beneath the ball when it reaches its maximum height. How far is this point from the person shooting the basketball? Explain your reasoning.

   **Sample answer**: The point directly beneath the ball when it reaches its maximum height is 3.33 m from the person on the left. The *x*-coordinate of the vertex is 6.65. Using the scale provided, this number must be divided by 2 to determine the point at which the maximum occurs.

**Note**: Students can also justify their reasoning by using other strategies, such as reading the value from the graph, using the **Trace** command, or using the **Maximum** command.

5. How high was the ball when it was a horizontal distance of 2 m from the person shooting the basketball? Explain your reasoning.

   **Sample answer:** The ball is 3.98 m high at a horizontal distance of 2 m from the person on the left. Use $x = 4$ since 4 tick marks on the graph represents 2 m. The function value at $x = 4$ is 7.96. Divide this value by 2 because of the scale.

> **Tech Tip:** Students can answer question 5 by evaluating the function for an *x*-value of 2. They can either insert a *Calculator* page and type **f1(2)** or use the **Scratchpad**. If they use the **Scratchpad**, they will need to record their equation on a piece of paper and then evaluate the function at $x = 2$.

6. If the ball followed the path modeled by your quadratic function and the basket was not there, how far would it have landed from the person on the left? Explain your reasoning.

   **Sample answer**: The ball would have landed 8 m from the person on the left if it had missed the basket and backboard. The $x$-intercept to the right of the vertex is (16, 0). To determine this, place a point on the function and then drag it toward the $x$-axis. This is the point where the ball hits the ground. Take this value and divide it by 2 because of the scale.

**Note**: Students can also justify their reasoning by using other strategies, such as reading the value from the graph, using the **Trace** command, using the **Zero** command (**Menu > Analyze Graph > Zero)**, or using the **nSolve** command in a *Calculator* page.

> **Tech Tip:** If a student uses the **nSolve** command, they will get the zero on the left that is the one closest to 0. They will need to specify the constraints to solve for the zero on the right. The command could be **nsolve** (**f1(*x*) = 0, *x*, 0, 20)**.

7. Insert a *Calculator* page. Type **f1(*x*)** to recall the function you used to model the path of the basketball. Record the equation here. What information does this form of the equation tell us about the path of the basketball?

   **Sample answer**: The equation is: **f1**($x$) = $0.1x^2 + 1.33x + 4.23775$. This is the standard form of the quadratic function. The standard form tells us that the parabola opens down and therefore has a maximum. It also tells us that the $y$-intercept is 4.24. Using the scale, the initial height of the basketball is 2.12 m.

8. Press **Menu> Algebra > Factor** and enter the following command: **factor (f1(*x*), *x*)**. Record the answer here. What information is this form of the equation telling us about the path of the basketball?

   **Sample answer:** The equation is: **f1**($x$) = $-0.1(x - 15.9559)(x + 2.65591)$. This is the factored form of the quadratic function. The factored form tells us that this parabola opens down and therefore has a maximum. It also tells us the zeros of the parabola are 15.96 and –2.66. Based on the scale, the zeros are at 7.98 and –1.33. The positive zero is very close to the value determined in question 6.

**Extensions**:

1. How far, horizontally, from the person shooting the basketball would the ball be when it reached a height of 5 m?
2. How far is the person standing from the basket?
3. The equation $y = -0.1(x - 8)^2 + 9$ describes the path of another basketball. The person throwing the ball is positioned on the $y$-axis. How is the path of this ball similar and how is it different from the path of the ball in the activity? (Assume the scale is the same.)

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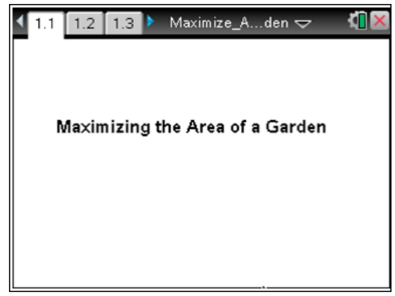
# Maximizing the Area of a Garden

**Student Activity**

**Name** ______________

**Class** ______________

**Open the TI-Nspire™ document Maximize_Area_Garden_CAS.tns.**




A garden with a rectangular shape is attached to a barn. Exactly three sides of the garden must be fenced, and 22 meters of fencing will be used. What are the dimensions of the garden with the maximum area?

**Move to page 1.2.**

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

1. As directed on page 1.2, draw a sketch of each of your five different gardens. Be sure to use a variety of width values. Remember that only three sides of the garden are to be fenced and that you will use 22 m of fencing.

2. Record the width, length, and area of each garden in the table below. Be sure to include appropriate units of measurement.

| Sketch | Width | Length | Area |
|---|---|---|---|
| **1** | | | |
| **2** | | | |
| **3** | | | |
| **4** | | | |
| **5** | | | |

3. Considering the data from your sketches, describe what happens to the area of the garden as the width of the garden increases.

4. Compare your answer to question 3 with the answers of other students in your class. Use the class data to describe what happens to the area of the garden as the width of the garden increases.

5. If the goal is to maximize the area of the garden, which of your garden sketches would be best to use? Why?

**Move to page 1.3.**

6. On page 1.3, enter the width and area data from each of your five garden sketches into the spreadsheet in the lower-left work area of the screen.

**Note**: Press [ctrl] [tab] to move from one work area on the screen to another, or move the cursor to that region of the screen with the Touchpad and press [click].

7. As you enter data in the spreadsheet, a scatter plot of the data set will be graphed. Describe the shape of the plot.

8. Write a formula for the amount of fencing used in terms of the width ($w$) and length ($l$) of the garden.

9. Rearrange the formula from question 8 to solve for the length ($l$) of the garden in terms of the width ($w$).

# Maximizing the Area of a Garden

**Student Activity**

**Name** ________________

**Class** ________________

10. Write an equation that could be used to determine the area ($A$) of the garden if you only know the width ($w$) of the garden. Hint: Use your answer from question 9 that expresses the length of the garden in terms of the width.

11. Let $x$ represent the width of the garden and let **f**$(x)$ represent the area of the garden in terms of its width. Write a function to express the area of the garden in terms of the width of the garden.

12. What values can be used for the width of the garden in this problem? In other words, what is the domain of your function?

**Move to page 1.4.**

13. On page 1.4, graph your function with the scatter plot on a full page.
    - Press [tab] to display the entry line (Alternate methods: Click on the chevron or press [ctrl] [G].)
    - f1($x$) = is displayed. Enter your function definition and then press [enter].

14. If the graph of the function doesn't fit your data, recheck your data and your answer for question 11.

15. What is the width and area of the garden with the maximum area?

16. How did you determine the maximum area of the garden?

Name ________________
Class ________________

17. Suppose that a rectangular garden of this type (using 22 m of fencing) had an area of 52.5 $m^2$.
    a. What width and length could be used to form a garden with this area? (Add pages, as needed, to the TI-Nspire™ document file to solve this problem.)
    b. Describe the method you used to find the width and length.

18. Jackie has 44 m of fencing to use to make a rectangular garden (with exactly three fenced sides) that is attached to a barn. How would the maximum area of her garden compare to the maximum area of the same type of garden that used 22 m of fencing? Justify your answer. (Add pages, as needed, to the TI-Nspire™ document file to solve this problem.)

19. Return to problem 1 and find the dimensions of the rectangles with maximum area when the perimeter is 24 m, 36 m, and 300 m. Find a relationship between the length and width of a rectangle with one side attached to a barn.

**Move to problem 2.**

20. As outlined on page 2.1, we are going to investigate the relationship between the length and perimeter if we are given a fixed perimeter of fence and are fencing all four sides.

21. On page 2.2, find an expression for the length in terms of the width and the perimeter.

22. On page 2.3, find an expression for the area in terms of the width only.

23. On page 2.4, find the value of the width, length, and perimeter that produces the maximum area.

**Extension:**

1. The perimeters of three rectangular gardens are 24 m, 36 m, and 300 m. Find the dimensions of each garden if you were fencing all four sides and wanted to maximize the area.

2. Use problem 2 in the TI-Nspire™ document file to explore the dimensions of this type of garden. Add pages, as needed, to determine the width and length that will result in a garden with the maximum area.

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# Maximizing the Area of a Garden

**TEACHER NOTES**

**TI PROFESSIONAL DEVELOPMENT**

## Math Objectives

- Students will determine the relationship between the width and length of a garden with a rectangular shape and a fixed amount of fencing. The garden is attached to a barn, and exactly three sides of the garden will be fenced.
- Students will determine a formula that can be used to compute the area of the garden when given the width.
- Students will find the dimensions of the garden that has the maximum area.
- Students will make sense of problems and persevere in solving them. (CCSS Mathematical Practice)

## Vocabulary

- perimeter
- area
- maximize
- conjecture

## About the Lesson

- In this activity, students explore the area of a garden with a rectangular shape that is attached to a barn. Exactly three sides of the garden must be fenced. Students will sketch possible gardens and enter their data into a spreadsheet.
- As a result, students will:
    - Graph the data, find an equation for the area of the garden in terms of its width, find the maximum area of the garden, and solve related problems
    - Determine that, given a fixed perimeter, the area enclosed depends on the dimensions chosen
- The CAS extension problem provides an opportunity for students to explore a different scenario—a garden with a rectangular shape that must be fenced on all four sides.

**TI-Nspire™ Technology Skills:**

- Download a TI-Nspire™ document
- Open a document
- Move between pages
- Grab and drag a point
- Enter data into a spreadsheet

**Tech Tips:**

- Make sure the font size on your TI-Nspire™ handheld is set to Medium.
- You can hide the function entry line by pressing ctrl G.

**Lesson Materials:**

*Student Activity*

Maximize_Area_Garden_Student_CAS_pdf

Maximize_Area_Garden_Student_CAS_doc

*TI-Nspire™ document*

Maximize_Area_Garden.tns

## Discussion Points and Possible Answers

**Move to page 1.2.**

1. As directed on page 1.2, draw a sketch of each of your five different gardens. Be sure to use a variety of width values. Remember that only three sides of the garden are to be fenced and that you will use 22 m of fencing.

2. Record the width, length, and area of each garden in the table below. Be sure to include appropriate units of measurement.

   **Sample answers**: Answers will vary—one possible set of answers follows:

| Sketch | Width | Length | Area |
|---|---|---|---|
| **1** | 2 m | 18 m | 36 $m^2$ |
| **2** | 4 m | 14 m | 56 $m^2$ |
| **3** | 6 m | 10 m | 60 $m^2$ |
| **4** | 7 m | 8 m | 56 $m^2$ |
| **5** | 8 m | 6 m | 48 $m^2$ |

3. Considering the data from your sketches, describe what happens to the area of the garden as the width of the garden increases.

   **Sample answers**: Answers will vary. Students might say that the area increases, decreases, or both increases and decreases.

> **Teacher Tip:** Depending on the values that students choose for the width, students might conclude that the area values always increase or always decrease. Consequently, question 4 was included so that students may compare their data to that of other students.

4. Compare your answer to question 3 with the answers of other students in your class. Use the class data to describe what happens to the area of the garden as the width of the garden increases.

   **Sample answers**: Students should discover that for a large sample of different widths, as the width of the garden increases, the area of the garden increases and then decreases.

5. If the goal is to maximize the area of the garden, which of your garden sketches would be the best to use? Why?

   **Sample answers**: Answers will vary. Students should choose their garden sketch with the largest area but might have other ideas about the "best" garden after comparing their sketches with those of other students.

**Move to page 1.3.**

6. On page 1.3, enter the width and area data for each of your five garden sketches into the spreadsheet in the lower-left work area of the screen.

**Note:** Press ctrl tab to move from one work area on the screen to another, or move the cursor to that region of the screen with the Touchpad and press .

   **Sample answers**: Values for the width and area shown in the table in question 2 have been entered in the spreadsheet.

**Tech Tip:** The active work area will have a bold outline.

**Teacher Tip:** Remind students to pay close attention to the list names in the spreadsheet and to enter their data into the appropriate lists.

**Teacher Tip:** Students might need verbal prompts to notice that the *x*-values of the ordered pairs of the points always increase from left to right, while the *y*-values first increase and then decrease.

7. As you enter data in the spreadsheet, a scatter plot of the data set will be graphed. Describe the shape of the plot.

**Sample answers**: Answers may vary depending upon the data that students have entered in their spreadsheets. If they have a good variety of points (a mix of width values that includes both small and large values), students should notice that the data points "rise" and then "fall" as you look at the graph from left to right

8. Write a formula for the amount of fencing used in terms of the width ($w$) and length ($l$) of the garden.

**Answer**: $2w + l = 22$ or $l + 2w = 22$ or an equivalent formula

9. Rearrange the formula from question 8 to solve for the length ($l$) of the garden in terms of the width ($w$).

**Answer**: $l = 22 – 2w$ or $22 – 2w = l$ or an equivalent formula

10. Write an equation that could be used to determine the area ($A$) of this garden if you only know the width ($w$) of the garden. Hint: Use your answer from question 9 that expresses the length of the garden in terms of the width.

**Answer**: $A = w(22 – 2w)$ or $A = 22w – 2w^2$ or an equivalent formula

11. Let $x$ represent the width of the garden and let $\mathbf{f}(x)$ represent the area of the garden in terms of its width. Write a function to express the area of the garden in terms of the width of the garden.

**Answer**: $\mathbf{f}(x) = x(22 – 2x)$ or $\mathbf{f}(x) = 22x – 2x^2$ or an equivalent formula

12. What values can be used for the width of the garden in this problem? In other words, what is the domain of your function?

**Answer:** The width must be greater than 0 m and less than 11 m, or $0 < x < 11$.

**Move to page 1.4.**

13. On page 1.4, graph your function with the scatter plot on a full page.
    - Press tab to display the entry line (Alternate methods: Click on the chevron or press ctrl G.)
    - **f1*(x)* =** is displayed. Enter your function definition and then press enter.

**Note**: The scatter plot label (width, area) and the function label were moved.

14. If the graph of the function doesn't fit your data, recheck your data and your answer for question 11.

15. What is the width and area of the garden with the maximum area?

    **Answer:** width = 5.5 m and area = 60.5 $m^2$

16. How did you determine the maximum area of the garden?

    **Sample answers**: Answers will vary since students have a variety of methods to find the maximum area. Some students may trace on their function, while others may find the vertex.

    > **Teacher Tip:** If students use a table, it's important to check that they change the **Table Step** value for the width and that they understand that a table might not provide an accurate result. Depending on what students have previously learned about quadratic functions, they might know that the vertex of a quadratic function yields the maximum or minimum function value. Aside from traditional methods of finding the vertex, other methods for solving this problem are included in the Tech Tips at the end of this document.

17. Suppose that a rectangular garden of this type (using 22 m of fencing) had an area of 52.5 $m^2$.

    a. What width and length could be used to form a garden with this area? (Add pages, as needed, to the TI-Nspire™ document file to solve this problem.)

    **Sample answers**: width = 3.5 m and length = 15 m; or width = 7.5 m and length = 7 m

b. Describe the method you used to find the width and length.

**Sample answers**: Methods for finding the width will vary. See the Teacher Tip below.

> **Teacher Tip:** There are many ways to solve this problem. The methods include the following:
> 1. Graph the function **f2**($x$) = 52.5 with the graph of the area function. Find the points of intersection of the graphs.
> 2. Add a point to the graph of the function. When the $y$-value of the point's ordered pair is changed to 52.5, the value of $x$ that results in this function value is computed.
> 3. Use the **Numerical Solver** to find the width.
> 4. Change the **Table Step** value in the function table until $x$-values (width values) that produce the desired area value are found.
> 5. Set up the appropriate equation, and use the quadratic formula to solve for the width.
>
> (Tech Tips for some of these methods can be found at the end of this document.)

18. Jackie has 44 m of fencing to use to make a rectangular garden (with exactly three fenced sides) that is attached to a barn. How would the maximum area of her garden compare to the maximum area of the same type of garden that used 22 m of fencing? Justify your answer. (Add pages, as needed, to the TI-Nspire™ document file to solve this problem.)

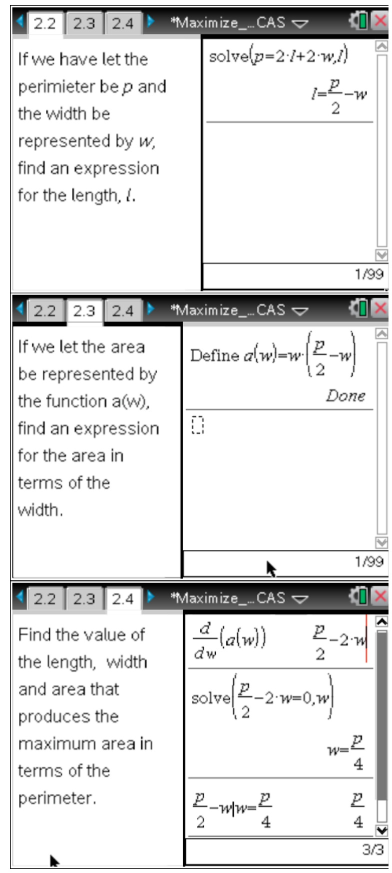
    **Answer**: The area of Jackie's garden would be four times the area of the garden with 22 m of fencing. Methods similar to those used for the solution for the garden with a perimeter of 22 m can be used to solve this problem.

19. Return to problem 1 and find the dimensions of the rectangles with maximum area when the perimeter is 24 m, 36 m, and 300 m. Find a relationship between the length and width of a rectangle with one side on a barn.

    **Answers**: If the perimeter is 24 m, the width is 6 m and the length is 12 m. If the perimeter is 36 m, the width is 9 m and the length is 18 m. If the perimeter is 300 m, the width is 75 m and the length is 150 m. The length is always double the width. The width is one-fourth of the perimeter, and the length is half the perimeter.

**Move to problem 2.**

20. As outlined on page 2.1, we are going to investigate the relationship between the length and perimeter if we are given a fixed perimeter of fence and are fencing all four sides.




21. On page 2.2, find an expression for the length in terms of the width and the perimeter.

    **<u>Answer</u>**: Let *w* be the width of the rectangle. Define the length as *p/2* – *w*.

22. On page 2.3, find an expression for the area in terms of the width only.

    **<u>Answer</u>**: The area would be $a = w \cdot (p/2 - w)$.

23. On page 2.4, find the values of the width, length, and perimeter that produce the maximum area.

**Teacher Tip:** This solution uses methods students would be taught in calculus classes. Another method is provided at the end of this activity that utilizes the command for completing the square.

**Extension:**

1. The perimeters of three rectangular gardens are 24 m, 36 m, and 300 m. Find the dimensions of each garden if you were fencing all four sides and wanted to maximize the area.

   **<u>Answers:</u>** If the perimeter is 24 m, the length and width are each 6 m. If the perimeter is 36 m, the length and width are each 9 m. If the perimeter is 300 m, the length and width are each 75 m.

2. Use problem 2 in the TI-Nspire™ document file to explore the dimensions of this type of garden. Add pages, as needed, to determine the width and length that will result in a garden with the maximum area.

> **Tech Tip:** The rectangle on page 3.2 displays various dimensions and area values as the students drag the point. The spreadsheet is set up for automated data capture. To view the data points in a scatter plot, students will need to add a *Graphs* or *Data & Statistics* application page and set up the plot.

> **Teacher Tip:** The perimeter equation is $2w + 2l = 22$, and the equation for the area in terms of the width is $A = w \cdot (11 - w)$. The maximum value of the area function can be found using any of the strategies described for the other maximum-area problem in this activity.

## Additional Tech Tips for this Activity

**Tech Tip: Tracing on a Function**

Students can trace on their function to determine the maximum function value.'

1. Select **Menu > Trace > Graph Trace**.
   - If both a scatter plot and a function have been graphed, the **Graph Trace** will display the coordinates of the first ordered pair plotted in the scatter plot. Press ▲ or ▼ to move to the graph of the function and display a function value.
   - Then, use the right (▶) or left (◀) arrow keys to trace on the function. The window will adjust automatically.
   - When the maximum value of the function is approached, the tracing point moves to the maximum function value, and the word **maximum** is displayed.
   - The coordinates of this point are displayed in the lower-right corner of the screen.
2. To change the **Trace Step**, select **Menu > Trace > Trace Step**.
   - The current **Trace Step** setting is **Automatic**.
   - If desired, enter a **Trace Step** value, press [tab] to move to **OK**, and press [enter].
3. To exit the tracing mode, press [esc].

**Tech Tip: Adding a Function Table**

1. To add a function table, select **Menu > View > Show Table**. (The shortcut is ctrl T.) When the **Table** work area is selected (outlined in bold), the **Table Start** and **Table Step** values may be edited.
2. Select **Menu > Table > Edit Table Settings**.

**Tech Tip: Computing a Regression Equation**

1. To compute a regression equation, first add a page by pressing ctrl doc▾. Select **Add Calculator**.
2. Select **Menu > Statistics > Stat Calculations > Quadratic Regression**. Press to display the list names, and choose **width** for the **X List**.
4. Press tab to move to **Y List**.
5. Press and choose **area** for the **Y List**.
6. Press tab to move to **OK**, and press or enter

**Note:** A regression equation can also be computed in a *Lists & Spreadsheet* application. The advantage of that method is that if data are changed or additional data added, the regression equation is updated.

**Tech Tip: Graphing the Regression Equation**

1. To graph the regression equation, first return to a page that contains a graph of the data by pressing ctrl ◀. Be sure that the *Graphs* work area is active by clicking on that region of the screen.
2. Press tab to display the entry line. The function **f3(*x*) =** is displayed.
3. Press the up arrow (▲) to display **f2(*x*)**, the regression equation.
4. Press enter to graph the regression equation Follow the steps described above to trace on the regression equation.

**Tech Tip: Using the Function Maximum Command**

This menu option will determine the value of the independent variable that produces the maximum function value.

1. To compute the value on a new *Calculator* page, press ctrl doc▾ and choose **Add Calculator**. Select **Menu > Calculus > Function Maximum.**
2. On the line showing **fMax**( ), type f1(*x*),*x* between the parentheses and press enter. The function value at this value of *x* can be computed as shown.

**Note**: The function **f1**(*x*), the function that students should have first entered on page 1.4, is used rather than the regression equation. Students can convert the answers to decimal by pressing ctrl enter after each line.

**Tech Tip: Method 1 in the Teacher Tips for Question 17**

<u>**Note**</u>: These screenshots are shown in a new problem. This problem 2 is not related to problem 2 in the .tns file.

**Method 1:** Graph the function **f2**($x$) = 52.5 with the graph of the area function (**f1**($x$)). Find the points of intersection of the graphs.

1. Select **Menu > Points & Lines > Intersection Point(s).**
2. Move the cursor close to one of the graphs and press [click] or [enter].
3. Move the cursor near the second graph and press [click] or [enter]. Both points of intersection are displayed.
4. Press [esc] to exit the **Intersection Point(s)** tool.

**Tech Tip: Method 2 in the Teacher Tips for Question 17**

**Method 2:** Add a point to the graph of the function. When the *y*-value of the point's ordered pair is changed to 52.5, the value of *x* that results in this function value is computed.

1. To add a point to the graph of the function, select **Menu > Points & Lines > Point On**.
2. Click twice on the graph of the function.
3. Press [esc].
4. Move the cursor over the *y*-value of the point, and press [enter] twice to open a text box.
5. Press [del] to erase the current value.
6. Enter **52.5**, and press [enter] **7**. Place a point to the right of the vertex, and repeat the process to obtain the second solution.

**Tech Tip: Method 3 in the Teacher Tips for Question 17**

**Method 3:** Use the **Solve** command to find the width.

1. Add a *Calculator* page by pressing [ctrl] [doc▾] and choosing **Add Calculator**.
2. Select **Menu > Algebra > Solve**.
3. On the line that shows **Solve( )**, enter $\mathbf{22x - 2x^2 = 52.5,\ x}$ between the parentheses and then press [enter]. Alternatively, enter **Solve(f1(*x*) = 52.5, x)**.

**Tech Tip: Using the Complete the Square Command for Question 23**

1. Select **Menu > Algebra > Complete the Square**.
2. On the line that shows **completeSquare( )**, enter ***a*(*w*), *w*** between the parentheses and then press [enter].

# Solving Linear Equations

**TI PROFESSIONAL DEVELOPMENT**

**TEACHER NOTES**

## Activity Overview:

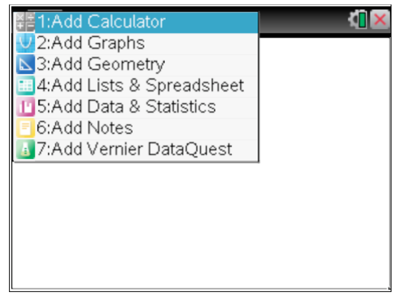
*This activity describes how to solve a linear equation using an explicit method of solving rather than the Solve command.*

### Step 1:

Press on and select **New Document** to start a new document.

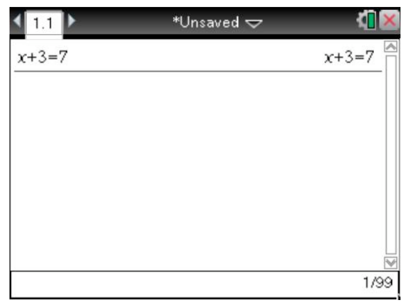
### Step 2:

Select **Add Calculator.**



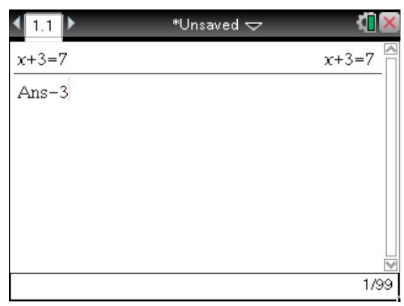

### Step 3:

Enter the first equation, x + 3 = 7, as shown. Press enter. This stores the equation in memory. The cursor should be flashing on the next line.



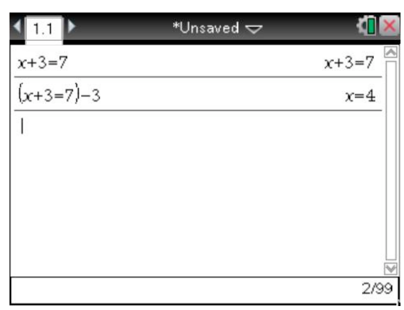

### Step 4:

To solve this equation, we need to subtract 3 from each side. The TI-Nspire™ CAS permits the user to type in the operation and the value needed. Press the subtraction key, − ,followed by the digit 3. As soon as the subtraction key is pressed, the device inserts the phrase “Ans”, referring to the result from the previous line.




### Step 5:

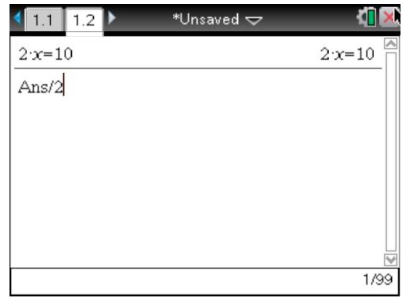
Press enter. On the left side of the line, the device replaces “Ans” with the result from the previous line in parentheses.  The answer appears on the right side.



**Step 6:**

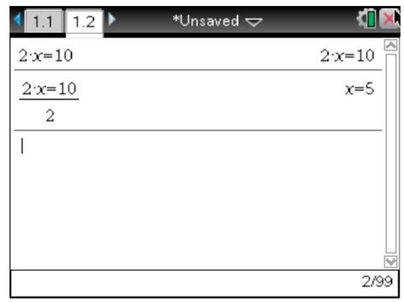
Press ctrl followed by the letter I to insert a new page. Select **Add Calculator** again. Enter the second equation, 2x = 10.

In order to solve this equation, we need to divide each side by 2. As you press the ÷ key, the handheld places the phrase "Ans" again in the current line. Complete the operation by pressing the digit 2 and enter.



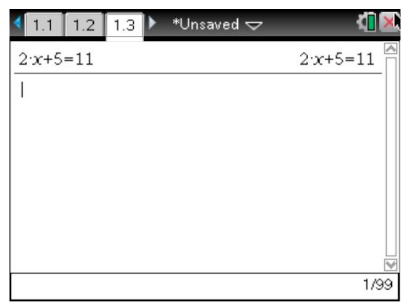

**Step 7:**

Again, the device replaces the phrase "Ans" with the result from the previous line. The display on the left side should match the screen to the right. The answer is displayed on the right side.



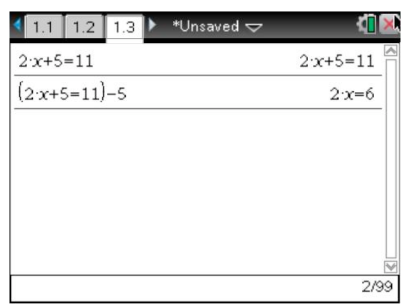

**Step 8:**

Insert another *Calculator* page and enter the third equation, 2x + 5 = 11. The solution to this equation will take two steps.



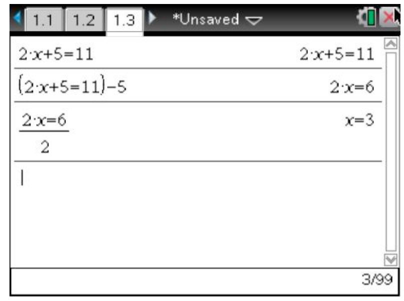

**Step 9:**

To balance the equation, subtract 5 from each side. Press − 5 followed by enter.



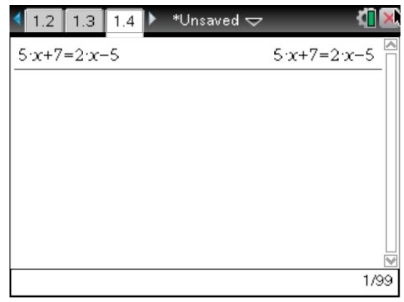
**Step 10:**

Divide each side by 2 by pressing $\boxed{\div}$ $\boxed{2}$. The answer is shown on the right of the calculator screen.



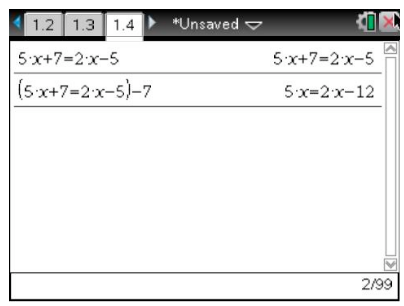

**Step 11:**

Insert another *Calculator* page and enter the fourth equation, 5x + 7 = 2x - 5. The solution to this equation will take three steps.



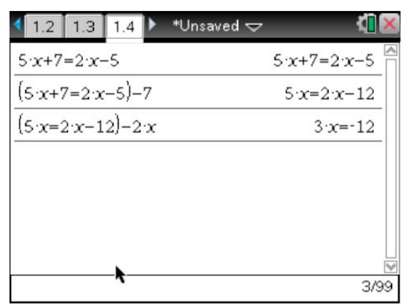

**Step 12:**

To remove the 7 from the left side, press $\boxed{-}$ $\boxed{7}$. The answer is shown on the right of the calculator screen.



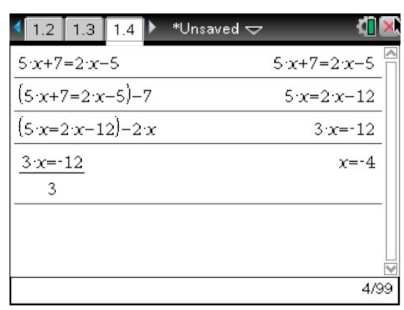

**Step 13:**

To remove the 2x from the right side, press $\boxed{-}$ $\boxed{2}$ $\boxed{X}$. As before, the result is shown on the right of the calculator screen. The order of the first two steps will not matter. When you have finished, start the problem over again and try reversing the steps.




**Step 14:**

Finally, to isolate the variable x, press $\boxed{\div}$ $\boxed{3}$. The answer is shown on the right of the calculator screen.



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# Solving by Elimination with CAS
**MATH NSPIRED**

**Teacher Notes**

## Activity Overview
This activity steps you through the process of solving a system of two linear equations by the method of elimination.

---

**Step 1:**

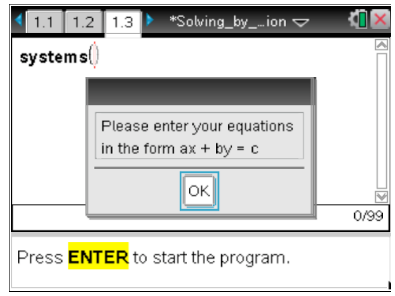
On page 1.3, run the **systems()** program by pressing [enter] and work through the process of solving a system of your choice.

<u>Note</u>: The system must defined in terms of *x* and *y*.

**Possible System:**

$8x - 3y = -10$

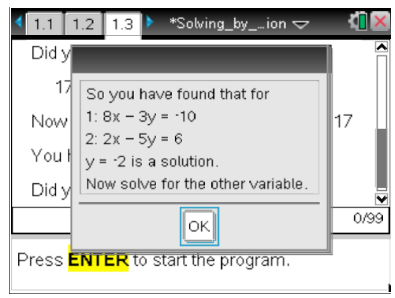
$2x - 5y = 6$

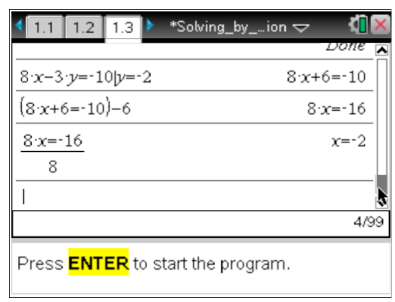



**Step 2:**

Once you have solved your system of equations for one variable, use the CAS functionality to solve for the other variable. If you want to run the program again, type **systems()** and press [enter].

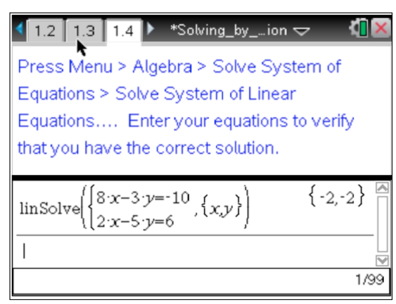
<u>Note</u>: You can also recall the program name by pressing [var] and selecting the name from the list of variables.




**Step 3:**

Move to page 1.4. Press **Menu > Algebra > Solve System of Equations > Solve System of Linear Equations**. Enter the pair of equations from your system and press [enter] to verify the solution.



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# Creating a Slider

**TI PROFESSIONAL DEVELOPMENT**

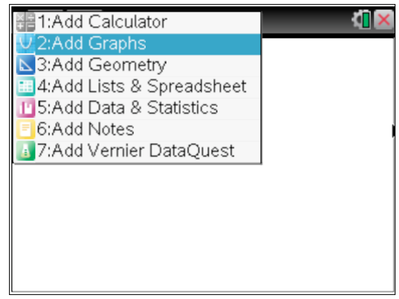


## Activity Overview:

*In this activity you will graph two functions and explore various methods for finding points of intersection.*

**Step 1:**

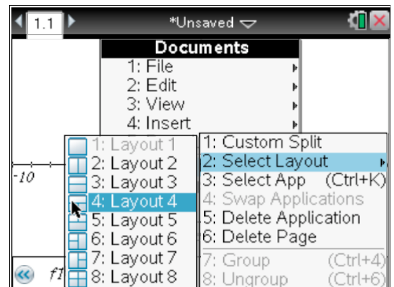
Press [⌂ on] and select **New Document** to start a new document and select Add Graphs.




**Note**: If you would like to save the document you were working on select Yes, otherwise select No.

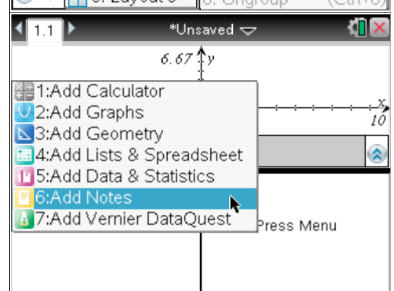
**Step 2:**

Create a new page layout. Press [doc▾] **> Page Layout > Select Layout > Layout 4**. This will create a layout with a single pane on top and two panes in the lower part of the screen.




**Step 3:**

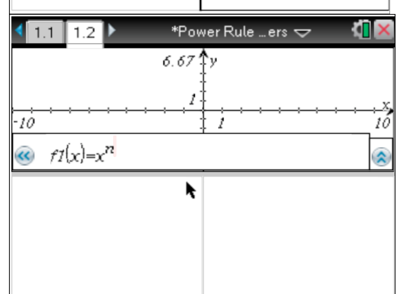
Select each of the lower panes by moving the cursor to the pane and pressing [☝]. In each of the lower panes, select Add Notes.




**Note**: You can also move to each section of the layout by pressing [ctrl] [tab].

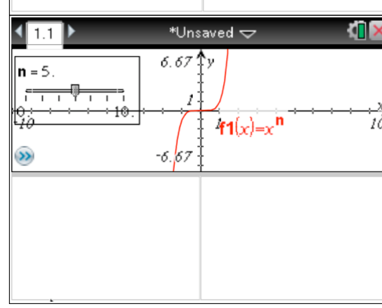
**Step 4:**

Move to the entry line of the Graphs application and enter f1(x) as $x^n$. When you press [enter], the graph will not appear since the value of n has not been defined.



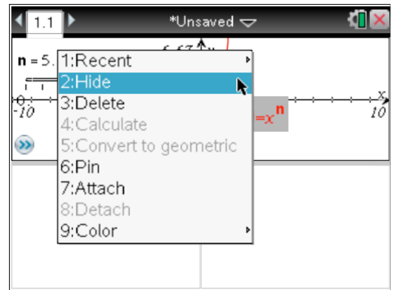

**Step 5:**

Press **Menu > Actions > Insert Slider**. The slider will be grabbed by the cursor. Position the slider in the upper left corner and press [☝] to drop it in place. Change the variable from v1 to n. By default, the value of the slider will be 5 and its values will vary from 0 to 10. You should see the graph of f(x) = $x^5$ in the graphing window.



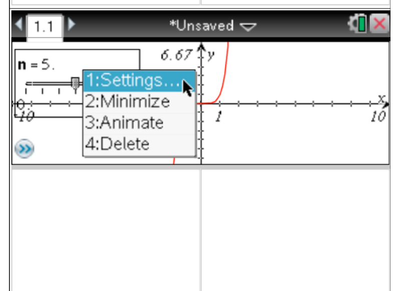
**Step 6:**

Move the cursor to the graph's label and press ctrl menu. This displays the contextual menu for this object. This is equivalent to a right click on a mouse. Choose Hide from the menu.



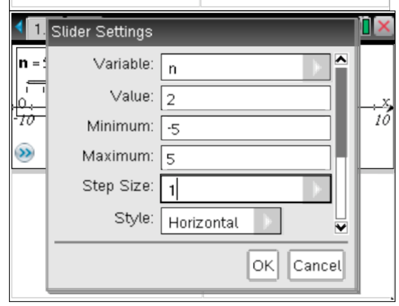

**Step 7:**

Move to the slider until a frame appears around it and press ctrl menu. Select Settings from the menu.




**Step 8:**

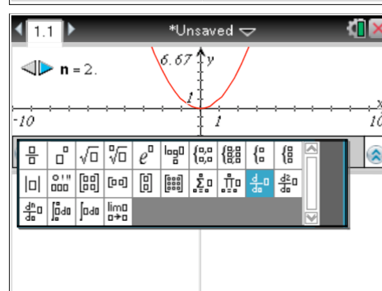
Change the settings as shown on the right. Press tab to move from one field to the next. Make sure that the checkbox labeled Minimized is checked. Press enter to complete the changes.




**<u>Note</u>:** You can also Minimize the slider by pressing ctrl menu and selecting Minimize.

**Step 9:**

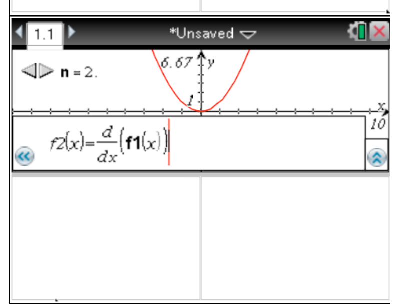
Press tab to view the function entry line. This is where the derivative function will be defined. Press  and select the derivative template.




**<u>Note</u>:** You can also view the function entry line by pressing ctrl G.

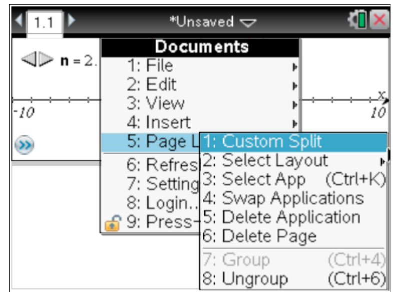
**Step 10:**

The template will be pasted in the entry line with the cursor in the bottom field of the derivative template. Complete the template as shown on the right. Press enter to display the graph of the derivative function. Hide the function label as described in **Step 6**.



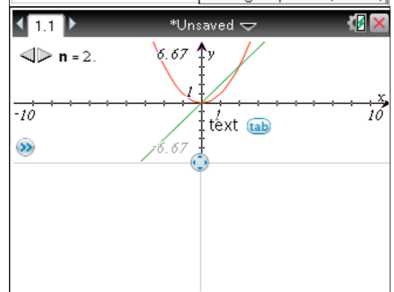
**Step 11:**

The horizontal split was set halfway down the page by default. To move the horizontal split, press doc▾ **> Page Layout > Custom Split**.



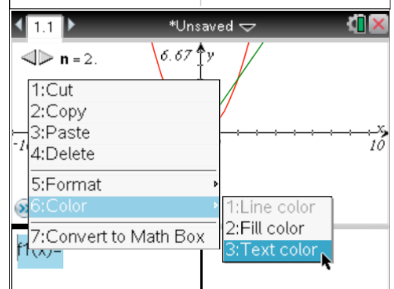

**Step 12:**

Press ▼ on the Touchpad until the Graph application is about three-quarters of the screen.



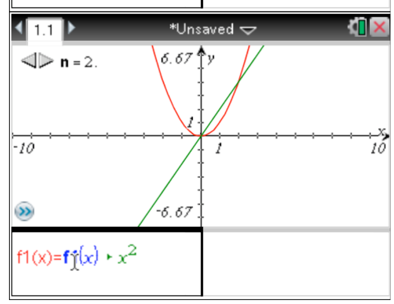

**Step 13:**

Move to the lower left *Notes* application. Type “f(x) =”. Highlight the text by holding down the ⇧shift key and pressing ◀ or ▶ until the entire expression has been highlighted. Press ctrl menu and select Color > Text Color. Change the text color to red in order to match with the graph above.




**Step 14:**

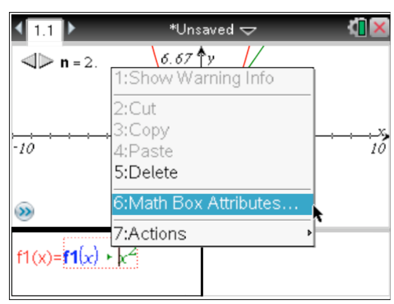
Press Menu > Insert > Math Box to create a math box. Type in “f1(x)” in the math box field and press enter. A new math box will appear on the next line and may push your result up to a location where you cannot see all of it. Press del until the new math box and the new line disappear.




**Note:** A math box can also be created by pressing ctrl M.

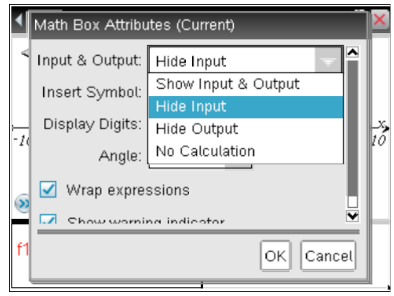
**Step 15:**

Move the cursor back into the math box and press ctrl menu. Select **Math Box Attributes**.



**Step 16:**

Open the Input & Output field by pressing ▶. Select **Hide Input** and press [enter]. Press [enter] to close the Math Box Attributes dialog box.

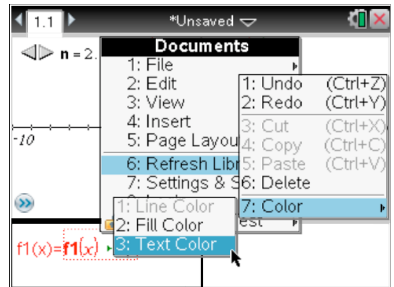



**Step 17:**

Press ◀ or ▶ to move the cursor out of the math box. The input field will disappear.

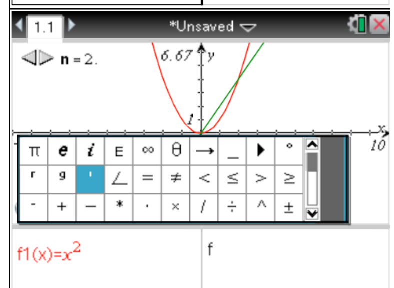
**Step 18:**

To change the color of the output, move the cursor into the output text and press [doc▾] > **Edit > Color > Text Color** and select red. Move the cursor out of the math box to see the output only.



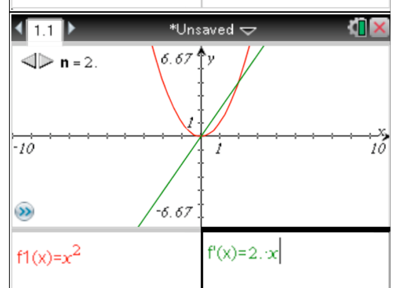

**Step 19:**

Press [ctrl] [tab] to move to the lower right *Notes* application. Type "f´(x) = ". (Press [ctrl] [📖] to view the symbols palette and select the "prime" symbol.) Change the text color to green.




**Step 20:**

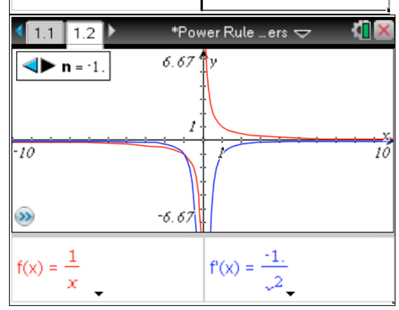
Insert a math box and type in f2(x). Hide the input and change the output color to green.




**Step 21:**

Press [ctrl] [tab] to move to the *Graphs* application. Move the cursor to the slider arrows and press [☟] to change the value of the slider. Adjust the slider to observe the function and its derivative for various exponents.

With negative exponents, the expressions in the *Notes* boxes may not be completely visible. Adjust the custom split ([doc▾] **> Page Layout > Custom Split**) as needed.



# Match Me
## Student Activity

**Name** ____________________

**Class** ____________________

### Overview

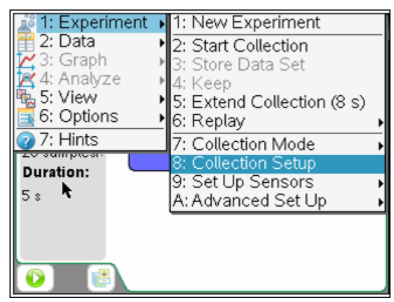
In this activity you will match your motion to a given graph of position versus time. You will apply the mathematical concepts of slope and *y*-intercept to a real-world situation.

### Materials

- TI-Nspire™ handheld or software with *Vernier DataQuest*™ application
- CBR 2™ with USB cable

### Part 1—Easy, step-by-step setup

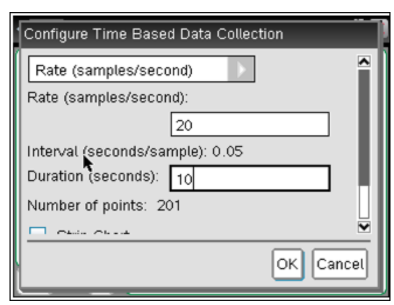

To utilize the built-in, easy-to-use **Motion Match** activity, first turn on the TI-Nspire™ and choose **New Document**. Then plug in the CBR 2™ and the screen to the right will automatically launch.




Hold the CBR 2™ so that it points toward a smooth surface like the wall or door. Move forward and backward to observe the reading changes on the meter.

1. How far are you from the wall? _________

Record all the digits that are given, as well as the units.



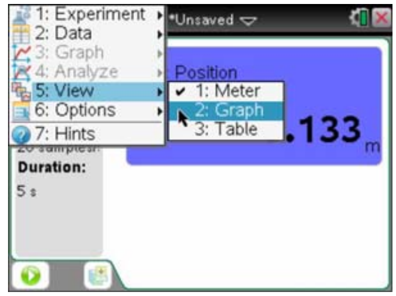

You will set up an experiment for 10 seconds. Press **Menu > Experiment > Collection Setup.** Change the duration to 10 seconds.

# Match Me
## Student Activity

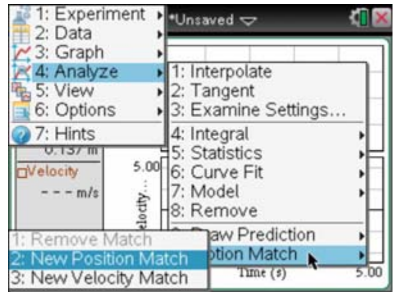
**Name** ______________________

**Class** ______________________

Now, set up the graph. Press **Menu > View**. There are three views. The first view you had was **Meter**. Choose the **Graph** view for additional menu options.



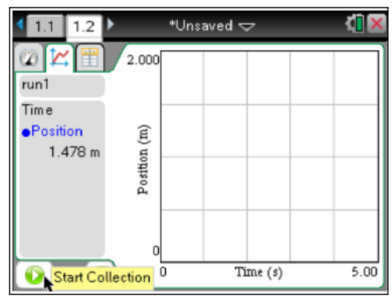

Press **Menu > Analyze > Motion Match > New Position Match**. These menu selections are shown in the screen shot on the right.




2. What physical quantity is the dependent variable? ____
   A. velocity in meters/second
   B. position in meters
   C. time in seconds

3. What variable is plotted on the *x*-axis? ____________

Draw your Position Match on the graph to the right.




4. What is the domain? Include units. _________

5. What is the range? Include units. __________

6. Record your observations about the graph by answering the following questions:
   a. What is the *y*-intercept?

   b. What does the *y*-intercept represent physically?

   c. Approximately what distance from the wall will the motion detector need to be located to match the initial position in the motion graph?

   d. The slope is the rate of change of position with respect to time. When does the graph depict the slowest motion?

7. Press the **Start Collection** arrow on the bottom-left of the screen. Point the CBR 2™ at a wall and move yourself back and forth until your graph matches the Position Match graph as closely as possible. If you are not pleased with your first attempt, you can press **Start Collection** again to repeat. You may want to review the information that you wrote about the graph to assist you. When you are satisfied, sketch the graph you created on top of the given graph.

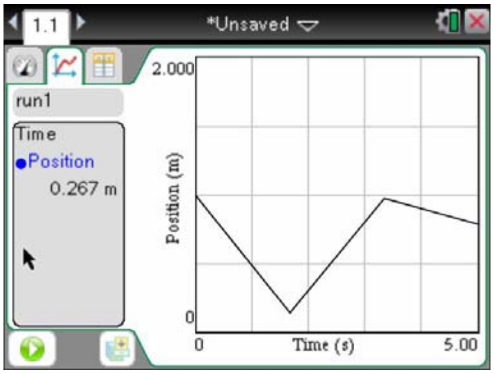
# Match Me
**Student Activity**

**Name** ____________________

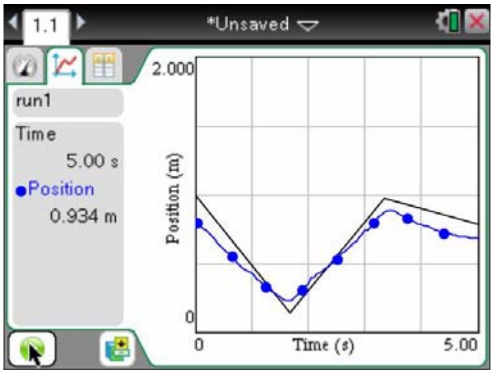
**Class** ____________________

8. Describe the parts of your graph that were difficult to match and how you made adjustments, based on your graph of your walk, to make a better match in your next attempt..

Now, look at the graph shown to the right.




9. Describe how you would need to walk in order to match that graph with your motion. Be sure to include information about the *y*-intercept, position at various times, velocity, and direction. For what times does the graph depict the slowest motion and the fastest motion?




10. Describe the curve with round dots that was created when **Start Collection** was pressed. Contrast the motion graph that should have been created to what actually happened. Write at least two complete sentences. For example, *from 2 to 3.5 seconds the person is moving too slow to reach the maximum distance away*.

**Part 2—Extend and Explore**

Press **Menu > Analyze > Motion Match > New Position Match**. Press **Start Collection** and walk to match the graph. A trial can be saved by pressing the file cabinet icon next to **Start**.

11. Discuss your new match with a classmate. Use words like *positive and negative slope*.

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## Math and Science Objectives

- Students will examine graphs of position versus time and match them with their motion to demonstrate their understanding of the graph.
- Students will explain how velocity and starting position relate to slope and *y*-intercept.
- Students will use appropriate tools strategically. (CCSS Mathematical Practice)

## Vocabulary

- speed
- velocity
- initial position

## About the Lesson

- In this lesson, students will examine a graph of position versus time and collect data by moving in front of a CBR 2™ to match their motion to the given graph.
- As a result, students will:
  - Develop a conceptual understanding of how their motion affects the slope and position values on the graph
  - Make a real-world connection between position, time, and velocity

## Materials and Materials Notes

- CBR 2™ with USB CBR 2™–to–calculator cable.
- Using the CBR 2™ with a computer requires the use the mini-standard USB adaptor to plug the CBR 2™ into a computer with TI-Nspire™ Teacher or Student Software. This adapter will convert the CBR 2™ USB cable to a standard USB connection so that it can be connected to the computer.
- **<u>New option</u>**: Use the legacy CBR™ with the new TI-Nspire™ Lab Cradle. You will need the MDC-BTD cord to connect a motion detector to the TI-Nspire™ Lab Cradle. With the Lab Cradle, you can even connect multiple motion detectors to extend your exploration.


**TI-Nspire™ Technology Skills:**

- Collect motion data with the *Veriner DataQuest*™ app.

**Tech and Troubleshooting Tips:**

1. Flip the motion detector open. Set the switch to normal.
2. Check that the four AA batteries in the motion detector are good.
3. Unplug and plug the CBR 2™ back in.
4. When using an older CBR™ or motion detector with the Lab Cradle, you may need to launch Vernier LabQuest™. Then press **Menu > Experiment > Advanced Setup > Configure Sensor > TI-Nspire Lab Cradle: dig1 > Motion Detector**.

**Lesson Files:**
*Student Activity*
Match_Me_Student.pdf
Match_Me_Student.doc

**Discussion Points and Possible Answers**

**Part 1—Easy, step-by-step setup**


To utilize the built-in, easy-to-use **Motion Match** activity, first turn on the TI-Nspire™ and choose **New Document**. Then plug in the CBR 2™ and the screen to the right will automatically launch.

Hold the CBR 2™ so that it points toward a smooth surface like a wall or door. Move forward and backward to observe the reading changes on the meter.

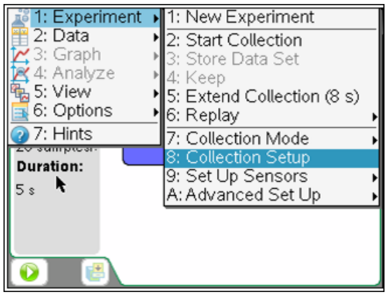
**Tech Tip:** The *Vernier DataQuest*™ app is user friendly. It should launch when the CBR 2 is connected. To begin the data collection, click the green Play button in the lower left corner of the screen.

1. How far are you from the wall? Record all the digits that are given, as well as the units.

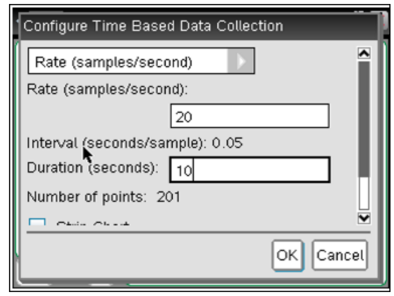
 **Sample answer:** Answers will vary. The meter in the **Screen Capture** above shows 0.289 m from the wall or closest object.

**Teacher Tip:** When the CBR 2™ is first connected it, begins clicking and recording measurements. Have the students move the CBR 2™ by pointing it at different objects. Ask them what the motion detector is doing. It should be measuring the distance from the CBR 2™ to the object directly in front of it. Be aware that it reads the distance to the closest item in its path, so students should keep an open area between the wall and the target object or person.

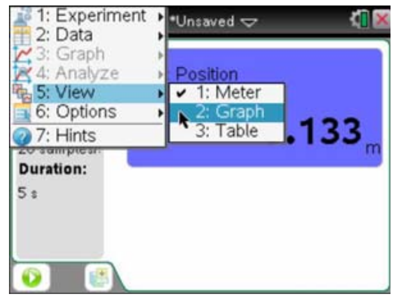
You will set up an experiment for 10 seconds. Press **Menu > Experiment > Collection Setup.**



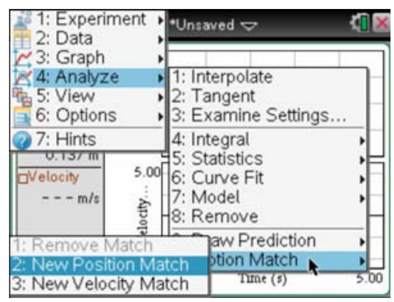
Change the duration to 10 seconds.




Now, set up the graph. Press **Menu > View**. There are three views. The first view displayed was **Meter**. Choose the **Graph** view for additional menu options.




Press **Menu > Analyze > Motion Match > New Position Match**.



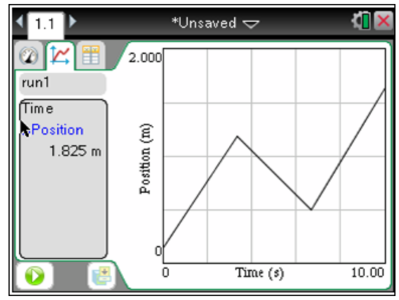

2. What physical quantity is the dependent variable?
   A. velocity in meters/second
   B. position in meters
   C. time in seconds

   **<u>Answer</u>:** B. position in meters

3. What variable is plotted on the *x*-axis?

   **<u>Sample answer</u>:** The time in seconds, the independent variable, is graphed on the *x*-axis.

Draw your Position Match on the graph to the right.




**Answer:** Student graphs will vary because the *Vernier DataQuest*™ application randomly generates new graphs.

4. What is the domain? Include units.

   **Sample answer:** The domain is from 0 to 10 seconds.

5. What is the range? Include units.

   **Sample answer:** The range is from 0 to 2 meters (This could vary).

6. Record your observations about the graph by answering the following questions.

   a. What is the *y*-intercept?

      **Sample answer:** Numerical values may vary but the answer should be in meters.

   b. What does the *y*-intercept represent physically?

      **Sample answer:** The *y*-intercept represents the starting position of the target object or person, sometimes referred to as the initial position. It indicates how close the target should be to the wall before beginning to move.

   c. Approximately what distance from the wall will the motion detector need to be located to match the initial position in the motion graph?

      **Sample answer:** Answers will vary depending on the motion graph generated, but the answer should be in meters.

   d. The slope is the rate of change of position with respect to time. When does the graph depict the slowest motion?

      **Sample answer:** Answers will vary depending on the motion graph generated. The slope is the velocity that describes how fast the target object or person is moving and in what direction. Some students may say that velocity is speed. This is a great opportunity to explain the difference between speed and velocity. Speed indicates how fast the target is moving, but it does not include direction. Since speed has magnitude only, it is referred to as a scalar quantity. Speed is always positive. Velocity is called a vector quantity. It includes both the speed and direction. Velocity can be positive or negative for a person moving back and forth along a line. Velocity is positive when the target moves away from the motion detector, increasing the distance, and negative when the target moves toward the motion detector, decreasing the distance between the detector and itself.

> **Teacher Tip:** It is important for students to make a prediction before simply pressing the **Start** button. Making predictions and testing those predictions supports higher level thinking.

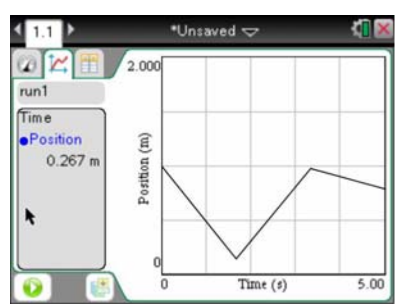
7. Press the **Start Collection** arrow on the bottom-left of the screen. Point the CBR 2™ at a wall and move yourself back and forth until your graph matches the Position Match graph as closely as possible. If you are not pleased with your first attempt, you can press Start Collection again to repeat. You may want to review the information that you wrote about the graph to assist you. When you are satisfied, sketch the graph you created on top of the given graph.

> **Tech Tip:** If the students are not satisfied with their results, they can repeat the data collection by clicking the **Start** button again. This will overwrite the previous trial.

8. Describe the parts of your graph that were difficult to match and how you made adjustments, based on your graph of your walk, to make a better match in your next attempt.

   **<u>Sample answer</u>:** Answers will vary.

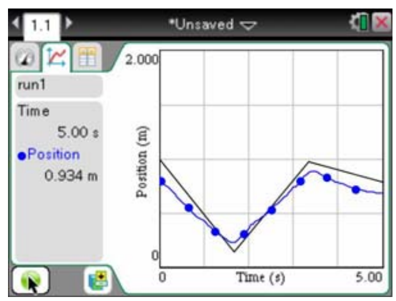
Now, look at the graph shown at the right.



9. Describe how you would need to walk in order to match that graph with your motion. Be sure to include information about the *y*-intercept, position at various times, velocity, and direction. For what times does the graph depict the slowest motion and the fastest motion?

   **Sample answer:** The walker begins one meter from the wall and moves toward the wall at a constant velocity for about 1.7 seconds. The walker gets about 0.3 meters from the wall and then begins walking away from the wall at about the same rate for another 1.7 seconds, arriving back at 1.0 meters from the wall. The walker then begins to slowly move toward the wall until a total of 5 seconds has elapsed. The slopes of the first two sections appear to indicate the same speed, but the first of these velocities is negative, while the second is positive. The walker moved slowest during the time period from 3.4 to 5 seconds.

10. Describe the graph with round dots at the right that was created when **Start Collection** was pressed. Contrast the graph of position versus time that should have been created with what actually happened. Write at least two complete sentences. For example, *from 2 to 3.5 seconds the person was moving too slow to reach the maximum distance*.




   **Sample answer:** Answers will vary but may include the following information: The walker began a little too close to the wall, so the *y*-intercept is smaller than it should be. The walker was moving too slowly in the second section of the graph between 1.7 and 3.4 seconds. The walker was moving at about the right velocity for the third section of the graph, but the position was a little closer to the wall than it should have been.

> **Teacher Tip:** If time permits, you should have each student match a graph without coaching. You may want to have them save the document and send it in via TI-Nspire™ Navigator™ as an individual evaluation. When students can match the graphs on their own, you are more assured that they understand the meaning of the *y*-intercept and slope as they relate to motion graphs.

**Part 2—Extend and Explore**

Press **Menu > Analyze > Motion Match > New Position Match**. Press **Start Collection** and walk to match the graph. A trial can be saved by pressing the file cabinet icon next to **Start**.

11**.** Discuss your new match with a classmate. Use words like *positive and negative slope*.

**Sample answer:** Answers will vary depending upon the graph generated.

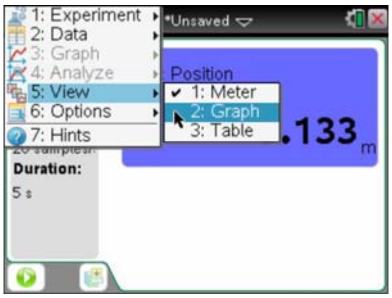
**Teacher Extension**

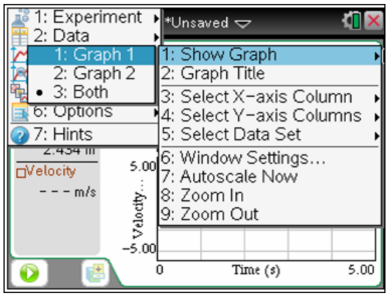
You can create your own matches for students if you want to be sure that they can match a graph with specific criteria. Follow these steps.

1. Open a new document and then connect the CBR 2™.

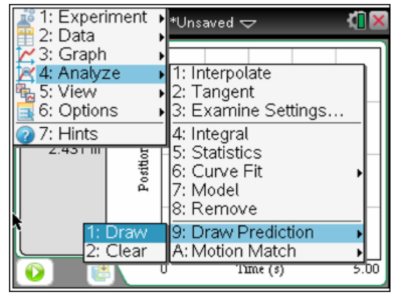
2. You will set up an experiment for 10 seconds. Press **Menu > Experiment > Collection Setup**. Change the duration to 10 seconds.

3. Now, set up the graph. Press **Menu > View**. Choose the **Graph** view. Then press **Menu > Graph > Show Graph > Graph 1**.

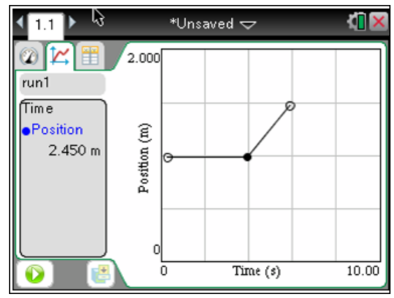


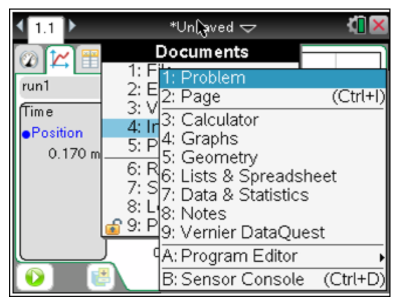
4. To draw your own match, press **Menu > Analyze > Draw Prediction > Draw**.




5. A pencil appears on the grid. Move the pencil to a point just off of the vertical axis on the left side of the grid, and click to set the initial value. Use the pencil to draw the path that you want students to match. Click at each point to set the end of a segment. Use the esc key to exit the draw mode when you have completed the match.




6. To create a document with multiple matches, insert a new problem for each match. To insert a new problem, press doc▾ and select **Insert > Problem**. Follow the directions for creating a match. If you want to create a velocity match rather than a position match, choose to view **Graph 2** rather than **Graph 1** (**Menu > Graph > Show Graph > Graph 2**.)



# Solving Linear Equations

**TI PROFESSIONAL DEVELOPMENT**



## Activity Overview:

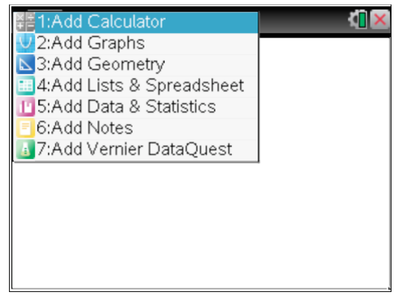
*This activity describes how to solve a linear equation using an explicit method of solving rather than the Solve command.*

**Step 1:**

Press [⌂ on] and select **New Document** to start a new document.

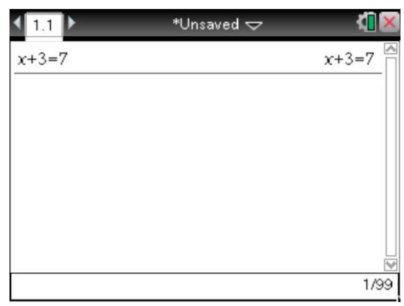
**Step 2:**

Select **Add Calculator.**



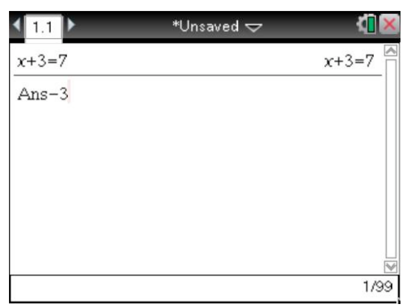

**Step 3:**

Enter the first equation, x + 3 = 7, as shown. Press [enter]. This stores the equation in memory. The cursor should be flashing on the next line.



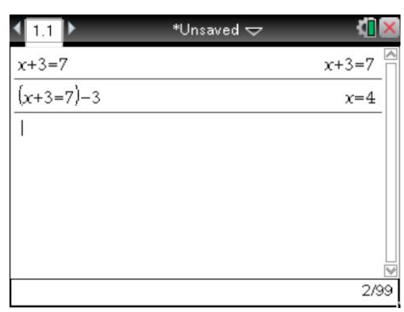

**Step 4:**

To solve this equation, we need to subtract 3 from each side. The TI-Nspire™ CAS permits the user to type in the operation and the value needed. Press the subtraction key, [−] ,followed by the digit [3]. As soon as the subtraction key is pressed, the device inserts the phrase "Ans", referring to the result from the previous line.




**Step 5:**

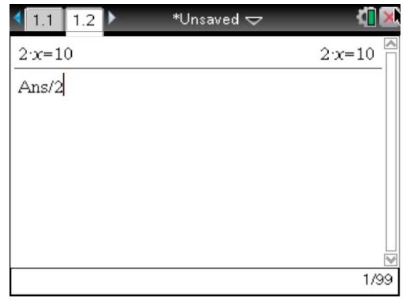
Press [enter]. On the left side of the line, the device replaces "Ans" with the result from the previous line in parentheses. The answer appears on the right side.



**Step 6:**

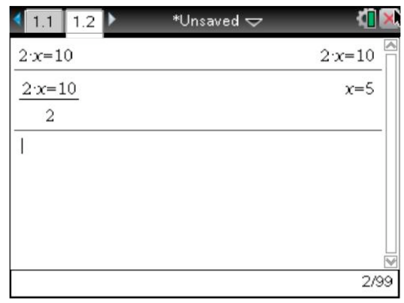
Press [ctrl] followed by the letter [I] to insert a new page. Select **Add Calculator** again. Enter the second equation, 2x = 10.

In order to solve this equation, we need to divide each side by 2. As you press the [÷] key, the handheld places the phrase “Ans” again in the current line. Complete the operation by pressing the digit [2] and [enter].



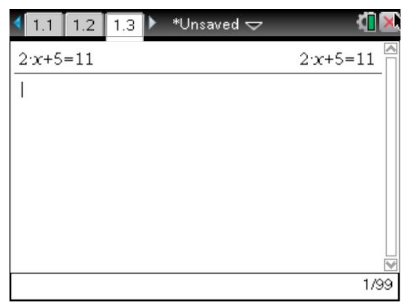

**Step 7:**

Again, the device replaces the phrase “Ans” with the result from the previous line. The display on the left side should match the screen to the right. The answer is displayed on the right side.



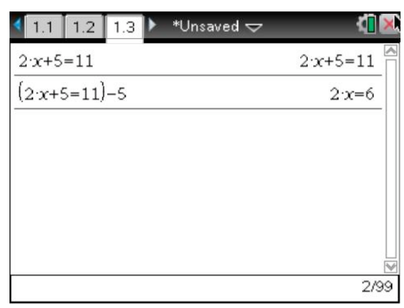

**Step 8:**

Insert another *Calculator* page and enter the third equation, 2x + 5 = 11. The solution to this equation will take two steps.



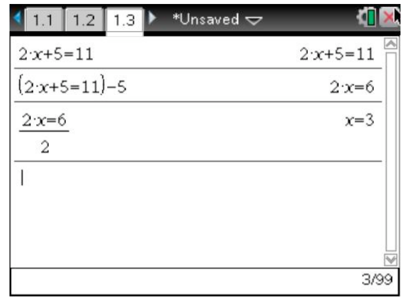

**Step 9:**

To balance the equation, subtract 5 from each side. Press [−] [5] followed by [enter].



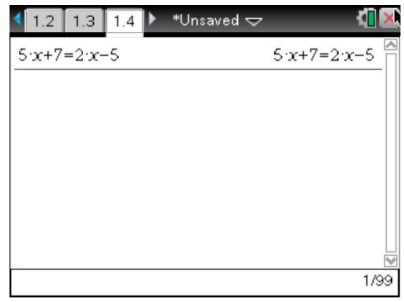
**Step 10:**

Divide each side by 2 by pressing [÷] [2]. The answer is shown on the right of the calculator screen.



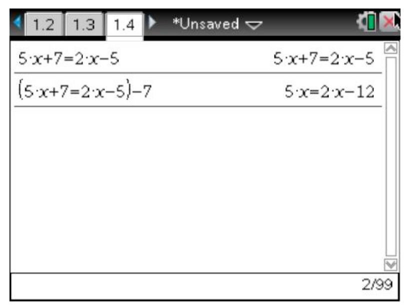

**Step 11:**

Insert another *Calculator* page and enter the fourth equation, 5x + 7 = 2x - 5. The solution to this equation will take three steps.



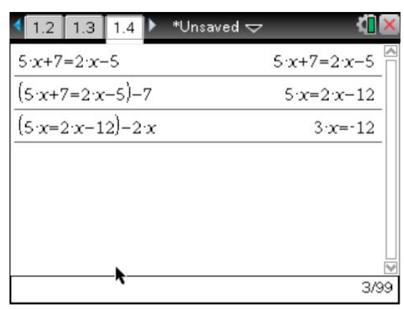

**Step 12:**

To remove the 7 from the left side, press [−] [7]. The answer is shown on the right of the calculator screen.



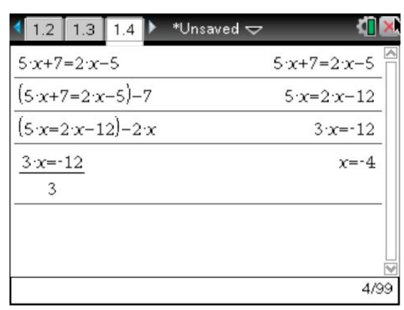

**Step 13:**

To remove the 2x from the right side, press [−] [2] [X]. As before, the result is shown on the right of the calculator screen. The order of the first two steps will not matter. When you have finished, start the problem over again and try reversing the steps.




**Step 14:**

Finally, to isolate the variable x, press [÷] [3]. The answer is shown on the right of the calculator screen.



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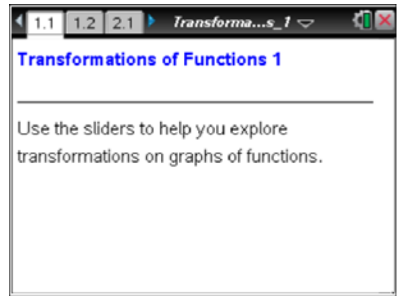
# Transformations of Functions 1

## Student Activity

Name ________________

Class ________________

**Open the TI-Nspire document *Transformations_of_Functions_1.tns.***




This activity investigates some transformations of functions. The graph of a function $y = f(x)$ will be *translated*. You will be able to compare the new graph with the original to determine the impact of changes to the function on the graph.

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**Move to page 1.2.**

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

**Part One: $y = f(x) + k$.**

1. Drag the point to change the value of $k$.
   a. What happens to the graph of $y_2 = f(x) + k$ as the value of $k$ changes?

   b. Move the point so that $k > 0$. Where is the graph of $y_2 = f(x) + k$ compared to $y_1 = f(x)$?

   c. Move the point so that $k < 0$. Where is the graph of $y_2 = f(x) + k$ compared to $y_1 = f(x)$?

   d. Move the point so that $k = 0$. Where is the graph of $y_2 = f(x) + k$ compared to $y_1 = f(x)$?

2. For each of the following statements, indicate if it is True or False, and explain why you think so.
   a. When $k$ is negative, the graph of $y_2 = f(x) + k$ is below the graph of $y_1 = f(x)$.

   b. When $k$ is positive, the graph of $y_2 = f(x) + k$ is below the graph of $y_1 = f(x)$.

   c. There is a value of $k$ that will make part of the graph of $y_2 = f(x) + k$ above the graph $y_1 = f(x)$ and the rest below the graph of $y_1 = f(x)$.

3. The graph of $y_2 = f(x) + k$, when $k \neq 0$, is a *vertical shift* of the graph of $y_1 = f(x)$. Why does the graph shift vertically?

**Move to page 2.1.**

**Part Two: *y* = *f*(*x* – *h*)**

4. Drag the point to change the value of *h*.
   a. What happens to the graph of $y_2 = f(x-h)$ as the value of *h* changes?

   b. Move the point so that $h > 0$. Where is the graph of $y_2 = f(x-h)$ compared to $y_1 = |x|$?

   c. Move the point so that $h < 0$. Where is the graph of $y_2 = f(x-h)$ compared to $y_1 = f(x)$?

   d. Move the point so that $h = 0$. Where is the graph of $y_2 = f(x-h)$ compared to $y_1 = f(x)$?

5. The graph of $y_2 = f(x-h)$, when $h \neq 0$, is a *horizontal shift* of the graph of $y_1 = f(x)$. Why does the graph shift horizontally?

6. All of the functions on pages 1.2 through 3.1 were of the absolute value type. In other words, $y_1 = |x|$ and $y_2 = |x-h| + k$. How does the graph of $y_2 = |x-2| - 1$ compare to the graph of $y_1 = |x|$? Use page 3.1 of the tns document on your handheld to help determine the transformations.

7. The vertex of the absolute value graph function is where the graph turns back up or goes back down. What is the vertex of $y_2 = |x-2| - 1$? Check with page 3.1.

8. What is the vertex of $y_2 = |x+3| + 4$? What is the vertex of $y_2 = |x-h| + k$ ?

# Transformations of Functions 1
**Student Activity**

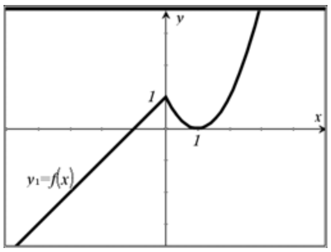
**Name** ________________
**Class** ________________

9. Pages 4.1 and 5.1 use a different type of function. For each transformation in a, b and c, describe the changes in the graph of $y_1 = f(x)$ shown. Then sketch the graph of $y_2$.

   Use pages 4.1 and 5.1 to check answers.

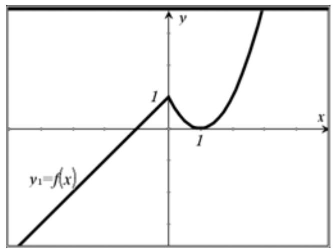
a. $y_2 = f(x-1)$

____________________



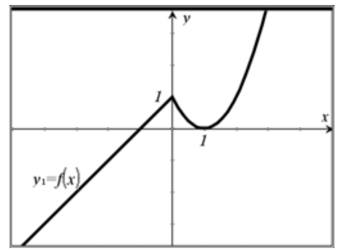

b. $y_2 = f(x)+2$

____________________




c. $y_2 = f(x-1)+2$

____________________



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# Transformations of Functions 1

**MATH NSPIRED**

**TEACHER NOTES**

## Math Objectives

- Students will recognize the effect of a horizontal and vertical translation on the graph of a function.
- Students will relate the transformation of a graph $y = f(x)$ by a horizontal and vertical translation to the symbolic representation of the transformation: that is $y = f(x) + k$ shifts the graph up or down and $y = f(x - h)$ shifts the graph right or left.
- Students will combine translations to describe the graph of the function $y = f(x - h) + k$ in terms of $y = f(x)$.
- Students will look for and make use of structure (CCSS Mathematical Practice).
- Students will use appropriate tools strategically (CCSS Mathematical Practice).

## Vocabulary

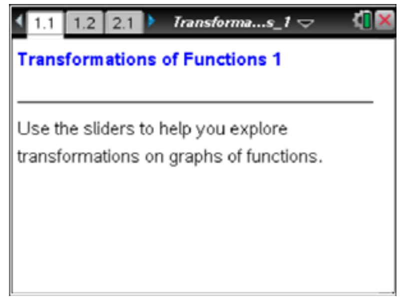
- vertical translation
- horizontal translation
- vertex of an absolute value function

## About the Lesson

- This lesson involves investigating vertical and horizontal translations of a function.
- As a result, students will:
  - Recognize how transformations of the form $y = f(x) + k$ and $y = f(x - h)$ change the graph of $y = f(x)$.

## TI-Nspire™ Navigator™ System

- Use Quick Polls to check student understanding.
- Use Screen Capture to examine patterns that emerge.
- Use Live Presenter to engage and focus students.
- Use Teacher Edition computer software to review student documents.




**TI-Nspire™ Technology Skills:**

- Download a TI-Nspire document
- Open a document
- Move between pages

**Tech Tips:**

- Make sure the font size on your TI-Nspire handheld is set to Medium.
- You can hide the function entry line by pressing ctrl G.

**Lesson Materials:**

*Student Activity*

Transformations_of_Functions_1_Student.pdf

Transformations_of_Functions_1_Student.doc

*TI-Nspire document*

Transformations_of_Functions_1.tns

Visit www.mathnspired.com for lesson updates and tech tip videos.

## Discussion Points and Possible Answers

**Tech Tip:** If students experience difficulty grabbing and dragging the point, check to make sure that they have moved the arrow until it becomes a hand ( ) getting ready to grab the point. Press ctrl to grab the point and close the hand ( ). When finished moving the point, press esc to release the point.

---

**Teacher Tip:** You might want to break this activity into two different lessons, with the vertical translations in questions 1–3 as the first lesson and horizontal translations questions 4–7 as the second lesson.

It is important that students recognize that each tick on the horizontal and vertical axis represents one unit. They should also note that the basic function is represented by $y_1 = f(x)$, and the functions obtained by the translations are labeled $y_2 = f(x) + k$, where the subscripts are used to denote related but different functions.

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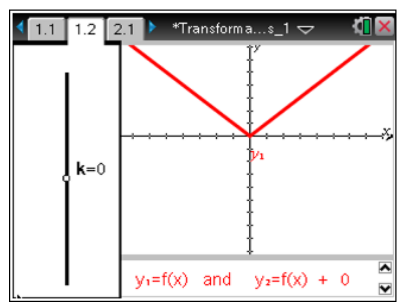
**Move to page 1.2.**




**Part One: *y* = *f*(*x*) + *k*.**

1. Drag the point to change the value of *k*.
   a. What happens to the graph of $y_2 = f(x) + k$ as the value of *k* changes?

   **Answer:** As *k* increases, the graph shifts up. As *k* decreases, the graph shifts down.

   b. Move the point so that $k > 0$. Where is the graph of $y_2 = f(x) + k$ compared to $y_1 = f(x)$?

   **Answer:** For $k > 0$, the graph of $y_2 = f(x) + k$ is above the graph of $y_1 = f(x)$.

   c. Move the point so that $k < 0$. Where is the graph of $y_2 = f(x) + k$ compared to $y_1 = f(x)$?

   **Answer:** For $k < 0$, the graph of $y_2 = f(x) + k$ is below the graph of $y_1 = f(x)$.

d. Move the point so that $k = 0$. Where is the graph of $y_2 = f(x) + k$ compared to $y_1 = f(x)$?

**Answer:** For $k = 0$, the graph of $y_2 = f(x) + k$ is on the graph of $y_1 = f(x)$—the two graphs coincide.

| |
|---|
| **TI-Nspire Navigator Opportunity: *Screen Capture*** <br> **See Note 1 at the end of this lesson.** |

2. For each of the following statements, indicate if it is True or False, and explain why you think so.

a. When $k$ is negative, the graph of $y_2 = f(x) + k$ is below the graph of $y_1 = f(x)$.

**Answer:** True. Each point on the graph $y_1 = f(x)$ is ($x$, $y$) and each point on $y_2 = f(x) + k$ is ($x$, $y + k$). When $k$ is negative, you are actually subtracting from the $y$-value, so the translated point is lower than the original point. This is true for all points on the graph.

b. When $k$ is positive, the graph of $y_2 = f(x) + k$ is below the graph of $y_1 = f(x)$.

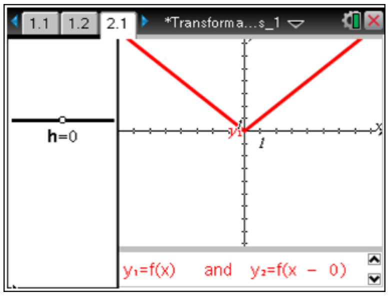
**Answer:** False because adding a positive value to $f(x)$ shifts the graph up by that amount.

c. There is a value of $k$ that will make part of the graph of $y_2 = f(x) + k$ above the graph $y_1 = f(x)$ and the rest below the graph of $y_1 = f(x)$.

**Answer:** False because the way $k$ affects one point is the way it will affect all of the points. The whole graph moves together for any value of $k$.

| |
|---|
| **TI-Nspire Navigator Opportunity: *Quick Polls*** <br> **See Note 2 at the end of this lesson.** |

**Teacher Tip:** You might want to point out to students that a vertical shift is called a vertical translation.




**Move to page 2.1.**

**Part Two: *y* = *f*(*x* – *h*)**

4. Drag the point to change the value of *h*.
   a. What happens to the graph of $y_2 = f(x-h)$ as the value of *h* changes?

   **Answer:** As *h* increases, the graph shifts right. As *h* decreases, the graph shifts left.

   b. Move the point so that *h* > 0. Where is the graph of $y_2 = f(x-h)$ compared to $y_1 = f(x)$?

   **Answer:** For *h* > 0, the graph of $y_2 = f(x-h)$ is to the right of the graph of $y_1 = f(x)$.

   c. Move the point so that *h* < 0. Where is the graph of $y_2 = f(x-h)$ compared to $y_1 = f(x)$?

   **Answer:** For *h* < 0, the graph of $y_2 = f(x-h)$ is to the left of the graph of $y_1 = f(x)$.

   d. Move the point so that *h* = 0. Where is the graph of $y_2 = f(x-h)$ compared to $y_1 = f(x)$?

   **Answer:** For *h* = 0, the graph of $y_2 = f(x-h)$ is on the graph of $y_1 = f(x)$—the two graphs coincide.

5. The graph of $y_2 = f(x-h)$, when $h \neq 0$, is a *horizontal shift* of the graph of $y_1 = f(x)$. Why does the graph shift horizontally?

   **Answer:** A transformation of the form $x \rightarrow x-h$ shifts all of the points in the original function either right or left because you are subtracting a constant from each *x*-value.

> **Teacher Tip:** This is a very complicated concept, and one that is counter-intuitive. Encourage students to think about what happens to points such as the zeros of the function or the minimum values of a transformed function under the horizontal shift to see what would be necessary in order to return to the base (parent) function. You might want to tell students that a transformation of this form is called a horizontal translation.

6. All of the functions on pages 1.2 through 3.1 were of the absolute value type. In other words, $y_1 = |x|$ and $y_2 = |x-h|+k$ . How does the graph of $y_2 = |x-2|-1$ compare to the graph of $y_1 = |x|$ ? Use page 3.1 of the tns document on your handheld to help determine the transformations.

   **Answer:** To obtain the graph of $y_2 = |x-2|-1$, the graph of $y_1 = |x|$ is shifted right 2 units and down 1 unit.

7. The vertex of the absolute value graph function is where the graph turns back up or goes back down. What is the vertex of $y_2 = |x-2|-1$? Check with page 3.1.

   **Answer:** The vertex is (2,-1)

8. What is the vertex of $y_2 = |x+3|+4$? What is the vertex of $y_2 = |x-h|+k$ ?

   **Answer:** The vertex is (-3,4) and (h,k)

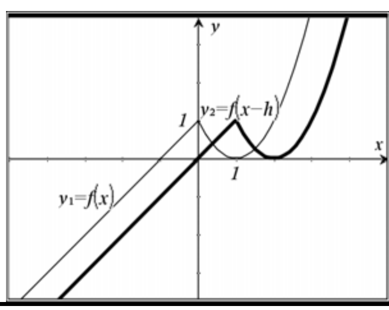
9. Pages 4.1 and 5.1 use a different type of function. For each transformation in a, b and c, describe the changes in the graph of $y_1 = f(x)$ shown. Then sketch the graph of $y_2$.

   Use pages 4.1 and 5.1 to check answers

   **Answers:**

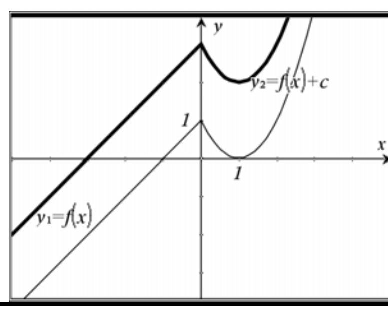
a. $y_2 = f(x-1)$

**shifts right 1 unit**



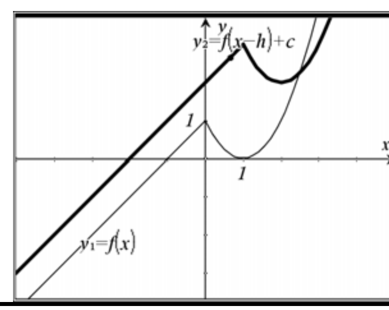

b. $y_2 = f(x)+2$

**shifts up 2 units**




c. $y_2 = f(x-1)+2$

**shifts right 1 unit, up 2 units**




**TI-Nspire Navigator Opportunity: *Quick Polls***
**See Note 3 at the end of this lesson.**

## Wrap Up

Upon completion of the discussion, the teacher should ensure that students understand:

- The transformation $y = f(x) + k$ on a function $y = f(x)$ will result in a vertical shift, while the transformation $y = f(x - h)$ will result in a horizontal shift.
- How to distinguish between horizontal and vertical translation both graphically and symbolically.
- When a table has $x$-values that repeat but different $y$-values, then it does not represent a function.
- How to graph a function $y = f(x - h) + k$ given the function $y = f(x)$.
- Why a transformation of $y = (x - h)$ will shift to the right if $h$ is positive and to the left if $h$ is negative.

## TI-Nspire Navigator

**Note 1**

**Question 1, *Screen Capture*:** Whenever visual patterns from the class are involved, this is an ideal application for the Screen Capture feature of TI-Nspire Navigator.

**Note 2**

**Question 2, *Quick Poll*:** Quick Polls are suitable whenever either open or closed questions are asked; used with the slideshow feature, they allow students to learn from the contributions (and mistakes) of others. Use the True False feature to ask students to submit their answers to questions 2a, b, and c. Discuss why and why not.

**Note 3**

**Question 7, *Quick Poll*:** Use the Open Response feature. Send students the following prompts, one at a time, and ask them to tell how the graph of the function that is sent to them differs from the original function, $y = f(x)$. Use ‘up’, ‘down’, ‘left’, ‘right’, and how many units in the answers.

1. $y = f(x + 2)$ Answer: left 2
2. $y = f(x) + 2$ Answer: up 2
3. $y = f(x - 3)$ Answer: right 3
4. $y = f(x) - 3$ Answer: down 3
5. $y = f(x + 1) - 4$ Answer: left 1, down 4

# Inserting an Image into a TI-Nspire™ Document

**TEACHER NOTES**

**TI PROFESSIONAL DEVELOPMENT**

## Activity Overview:

In this activity, you will learn how to insert images into *Graphs*, *Geometry*, and *Question* applications. You will also learn how to move, resize, compress, and stretch an image, as well as make it appear more transparent.

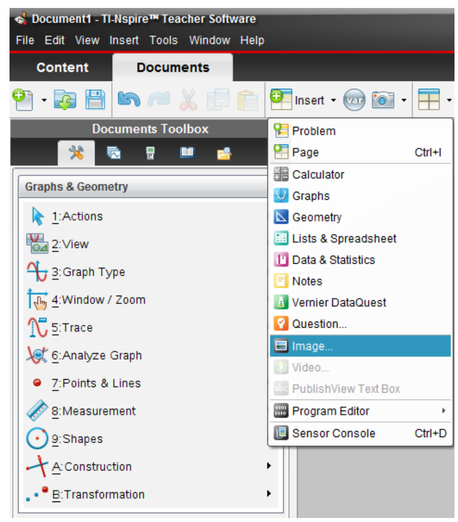
## Materials

- TI-Nspire™ Teacher Software

**Step 1:** Open the TI-Nspire™ Teacher Software. If the **Welcome Screen** appears when the software is opened, click to create a new document with a *Graphs* application as its first page. Otherwise, insert a *Graphs* application by clicking **Insert** > **Graphs**.

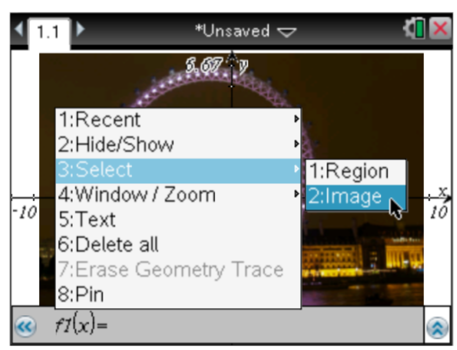
**Note:** Images can be inserted into *Graphs*, *Geometry*, *Data & Statistics*, *Notes*, and *Question* applications.

**Step 2:** Insert an image into the *Graphs* application by clicking **Insert >** **Image**. A selection of images is preloaded in the **My Documents > TI-Nspire > Images** folder. Select **Ferris Wheel.jpg** and click **Open**.




**Note:** Although the TI-Nspire™ Teacher Software comes with a selection of preloaded images, all .jpg, .jpeg, .bmp, and .png images are supported. The optimal format for images is .jpeg 560×240. Images substantially larger than this may take the document longer to load on the handheld. Images appear in grayscale for TI-Nspire™ Touchpad and Clickpad handhelds updated to the latest operating system.

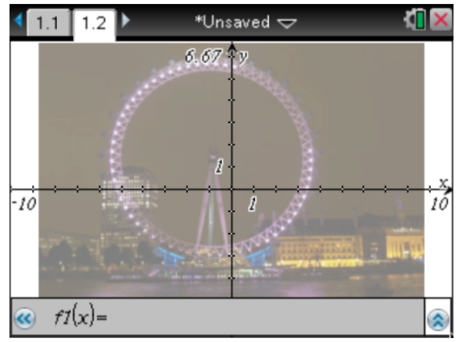
**Step 3:** Images can be moved, resized, and vertically or horizontally stretched or compressed. To select an image in the *Graphs*, *Geometry*, or *Question* application, right-click the image and choose **Select > Image**. To select an image in the *Notes* application, click the image. To move the image, grab and move its interior. To resize the image, grab and move a corner. To vertically stretch or compress the image, grab and move the top or bottom edge. To horizontally stretch or compress the image, grab and move the left or right edge.




**Note:** To right-click on a handheld, press ctrl menu. To grab an object, press ctrl. To let go of an object, press esc.

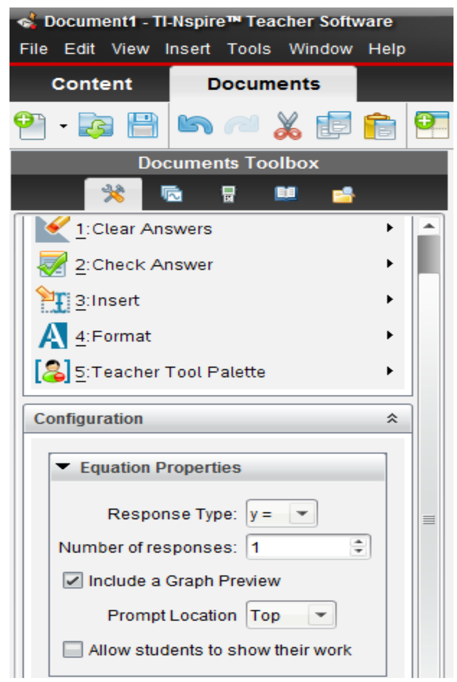
**Step 4:** To make an image appear more transparent, insert it in a *Geometry* application and then change the page to a *Graphs* application.

Insert a *Geometry* application by clicking **Insert > Geometry**. Then insert an image by selecting **Insert > Image**. Again, choose **Ferris Wheel.jpg.** Change the *Geometry* application to a *Graphs* application by selecting **View > Graphing**.




**Step 5:** Insert a *Question* application by clicking **Insert > Question**. The **Choose Question Type** window appears. There are four general question types: **Multiple Choice**, **Open Response**, **Equations**, and **Coordinate Points & Lists**. Images can be inserted into each question type. Select **Equation >** ***y*** **=**.

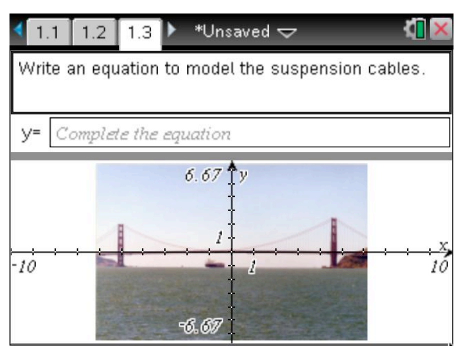
**Step 6:** To change the question properties in the **Document Tools** pane, go to the **Configuration** panel. In the **Equation Properties** panel, select **Include a Graph Preview** and change the **Prompt Location** to **Top**.




<u>**Note**</u>: To maximize the area of the **Graph Preview**, grab and move the gray bar separating the question and answer fields from the **Graph Preview**.

**Step 7:** Insert an image into the **Graph Preview** by clicking the graph and selecting **Insert > Image**. Choose **Bridge1.jpg** and click **Open**. Type the following into the question field:

Write an equation to model the suspension cables.



# Creating a Self-Check Document

**TI PROFESSIONAL DEVELOPMENT**



## Activity Overview:

In this activity, you will create a new self-check document with the *Question* application of the TI-Nspire™ Teacher Software. As you create this document, you will explore the properties of each of the four question types: Multiple Choice, Open Response, Equations, and Coordinate Points & Lists. Students can use this self-check document on their handhelds to answer questions and check their responses.

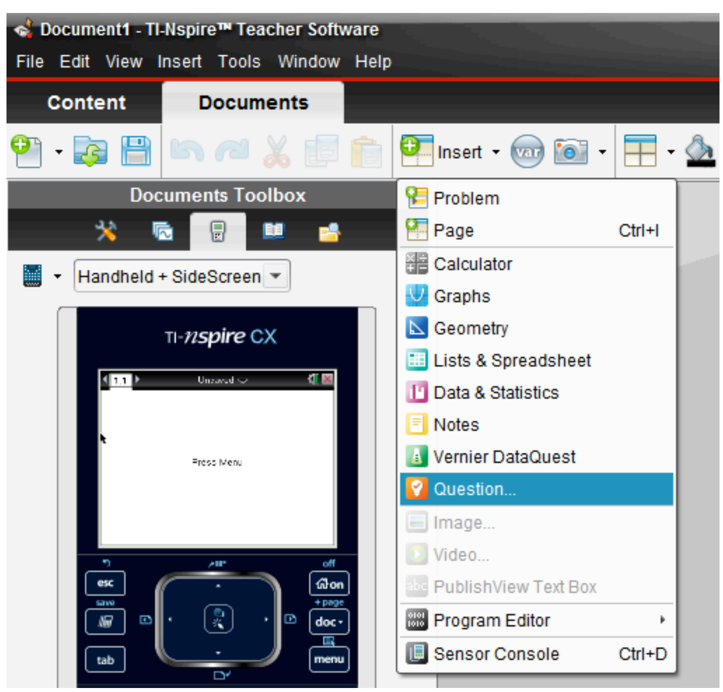
## Materials

- TI-Nspire™ Teacher Software

### Step 1:

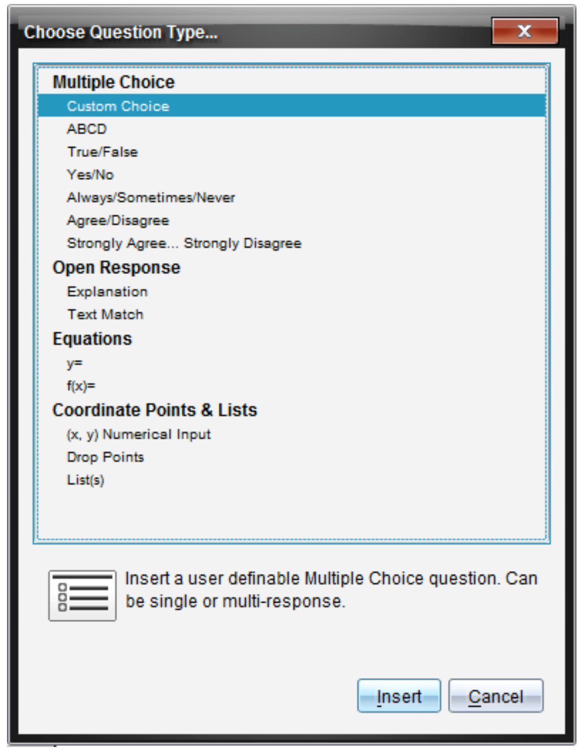
Open the TI-Nspire™ Teacher Software. If the **Welcome Screen** appears when the software is opened, click to create a new document with a *Question* application as the first page. Otherwise, insert a *Question* application by clicking **Insert >** **Question**.

**Note**: TI-Nspire™ documents with *Question* applications can be created only with TI-Nspire™ Teacher Software. Documents with *Question* applications cannot be created with the handheld or Student Software. Therefore, when the Teacher Software is in Handheld view and **Menu** is pressed, the *Question* application does not appear on the handheld screen or in TI-SmartView's list of applications.



**Step 2:**

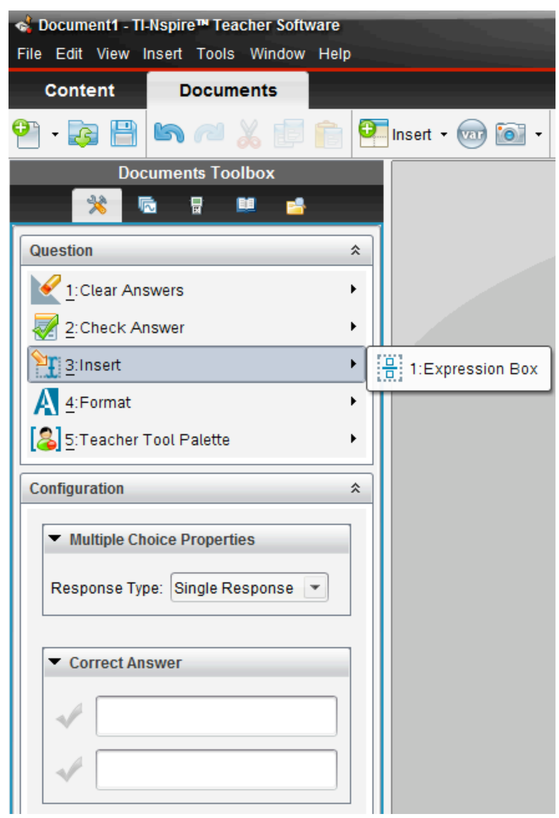
The **Choose Question Type** window appears. Select **Custom Choice** and click **Insert**.




**Note:** A brief description of the highlighted question type appears at the bottom of the window.

**Step 3:**

Enter the prompt given below. To type the equation into an Expression Box, go to the **Documents Toolbox**, select the **Document Tools** pane, and select **Insert > Expression Box**.



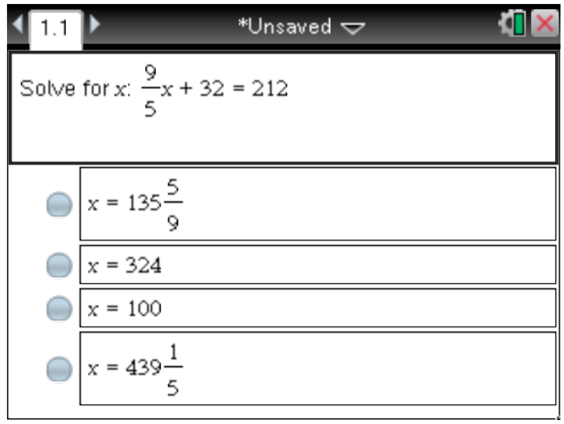

Solve for $x$: $\frac{9}{5}x + 32 = 212$

**Note:** An Expression Box can also be inserted by pressing ctrl M. A variety of math templates can be accessed in the **Documents Toolbox** by selecting the **Utilities** pane.

**Step 4:**

Type the first answer choice into the first field by clicking it and inserting an **Expression Box**. To move to the next field, click in the next field or press enter. Type the following answer choices:

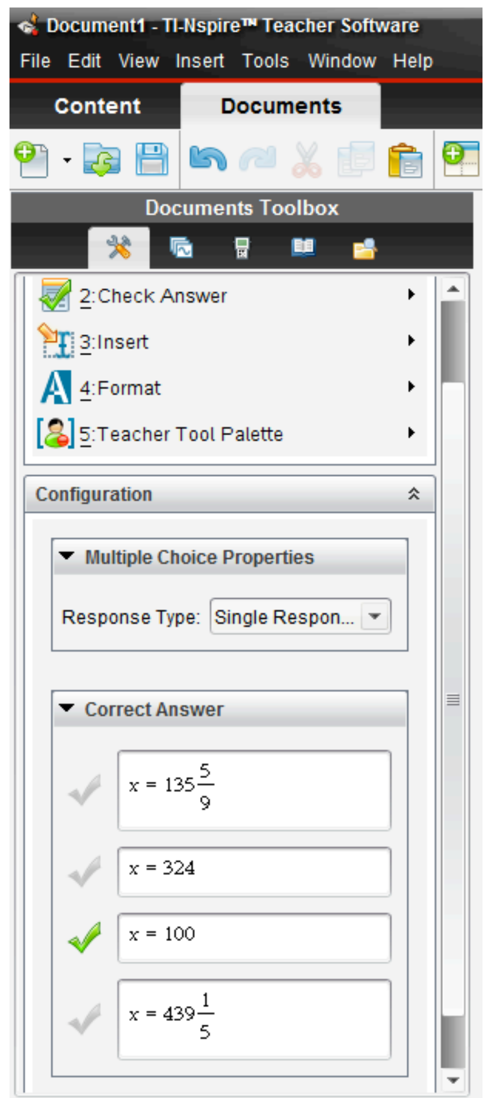
$x = 135\frac{5}{9}$, $x = 324$, $x = 100$, $x = 439\frac{1}{5}$




**Note:** To remove an empty answer field, click in that field and press the **Backspace** key.

**Step 5:**

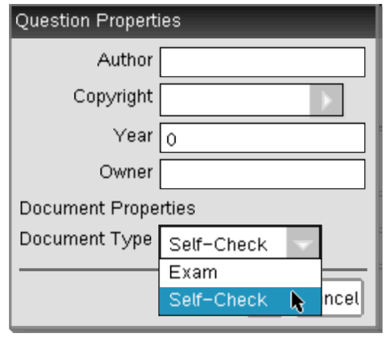
As you type answer choices, they automatically appear in the **Correct Answer** fields in the **Configuration** panel. Select the correct answer by clicking the check mark in front of the answer choice.




**Note:** In the **Configuration** panel, the **Multiple Choice Properties** can be changed to allow a different **Response Type**. **Single Response** allows for one correct answer, while **Multiple Response** allows for multiple correct answers. The **Multiple Choice Properties** and **Correct Answer** fields can be collapsed by clicking ▼ and expanded by clicking ▶.

**Step 6:**

To allow students to check their answers, select Teacher Tool Palette > Question Properties. Change the Document Type to Self-Check and click OK.



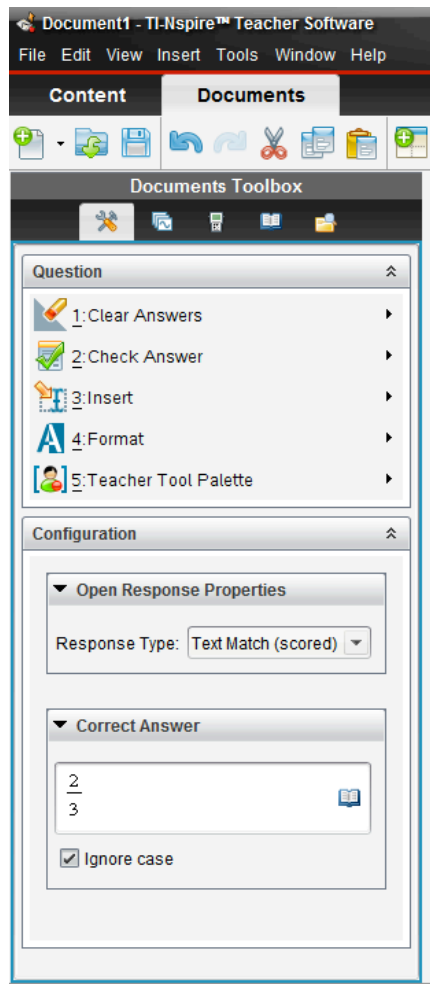

**Note:** The **Document Type** applies to all questions in the current document. Therefore, all questions in the document will become **Self-Check**.

After students answer a question, they can check their answers by pressing menu and selecting **Check Answer**. A message (“Your current answer is correct.” or “Your current answer is incorrect.”) is displayed. If the answer is incorrect, two options appear: **Show Correct Answer** and **Try Again**.

**Step 7:**

Insert a new question by clicking on the **Insert** menu and selecting **Question > Open Response > Text Match**. Inserting an **Expression Box** for the equation, type the following into the question field:

What is the slope of the line $2x - 3y = 12$?




**Step 8:**

Using an **Expression Box**, type $\frac{2}{3}$ into the **Correct Answer** field. To access math templates and symbols, click the **Utilities** icon in the **Correct Answer** field. Double-click the **Fraction** template, and close the window by clicking **Cancel**.

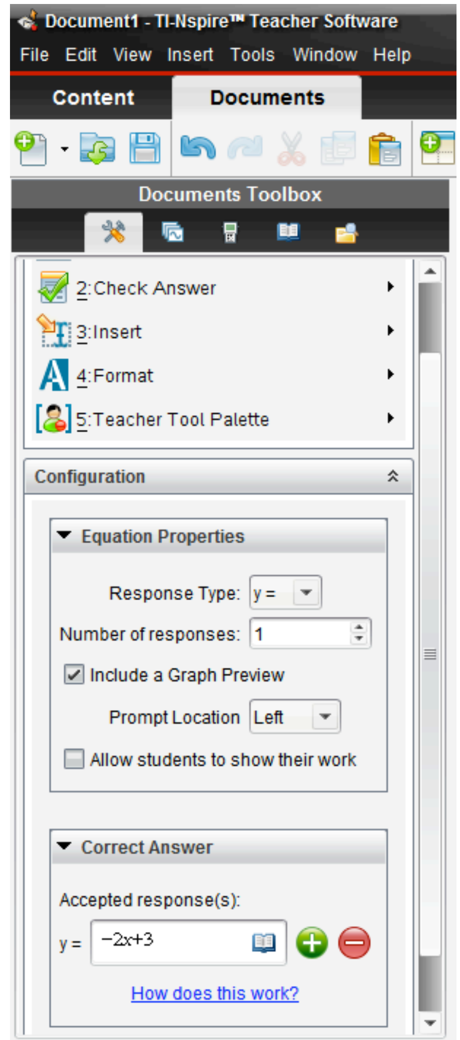
**Note:** The **Explanation** response type (not scored) allows students to give answers that closely match the correct answer. When students select **Check Answer**, the correct or incorrect answer message will not be displayed. However, any suggested response entered by the teacher will be displayed.

The **Text Match** response type (scored) requires students to exactly match the correct answer, including templates (if applicable). When students select **Check Answer**, the correct or incorrect answer message will be displayed.

**Step 9:**

Insert a new question by clicking the **Insert** menu and selecting **Question > Equation >** ***y*** **=**. Type the following into the question field:

> Write the equation of a line whose slope is –2 and whose *y*-intercept is 3.

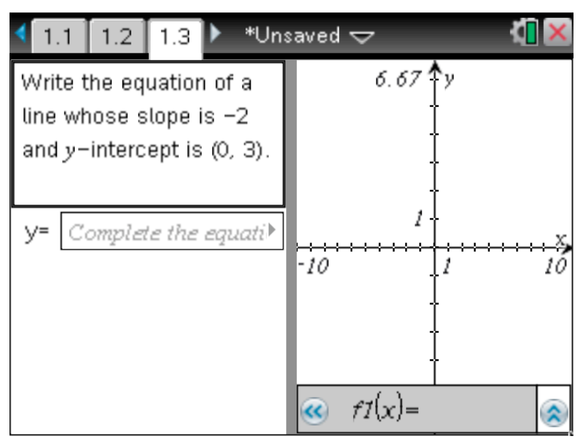



**Step 10:**

In the **Configuration** panel, choose **Equation Properties** and check the box for **Include a Graph Preview**. In the **Correct Answer** field, type **–2*x* + 3** as an accepted response.

**Note:** In the **Configuration** panel, the **Equation Properties** can be changed to allow **Response Type** in *y* = or **f**(*x*) = notation. The number of responses and prompt location can be changed, and students can be allowed to show their work in a series of blank fields.

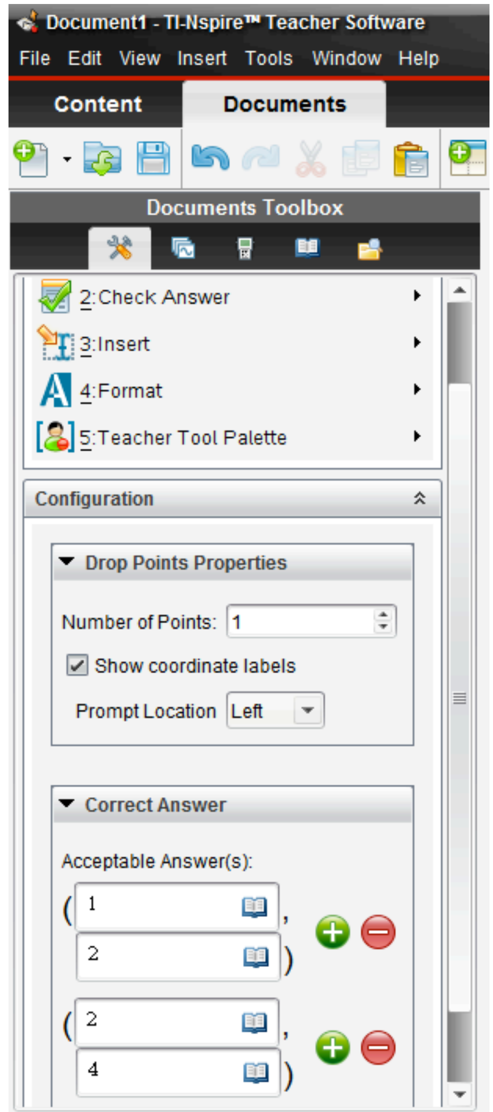
**Note:** By changing the **Equation Properties** to **Include a Graph Preview**, the page layout of the question is automatically changed and a *Graphs* application is inserted on the right. When an expression is typed into the ***y*** **=** field, it automatically appears on the graph. If enter is pressed, another ***y*** **=** field appears.



**Step 11:**

Insert a new question by clicking the **Insert** menu and selecting **Question > Coordinate Points & Lists > Drop Points**. Type the following into the question field:

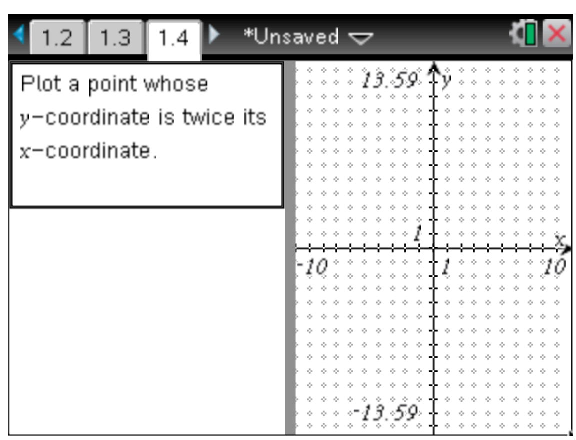
Plot a point whose *y*-coordinate is twice its *x*-coordinate.




**Step 12:**

In the **Correct Answer** field, enter (1, 2) as an acceptable answer. Add an additional acceptable answer field by clicking the green addition icon. Enter (2, 4) as an acceptable answer.

**Note:** The **Drop Points** question type automatically includes a *Graphs* application with a grid.



# TI-Nspire™ Teacher Software: The Content Workspace

**TI PROFESSIONAL DEVELOPMENT**



## Activity Overview

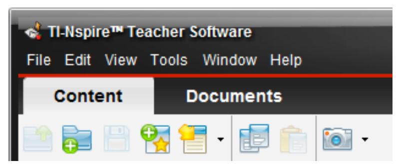
In this activity, you will explore the **Content Workspace** of the TI-Nspire™ Teacher Software. You will learn how to browse for web content on the Internet, download an activity, and locate and manage local content on your computer. You will also use the **Preview** pane to preview TI-Nspire™ documents and learn how to create lesson bundles.

## Materials

- TI-Nspire™ Teacher Software
- Internet connection

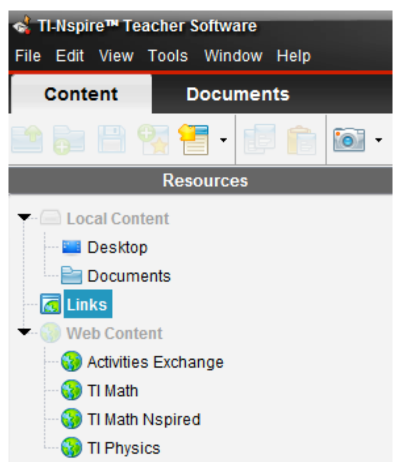
**Step 1:**

Open the TI-Nspire™ Teacher Software. If the **Welcome Screen** appears when the software is opened, go to the **Content Workspace** by clicking **View Content**. Otherwise, go to the **Content Workspace** by clicking the **Content** tab.




**Step 2:**

The **Resources** panel contains three types of resources: **Local Content**, **Links**, and **Web Content.** If a handheld is connected to the computer, a fourth resource, **Connected Handhelds**, appears. Select **Links**.




**Note:** Each resource can be collapsed by clicking ▼ and expanded by clicking ▶.

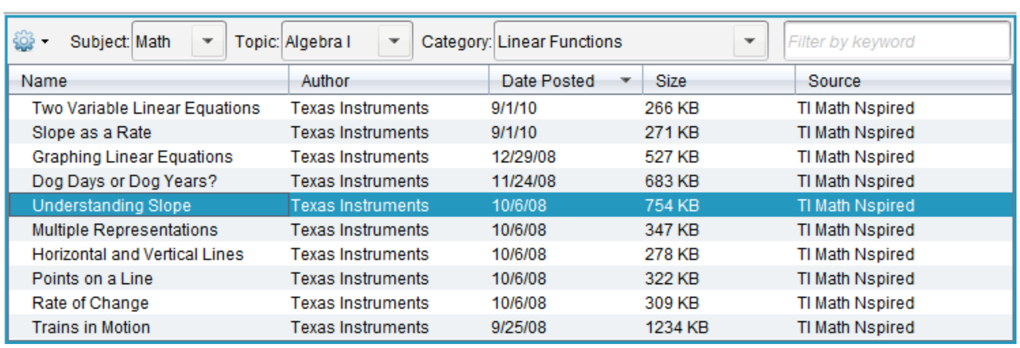
 

**Step 3:**

The **Content Workspace** allows you to access online resources by creating links to various websites. A list of links appears in the **Content Window,** along with details for each link. When a given link is clicked, a Web browser is launched and the website can be accessed. Links can be added, edited, and removed by clicking the **Add Link**, **Edit Link**, and **Remove Link** icons.


**Step 4:**

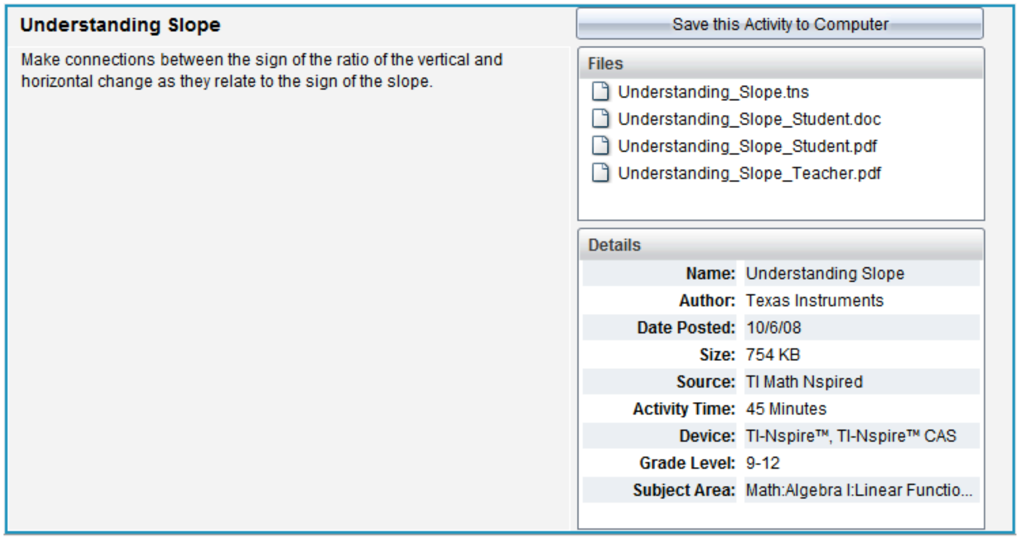
The **Content Workspace** also allows you to search for TI-Nspire™ activities that are available online. In the **Resources** panel, go to **Web Content** and click **TI Math Nspired**. The **Content** pane toolbar contains cascading fields for **Subject**, **Topic**, and **Category.** Activities can also be located using the **Filter by keyword** field. Locate the activity “Understanding Slope” by going to **Math > Algebra 1 > Linear Functions > Understanding Slope**.



**Step 5:**

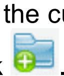
Once an activity is located, details about the activity appear in the **Preview** pane. The activity may appear as a lesson bundle, which consists of multiple files and can contain multiple file types. If the activity is a lesson bundle, the **Files** window appears and lists the individual files in the lesson bundle.

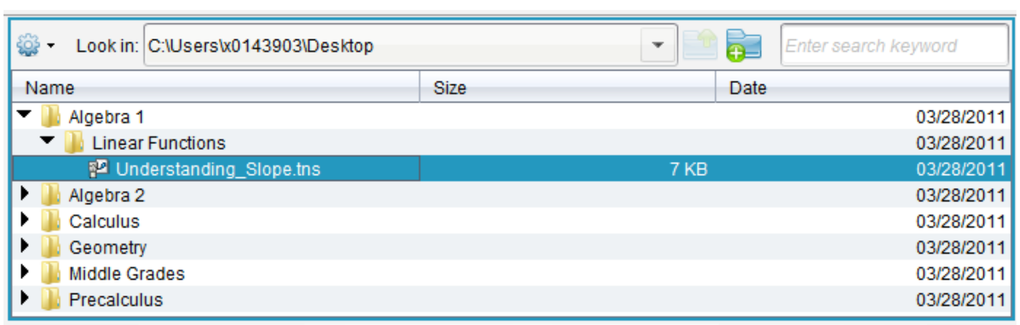
Save the lesson bundle to your Desktop by clicking **Save this Activity to Computer**. To save an individual file, right-click it and select **Save to Computer**.




**Step 6:**

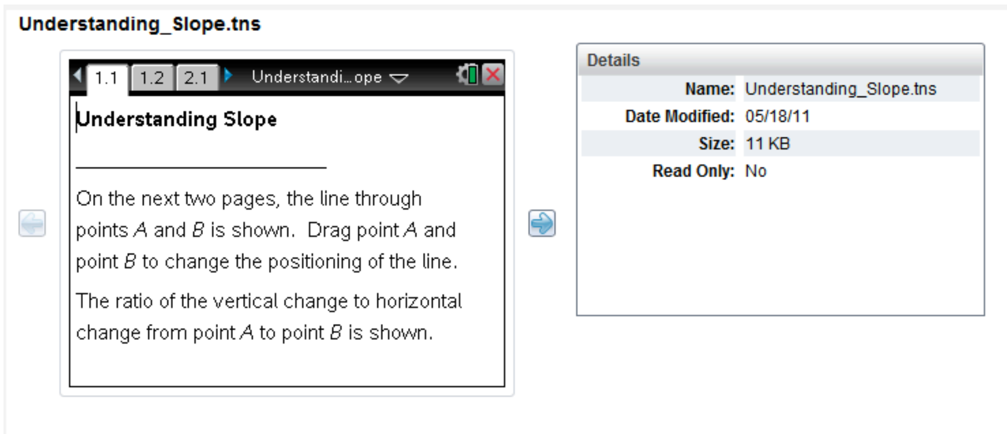
In the **Resources** panel, go to **Local Content** and click **Desktop**. The **Content** pane shows the folders and files that are available on your Desktop. Click **Documents**, and the **Content** pane shows the folders and files that are available in the **My Documents** folder.

The **Content** pane tool bar provides tools needed to locate folders and files. The **Look in** field contains the path of the current folder or file. To move up a level in the folder hierarchy, click . To create a new folder, click . To search for a file containing a specific word, type into the keyword field and press **Enter**. Locate the activity “Understanding Slope” on your Desktop.



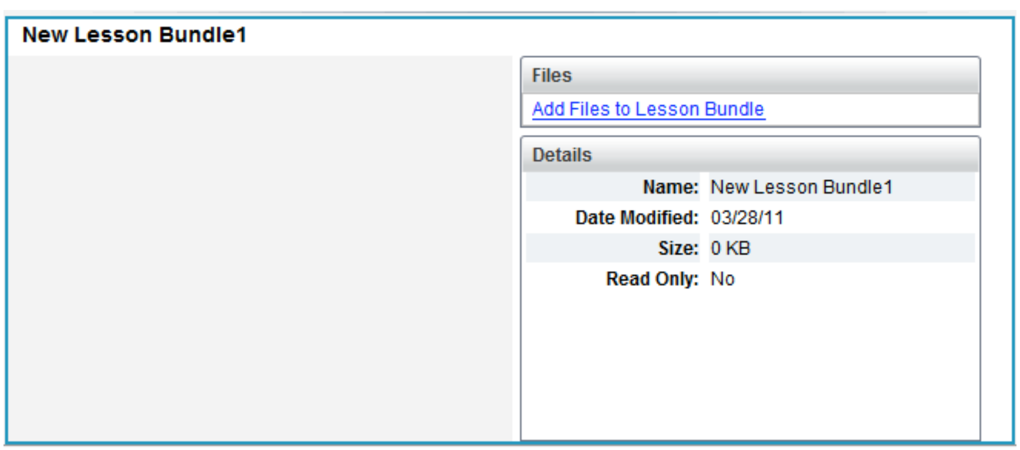
**Step 7:**

Select the TI-Nspire™ document, and the first page of the document appears in the **Preview** pane. If the document has multiple pages, use the forward arrow to preview the next page. Details about the file or folder are available to the right of the preview. To open a TI-Nspire™ document in the Teacher Software, double-click it.




**Step 8:**

To create a lesson bundle of your own, click the **Create a New Lesson Bundle** icon on the **Content Workspace** tool bar. Click **Add Files to Lesson Bundle** and a dialogue box appears that allows you to browse local content. Select a file and click **Add**. Once a TI-Nspire™ document is added to the lesson bundle, the first page of the document appears in the preview pane.




## Math Objectives

- Students will identify the mathematical model that best fits a given set of data.
- Students will develop models for data.
- Students will reflect on the appropriateness of a model.
- Students will make sense of problems and persevere in solving them. (CCSS Mathematical Practice)
- Students will model with Mathematics. (CCSS Mathematical Practice)

## Vocabulary

- data
- model
- regression equation
- conjecture
- finite differences

## About the Lesson

- This lesson involves analyzing sets of data.
- As a result students will:
  - Graph a scatter plot
  - Determine an appropriate model for each data set
  - Answer questions related to the data sets

## TI-Nspire™ Navigator™ System

- Use **Screen Capture** to observe students' analyses.
- Use **Live Presenter** to allow students to demonstrate computing regression equations, as appropriate, and to present their solutions to the class.
- Send the TI-Nspire™ document to students.
- Collect the TI-Nspire™ document from students.

**TI-Nspire™ Technology Skills:**

- Download a TI-Nspire™ document
- Open a document
- Move between pages
- Manipulate a slider
- Trace on a regression equation

**Tech Tips:**

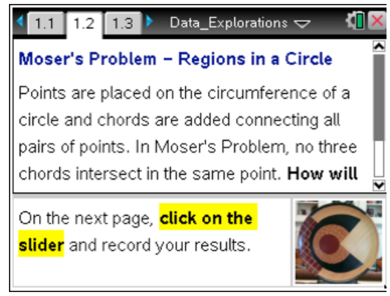
- Make sure the font size on your TI-Nspire™ handhelds is set to Medium.

**Lesson Files:**
*TI-Nspire™ Documents*
Data_Exploration.tns

## Discussion Points and Possible Answers

**Move to page 1.2.**

This activity investigates a little known relationship in geometry known as Moser's Problem.

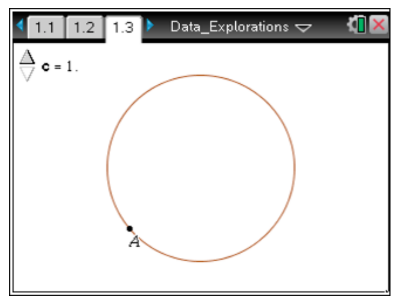



Ask students to make a table on a sheet of paper. They should record the number of points on the circumference and the number of regions formed for the first five points placed on the circumference.

**Teacher Tip:** You may need to demonstrate using the slider on page 1.3. One approach is to press tab to move the focus to the slider (the slider should be "boxed"). Then, press enter to select the slider. The Touchpad arrow keys can then be used to increase or decrease the value of **c**, the number of points on the circle.

**Move to page 1.3.**

Increase the slider value. For each click on the slider, a new point will appear and chords will be shown connecting the new point to each previous point. A maximum of seven points are displayed.



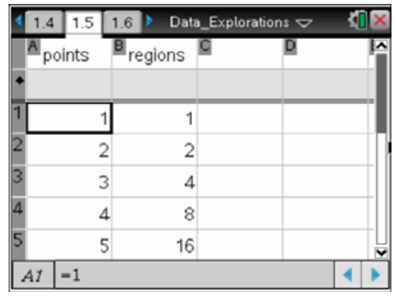

If students count the regions correctly for one through five points, they should note that the relationship appears exponential.

| Points | Regions |
|---|---|
| 1 | 1 |
| 2 | 2 |
| 3 | 4 |
| 4 | 8 |
| 5 | 16 |

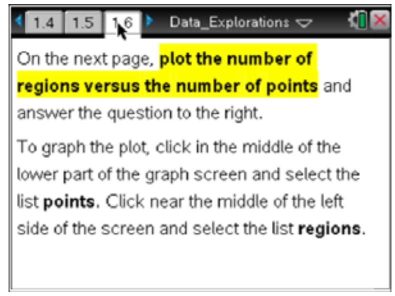
Students who attempt to also count the number of regions for six or seven points on the circumference may discover that adding the sixth point on the circumference is the event where the number of regions is no longer a power of two. If they counted the number of regions accurately for one to five points on the circumference, they may expect the number of regions to be 32 for six points on the circumference. The actual number of regions is 31.

**Move to pages 1.4 and 1.5.**
Read the instructions on page 1.4.

The actual numbers of regions for each number of points on the circumference have been entered in the spreadsheet on page 1.5.

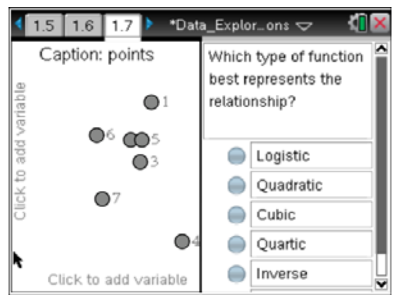



**Move to page 1.6.**
Page 1.6 instructs the students to plot the number of regions versus the number of points and includes directions for setting up the plot.



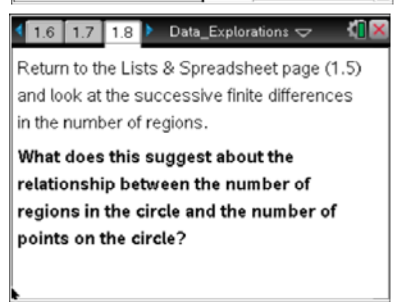

**Move to page 1.7.**

Question: Which type of function best represents the relationship?



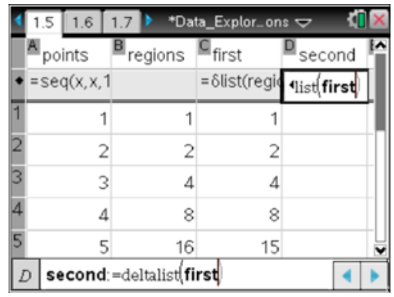

<u>**Answer**</u>: Answers will vary, but some of the options would not be reasonable (such as inverse functions).

**Move to page 1.8.**
This page instructs the student to move back to page 1.5 (the *Lists & Spreadsheet* page) to calculate successive finite differences. Since the fourth differences are the same, it suggests that the relationship may be quartic.



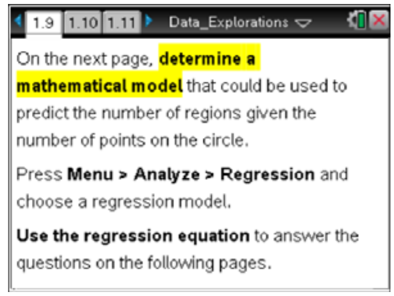

**Teacher Tip:** You may choose to have students compute the successive differences by hand. They previously recorded the points and regions for one through five points. Ask them to add the number of regions for six and seven points to their table (from page 1.5). They should then add columns to their tables and compute the successive differences through the fourth differences. Alternatively, they could enter the differences in the spreadsheet manually. Regardless of whether they compute the differences on paper or in the spreadsheet, remind students that it is a good idea to label each column. For example, label the first differences column as "first," the second differences column as "second," and so on.

**Tech Tip:** The successive differences can be computed in the spreadsheet using the **deltaList** command. This command is located in the **Catalog**. Place the cursor in the diamond row of the spreadsheet (below the list name). Press and then `D`. Scroll down to **deltaList(** and press . Press `var` and arrow to the appropriate list variable. Press or `enter` to select the list and then press `enter`.



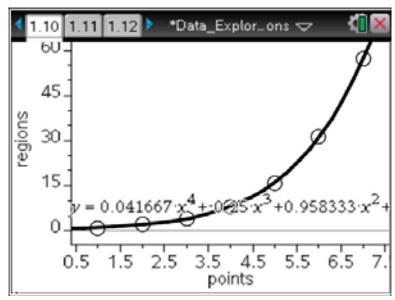

**Move to pages 1.9 and 1.10.**

Page 1.9 instructs the students to move to page 1.10, where they will choose a regression model.




__Note__: After the differences are explored, discuss which of the models may be most appropriate.

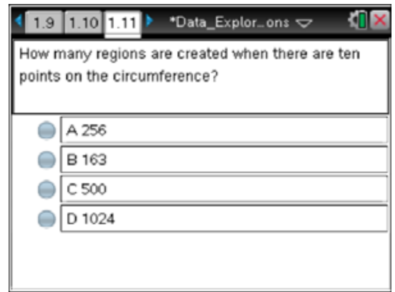
On page 1.10, press **Menu > Analyze > Regression > Show Quartic**. The regression equation and graph will be displayed.




**Teacher/Tech Tip:** Students should add a *Calculator* application page and use their regression equation to determine the answers to questions on pages 1.11 and 1.12. The page may be added at any location in the document. The regression equation (stat.regeqn) is a stored variable and can be accessed by pressing `var`. If multiple regression equations have been calculated, the regression equation stored is the most recent one calculated. The **nSolve** command is located in the menu of the *Calculator* application (**Menu > Algebra > Numerical Solve**).

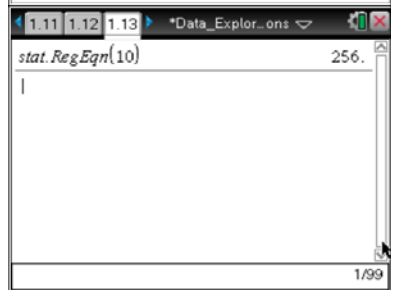
**Move to page 1.11.**

Question: How many regions are created when there are 10 points on the circumference?

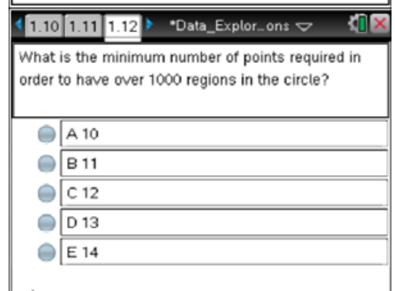



**__Answer__:** For 10 points on the circumference, there are 256 regions.

**Move to page 1.12.**

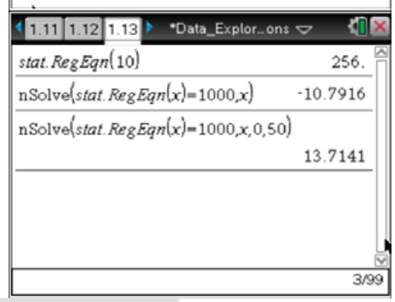



**__Question__**: What is the minimum number of points required in order to have more than 1000 regions in the circle?



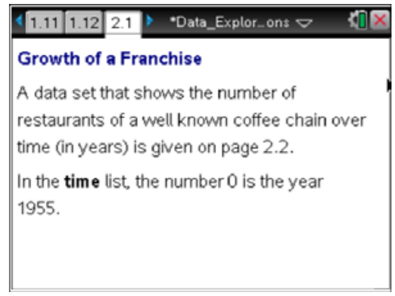

**__Answer__**: A minimum of 14 points must be placed on the circumference in order to have more than 1000 regions.

Note that the first solution shown for the number of points is negative. Since the domain of the problem situation does not include negative numbers, additional constraints were added to the **nSolve** command.




**Tech Tip:** The **nSolve** command will find the solution in the domain of a function that is closest to zero. To find other solutions, specify constraints that may contain the desired solution. These values (the constraints) can be estimated from the graph of the function.

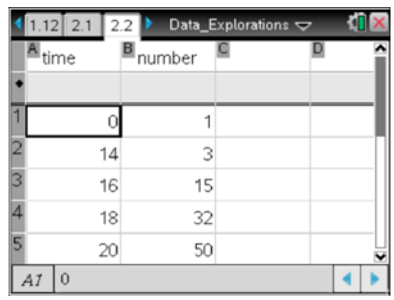
**Move to page 2.1.**




Successful franchise operations tend to grow in a predictable pattern. The number of franchises grows very slowly in the first few years while the franchise establishes a reputation. Growth in the number of franchises accelerates when their reputation is established. However, the growth in the number of franchises will slow down when the market is saturated. Then, the number of franchises tends to level out.

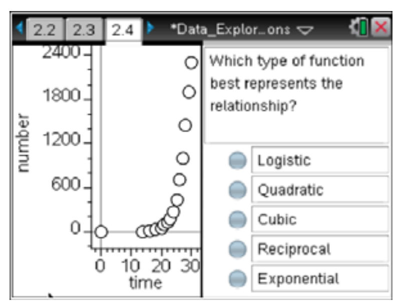
This is an example of a logistic relationship, which is characterized by the growth of a population that is confined by a physical space. In this case, the confining characteristic is the population that the franchise serves. As the number of restaurants grows, the company saturates the market, leaving no more room for growth.

**Move to page 2.2.**




In this activity, students are given a set of data that shows the number of restaurants over time (in years).

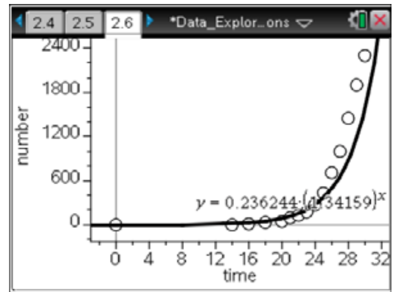
**Move to pages 2.3 and 2.4.**




On page 2.3, the students are instructed to move to page 2.4 to construct a scatter plot and answer the question. Students may observe the growth over the first few years and conclude that the relationship is exponential. Allow them to pursue this line of thinking; the exercise will ask them to consider whether their model is reasonable. When they realize that the number of restaurants for the year 2020 predicted by the exponential model may not be reasonable, the teacher will have an opportunity to present the logistic model.

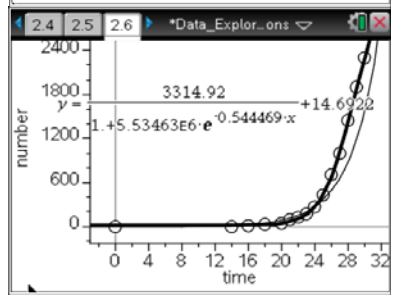
**Move to pages 2.5 and 2.6.**

On page 2.5, the students are instructed to move to page 2.6 to plot a regression equation with the scatter plot.



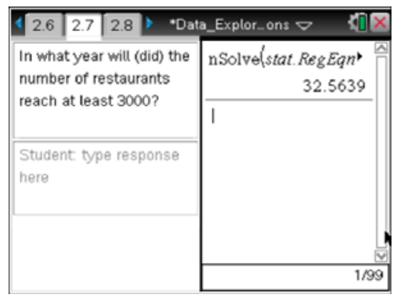

An exponential model is shown to the right. Some students may comment that the graph does not pass through several of the points.

The logistic model, with *d* not equal to zero, is a better fit for the data.




**Note**: The regression equation was moved to the upper part of the screen.

**Move to page 2.7.**

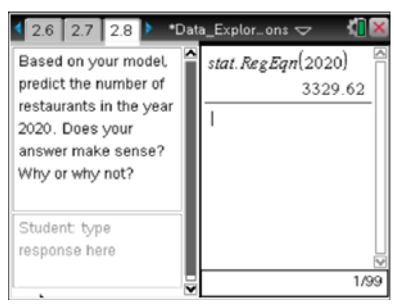



**Question**: In what year will (did) the number of restaurants reach at least 3000?

**Answer**: 1988

The number of restaurants reaches 3000 at year 32.16 with an exponential model. The year 33 years after 1955 is 1988.
The number of restaurants reaches 3000 at year 32.56 with a logistic model (as shown at the right). The year 33 years after 1955 is 1988.

**Move to page 2.8.**



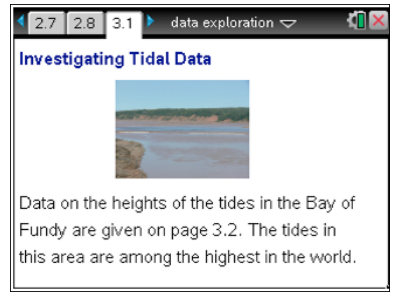

**Question**: Based on your model, predict the number of restaurants in the year 2020. Does your answer make sense? Why or why not?

**Answer**: For an exponential model, the result is more than 46,000,000 restaurants, which does not make sense. For a logistic model (as shown at the right), the result is 3329 restaurants, which seems reasonable.

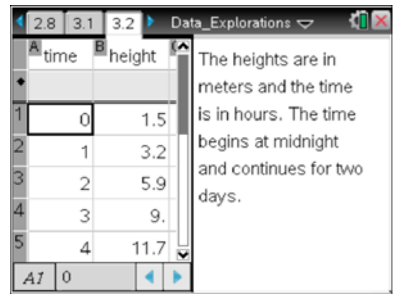
**Teacher Tip:** Depending upon the choice of regression model, the students' solutions may or may not make sense in the context of the problem.

.

**Move to page 3.1.**

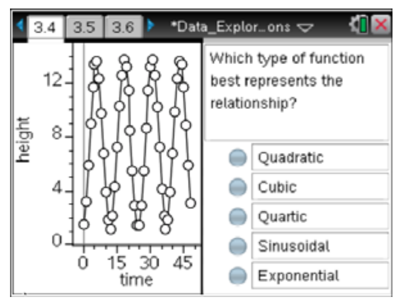



**Move to page 3.2.**




Instruct students to look at the data in the spreadsheet and note the heights in the second column.

**Move to page 3.3 and then to page 3.4.**




When the scatter plot is constructed, it may be difficult to see a pattern since the graph is compressed horizontally.

Instruct the students to press ctrl menu, to "right-click" on one of the data points and select **Connect Data Points**. This relationship is sinusoidal. Students may anticipate that fact, since tides are known to be cyclical.

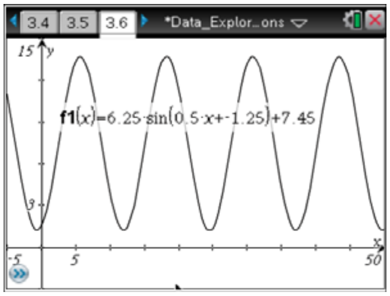
**Tech Tip:** When students set up a scatter plot on page 3.4, they will notice that additional list variables are available. A regression equation was computed and hidden in the spreadsheet. The list variables (other than height and time) are associated with that regression. Students will graph the regression equation on page 3.6.

**Question**: Which type of function best represents the relationship?

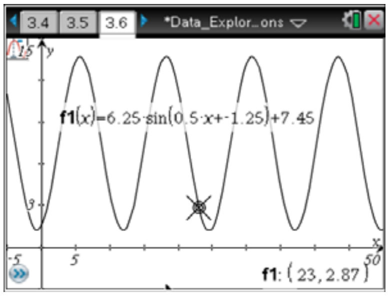
**Answer**: Sinusoidal

**Move to page 3.5 and then to page 3.6.**

On page 3.5, students are given instructions to move to page 3.6, where they will trace on the graph of the sinusoidal regression. When students advance to this page, the focus will be on the open entry line, which will display **f2**(*x*). They will arrow up to display **f1**(*x*), the regression equation, and press enter to graph the function.



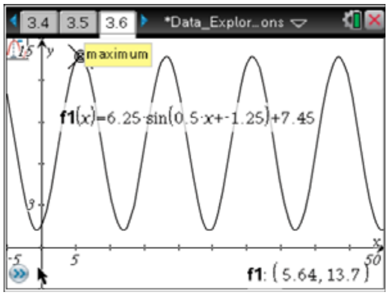

To trace on the function, press **Menu > Trace > Graph Trace**. A trace point will be added to the graph. Press the right or left arrow key on the Touchpad to trace on the graph. The ordered pair for the point is displayed in the lower-right corner of the page. Students will need to move to various locations on the graph to answer the questions on the following pages. Press esc to exit **Graph Trace**.




**Move to page 3.7.**

<u>**Question**</u>: If a person wants to go out on the high tide, when is the first time that he or she can leave?

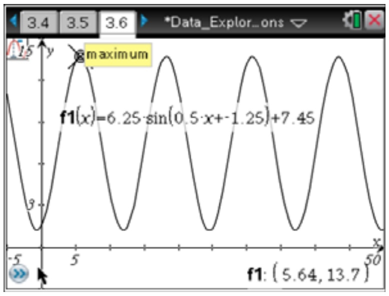
<u>**Answer**</u>: 5:38 a.m. (5.64 is the *x*-coordinate of the first maximum function value after *x* = 0. The decimal portion of an hour must be multiplied by 60 in order to convert it to minutes.)



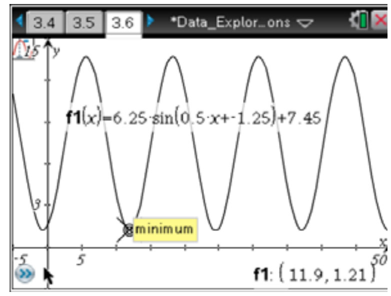

**Move to page 3.8.**

<u>**Question**</u>: Using your model, what is the height at high tide?

<u>**Answer**</u>: 13.7 meters (This is the *y*-coordinate of the maximum function value.)



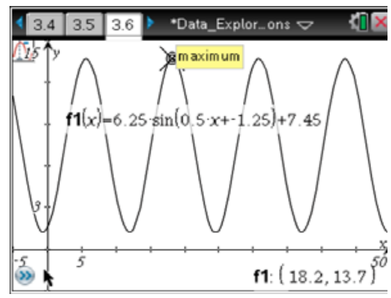
**Move to page 3.9.**




**<u>Question</u>**: Using your model, what is difference in the height of the water between high tide and low tide?

**<u>Answer</u>**: 13.7 – 1.21 = 12.49 meters (This is the difference in the *y*-coordinates of the function maximum and the minimum.)

**Move to page 3.10.**




**<u>Question</u>**: Using your model, what is the time between successive high tides?

**<u>Answer</u>**: About 12 hours and 34 minutes (This is the difference in the *x*-coordinates at successive maximum function values. 18.2 – 5.64 = 12.56 hours. Convert the decimal portion of the result to minutes by multiplying by 60.)

> **Teacher Tip:** Remind students that the answers to the questions on pages 3.7 – 3.10 are based on the sinusoidal model. They should not assume, for example, that the time between two successive high tides will always be 12 hours and 34 minutes. Also, the heights of the high and low tides may vary from day to day.

## Wrap Up

Upon completion of the activity, the teacher should ensure that students understand the following ideas:

- Different sets of data can be analyzed using different models.
- In the case of the tidal data, students' understanding of the nature of tides should suggest that the relationship is sinusoidal.
- For Moser's Problem, the use of finite differences is a tool can lead to the selection of a possible model.
- For the growth of the franchise, reflection upon the reasonableness of the number of restaurants predicted by the model could help students understand that a model that at first seemed reasonable may not be the appropriate model.

# Aggregating Data with TI-Nspire™ Navigator™ Teacher Software



TI PROFESSIONAL DEVELOPMENT

## Activity Overview

This activity demonstrates the data aggregation features of the TI-Nspire™ Navigator™ Teacher Software. You will answer a **Quick Poll** question, and the instructor will aggregate the data. You will then find a line of best fit for the data, and the instructor will collect participants' responses with a **Quick Poll**.

**Step 1:**

Login to the TI-Nspire™ Navigator™ class.

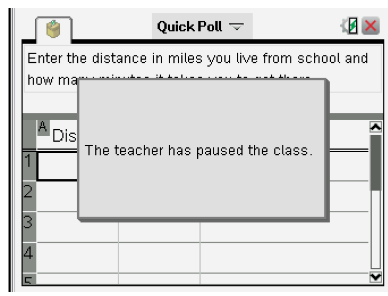
Turn the handheld on. If the **Login to Class** window is not open, press [⌂ on] and select **Settings > Login**. Type the user name. Tab to the **Password** field by pressing [tab], type the password, and press [enter].

A message appears indicating that you are logged in to class. Close the **Login Successful** window by pressing [enter].

Go to the **My Documents** folder on the handheld by pressing [⌂ on] **> My Documents**. Locate the Class folder and open **Aggregating_ Data_1**.

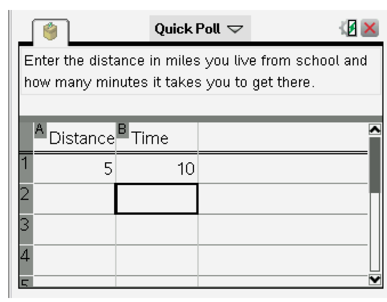

**Step 2:**

The instructor will send a **Quick Poll** question, and the class will be immediately paused. This gives the instructor the opportunity to discuss the **Quick Poll.**



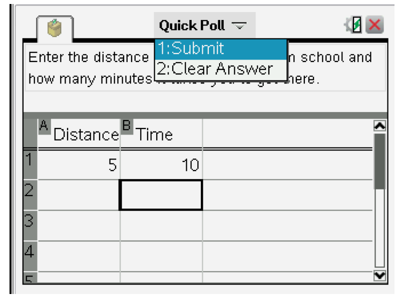

**Step 3:**

Once class is resumed, enter the appropriate data into the given lists. Type a value for **Distance** and move to the **Time** cell by pressing [tab]. Type a value for **Time** and press [enter].



**Step 4:**

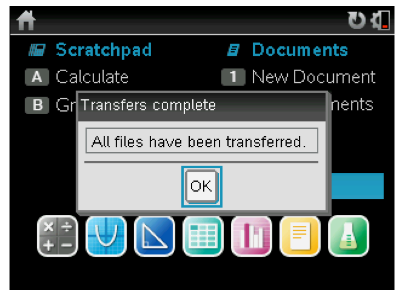
Submit your answer to the **Quick Poll.** Use your Touchpad and cursor to access the **Quick Poll** drop-down menu and select **Submit**.




**Note:** The **Quick Poll** drop-down menu can also be accessed by pressing [doc▾], and the answer can be submitted by pressing [1].

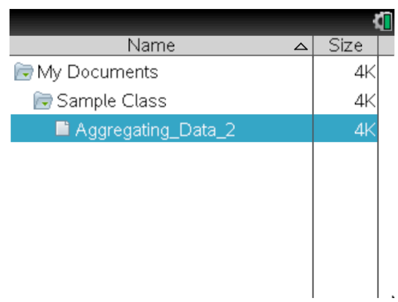
**Step 5:**

The instructor will aggregate the data and send a TI-Nspire™ document to the class. Once the **Transfers Complete** window appears, press [enter].




**Step 6:**

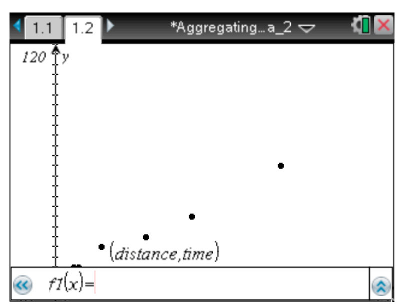
Go to the **My Documents** folder on the handheld by pressing [⌂ on] > **My Documents**. Locate the Class folder and open **Aggregating_ Data_2**.




**Note:** If a window appears that asks "**Do you want to save 'Unsaved Document'?**," press [tab] to select **No** and then press [enter].

**Step 7:**

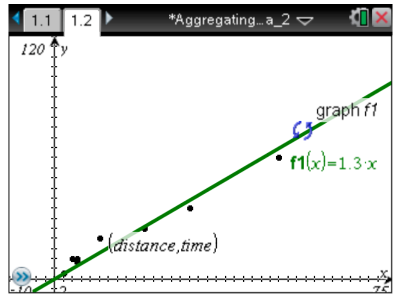
The aggregated data is on page 1.1. Move to page 1.2 by pressing [ctrl] ▶. Open the entry line by pressing [tab].




**Step 8:**

Graph an initial line of best fit by typing an expression and pressing [enter].

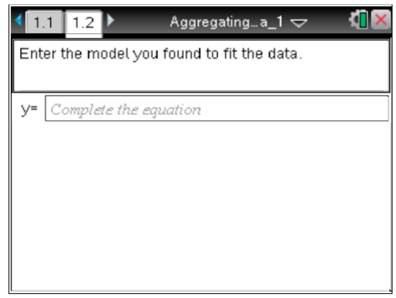
**Step 9:**




Transform the line of best fit to best model the given data. Rotate the line by hovering the cursor over either "end" of the line. When the rotational cursor appears, rotate the line by clicking and dragging it.

Translate the line by hovering the cursor over the line near the "middle." When the translational cursor appears, translate the line up and down by clicking and dragging it.

**Step 10:**




The instructor will send a **Quick Poll** that asks you enter the equation of your line of best fit. After you type your equation, submit it by clicking the **Quick Poll** drop-down menu and selecting **Submit or** pressing doc▾ and selecting **Submit**.

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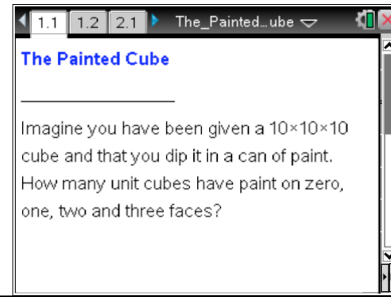
# The Painted Cube
## Student Activity

**Name** ____________________
**Class** ____________________

**Open the TI-Nspire™ document The_Painted_Cube.**




A cube with dimensions $n \times n \times n$ that is built from unit cubes is dipped in a can of paint. You will model the relationships between the dimensions of a cube and the number of faces of the unit cubes that are painted.

**Part 1—Introduction to the Problem**

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

**Move to page 1.2.**

One strategy for solving a problem is to solve a simpler related problem.

1. Consider a 2 × 2 × 2 cube.

   a. How many unit cubes does it take to build a 2 × 2 × 2 cube?

   b. Rotate the model on page 1.2 by dragging the open points on the left side of the screen. If needed, build your own model using cubes. If this cube were dipped in paint, what is the greatest number of faces of a single unit cube that could be painted?

   c. How many faces of *each* of the unit cubes are painted on the 2 × 2 × 2 cube?

**Move to page 2.1.**

2. Now consider a 3 × 3 × 3 cube.

   a. How many unit cubes does it take to build a 3 × 3 × 3 cube?

   b. Rotate the model on page 2.1 by dragging the open points on the left side of the screen. If needed, build your own model using cubes. If the 3 × 3 × 3 cube were dipped in a can of paint, how many faces of *each* of the unit cubes would be painted?

Name ________________

Class ________________

3. a. Record your findings for the 2 × 2 × 2 and 3 × 3 × 3 cubes in the table below. Then determine how many faces of each of the unit cubes would be painted for the 4 × 4 × 4 and 5 × 5 × 5 cubes if the large cubes were dipped in paint.

| ***n*** (side length of cube) | **Number of unit cubes with paint on zero faces** | **Number of unit cubes with paint on one face** | **Number of unit cubes with paint on two faces** | **Number of unit cubes with paint on three faces** |
|---|---|---|---|---|
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |

b. What patterns do you notice in the table?

**Part 2—Investigating Paint on Three Faces**

**Move to page 2.2.**

You will now analyze the data you collected and explore the relationships graphically for a cube with any side length *n*. You will then use the graph to make predictions for the case where *n* = 10.

**Move to page 3.1.**

4. Enter the values from your table above into the spreadsheet on page 3.1.

5. From the information in the table, how many unit cubes would have paint on <u>three</u> faces in a 10 × 10 × 10 cube? Explain your reasoning.

**Part 3—Investigating Paint on Two Faces**

**Move to page 3.2.**

This page uses the data that you entered on page 3.1 to make a scatter plot of the number of unit cubes with paint on two faces versus the side length of the cube, *n*.

6. Describe the relationship between the two variables.

7. Add a movable line by selecting **Menu > Analyze > Add Movable Line**.
   a. Grab the line and transform it to get a line of best fit. What is the equation of your line of best fit?

   b. Test your equation with known values from your table and adjust your movable line as necessary. Once your equation matches the known values, what is the equation of your line?

   c. Write your equation in factored form. What is the meaning of this form of the equation in the context of the painted cube problem?

8. Use your equation to determine the number of unit cubes that would have paint on two faces in a $10 \times 10 \times 10$ cube.

9. Explain how your answer makes sense in terms of the graph on page 3.2.

**Part 4—Investigating Paint on One Face**

**Move to page 3.3.**

This page uses the data that you entered on page 3.1 to make a scatter plot of the number of unit cubes with paint on one face versus the side length of the cube, *n*.

10. Describe the relationship between the two variables.

11. Determine the equation of the curve of best fit. Press **Menu > Analyze > Regression** and select the type of function that you think will best fit the data.

    a. What is the regression equation?

    b. Test your equation with known values from your table. If needed, choose a different type of regression equation. Once the equation matches the known values, what is the equation?

    c. Write your equation in factored form. What is the meaning of this form of the equation in the context of the painted cube problem?

12. Use your equation to determine the number of unit cubes that would have paint on <u>one</u> face in a 10 × 10 × 10 cube.

**Part 5—Investigating Paint on Zero Faces**

**Move to page 3.4.**

This page uses the data that you entered on page 3.1 to make a scatter plot of the number of unit cubes with paint on zero faces versus the side length of the cube, *n*.

13. Describe the relationship between the two variables.

14. Determine the equation of the curve of best fit. Press **Menu > Analyze > Regression** and select the type of function that you think will best fit the data.

    a. What is the regression equation?

    b. Test your equation with known values from your table. If needed, choose a different type of regression equation. Once the equation matches the known values, what is the equation?

15. Use your equation to determine the number of unit cubes that would have paint on <u>zero</u> faces in a 10 × 10 × 10 cube?

**Part 6—Reflecting on the Problem**

16. a. Record the type of relationship (e.g., linear, quadratic) for each of the numbers of painted faces you investigated.

| Painted Faces | Type of Relationship |
|---|---|
| 3 | |
| 2 | |
| 1 | |
| 0 | |

b. Think about the painted cubes and how the numbers of painted faces change as the side length of the cube, $n$, increases. Justify why each type of relationship makes sense in the context of the problem.

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# The Painted Cube



TI PROFESSIONAL DEVELOPMENT

## Math Objectives

- Students will explore constant, linear, quadratic, and cubic functions. The functions will be modeled from numerical data that they generate by thinking of an $n \times n \times n$ cube being dipped in paint, and how many of the cubes have paint on zero, one, two, or three faces.
- Model with mathematics. (CCSS Mathematical Practice)
- Construct viable arguments and critique the reasoning of others. (CCSS Mathematical Practice)

## Vocabulary

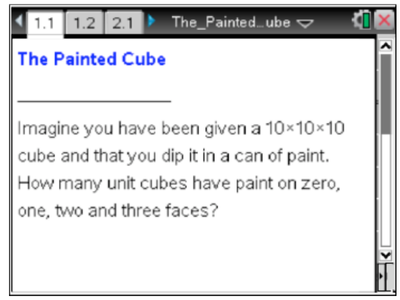
- regression
- constant, linear, quadratic, cubic
- scatter plot
- factored form of a polynomial equation

## About the Lesson

- This lesson involves having the students hypothesize about the different relationships that exist between the size of the cube and the number of cubes that have paint on one, two, three, and zero faces. In order to help students visualize the problem, interlocking cubes could be made available.
- As a result, students will model the relationships between the cube size and the number of painted faces by looking at the graphical representations and then creating algebraic models.

## TI-Nspire™ Navigator™ System

- Use **Screen Capture** to monitor the models that students are using for each of the different problems.
- Use **Live Presenter** as needed to model the manipulation of the movable line.




**TI-Nspire™ Technology Skills:**

- Download a TI-Nspire™ document
- Open a document
- Move between pages
- Add and manipulate a moveable line

**Tech Tips:**

- Make sure the font size on your TI-Nspire™ handhelds is set to Medium.

**Lesson Materials:**

*Student Activity*

- The_Painted_Cube_Student.pdf
- The_Painted_Cube_Student.doc

*TI-Nspire™ document*

- The_Painted_Cube.tns

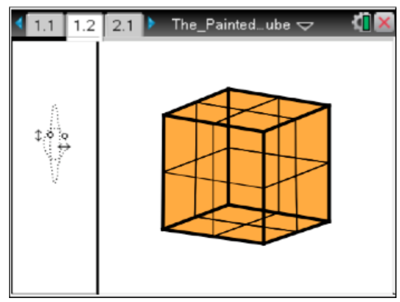
## Lesson Procedures, Discussion Points, and Possible Answers

**Tech Tip:** If students experience difficulty dragging a point, check to make sure that they have moved the arrow until it becomes a hand ( ) getting ready to grab the point. Press ctrl to grab the point and close the hand ( ).

### Part 1—Introducing the Problem

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

**Move to page 1.2.**




One strategy for solving a problem is to solve a simpler related problem.

1. Consider a 2 × 2 × 2 cube.

   a. How many unit cubes does it take to build a 2 × 2 × 2 cube?

   **<u>Answer:</u>** 8 unit cubes

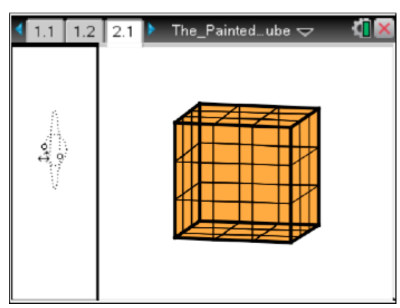
   b. Rotate the model on page 1.2 by dragging the open points on the left side of the screen. If needed, build your own model using cubes. If this cube were dipped in paint, what is the greatest number of faces of a single unit cube that could be painted?

   **<u>Answer:</u>** The greatest number of faces that could be painted is three.

   c. How many faces of *each* of the unit cubes are painted on the 2 × 2 × 2 cube?

   **<u>Answer:</u>** All cubes have three faces painted.

**Move to page 2.1.**




2. Now consider a 3 × 3 × 3 cube.

   a. How many unit cubes does it take to build a 3 × 3 × 3 cube?

   **<u>Answer:</u>** 27 cubes

b. Rotate the model on page 2.1 by dragging the open points on the left side of the screen. If needed, build your own model using cubes. If the 3 × 3 × 3 cube were dipped in a can of paint, how many faces of *each* of the unit cubes would be painted?

**Answer:** 8 cubes would have three faces painted; 12 cubes would have two faces painted; 6 cubes would have one face painted; 1 cube would have zero faces painted.

3. a. Record your findings for the 2 × 2 × 2 and 3 × 3 × 3 cubes in the table below. Then determine how many faces of each of the unit cubes would be painted for the 4 × 4 × 4 and 5 × 5 × 5 cubes if the large cubes were dipped in paint.

| ***n*** (side length of cube) | **Number of unit cubes with paint on zero faces** | **Number of unit cubes with paint on one face** | **Number of unit cubes with paint on two faces** | **Number of unit cubes with paint on three faces** |
|---|---|---|---|---|
| 2 | 0 | 0 | 0 | 8 |
| 3 | 1 | 6 | 12 | 8 |
| 4 | 8 | 24 | 24 | 8 |
| 5 | 27 | 54 | 36 | 8 |

b. What patterns do you notice in the table?

**Sample Answer:** For any value of $n$ where $n \geq 2$, there will always be 8 cubes that have three faces painted.

The number of cubes with two faces painted is always a multiple of 12. The number of unit cubes with paint on two faces increases by 12 each time.

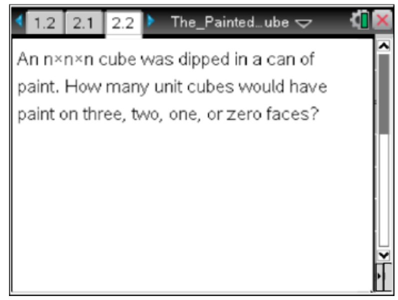
For the number of cubes with one face painted, the number increases by 6, then 18, then 30. There is a difference of 12 between each of those numbers.

The number of unit cubes with paint on zero faces is a perfect cube. It is the cube of the number that is two less than the side length of the cube.

**Teacher Tip:** Some students might already see functional relationships, but the expectation at this point is that they at least see some kind of pattern in the numbers.

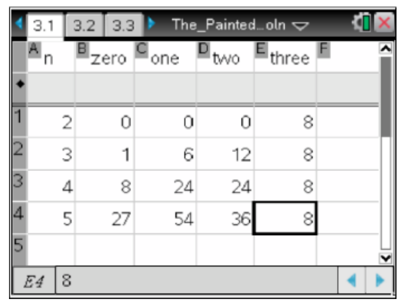
**Part 2—Investigating Paint on Three Faces**

**Move to page 2.2.**




You will now analyze the data you collected and explore the relationships graphically for a cube with any side length *n*. You will then use the graph to make predictions for the case where *n* = 10.

**Move to page 3.1.**



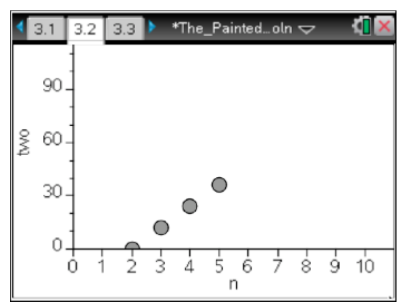

4. Enter the values from your table above into the spreadsheet on page 3.1.

5. From the information in the table, how many unit cubes would have paint on <u>three</u> faces in a 10 × 10 × 10 cube? Explain your reasoning.

   <u>**Answer:**</u> There will be 8 cubes with paint on three faces. The only cubes that can have paint on three faces are the corner cubes, and there will always be 8 of them.

**Part 3—Investigating Paint on Two Faces**

**Move to page 3.2.**




This page uses the data that you entered on page 3.1 to make a scatter plot of the number of unit cubes with paint on two faces versus the side length of the cube, *n*.

6. Describe the relationship between the two variables.

   <u>**Answer:**</u> The data looks linear.

7. Add a movable line by selecting **Menu > Analyze > Add Movable Line**.

   a. Grab the line and transform it to get a line of best fit. What is the equation of your line of best fit?

      <u>**Answer:**</u> **m1**($x$) = $12x - 24$ or **f**($n$) = $12n - 24$

**Tech Tip:** Moving the cursor near the middle of the movable line will display the translate tool. Moving the cursor on either end of the movable line will display the rotation tool. Press ctrl to grab the line and translate or rotate it.

b. Test your equation with known values from your table and adjust your movable line as necessary. Once your equation matches the known values, what is the equation of your line?

**Answer:** $\mathbf{f}(n) = 12n - 24$

**Tech Tip:** Students can use the **Scratchpad** as needed for calculations.

c. Write your equation in factored form. What is the meaning of this form of the equation in the context of the painted cube problem?

**Answer:** $\mathbf{f}(n) = 12n - 24 = 12(n - 2)$

The cubes that have paint on two faces are the cubes on the edges of the large cube, excluding the corners. There are 12 edges on a cube. Subtracting 2 removes the corner cubes.

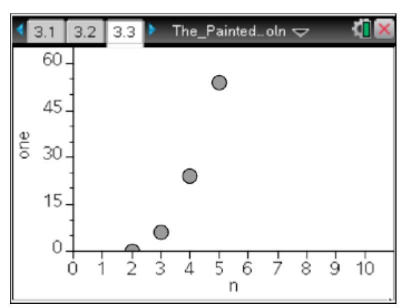
8. Use your equation to determine the number of unit cubes that would have paint on two faces in a 10 × 10 × 10 cube.

**Answer:** 96 unit cubes

9. Explain how your answer makes sense in terms of the graph on page 3.2.

**Answer:** The point (10, 96) would be on the line.

**Part 4—Investigating Paint on One Face**




**Move to page 3.3.**

This page uses the data that you entered on page 3.1 to make a scatter plot of the number of unit cubes with paint on one face versus the side length of the cube, *n*.

10. Describe the relationship between the two variables.

**Answer:** The data looks quadratic.

11. Determine the equation of the curve of best fit. Press **Menu > Analyze > Regression** and select the type of function that you think will best fit the data.

    a. What is the regression equation?

    **Answer:** $y = 6x^2 - 24x + 24$

    b. Test your equation with known values from your table. If needed, choose a different type of regression equation. Once the equation matches the known values, what is the equation?

    **Answer:** $y = 6x^2 - 24x + 24$ or $\mathbf{f}(n) = 6n^2 - 24n + 24$

    c. Write your equation in factored form. What is the meaning of this form of the equation in the context of the painted cube problem?

    **Answer:** $\mathbf{f}(n) = 6n^2 - 24n + 24 = 6(n^2 - 4n + 4) = 6(n - 2)(n - 2) = 6(n - 2)^2$

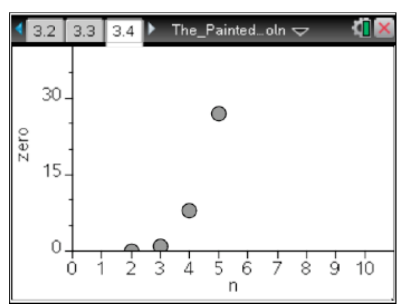
    The cubes that have paint on one face are the cubes on the faces of the large cube, excluding the edges. There are six faces on a cube. On the face of an $n \times n \times n$ cube, the number of squares in the center (excluding the edges) is $(n - 2)^2$.

12. Use your equation to determine the number of unit cubes that would have paint on one face in a 10 × 10 × 10 cube.

    **Answer:** 384 unit cubes

**Part 5—Investigating Paint on Zero Faces**

**Move to page 3.4.**




This page uses the data that you entered on page 3.1 to make a scatter plot of the number of unit cubes with paint on zero faces versus the side length of the cube, $n$.

13. Describe the relationship between the two variables.

    **Answer:** The data looks cubic.

14. Determine the equation of the curve of best fit. Press **Menu > Analyze > Regression** and select the type of function that you think will best fit the data.

    a. What is the regression equation?

    **Answer:** $y = x^3 - 6x^2 + 12x - 8$ or $\mathbf{f}(n) = n^3 - 6n^2 + 12n - 8$

    b. Test your equation with known values from your table. If needed, choose a different type of regression equation. Once the equation matches the known values, what is the equation?

    **Answer:** $\mathbf{f}(n) = n^3 - 6n^2 + 12n - 8$

15. Use your equation to determine the number of unit cubes that would have paint on zero faces in a 10 × 10 × 10 cube?

    **Answer:** 512 unit cubes

**Part 6—Reflecting on the Problem**

16. a. Record the type of relationship (e.g., linear, quadratic) for each of the numbers of painted faces you investigated.

| Painted Faces | Type of Relationship |
|---|---|
| 3 | Constant |
| 2 | Linear |
| 1 | Quadratic |
| 0 | Cubic |

    b. Think about the painted cubes and how the numbers of painted faces change as the side length of the cube, $n$, increases. Justify why each type of relationship makes sense in the context of the problem.

    **Sample Answer:** As $n$ increases:

- The number of corner cubes stays constant: 3 faces painted
- The edges of the cube grow constantly (linear relationship): 2 faces painted
- The faces of the cube grow in area (quadratic relationship): 1 face painted
- The middle of the cube (excluding the faces) grows in volume (cubic relationship): 0 faces painted.

**Extension—Making Sense of the Cubic Relationship**

The regression formula for the cubic relationship, $\mathbf{f}(n) = n^3 - 6n^2 + 12n - 8$, is not as easy to understand in the context of the problem. Ask students to look back at their table on the Student Worksheet, specifically at the column for zero faces painted. Lead class discussion with questions such as these:

1. Looking at the table on page 1, what kind of numbers are in the zero column?

   **Answer**: They are perfect cubes.

2. Write these numbers as powers of three.

   $0 = 0^3$, $1 = 1^3$, $8 = 2^3$, $27 = 3^3$,

3. How do the bases of these numbers relate to *n*?

   **Answer**: The bases are two less than *n*.

4. How else could we express the number of cubes with zero faces painted as a function of *n*?

   **Answer:** $\mathbf{f}(n) = (n - 2)^3$

5. How does this formula compare to the one found in question 14b?

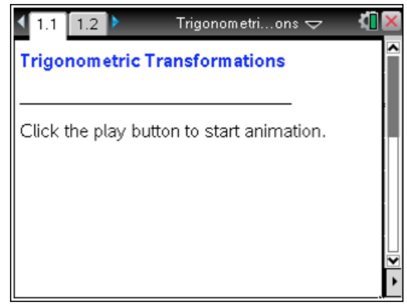
   **Answer**: $(n - 2)^3 = (n - 2)(n - 2)^2 = (n - 2)(n^2 - 4n + 4) = n^3 - 6n^2 + 12n - 8$ ✓

# Trigonometric Transformations
## Student Activity

**Name** ________________
**Class** ________________

**Open the TI-Nspire™ document Trigonometric_ Transformations.tns.**

In this activity, you will use an observation wheel to apply transformations to periodic functions and write an equation for a trigonometric function.




**Move to page 1.2.**

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

The London Eye is an observation wheel in London that can carry 800 passengers in 32 capsules. It turns continuously, completing a single rotation once every 30 minutes.

1. On the screen, you see a model of the London Eye on the left side and a graph on the right. Click on the **Play** button to start the animation. Click the button again to stop it. What type of function was created as a result of the animation?

2. What does the changing measurement on the left screen represent as the capsule (represented by the open circle) moves around the observation wheel?

3. What are the units of the *x*- and *y*-axes on the right?

4. a. What is the maximum height a capsule reaches from the platform?

   b. The horizontal line halfway between the maximum and minimum of the function is called the *midline* of the graph. What is the equation of the midline? Explain your reasoning.

5. The function $y = -A \cdot \cos(Bx) + D$ can be used to model the capsule's height above the platform at time $x$. This is a transformation of a basic cosine curve.

   a. Use your knowledge of transformations to explain why there is a negative sign in front of the variable $A$.

b. The variable $A$ represents the *amplitude*, which is the vertical distance between the midline and the maximum or the minimum. What is the amplitude of the “observation wheel” function, and how did you find the value?

c. Which variable of the equations represents the midline of the function? Explain your reasoning.

d. The *period* of a function is the time it takes to complete one cycle of a periodic function. What is the period of the “observation wheel” function, and how is it visible in the graph?

6. What characteristic of the observation wheel does the amplitude represent? Explain your reasoning.

7. The variable $B$ represents *frequency*. Frequency is the measure of the arc (in radians) traveled by the capsule divided by the time traveled (in minutes).

   a. What is the measure of the arc traveled by the capsule in one complete revolution?

   b. How long does it take for a capsule to complete one revolution?

   c. What is the frequency for the “observation wheel” function?

8. Using $y = -A \cdot \cos(Bx) + D$ and the variable information found in question 5, write the equation representing the height above the platform of a London Eye capsule at time $x$. Verify your answer by graphing the function.

9. Imagine that the boarding platform for the observation wheel stands 10 feet above the ground. If you wanted to measure the distance of a capsule from the ground rather than the platform, what parameters of the equation from question 8 would change? What parameters would stay the same?

# Trigonometric Transformations
**MATH NSPIRED**

**TEACHER NOTES**

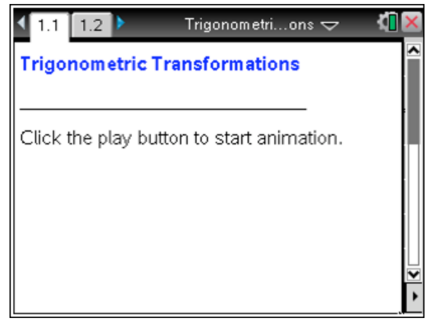
## Math Objectives
- Students will determine the type of function modeled by the height of a capsule on the London Eye observation wheel.
- Students will translate observational information to use as the parameters of a cosine function.
- Students will determine the amplitude, frequency, period, and midline of a cosine function when given information in verbal or graphical form.
- Students will model the height of a capsule on the London Eye by writing an equation in the form $y = -A \cdot \cos(Bx) + D$.
- Students will model with mathematics. (CCSS Mathematical Practice)

## Vocabulary
- amplitude
- frequency
- midline
- parameters of a function
- period
- periodic function
- sinusoidal function

## About the Lesson
- This lesson involves creating an appropriate equation to model the height of a capsule on the wheel.
- As a result, students will:
  - Use a slider to animate the function modeled by the height of a capsule on the London Eye observation wheel.
  - Discover the concepts of amplitude, frequency, period, and midline.
  - Determine the amplitude, frequency, period, and midline of the "observation wheel" function.

## Related Lessons
- Prior to this lesson: Unit Circle

## TI-Nspire™ Navigator™
- Use of **Document Collection/Quick Poll/Screen Capture** will allow the teacher to assess student understanding during the lesson.
- Use **Screen Capture** to examine results.




**TI-Nspire™ Technology Skills:**
- Download a TI-Nspire™ document
- Open a document
- Move between pages
- Use a slider
- Click slider arrows to begin an animation
- Move between applications
- Show the function entry line
- Insert the equation of a function and graph it

**Tech Tips:**
- Make sure the font size on your TI-Nspire™ handhelds is set to Medium.
- In the *Graphs* application, you can hide the function entry line by pressing ctrl G.

**Lesson Materials:**
*Student Activity*
Trigonometric_Transformations_Student.pdf
Trigonometric_Transformations_Student.doc

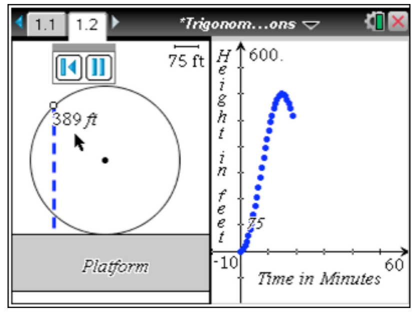
*TI-Nspire™ document*
Trigonometric_Transformations.tns

## Discussion Points and Possible Answers

**Tech Tip:** Press esc to hide the entry line if students accidentally press tab.

**Move to page 1.2.**

The London Eye is an observation wheel in London that can carry 800 passengers in 32 capsules. It turns continuously, completing a single rotation once every 30 minutes.




1. On the screen, you see a model of the London Eye on the left side and a graph on the right. Click on the **Play** button to start the animation. Click the button again to stop it. What type of function was created as a result of the animation?

   **Sample Answers**: A sinusoidal function, a cosine function, a periodic function, a cyclical function

**TI-Nspire™ Navigator™ Opportunity: Screen Capture or Live Presenter**
**See Note 1 at the end of this lesson.**

2. What does the changing measurement on the left screen represent as the capsule (represented by the open circle) moves around the observation wheel?

   **Teacher Tip:** Students should recognize the shape of the graph. Some students might recognize the transformations, while others will not.

   **Answer:** The measurement shows the height of a capsule from the platform.

3. What are the units of the *x*- and *y*-axes on the right?

   **Answer:** The *x*-axis represents time in minutes. The *y*-axis represents height in feet.

4. a. What is the maximum height a capsule reaches from the platform?

   **Answer:** 450 feet

**TI-Nspire™ Navigator™ Opportunity: *Screen Capture* or *Live Presenter***
**See Note 2 at the end of this lesson.**

b. The horizontal line halfway between the maximum and minimum of the function is called the *midline* of the graph. What is the equation of the midline? Explain your reasoning.

**Answer:** The equation of the midline is $y = 225$. The maximum height is 450 feet and the minimum is 0 feet, resulting in a midpoint of 225.

5. The function $y = -A \cdot \cos(Bx) + D$ can be used to model the capsule's height above the platform at time $x$. This is a transformation of a basic cosine curve.

a. Use your knowledge of transformations to explain why there is a negative sign in front of the variable $A$.

**Answer:** The basic cosine function starts at its maximum. This function starts at its minimum. The negative represents the reflection about the midline.

b. The variable $A$ represents the *amplitude*, which is the vertical distance between the midline and the maximum or the minimum. What is the amplitude of the "observation wheel" function, and how did you find the value?

**Answer:** The amplitude is 225. The distance from the maximum of 450 to the value of the midline is 225.

c. Which variable of the equations represents the midline of the function? Explain your reasoning.

**Answer:** The midline is the variable $D$, which is 225 in this function. In a basic cosine curve, the maximum is 1, the minimum is –1, and the midline is $y = 0$. In this function, the maximum is 450, the minimum is 0, and the midline is 225. Vertical shifts are represented as an addition or subtraction from the basic function.

d. The *period* of a function is the time it takes to complete one cycle of a periodic function. What is the period of the "observation wheel" function, and how is it visible in the graph?

**Answer:** The period is 30. From the graph we can see that it takes 60 minutes to complete two cycles. Thus, it takes 30 minutes to complete one cycle of the periodic function.

6. What characteristic of the observation wheel does the amplitude represent? Explain your reasoning.

   **Answer:** The amplitude represents the radius of the observation wheel.

7. The variable *B* represents *frequency*. Frequency is the measure of the arc (in radians) traveled by the capsule divided by the time traveled (in minutes).

   a. What is the measure of the arc traveled by the capsule in one complete revolution?

      **Answer:** The measure of the arc is $2\pi$.

      **Teacher Tip:** You might have to remind students that the measure of the arc is the measure of the central angle, and the length of the arc is the distance traveled. Frequency in this example is angular velocity.

   b. How long does it take for a capsule to complete one revolution?

      **Answer:** It takes 30 minutes.

   c. What is the frequency for the "observation wheel" function?

      **Answer:** Frequency is $\frac{2\pi}{30} = \frac{\pi}{15}$.

8. Using $y = -A \cdot \cos(Bx) + D$ and the variable information found in question 5, write the equation representing the height above the platform of a London Eye capsule at time $x$. Verify your answer by graphing the function.

   **Answer:** The equation is $y = -225 \cdot \cos\left(\frac{\pi x}{15}\right) + 225$.

**TI-Nspire™ Navigator™ Opportunity: Quick Poll**
**See Note 3 at the end of this lesson.**

9. Imagine that the boarding platform for the observation wheel stands 10 feet above the ground. If you wanted to measure the distance of a capsule from the ground rather than the platform, what parameters of the equation from question 8 would change? What parameters would stay the same?

**Answer:** The new equation would be $y = -225 \cdot \cos\left(\frac{\pi x}{15}\right) + 235$.

The only parameter that changes is *D*, the vertical shift. The amplitude and frequency stay the same because they are based on the observation wheel, not where it exists in space.

## Extension:

How can you model the London Eye using a sine function?

---

## Wrap Up

Upon completion of the discussion, the teacher should ensure that students are able to understand:

- The type of function modeled by the height of a capsule on an observation wheel
- Parameters of a cosine function
- How to determine the amplitude, frequency, period, and midline of a cosine function when given information in verbal or graphical form
- How to use parameters to write an equation in the form $y = -A \cdot \cos(Bx) + D$

## TI-Nspire™ Navigator™

**Note 1**

**Question 1, Screen Capture and Live Presenter**

As students begin this activity, use **Screen Capture** to be assured that each student is able to play the animation. You can choose one student to display his or her work on this and future problems and discuss the results.

**Note 2**

**Question 3 and 4, Screen Capture**

You can choose to use **Screen Capture** to share the work for these problems.

**Note 3**

**Whole Document, Quick Poll**

**Quick Poll** can be used throughout the lesson to assess student understanding.

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## Activity Overview

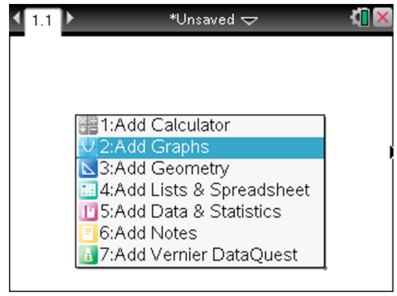
In this activity, you will graph trigonometric functions and solve trigonometric equations.

**Step 1:**

Press [⌂ on] and select **New Document** to start a new document.

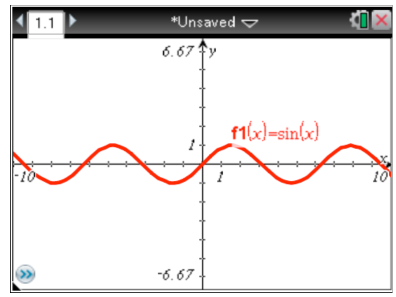
**Step 2:**

Choose **Add Graphs**.



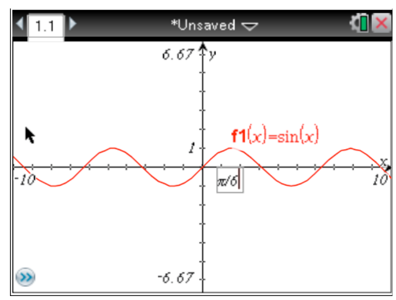

**Step 3:**

The cursor will be in the entry line at the bottom of the screen to the right of f1($x$) =. To graph **f1**($x$) = sin($x$), press [trig], select **sin** from the trigonometry template, and press [X]. Press [enter].




**Step 4:**

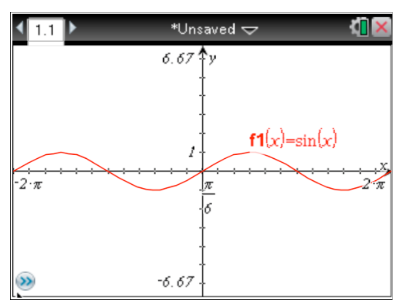
To change the scale of the horizontal axis to a scale that increases by multiples of $\frac{\pi}{6}$, move the cursor to the **1** on the horizontal axis. Press [click] to select the **1** and press [click] again to enter the field in order to edit the value. Press [del], and then press [π▸] [÷] [6] to set the scale as $\frac{\pi}{6}$.




**Note**: The π symbol can also be displayed by pressing [P] [I].

**Step 5:**

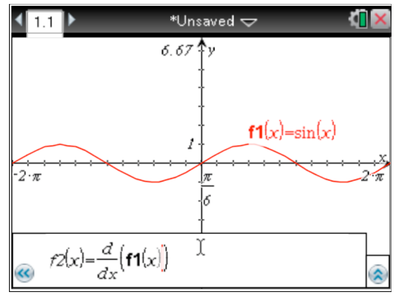
Change the end values of the horizontal axis to –2π and 2π by repeating the process in Step 4. You can change the vertical axis settings if desired.




**Note**: Changing the **Xmax**, **Xmin**, and **Xscale** of the **Window** settings would not have displayed the horizontal axis in multiples of π. The values would have been displayed as decimals.

**Step 6:**

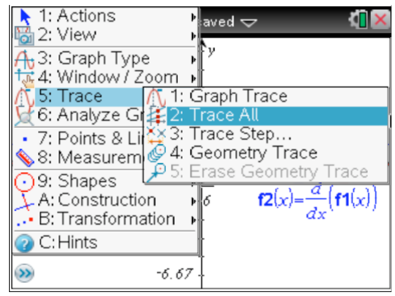
Press tab or ctrl G to view the function entry line. The cursor should be on the line for **f2**(*x*). Press and select the derivative template. Enter the derivative of **f1**(*x*) in **f2**(*x*) and press enter.




**Step 7:**

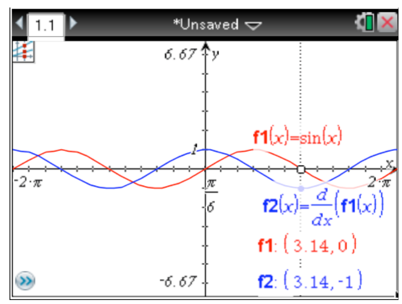
To trace and display function values for both functions, press **Menu > Trace > Trace All**.

To trace on the functions, press the left or right arrow key on the Touchpad.



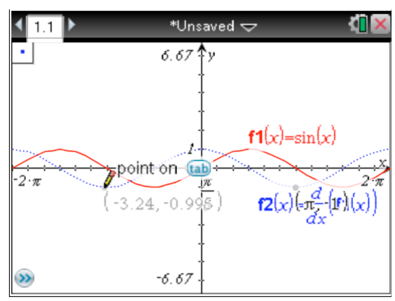

**Step 8:**

When the **Trace** tool is active, function values for a particular value of *x* may be displayed. Type a value for *x* (the number $\pi$ was chosen for this example) and then press enter to display the function values at that value of *x*. Press esc to stop the **Trace** tool.



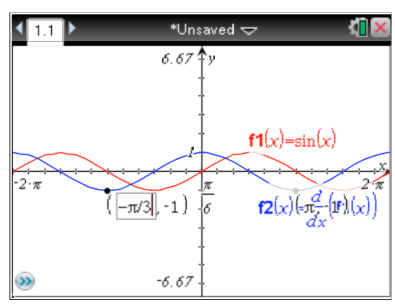

**Step 9:**

To view a point on the function in multiples of $\pi$, press **Menu > Points & Lines > Point**. Move the cursor to the function. The cursor will turn into a pencil and will indicate that it will place a point on the function. Press to place the point on the function and then press esc to turn off the **Point** tool.




**Step 10:**

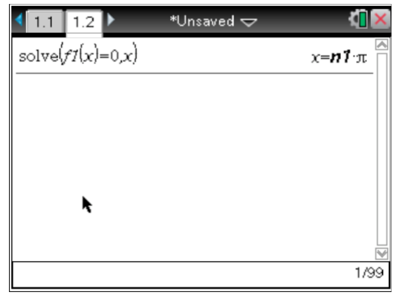
Move the cursor to the *x*-coordinate and press to select it. Press once more to edit the *x*-coordinate. Change the *x*-coordinate to $\frac{\pi}{3}$ by pressing (–) π ÷ 3, and then press enter. The point will move to the location on the function.




**Note**: You can grab and drag this point to view other values on the function and points of interest.

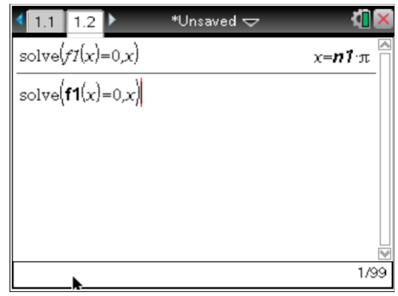
**Step 11:**

Press ctrl I or ctrl doc▾ to insert a new page in the document. Select **Add Calculator**. Press **Menu > Algebra > Solve**. Type **f1(*x*) = 0, *x*** within the parentheses and press enter. Note that the solution provided is for the entire domain of the sine function.




**Step 12:**

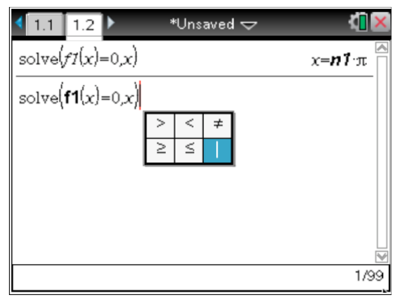
Press ▲ until the **solve** command is highlighted, and press enter to copy and paste the text into the current line.

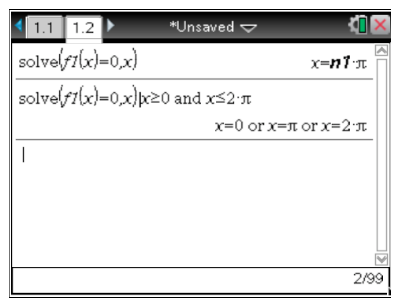



**Step 13:**

Press ctrl = and select the "such that" symbol (|). Enter the constraints on the domain so that the solutions will be restricted between 0 and $2\pi$. Try solving another trigonometric equation using either **f1**(*x*) or **f2**(*x*) for a restricted domain.

**<u>Note</u>:** To select the "greater than or equal to" symbol or the "less than or equal to" symbol, press ctrl =. The word **and** can be typed using the keypad.



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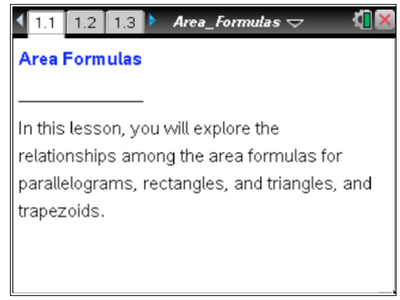
# Area Formulas
## Student Activity

**Name** ______________

**Class** ______________

**Open the TI-Nspire™ document Area_Formulas.tns.**

How is the area of a parallelogram related to the area of a rectangle? How are triangles and trapezoids related to parallelograms? This lesson lets you explore the relationships among their area formulas.




**Move to page 1.2.**

Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

1. Click ▲ to show the dimension labels of the rectangle.

   a. What are the labels for the dimensions of the given rectangle?

   b. What is the formula for the area of the rectangle in terms of base and height?

2. Drag the top-left or bottom-right vertex to change the dimensions of the rectangle. If you change the dimensions of the rectangle, does this change the formula for the area of the rectangle?

**Move to page 1.3. After reading the instructions, move to page 1.4.**

3. a. How do the base and height of the parallelogram compare to the base and height of the rectangle at the top of the screen?

   b. Move point *H* or point *B*. Describe the changes that occur in the rectangle and the changes in the parallelogram.

4. Drag point *P* to the right as far as you can.

   a. Explain why the new figure on the bottom of the screen is a rectangle.

   b. What does this tell you about the area of the original parallelogram?

   c. Why do the parallelogram and the rectangle have the same area?

   d. What could be a formula for the area of the parallelogram?

**Move to page 2.1. After reading the instructions, move to page 2.2.**

5. a. How do the base and height of the triangle compare to the base and height of the parallelogram at the top of the screen?

   b. Move point *H* or point *B* on the parallelogram. Describe the changes that occur in the parallelogram and the changes in the triangle.

6. Rotate point *Q* until it is as far to the right as possible.

   a. What type of figure is formed?

   b. How does the area of the original shaded triangle compare to the area of the parallelogram?

7. If the area of a parallelogram is base times height, then what could be a formula for the area of the triangle?

**Move to page 3.1. After reading the instructions, move to page 3.2.**

8. Rotate point *R* until it is as far to the right as possible.

   a. What type of figure is formed?

   b. How is the base of the parallelogram related to the trapezoid?

   c. Write an expression to represent the area of the parallelogram—either the parallelogram on the top of the screen or the newly formed parallelogram at the bottom of the screen.

9. How does the area of the original shaded trapezoid compare to the area of the parallelogram?

10. If the area of a parallelogram is base times height, then what could be a formula for the area of the trapezoid?

# Area Formulas
**Student Activity**

**Name** ________________
**Class** ________________

11. For each problem below,
    - Draw the figure.
    - Write a formula that could be used to find the area of each figure.
    - Use your formula to find the area of each figure.

a. A parallelogram with base of 7.5 units and height of 8 units

b. A triangle with base of 13 units and height of 4 units

c. A trapezoid with height of 5 units, and bases of 12 units and 6 units

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## Math Objectives

- Students will be able to describe how the area of a parallelogram relates to the area of a rectangle with the same base and height.
- Students will be able to describe how the area of a triangle relates to the area of a parallelogram with the same base and height.
- Students will be able to describe how the area of a trapezoid relates to the area of a parallelogram with the same height and with a base equal to the sum of the bases of the trapezoid.
- Students will be able to use relationships to compute the areas of parallelograms, triangles, and trapezoids, given their dimensions.
- Students will reason abstractly and quantitatively. (CCSS Mathematical Practice)
- Students will look for and make use of structure. (CCSS Mathematical Practice)

## Vocabulary

- rectangle
- parallelogram
- triangle
- trapezoid

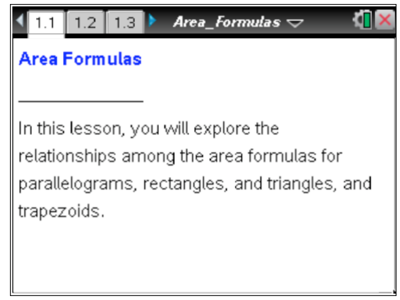
## About the Lesson

Students will:

- Observe the relationships between figures and compare the areas of the figures
- Formulate expressions to compute the areas of parallelograms, triangles, and trapezoids

## TI-Nspire™ Navigator™ System

- **Quick Poll**
- **Screen Capture**




**TI-Nspire™ Technology Skills:**

- Download a TI-Nspire™ document
- Open a document
- Move between pages
- Grab and drag a point

**Tech Tips:**

- Make sure the font size on your TI-Nspire™ handhelds is set to Medium.
- You can hide the function entry line by pressing ctrl G.

**Lesson Materials:**

*Student Activity*

Area_Formulas.pdf

Area_Formulas.doc

*TI-Nspire™ document*

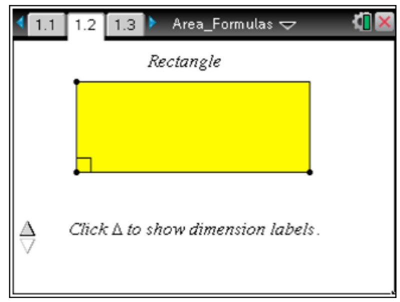
Area_Formulas.tns

Visit www.mathnspired.com for lesson updates and tech tip videos.

## Discussion Points and Possible Answers

**Tech Tip:** If students experience difficulty dragging a point, check to make sure that they have moved the arrow until it becomes a hand getting ready to grab the point. Then press ctrl to grab the point and close the hand. When finished moving the point, press esc to release the point.

**Move to page 1.2.**




1. Click ▲ to show the dimension labels of the rectangle.
   a. What are the labels for the dimensions of the given rectangle?

   **Answer:** base and height

   b. What is the formula for the area of the rectangle in terms of base and height?

   **Answer:** Area = base · height

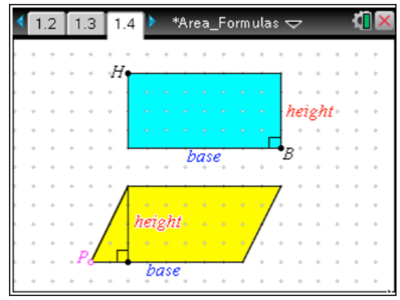
**Teacher Tip:** You may want to discuss the different vocabulary (labels) used for the dimensions of the rectangle (width and height, length and width, and base and height). For this activity, the dimensions will be referred to as base and height.

2. Drag the top-left or bottom-right vertex to change the dimensions of the rectangle. If you change the dimensions of the rectangle, does this change the formula for the area of the rectangle?

   **Answer:** No, the formula is still area = base · height.

**TI-Nspire™ Navigator™ Opportunity: Quick Poll**
**See Note 1 at the end of this lesson.**

**Move to page 1.3. After reading the instructions, move to page 1.4.**



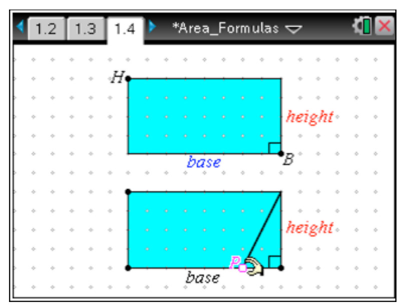

3. a. How do the base and height of the parallelogram compare to the base and height of the rectangle at the top of the screen?

**<u>Answer:</u>** The base of the parallelogram = the base of the rectangle.
The height of the parallelogram = the height of the rectangle.

b. Move point *H* or point *B*. Describe the changes that occur in the rectangle and the changes in the parallelogram.

**<u>Answer:</u>** As the base of the rectangle changes, the base of the parallelogram changes accordingly. As the height of the rectangle changes, the height of the parallelogram changes accordingly.

4. Drag point *P* to the right as far as you can.




a. Explain why the new figure on the bottom of the screen is a rectangle.

**<u>Answer:</u>** The new figure is a quadrilateral with four right angles.

b. What does this tell you about the area of the original parallelogram?

**<u>Answer:</u>** The original parallelogram has the same area as the rectangle.

c. Why do the parallelogram and the rectangle have the same area?

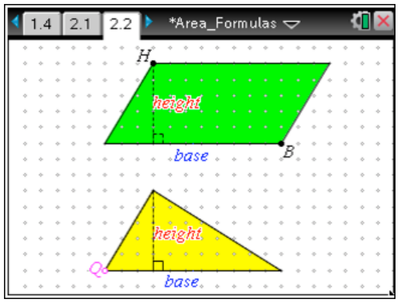
**<u>Answer:</u>** They have the same base and height.

d. What could be a formula for the area of the parallelogram?

**<u>Answer:</u>** area = base · height

**Teacher Tip:** Make sure students understand they cannot always just measure the sides to find area. You could ask students probing questions such as: Is a side length ever a height? If you know the area, can you find the base and height?

**Move to page 2.1. After reading the instructions, move to page 2.2.**



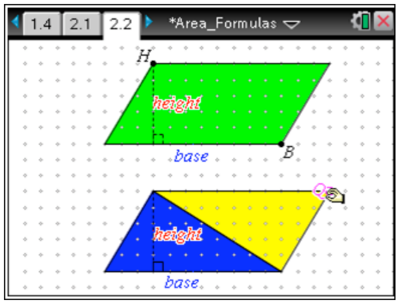

5. a. How do the base and height of the triangle compare to the base and height of the parallelogram at the top of the screen?

<u>**Answer:**</u> The base of the triangle = the base of the parallelogram.
The height of the triangle = the height of the parallelogram.

b. Move point *H* or point *B* on the parallelogram. Describe the changes that occur in the parallelogram and the changes in the triangle.

<u>**Answer:**</u> As the base of the parallelogram changes, the base of the triangle changes accordingly. As the height of the parallelogram changes, the height of the triangle changes accordingly.

6. Rotate point *Q* until it is as far to the right as possible.




a. What type of figure is formed?

<u>**Answer:**</u> a parallelogram

b. How does the area of the original shaded triangle compare to the area of the parallelogram?

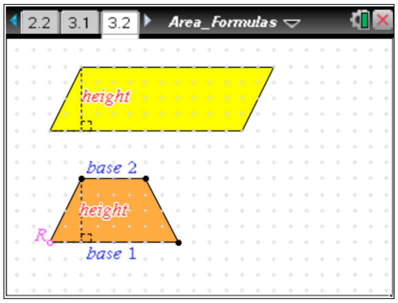
<u>**Answer:**</u> The area of the triangle is half the area of the parallelogram. (It takes two triangles to equal the parallelogram.)

7. If the area of a parallelogram is base times height, then what could be a formula for the area of the triangle?

**Answer:** Area = $\frac{1}{2} \cdot$ base $\cdot$ height

**CCSS Mathematical Practice:** Students will reason abstractly and quantitatively.
Mathematically proficient students will not only use the formula for the area of the triangle but will also attend to how the formula is related to the area of a parallelogram with equal base and height.

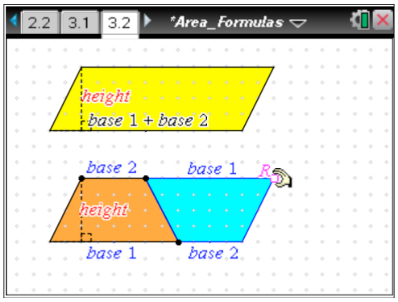
**Move to page 3.1. After reading the instructions, move to page 3.2.**




8. Rotate point *R* until it is as far to the right as possible.

   a. What type of figure is formed?

   **Answer:** a parallelogram




   b. How is the base of the parallelogram related to the trapezoid?

   **Answer:** The base of the parallelogram is the sum of the bases of the trapezoid, base 1 + base 2.

   c. Write an expression to represent the area of the parallelogram—either the parallelogram on the top of the screen or the newly formed parallelogram at the bottom of the screen.

   **Answer:** Area of a parallelogram = (base 1 + base 2) $\cdot$ height

**TI-Nspire™ Navigator™ Opportunity: Screen Capture**
**See Note 2 at the end of this lesson.**

9. How does the area of the original shaded trapezoid compare to the area of the parallelogram?

   **Answer:** The area of the trapezoid is half the area of the parallelogram.

10. If the area of a parallelogram is base times height, then what could be a formula for the area of the trapezoid?

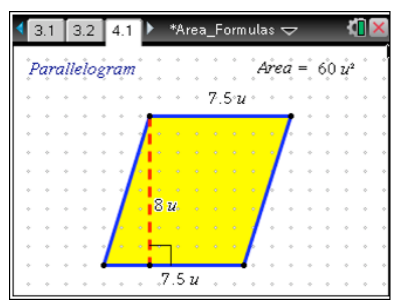
**Answer:** Area of the trapezoid = $\frac{1}{2}$(base 1 + base 2) · height

> **CCSS Mathematical Practice:** Students will look for and make use of structure.
> Mathematically proficient students will look closely to see how the parallelogram on top is composed of the trapezoids on the bottom. They will discern the pattern from the previous problems to generalize the area of the trapezoid.

> **Teacher Tip:** The following problems are designed to help students correctly associate specific shapes with the appropriate formula for area. In addition, the problems provide an opportunity for you to assess their understanding of how the variables and formulas are used. Students are expected to substitute values in the correct formula to find the area.

11. For each problem below,
    - Draw the figure.
    - Write a formula that could be used to find the area of each figure.
    - Use your formula to find the area of each figure.

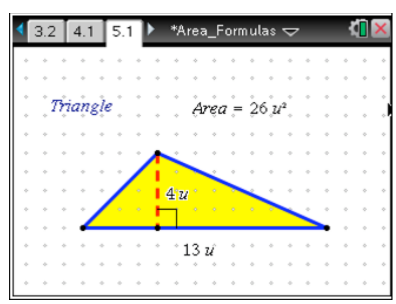
a. A parallelogram with base of 7.5 units and height of 8 units




**Answer**: area = base · height

area = 7.5 units · 8 units = 60 square units (60 $u^2$)

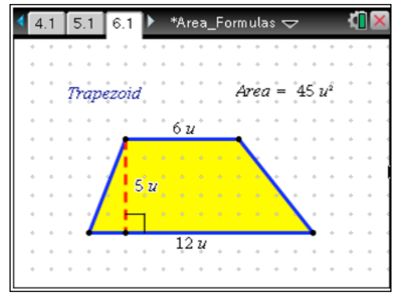
b. A triangle with base of 13 units and height of 4 units




**Answer**: area = $\frac{1}{2}$ · base · height

area = $\frac{1}{2}$ · 13 units · 4 units = 26 square units (26 $u^2$)

c. A trapezoid with height of 5 units and bases of 12 units and 6 units




**Answer**: area = $\frac{1}{2}$ · (base 1 + base 2) · height

Area = $\frac{1}{2}$ · (12 + 6) units · 5 units = 45 square units (45 $u^2$)

**TI-Nspire™ Navigator™ Opportunity: Quick Poll**
**See Note 3 at the end of this lesson.**

## Wrap Up

Upon completion of the discussion, the teacher should ensure that students:

- Understand how the area of a parallelogram relates to the area of a rectangle with the same base and height
- Understand how the area of a triangle relates to the area of a parallelogram with the same base and height
- Understand how the area of a trapezoid relates to the area of a parallelogram with the same height and with base equal to the sum of the bases of the trapezoid

## TI-Nspire™ Navigator™

**Note 1**

**Question 2, Quick Poll:** Send students the following Always/Sometimes/Never **Quick Poll**, and then have students justify their responses:

Rectangles with the same perimeter have the same area.

**Answer**: Sometimes. 3 rectangles with a perimeter of 12 units could have dimensions 2 × 4, 4 × 2, and 1 × 5.

**Note 2**

**Question 8, Screen Capture:** Have students change the base and/or height of the trapezoid. Show a **Screen Capture** to the class so that students can see the relationship between the trapezoid and parallelogram above it for trapezoids with various shapes.

**Note 3**

**Question 11, Quick Poll:** Have students send in their responses to the area problems using an Open Response **Quick Poll.**

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# Parallel Lines and Transversals

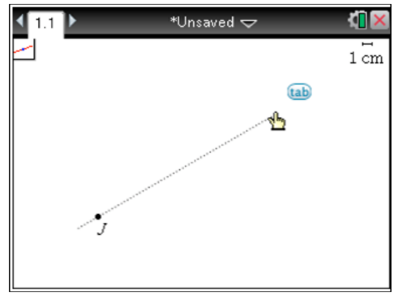


TI PROFESSIONAL DEVELOPMENT

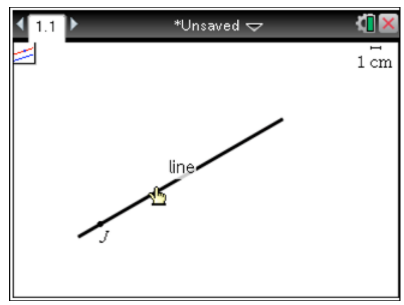
## Activity Overview:

In this activity, the TI-Nspire™ Teacher Software is used to construct a pair of parallel lines cut by a transversal and to measure a pair of corresponding angles.

### Steps

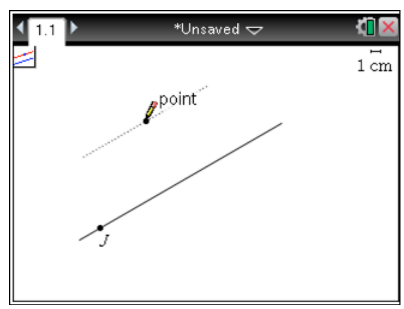


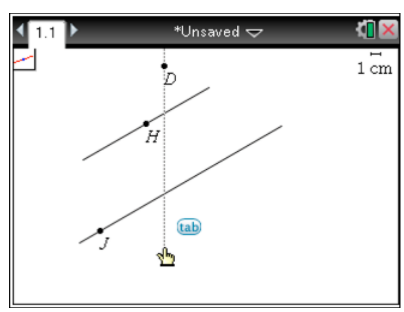

1. Start a new TI-Nspire™ document.
2. Add a *Geometry* application page.
3. To draw a line, select **Points & Lines > Line** from the Document Tools (in the Documents Toolbox). Move the cursor to a location near the bottom of the page and click to place a point on the page.
4. Press Shift+J to label the point *J*.
5. Move the cursor to the right and click to complete the line. Press Esc to exit the **Line** tool.




To construct a line parallel to a given line, it is necessary to identify a point and a line.

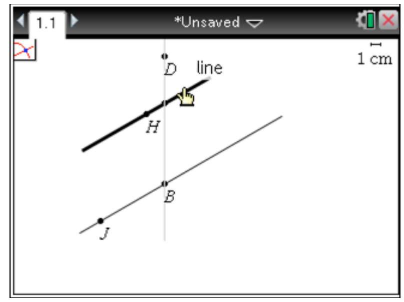
6. From the Documents Tools, select **Construction > Parallel**.
7. Move the cursor to the line that passes through point *J* and click to select the line. A ghosted line parallel to the line through point *J* will appear.
8. Move the cursor away from the line that passes through point *J*. Click to identify a new point and drop the line.
9. Press Shift+H to label the new point *H*. Press Esc to exit the **Parallel** tool.



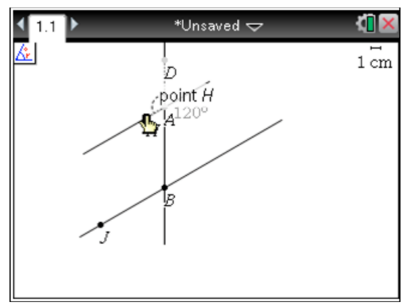

10. To draw a transversal to the lines through points *J* and *H*, select **Points & Lines > Line** from the Document Tools.
11. Click to place a point on the screen above the line that passes through point *H*. Press Shift+D to label the point *D*.
12. Move the cursor until a line is drawn through the parallel lines.
13. Click to complete the line. Press Esc to exit the **Line** tool.

14. To mark the points at which the lines intersect, select the tool **Points & Lines** > **Intersection Point(s)**.
15. Move the cursor to the line that passes through point *D*, and click to select the line.
16. Move the cursor to the line that passes through point *J*, and click to select the line.

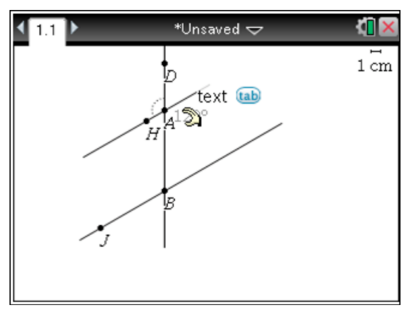



17. The point of intersection will appear. Press Shift+B to label the point *B*.
18. Move the cursor to the line that passes through point *D*, and click.
19. Then, move the cursor to the line that passes through point *H*, and click.
20. The point of intersection will appear. Press Shift+A to label the point *A*. Press Esc to exit the **Intersection Point(s)** tool.

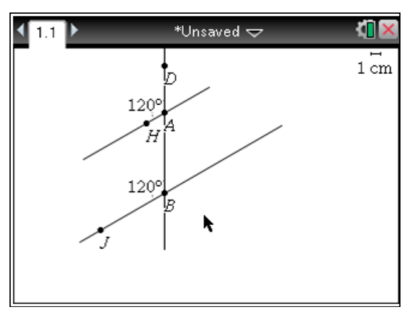
To measure an angle, three points must be selected: the vertex of the angle and a point on each ray that forms the angle. The vertex must be the second point selected.




21. To measure $\measuredangle DAH$, select **Measurement > Angle**.
22. Move the cursor to point *D*. The phrase **point *D*** will appear. Click when a "hand" appears and point *D* becomes bold.
23. Move the cursor to point *A*, and click when it becomes bold.
24. Move the cursor to point *H*, and click when it becomes bold.
25. The angle measure will appear but may need to be moved to the appropriate location.




26. To move the angle measure to the appropriate location, first press Esc to exit the measurement tool.
    - Move the cursor over the angle measure.
    - The arrow should become a hand (☝) getting ready to grab the measure, and the word **text** should be displayed.
    - Hold down the left click of the mouse and drag the angle measure.
    - Release the left click to place the measure at the desired location.




27. Next, measure $\measuredangle ABJ$ and place the angle measure at the appropriate location.

**Note**: If a tool is active, an icon for that tool appears in the upper-left corner of the screen. Press Esc to exit any tool before attempting to drag text or an object.

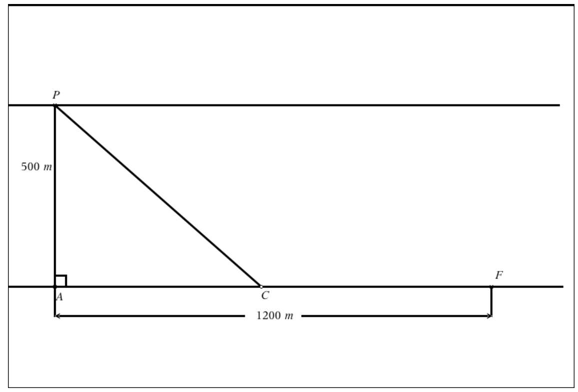
# Notes with Interactive Math Boxes— The Power Cable Problem
## TI Professional Development

**Teacher Notes**

**Activity Overview:**

*In this activity, you will model the laying of a cable from a power plant on one side of river to a factory on the opposite bank of the river. The river is 500 meters wide and the factory is 1200 meters downstream from a point on the riverbank directly across from the power plant. It costs $20/m to lay the cable under the river and $12/m to lay the cable along the riverbank.*

*This activity is written for Computer View to utilize the additional screen space. If the file is to be sent to students, create the document in Handheld View.*



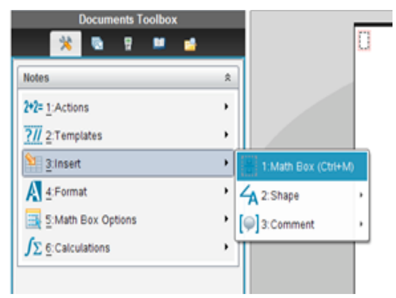

**Step 1:** Start a new TI-Nspire™ document.

**Step 2:** Add a Notes application page.

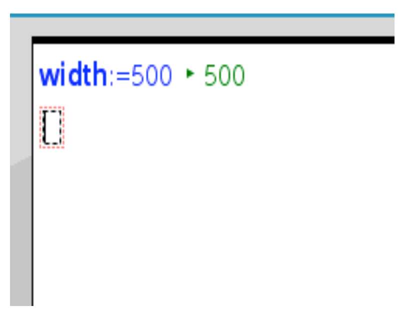
**Step 3:** Press View and select Computer.

**Step 4:** From the Document Tools, select **Insert**  **> Math Box**.

Note: The shortcut for a Math Box is shown in the Insert menu. For a Mac, this will appear as Cmd + M. On a PC, the shortcut is Ctrl + M.




**Step 5:** Define the variables needed for the problem. After typing a variable name, type := (a colon followed by an equals sign) to assign a value to a variable. Press Enter after typing the variable assignment.



**Step 6:** Follow the directions in Step 5 to define all variables as shown in the screen capture below. (Note that the initial distance from point A to point C is defined as 0 meters.)

The variables are:

**width** is the width of the river.

**length** is the distance downstream (from point A to the factory).

**ac** is the distance from point A to point C.

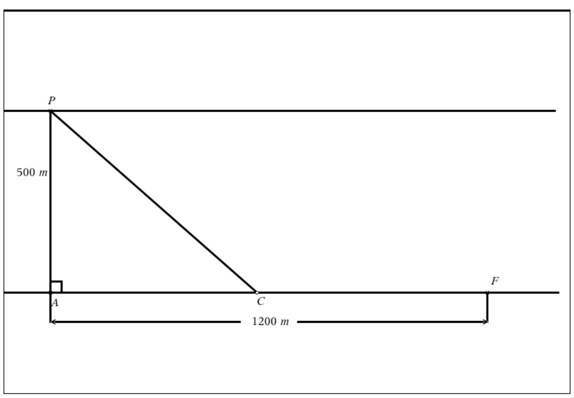
**bank** is the distance from point C to point F.

**river** is the distance from point P to point C.

**rivercost** is the cost per meter of laying cable under the river.

**bankcost** is the cost per meter of laying cable along the bank.

**total** is the total cost for laying the cable.




$\mathrm{width}:=500 \blacktriangleright 500$

$\mathrm{length}:=1200 \blacktriangleright 1200$

$\mathrm{ac}:=0 \blacktriangleright 0$

$\mathrm{bank}:=\mathrm{length}-\mathrm{ac} \blacktriangleright 1200$

$\mathrm{river}:=\sqrt{\mathrm{width}^2+\mathrm{ac}^2} \blacktriangleright 500$

$\mathrm{rivercost}:=20 \blacktriangleright 20$

$\mathrm{bankcost}:=12 \blacktriangleright 12$

$\mathrm{total}:=\mathrm{river}\cdot\mathrm{rivercost}+\mathrm{bank}\cdot\mathrm{bankcost} \blacktriangleright 24400$

**Step 7:** The distance from point A to point C (ac) was defined as 0 meters. This represents the situation in which the cable is laid directly across the river. Edit the value of **ac** by clicking on the 0 in the assignment statement. Change the value of **ac** to 1200 and press Enter.

$\mathrm{width}:=500 \blacktriangleright 500$

$\mathrm{length}:=1200 \blacktriangleright 1200$

$\mathrm{ac}:=1200 \blacktriangleright 1200$

$\mathrm{bank}:=\mathrm{length}-\mathrm{ac} \blacktriangleright 0$

$\mathrm{river}:=\sqrt{\mathrm{width}^2+\mathrm{ac}^2} \blacktriangleright 1300$

$\mathrm{rivercost}:=20 \blacktriangleright 20$

$\mathrm{bankcost}:=12 \blacktriangleright 12$

$\mathrm{total}:=\mathrm{river}\cdot\mathrm{rivercost}+\mathrm{bank}\cdot\mathrm{bankcost} \blacktriangleright 26000$

# Notes with Interactive Math Boxes— The Power Cable Problem

**Teacher Notes**

## TI Professional Development

**Step 8:** The total cost in Step 7 represents the cost of laying a cable directly from the power plant to the factory. Note the change in the total cost and compare this to the first situation.

**Step 9:** Next, change the placement of the cable (point C) on the factory side of the bank so that it is placed halfway between point A and the factory.

width:=500 ▸ 500
length:=1200 ▸ 1200
ac:=600 ▸ 600
bank:=length−ac ▸ 600
river:=$\sqrt{\text{width}^2+\text{ac}^2}$ ▸ 781.025
rivercost:=20 ▸ 20
bankcost:=12 ▸ 12
total:=river·rivercost+bank·bankcost ▸ 22820.5

**Step 10:** The new total cost is less than the cost of laying the cable directly across the river or laying the cable from the power plant directly to the factory. Determine the location for the placement of the cable (point C) that will minimize the total cost of laying the cable.

Possible tasks for students:

1. Continue to edit the value for **ac** in order to find the minimum cost of laying a cable in this situation.
2. Engineers have found a way to lower the costs of laying cable. It now costs $15/m to lay the cable under the river and $10/m to lay cable along the riverbank. Find the minimum cost for laying the cable.
3. The company has decided to build a new factory that is located only 800 m downstream of the power plant. Using the lower costs of laying cable, find the optimal route for laying the cable.

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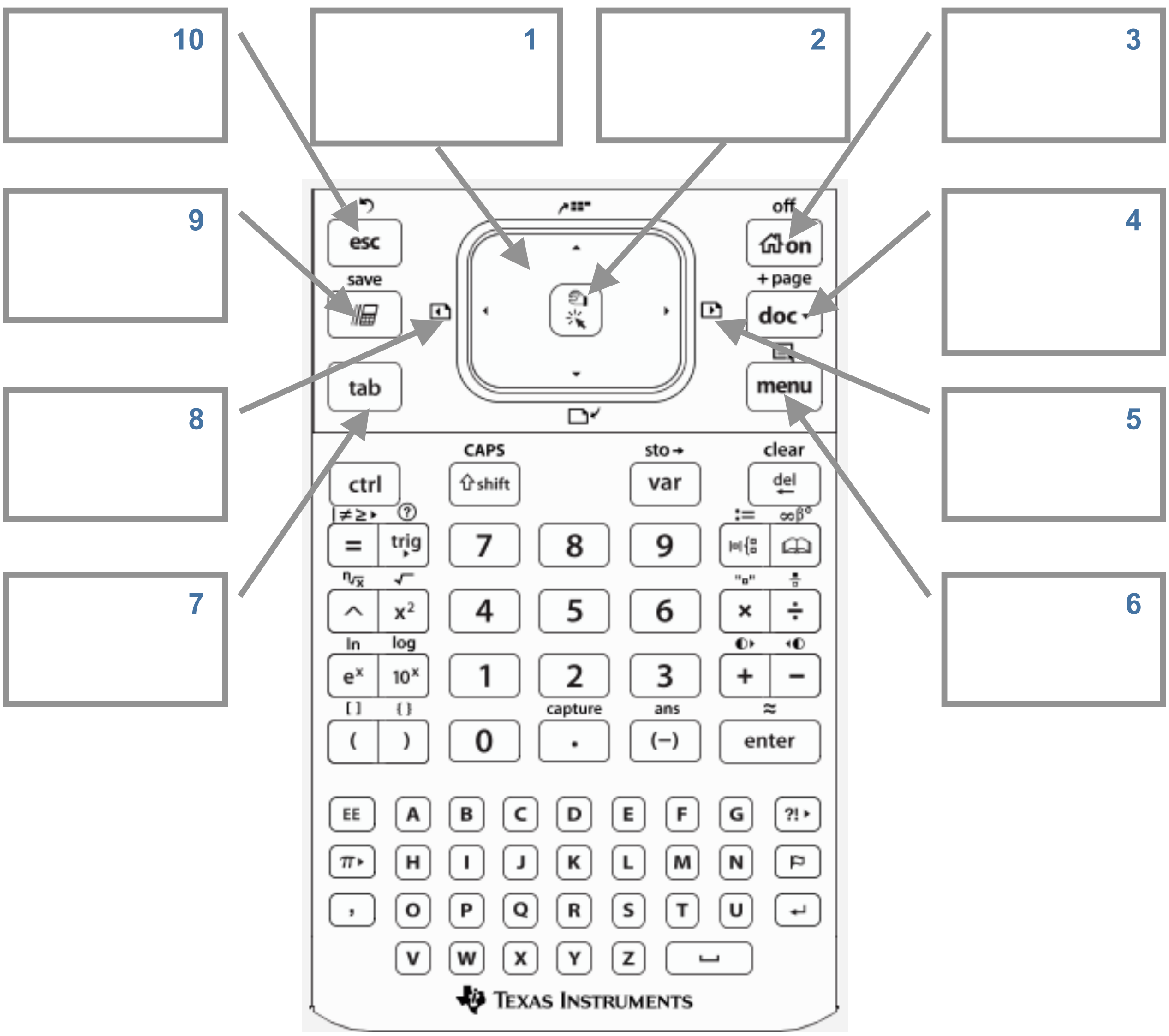
# TI-Nspire™ CX Family Touchpad Overview

**TI PROFESSIONAL DEVELOPMENT**

**Activity Overview:**

*In this activity you will become familiar with the most commonly used keys on the TI-Nspire™ CX and TI-Nspire™ CX CAS handhelds.*



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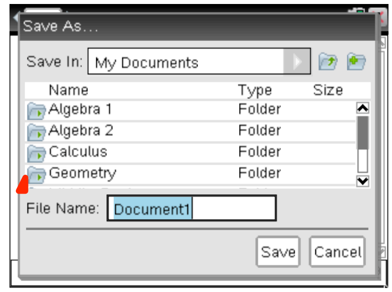
# Saving Files to Folders
## TI Professional Development

**To save a document on the TI-Nspire™ handheld:**

• Press doc▾ **> File > Save**. You can also press ctrl  or ctrl S.




• Type the name of the document into the **File Name** field. **Do not** press enter until you have designated the correct folder in which to save the file.

• The default destination folder is **My Documents**. If you wish to save the file in **My Documents**, press enter. Otherwise, you can change the destination folder.

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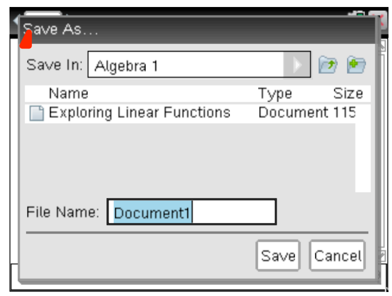
**If you wish to change the destination folder:**

• To save the document in a folder other than the **My Documents** folder, go to the **Save In:** field by pressing tab. Then follow step A below to move up a folder level and choose an existing folder, or step B below to add a new folder.

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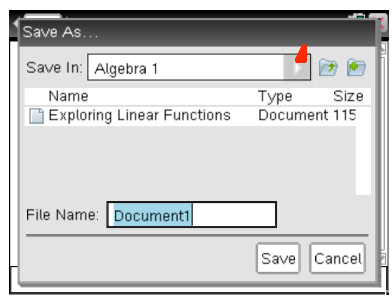
A. To move up a folder level:

- Press tab to move to . Press .
- Press ⇧shift tab and then use ▲ or ▼ until you have selected the desired folder. Press .
- When the folder and file name are correct, press enter to save the file.

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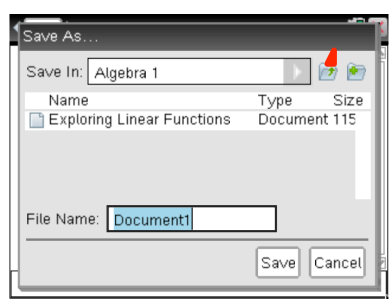
B. To add a new folder:

- Press tab to move to . Press .
- Type the name of the new folder.
- Press enter to name the folder.
- Press enter to open the folder.
- Press enter to save the file.



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# Checking and Updating the OS

**TI PROFESSIONAL DEVELOPMENT**

**TEACHER NOTES**

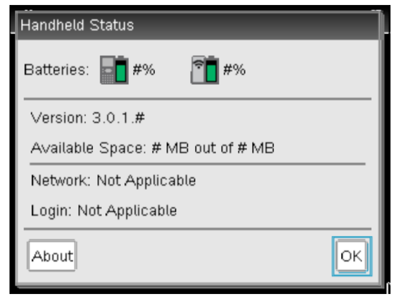
## Activity Overview:

*In this activity, you will learn how to check the operating system (OS) on a handheld and update it using the Content Workspace of the TI-Nspire™ Teacher Software.*

## Materials

- *TI-Nspire™ Teacher Software and USB connection cable*

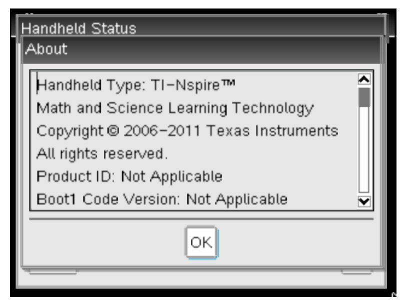
### Viewing handheld status




The **Handheld Status** screen displays the battery status, (OS) version, available space, the network (if any), and your student login name and whether you are logged in

To view the **Handheld Status**, press [on] and select **Settings** > **Status**. The **Handheld Status** dialog box opens.

### Viewing handheld details on the About screen




The **About** screen displays the handheld type and product ID. To view the **About** screen from the **Handheld Status** screen, click **About**. To return to the home screen, press [enter].

### Updating the handheld OS

You can update the OS on your TI-Nspire™ handheld using your computer and TI-Nspire™ Teacher Software or by transferring the OS from one handheld to another. OS upgrade operations do not delete user documents. If there is not enough room on the receiving handheld for the upgrade, the sending handheld is notified. The only time documents can be affected by an OS installation is if the receiving handheld has a corrupted OS. In this situation, documents may be affected by OS restoration. It is a good practice to back up your important documents and folders before installing an updated operating system.

### Important OS download information

The OS for the TI-Nspire™ CX handheld has the file extension *.tco*; the OS for the TI-Nspire™ CX CAS has the file extension *.tcc*; the OS for the TI-Nspire™ with Touchpad or Clickpad has the file extension *.tno*; and the OS for the TI-Nspire™ CAS with Touchpad or Clickpad has the file extension *.tnc*. Always install new batteries before beginning an OS download. When in OS download mode, the APD™ (Automatic Power Down) feature does not function. If you leave your handheld in download mode for an extended time before you begin the downloading process, your batteries may become depleted. You will then need to install new batteries before downloading the OS.

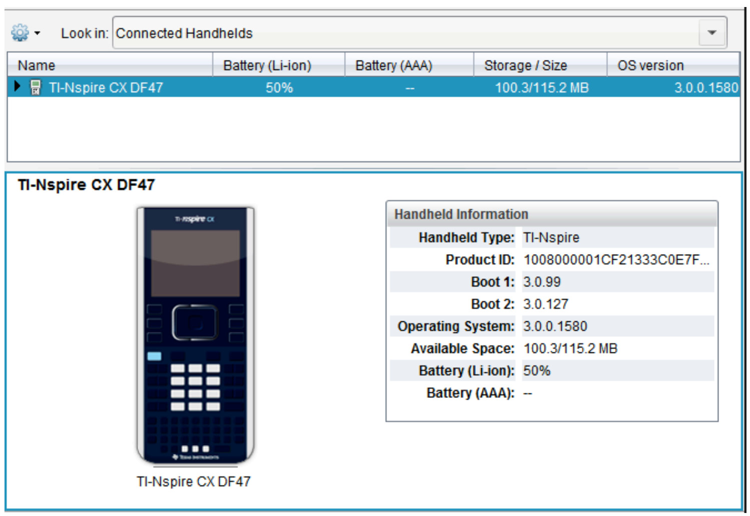
## Finding operating system upgrades

Your TI-Nspire™ Teacher Software has convenient links to a number of useful Texas Instruments web sites, including those with handheld OS updates. You will need an Internet connection and the appropriate USB cable to download and install the updates.

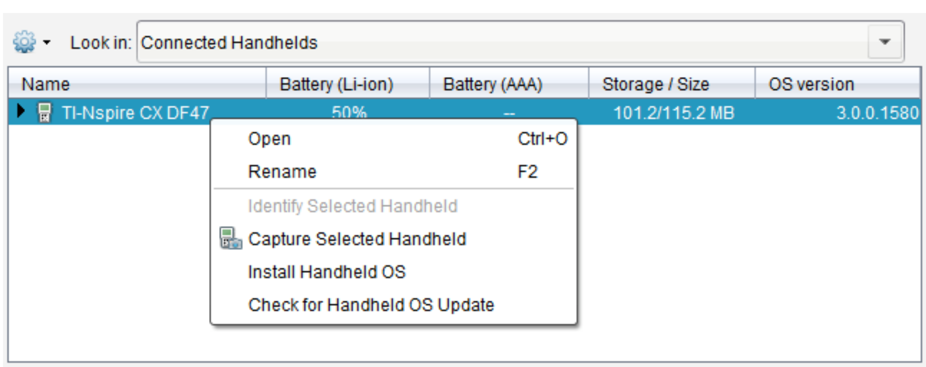
## Using TI-Nspire Teacher Software to update the handheld OS

Open the TI-Nspire Teacher Software and connect a TI-Nspire handheld to the computer using the USB connection cable. Go to the **Document Workspace**, select the **Content Explorer** tab, and click **Connected Handhelds**. Multiple handhelds can be connected to the computer using multiple USB ports, USB hubs, or the TI-Nspire™ Docking Station. If multiple handhelds are connected to the computer, then multiple handhelds appear in the list of **Connected Handhelds**.

The connected handheld appears in the **Content Window**, along with battery, storage, and OS information. More detailed information appears in the **Handheld Information** window.




To see if a new OS is available, right-click the handheld and select **Check for Handheld OS Update**. To update the OS, right-click the handheld and select **Install Handheld OS**. A window appears that asks you to select the handheld OS file. Select the OS file and click **Install OS**. A window appears informing you that any unsaved data will be lost, and it asks if you want to continue. Click **Yes**.

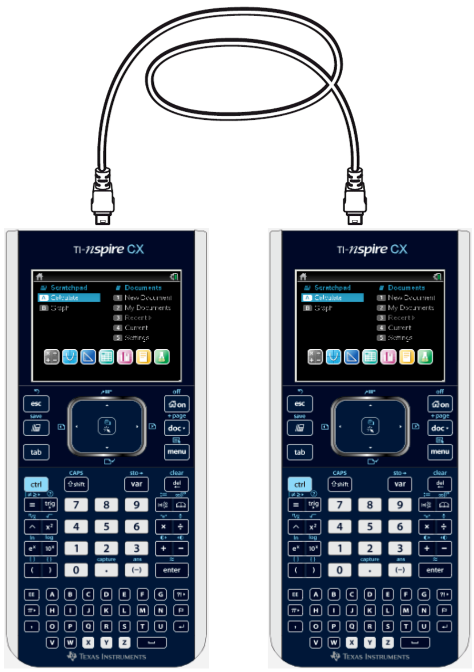


# Transferring Documents Between Handhelds
**TI Professional Development**

## Connecting two TI-Nspire™ handhelds with the USB handheld-to-handheld cable

You can share documents between two TI-Nspire™ handhelds by connecting them with the handheld-to-handheld USB cable. The TI-Nspire™ handheld USB A port is located at the center of the top of the handheld.

1. Firmly insert either end of the USB unit-to-unit cable into the USB A port.
2. Insert the other end of the cable into the receiving unit's USB A port.



## Sending a document

1. Open **My Documents** on the sending unit.
2. Press the ▲ and ▼ keys to highlight the document you want to send.
3. Select **Send** from the document menu.
4. When the file transfer is complete, a message displays on the receiving unit.

## Rules for sending files or folders

The rules for sending files apply also to those files within folders that you send.

- If you send a document with the same name as an existing document on the receiving TI-Nspire™ handheld, the system renames the sent document by appending a number to the name. For example, if you send a document named **Mydata** to another TI-Nspire™ handheld that already contains a document named **Mydata**, the document you send will be renamed **Mydata(2)**. Both the sending and receiving units display a message that shows the new name.

- There is a 255-character maximum length for a file name, including the entire path. If a transmitted file has the same name as an existing file on the receiving unit and the file names contain 255 characters, then the name of the transmitted file will be truncated to allow the software to follow the renaming scheme described in the previous bullet.

- All variables associated with the document being transmitted are transferred with the document.

- Transmissions will time out after 30 seconds.

### Receiving a document

No action is required by the user of the receiving TI-Nspire™ handheld.
Units are automatically powered on when the cable is attached.

### Sending a folder

When you send a folder from one handheld to another, the file structure in the sending folder is retained. If the folder does not exist on the receiving handheld, it will be created. If the folder does exist, files will be copied into it, with appended names added to any duplicate files that may be there.

To send a folder:

1. Open **My Documents**. Press [on] [2].
2. Using the touchpad, point to the folder you want to send.
3. Select **Send** from the **My Documents** menu. Press [tab][menu][6].
4. The file transfer begins. A progress bar displays to allow you to follow the transfer. There is a **Cancel** button on the **Sending...** dialog that allows you to cancel the transmission while it in progress. When the transfer is complete, a message displays. If the file was renamed on the receiving handheld, the new file name displays.

### Canceling a transfer

1. To cancel a transmission in progress, press **Cancel** on the dialog of the sending unit.
   **Note:** To cancel a file transfer from the receiving handheld, press [esc]. The receiving handheld cannot cancel a transfer of folders, however.
2. A link transmission error message displays.
3. Press [esc] or [enter] to cancel the transmission error message.

# Press-to-Test
**TI PROFESSIONAL DEVELOPMENT** **TEACHER NOTES**

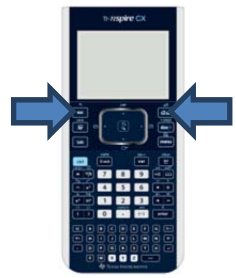
## Activity Overview:

The **Press-to-Test** feature enables you to quickly prepare student handhelds for exams by temporarily disabling folders, documents, and select features and commands. In this activity, you will learn how to enable and disable **Press-to-Test**.

## Materials

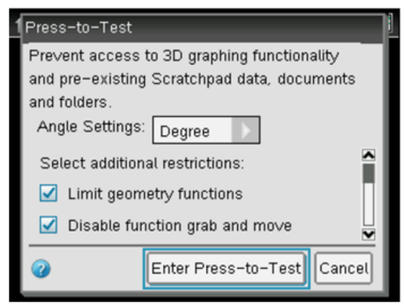
- TI-Nspire™ handheld-to-handheld or handheld-to-computer USB connection cable

**Step 1:** To enable **Press-to-Test** on TI-Nspire™ with Touchpad and TI-Nspire CX™, first ensure that the handheld is turned off. Press and hold [esc] and [on] until the **Press-to-Test** screen appears.



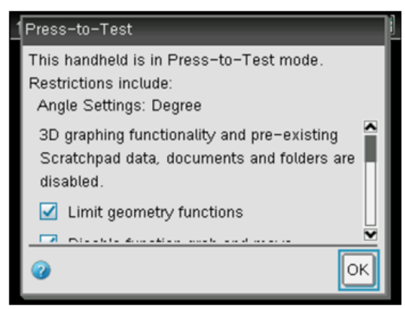
**<u>Note</u>:** To enable **Press-to-Test** on TI-Nspire™ with Clickpad, press and hold [esc], [on], and [off on].

**Step 2:** By default, **Press-to-Test** disables 3D graphing and pre-existing **Scratchpad** data, documents, and folders. The angle settings can be changed by pressing ▶, selecting the appropriate setting, and pressing ▶ or [enter].




By default, all of the commands and features listed are disabled. To enable a feature or command, uncheck its box. Keep all boxes checked and enable **Press-to-Test** mode by selecting **Enter Press-to-Test**.

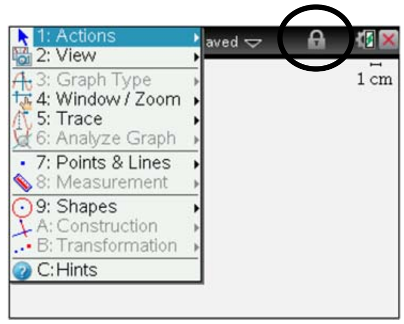
**Step 3:** Once **Press-to-Test** is enabled, the handheld reboots. A dialog box confirms that the handheld is in **Press-to-Test** mode and the restrictions are listed. Click **OK**.




**Step 4:** When **Press-to-Test** is enabled, the LED at the top of the handheld begins blinking. Green indicates that all restrictions are selected (default), while yellow indicates that one or more restrictions are unselected. During the initial reboot, the LED alternates between red and, depending on the restrictions, either green or yellow.

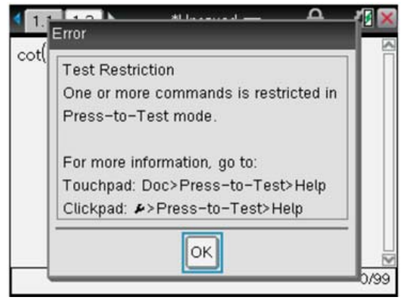
 

**Step 5:** Create a new document, add a *Graphs* page, and press menu. Since geometry functions are limited, observe that the **Graph Type**, **Analyze Graph**, **Measurement**, **Construction**, and **Transformation** menus are not accessible.

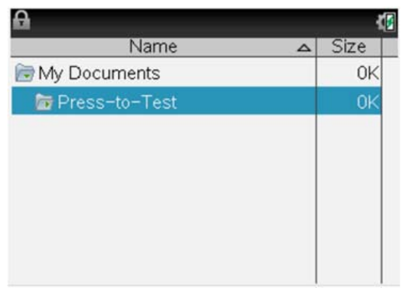



**Note:** The lock icon at the top of the handheld screen indicates that **Press-to-Test** is enabled.

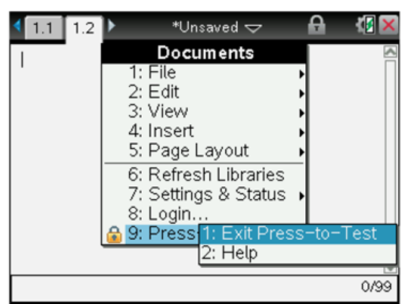
**Step 6:** Add a *Calculator* application by pressing doc▾ and selecting **Insert > Calculator**. Type **cot(*π*/2)** and press enter. Since trigonometric functions are limited, an error message appears. The dialog box tells students how to access additional information about the restrictions. Select **OK**.




**Step 7:** Go to **My Documents** by pressing on **> My Documents.** When **Press-to-Test** is enabled, a **Press-to-Test** folder is created in **My Documents.** All other folders and documents present on the handheld before **Press-to-Test** mode was entered are inaccessible.

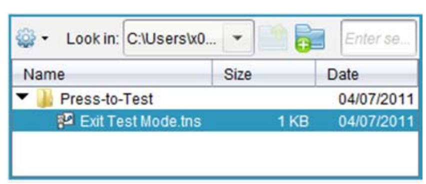



**Step 8:** **Press-to-Test** can be disabled by connecting two handhelds using the handheld-to-handheld USB connection cable. While the handhelds are connected, press doc▾ and select **Press-to-Test > Exit Press-to-Test**. A handheld in **Press-to-Test** mode can be disabled regardless of whether the other handheld is in **Press-to-Test** mode.




**Press-to-Test** can also be disabled with the TI-Nspire™ Navigator™ system. Begin a class in the TI-Nspire™ Navigator™ Teacher Software. Students can then press doc▾ and select **Press-to-Test > Exit Press-to-Test**.

**Step 9:** Alternatively, **Press-to-Test** can be disabled with TI-Nspire™ Teacher Software or TI-Nspire™ Navigator Teacher Software by creating a document named **Exit Test Mode.tns** and transferring it to connected handhelds. Go to the **Tools** menu and select **Transfer Tool**. Click **Add to Transfer List** and select the document **Exit Test Mode.tns**. In the Transfer List, select **Exit Test Mode.tns**. In the **Edit Destination Folder** field, select the **Press-to-Test** folder and click **Change**. Then click **Start Transfer.**



# $T^3$ Ticket Outta Here

2.71828

What went well today?

What caused you difficulty?

More of ?

Less of ?

2.71828

$T^3$ Ticket Outta Here

## $T^3$ Ticket Outta Here

2.71828

I have learned …

My question is …

2.71828

$T^3$ Ticket Outta Here

**$T^3$ Ticket Outta Here**

**2.71828**

I have learned …

My question is …

My next steps are …

**2.71828**

**$T^3$ Ticket Outta Here**