



# Getting Started with TI-Nspire™ Technology in High School Science

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Materials for Workshop Participant\*

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# Conversion – Direct or Inverse Variation?

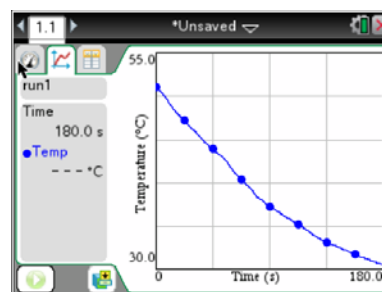
## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

In this activity you will examine the relationship between ounces and grams. By mathematically modeling the relationship with a linear equation, you will relate each of the parameters in the equation to a physical quantity.

In the second part of the activity, you will collect and analyze temperature data and draw conclusions about cooling objects.



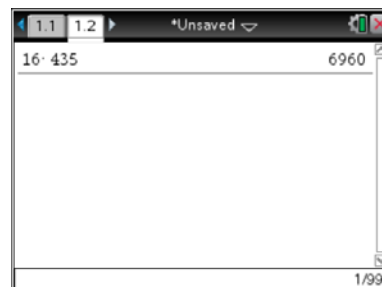
### Open a New Document and Add a Notes Page

1. Title the page “Conversion”.
2. Find five boxes (or box labels) with weight identified in both grams and ounces. Organize them from smallest to largest.



### Add a Calculator Page

3. Compare the grams to ounces on the box labels. Do the grams and ounces appear to be directly related or inversely related?
4. Calculate the product of ounces and grams for each box label. Does a consistent pattern occur when the two are multiplied together?
5. Calculate the quotient of grams divided by ounces for each box label. Does a consistent pattern appear?



### Add a Lists & Spreadsheet Page

6. Enter the data from the box labels into the spreadsheet.
  - Label Column A **ounce**, and enter the label values in ounces.
  - Label Column B **gram**, and enter the label values in grams.
  - Label Column C **prod** for product. In the diamond cell ♦, type **=ounces\*grams** and press **enter**.
  - Label Column D **quo** for quotient. In the diamond cell ♦, type **= grams/ounces** and press **enter**.

	ounce	gram	prod	quo
1	16	435		
2				
3				
4				
5				
6				



# Conversion – Direct or Inverse Variation?

## Student Activity

Name \_\_\_\_\_

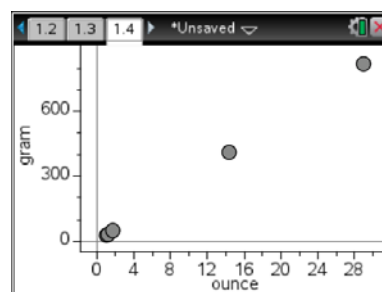
Class \_\_\_\_\_

### Analysis

7. Do you see any consistent trend in the data that is produced?
8. Do you believe the product or the quotient is most constant?
9. Does this mean that the grams and ounces are directly or inversely related?

### Add a Data & Statistics Page

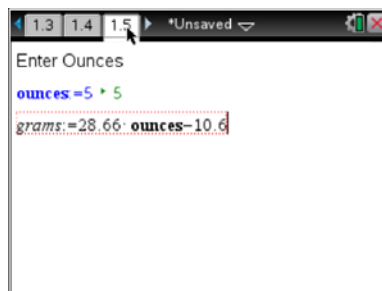
10. Place ounces on the x-axis and grams on the y-axis.
11. Determine the best fit line for this set of data by selecting **Menu > Analyze > Regression > Show Linear (mx+b)**.
12. What equation do you get when you perform the linear regression?



13. In the graph, x represents \_\_\_\_\_ and y represents \_\_\_\_\_.
14. How does the slope of the line compare to the values in the spreadsheet on page 1.3?
15. What are the units for the slope?

### Add a Notes Page

16. Type “Enter Ounces”.
  - Insert a Math Box by selecting **Menu > Insert > Math Box**.
  - Type **ounces:=5** and press **enter**.
17. Insert a second Math Box, and enter the equation that you received from the prior page.
  - Change y to grams and x to ounces: **Grams:= m\*ounces + b**.
  - Enter the values of *m* and *b* from the equation you generated on the prior page.
18. Change the value of the ounces, and observe the result of grams.
19. Create a “grams to ounces” calculator. The variable **grams** is already used, so use the variable **grams2** for grams and **ounces2** for ounces.





# Conversion – Direct or Inverse Variation?

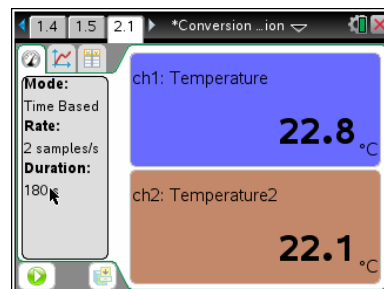
## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

### Add a New Problem to Compare Fahrenheit to Celsius

20. Select **doc** > **Insert > Problem**. The tab at the top of the screen should indicate that this is page 2.1.
21. Connect two Vernier® EasyTemp™ sensors to the TI-Nspire™ Lab Cradle. Slide the handheld onto the TI-Nspire Lab Cradle.
22. Wait for a moment for the Vernier DataQuest™ application to launch. If it does not launch, select **Add Vernier DataQuest**.
  - To set up the Vernier DataQuest app, think of variables that are being measured and how they are being measured.
23. Two temperature readings should appear in the **Meter View**.
  - Change the units on temperature probe 2 to Fahrenheit by selecting **Menu > Experiment > Set Up Sensors > Change Units**.
  - Selecting **Menu > Experiment > Collection Setup**. Set the **Mode** to Time graph for 5 samples per second for 30 seconds.
  - Place both temperature probes in hot water and allow them to equilibrate to the water.
  - Click on the Start button, and move both probes to ice water.
24. What happened to both temperature readings?
25. Do you believe the temperatures are directly or inversely related? Explain your answer.



### Add a Data & Statistics Page

26. Add **run1.temperature** (Celsius) to the x-axis and **run1.temperature2** (Fahrenheit) to the y-axis.
27. Determine the equation that best fits your data. Select **Menu > Analyze > Regression > Show Linear (mx+b)**. What does this equation represent?
28. Create an equation for converting from Fahrenheit to Celsius.

### Add a Notes Page

29. Create a Celsius to Fahrenheit converter and a Fahrenheit to Celsius converter.

**Conversion – Direct or Inverse Variation?**

Name \_\_\_\_\_

**Student Activity**

Class \_\_\_\_\_

**Wrap Up**

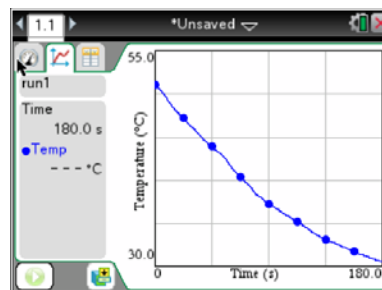
1. List three things that you learned by completing this activity.
  
2. What do you see as the greatest strength for your classes in this activity?
  
3. How could this activity help you to introduce your students to TI-Nspire™ Technology?





### Math and Science Objectives

- Students will first predict and then examine the relationship between ounces and grams.
- Students will mathematically model the relationship with the linear equation in the form  $y = mx + b$
- Students will relate each of the parameters in the equation to a physical quantity.
- Students will draw conclusions about cooling objects and make predictions about how changes in the data collection will affect the results.
- Students will use appropriate tools strategically (NGSS).



### TI-Nspire™ Technology Skills:

- Collect temperature data with the Vernier® DataQuest™ app

### Vocabulary

- ounces
- grams
- conversion factor

### About the Lesson

- Making predictions prior to the exploration is an important step in helping students to connect real world phenomena to mathematics.
- As a result, students will:
  - Organize the boxes in order from smallest ounces to largest ounces.
  - Analyze the relationship simply as products and quotients, as a list of numbers, and as a graph.
  - Develop a conceptual understanding of the relationships between different measures.
  - Make a real-world connection about linear functions and their use as a conversion equation.

### Materials and Materials Notes

- TI-Nspire™ handheld or TI-Nspire™ computer software
- TI-Nspire™ Lab Cradle and two Vernier® EasyTemp™ probes
- Five box labels with ounces and grams given.
- Cup of hot water with a temperature probe.

### Tech and Troubleshooting

#### Tips:

1. The temperature sensor can be heated using hot water or a hair dryer. If students use the hot water, they should wipe the sensor immediately after removing it from the water so that evaporation is not a factor in the cooling. The hair dryer simply requires heating the sensor and collecting data once the dryer is turned off.
2. As the temperature sensor cools, check to see that fans or air conditioners are not blowing directly on the sensor.

### Lesson Files:

#### Student Activity

- [Conversion\\_Direct\\_or\\_Inverse\\_Variation\\_Student.pdf](#)
- [Conversion\\_Direct\\_or\\_Inverse\\_Variation\\_Student.pdf](#)



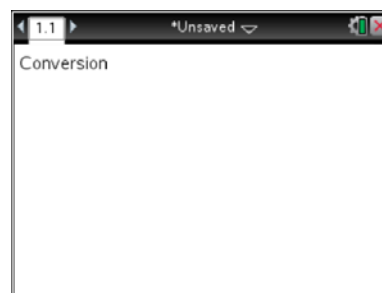
### Discussion Points and Possible Answers

**Tech Tip:** Using the TI-Nspire™ Lab Cradle with the standard temperature sensor requires a USB cable to connect to the teacher computer. If you do not have the adapter, you might want to collect data with the student handheld and transfer it to the computer using TI-Nspire™ Navigator™ System or Teacher Software.

**Teacher Tip:** Making predictions is very important to helping students to connect the physical world to the mathematical world. Ask students to make a prediction prior to analyzing the data and then to sketch it. You might then want to ask them to compare their predictions to those of other students in the class as you walk around and look at the sketches. Once the data is collected, come back to those predictions and discuss any errors.

### Open a New Document and Add a Notes Page

1. Title the page “Conversion”.
2. Find five boxes (or box labels) with weight identified in both grams and ounces. Organize them from smallest to largest.



### Add a Calculator Page

3. Compare the grams to ounces on the box labels. Do the grams and ounces appear to be directly related or inversely related?

**Answer:** Grams and ounces appear to be directly related.

50	28.4091
1.76	
408	28.3333
14.4	
823	28.3793
29	

4. Calculate the product of ounces and grams for each box label.  
Does a consistent pattern occur when the two are multiplied together?

**Sample Answer:** As the grams and ounces increase, their product increases.

5. Calculate the quotient of grams divided by ounces for each box label.  
Does a consistent pattern appear?

**Sample Answer:** Each quotient is approximately 28.



# Conversion – Direct or Inverse Variation?

## TI PROFESSIONAL DEVELOPMENT

## TEACHER NOTES

### Add a Lists & Spreadsheet Page

6. Enter the data from the box labels into the spreadsheet.
- Label Column A **ounce**, and enter the label values in ounces.
  - Label Column B **gram**, and enter the label values in grams.
  - Label Column C **prod** for product. In the diamond cell ♦, type **=ounces\*grams** and press **enter**.  
Label Column D **quo** for quotient. In the diamond cell ♦, type **= grams/ounces** and press **enter**.

	ounce	gram	prod	quo
			=gram*our	=gram/our
1	1.04	29	30.16	27.8846
2	1.18	33	38.94	27.9661
3	1.76	50	88	28.4091
4	14.4	408	5875.2	28.3333
5	29	823	23867	823/29
D1	=27.884615384615			

**Tech Tip:** Column labels must be typed into the cells at the top of each column (labeled A-D, respectively).

### Analysis

7. Do you see any consistent trend in the data that is produced?

**Sample Answer:** As the grams and ounces increase, their product increases.  
Each quotient is approximately 28.

8. Do you believe the product or the quotient is most constant?

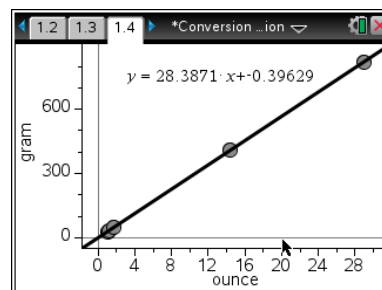
**Answer:** The quotient is most constant.

9. Does this mean that the grams and ounces are directly or inversely related?

**Answer:** When one quantity increases, the other quantity also increases (and vice versa).  
Therefore, grams and ounces are directly related

### Add a Data & Statistics Page

10. Place ounces on the x-axis and grams on the y-axis.
11. Determine the best fit line for this set of data by selecting  
**Menu > Analyze > Regression > Show Linear (mx+b).**
12. What equation do you get when you perform the linear regression?



**Sample Answer:**  $y = 28.3871x - 0.39629$

13. In the graph, x represents \_\_\_\_\_ ounces \_\_\_\_\_ and y represents \_\_\_\_\_ grams \_\_\_\_\_.



14. How does the slope of the line compare to the values in the spreadsheet on page 1.3?

**Sample Answer:** The slope of the line is approximately the same as the quotient of grams divided by ounces (in Column D).

15. What are the units for the slope?

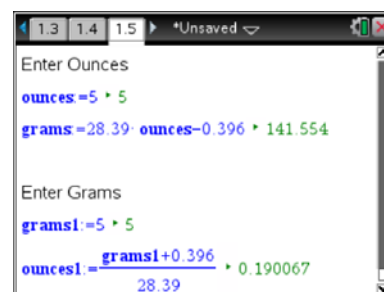
**Answer:** The units for slope are grams/ounce.

## Add a Notes Page

16. Type “Enter Ounces”.

- Insert a Math Box by selecting **Menu > Insert > Math Box**.
- Type **ounces:=5** and press **enter**.

**Tech Tip:** A Math Box can also be inserted by pressing **ctrl** **M**.



17. Insert a second Math Box, and enter the equation that you received from the prior page.

- Change  $y$  to grams and  $x$  to ounces: **Grams:= m\*ounces + b**.
- Enter the values of  $m$  and  $b$  from the equation you generated on the prior page.

18. Change the value of the ounces, and observe the result of grams.

19. Create a “grams to ounces” calculator. The variable **grams** is already used, so use the variable **grams2** for grams and **ounces2** for ounces.

## Add a New Problem to Compare Fahrenheit to Celsius

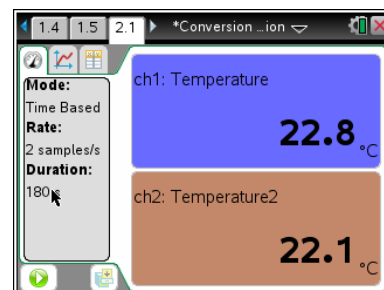
20. Select **doc** > **Insert > Problem**. The tab at the top of the screen should indicate that this is page 2.1.

21. Connect two Vernier® EasyTemp™ sensors to the TI-Nspire™ Lab Cradle. Slide the handheld onto the TI-Nspire Lab Cradle.

22. Wait for a moment for the Vernier DataQuest™ application to launch. If it does not launch, select **Add Vernier DataQuest**.

- To set up the Vernier DataQuest app, think of variables that are being measured and how they are being measured.

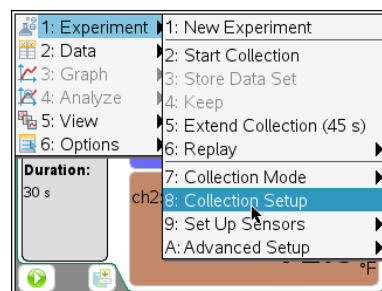
**Tech Tip:** Some settings can be changed using the Context menu. To access the context menu, click in the region whose settings you want to change, and press **ctrl** **menu**.





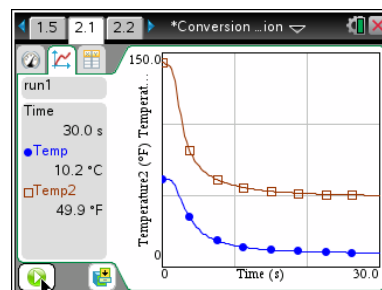
23. Two temperature readings should appear in the **Meter View**.

- Change the units on temperature probe 2 to Fahrenheit by selecting **Menu > Experiment > Set Up Sensors > Change Units**.
- Selecting **Menu > Experiment > Collection Setup**. Set the **Mode** to Time graph for 5 samples per second for 30 seconds.
- Place both temperature probes in hot water and allow them to equilibrate to the water.
- Click on the Start button, and move both probes to ice water.



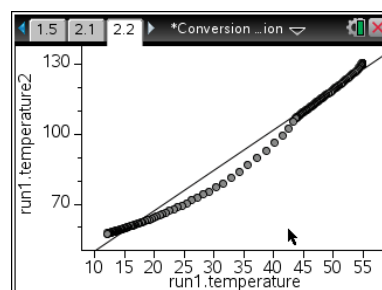
24. What happens to both temperature readings?

**Sample Answer:** Both temperatures begin to increase.



25. Do you believe the temperatures are directly or inversely related? Explain your answer.

**Sample Answer:** The plot is directly proportional which means as the Celsius temperature increases, so does the Fahrenheit.



### Add a Data & Statistics Page

26. Add **run1.temperature** (Celsius) to the x-axis and **run1.temperature2** (Fahrenheit) to the y-axis.

27. Determine the equation that best fits your data. Select **Menu > Analyze > Regression > Show Linear (mx+b)**. What does this equation represent?

**Sample Answer:** The equation should be around  $y = 1.8x + 32$ . The equation represents the relationship between Celsius and Fahrenheit.

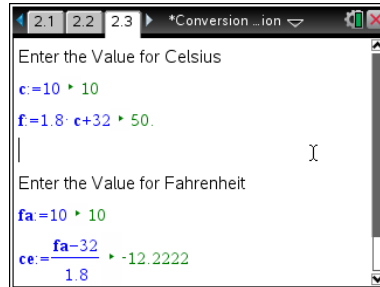
28. Create an equation for converting from Fahrenheit to Celsius.

**Sample Answer:**  $C = (F - 32)/1.8$



### Add a Notes Page

29. Create a Celsius to Fahrenheit converter and a Fahrenheit to Celsius converter.



**Tech Tip:** Students will need to enter their expressions in Math Boxes. For the first converter, recommend that students represent Celsius with a C and Fahrenheit with an F. The variables must be different for the second converter. If they are the same, they will conflict with one another.

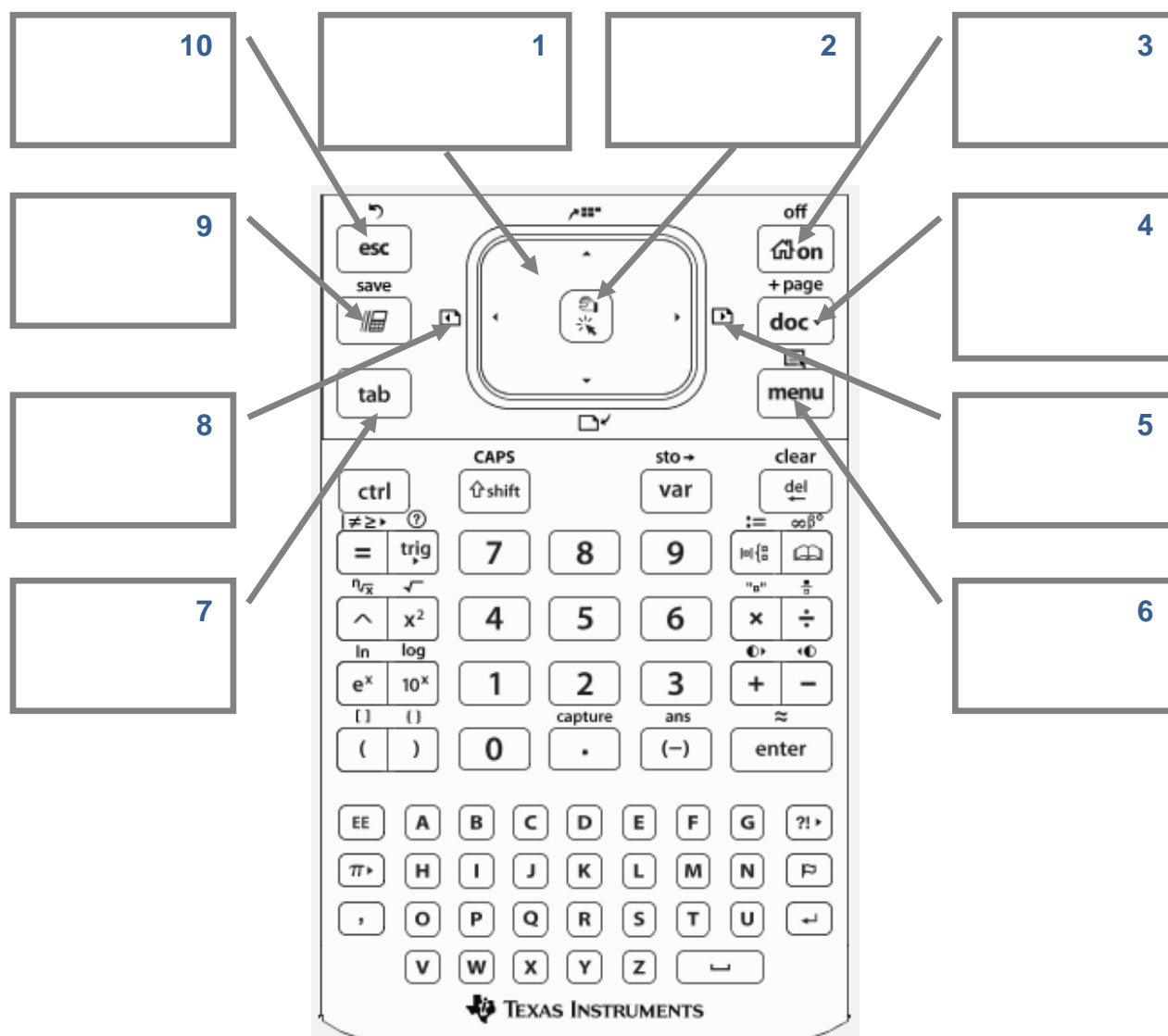


# TI-Nspire™ CX Family Overview

## TI PROFESSIONAL DEVELOPMENT

### Activity Overview

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



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# TI-Nspire™ Scavenger Hunt – The Calculator Application

## TI PROFESSIONAL DEVELOPMENT

### Activity Overview

*In this activity, you will learn how to perform basic calculations in the Calculator application. You will also be introduced to various features and commands.*

1. Press **on** twice. There are three sections on the screen. In the bottom section, there are seven icons which represent seven different applications. Predict what these applications are:  
\_\_\_\_\_
2. What happens to the screen when you press and hold **ctrl** and then tap **-** several times? What happens when you tap **+** instead?  
\_\_\_\_\_
3. Open a New Document by using the Touchpad to move your cursor to New Document. Click by pressing **on**. If the handheld asks you, “Do you want to save?” answer ‘no.’  
How did you answer “no”? \_\_\_\_\_
4. Select ‘Add Calculator’ by pressing **enter**. How else could you select it?  
\_\_\_\_\_
5. Press **6** **^** **5** and **enter**. How does the problem appear on your screen? \_\_\_\_\_  
What is the answer? \_\_\_\_\_ Press **2** **8** **^** and explain what happens when you press **^**.  
\_\_\_\_\_  
Where is the cursor located? \_\_\_\_\_ Find  $28^3$  \_\_\_\_\_.
6. Find  $36^2$  \_\_\_\_\_. There is a quicker way to type  $36^2$  without using **^**. Instead we can use the **x<sup>2</sup>**. Where is it located, and why is it faster this way? \_\_\_\_\_
7. Type **3** **÷** **8** and **enter**. What is the answer? \_\_\_\_\_  
Try **3** **÷** **8** again, only this time press **ctrl** and **enter**. What is the answer? \_\_\_\_\_  
One more time, type in **3** **÷** **8**, but this time include a decimal point at the end and then press **enter**. What is the answer? \_\_\_\_\_
8. Press **ctrl** **÷**. What appears on your screen? \_\_\_\_\_ Where is the cursor? \_\_\_\_\_  
Type in **1** **2**, press **tab**, type in **9** **8**, and press **enter**.  
What is the answer? \_\_\_\_\_ What did pressing **tab** do? \_\_\_\_\_
9. Press **▲** once so the last answer is highlighted, and then press **enter**. What happens?  
\_\_\_\_\_  
Press **◀** once. Where is the cursor? \_\_\_\_\_



# TI-Nspire™ Scavenger Hunt – The Calculator Application

## TI PROFESSIONAL DEVELOPMENT

Delete the current number by pressing . Type in , and press . What is the answer?

\_\_\_\_\_

10. Press several times, and then press . Try this a few times. What happens?

\_\_\_\_\_

11. Press twice (to highlight the last problem you entered) and press . What happens?

\_\_\_\_\_

Press several more times. What is happening each time you press ?

\_\_\_\_\_

12. Press and . What do you see? \_\_\_\_\_

Press . What does the screen say? \_\_\_\_\_

13. Press . This is a calculator screen, but what looks different about it? \_\_\_\_\_

Now type in and . What is the answer? \_\_\_\_\_

You typed in 3(5-8, but what does the problem look like on the handheld? \_\_\_\_\_

14. Press to get a square root. Then type , move one space to the right, and type . What is the answer? \_\_\_\_\_

What does the problem look like on the screen? \_\_\_\_\_

What happened to the square root bar? \_\_\_\_\_

Where did the cursor move when you moved one space to the right? \_\_\_\_\_

15. Press . What is the answer? \_\_\_\_\_

What makes the button different from the button? \_\_\_\_\_

16. Press and open a New Document. Select 'No' when it asks if you want to save the document.

Press to turn off the handheld. **These are the last things you should do on your handheld before you put it away each day!**

17. How can you clear your screen entirely? \_\_\_\_\_

18. How can you recall the last answer? \_\_\_\_\_

19. How do you know where you are typing on the Calculator screen? \_\_\_\_\_

20. How can you make sure your answer is in the form of a decimal and not a fraction? \_\_\_\_\_

\_\_\_\_\_



## Walk a Line Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

### Activity Overview

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

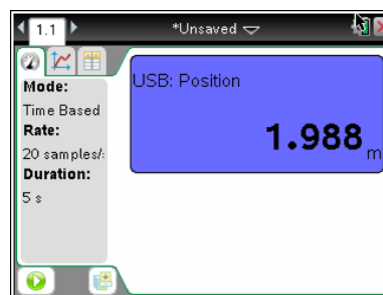
### Materials

- CBR 2
- USB Connection Cable for CBR 2

#### Step 1:

Open a New Document, and press esc.

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

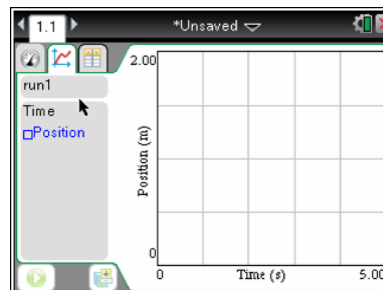


#### Step 2:


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.

#### 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?



# Walk a Line

## Student Activity

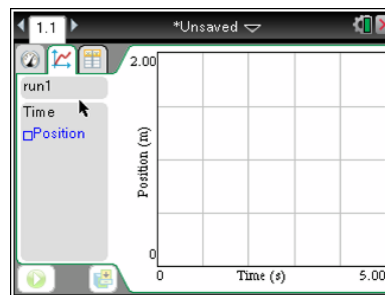
Name \_\_\_\_\_

Class \_\_\_\_\_

### Step 6:

To display only the position versus time graph, select **Menu > Graph > 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

- How can you estimate the average velocity of the walker?
- What was the position of the walker at time  $t = 0$  seconds? At time  $t = 5$  seconds?
- Show your work to calculate the slope of the graph using your positions at time  $t = 0$  seconds and  $t = 5$  seconds.
- What does the slope of the graph represent physically?
- Why is the velocity negative?
- 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.
- What does the  $y$ -intercept represent?



# Walk a Line

## Student Activity

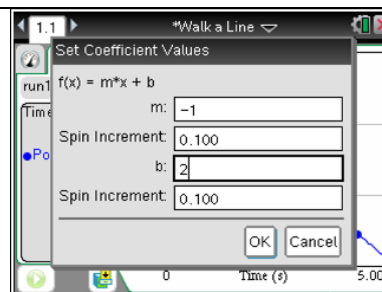
Name \_\_\_\_\_

Class \_\_\_\_\_

### Step 8:

Select **Menu > Analyze > Model**. Select  $m \cdot x + b$  to create a linear model, and press **OK**.

Type the values for the coefficients  $m$  and  $b$  that you estimated in Step 7 in the spaces provided, and click **OK**.

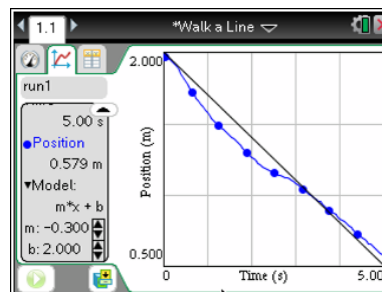


### Step 9:

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

$m =$

$b =$



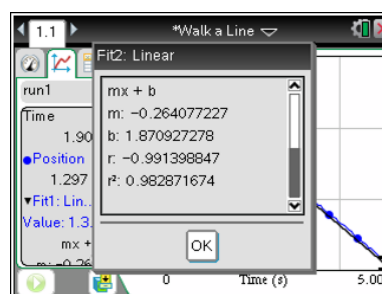
### Step 10:

Analyzing the data with a linear regression curve can be performed within the Vernier DataQuest™ application.

Select **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.

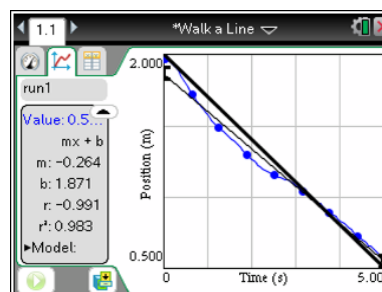
$m =$

$b =$



### 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?





## Walk a Line

### Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

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### Discussions/Explorations

1. As you might 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.



## 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).

## Vocabulary

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

## About the Lesson

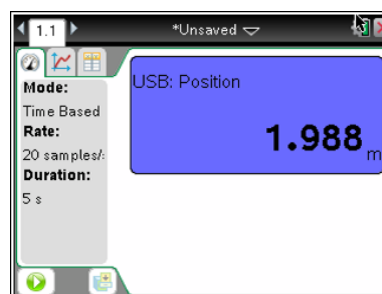
- In this lesson, students collect data by moving at a constant velocity in front of a CBR 2™ motion sensor.
- As a result, students will:
  - Develop a linear model for a scatter plot of position versus time data
  - Make a real-world connection between a linear equation used to model the data and the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

## Materials

- CBR 2 with USB CBR 2-to-calculator cable
- Mini-standard USB cable (for CBR 2 and computer)
- TI-Nspire Teacher or Student Software (for CBR 2 and computer)
- TI-Nspire™ Lab Cradle (for legacy CBR).
- MDC-BTD cord (for legacy CBR and Lab Cradle)

## TI-Nspire™ Navigator™ System

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



## TI-Nspire™ Technology Skills:

- Collect motion data with the Vernier® DataQuest™ app.
- Run a linear regression in the Vernier DataQuest app.

## Tech Tips:

- Flip the motion detector open. Set the switch to normal.
- Check the four AA batteries in the CBR 2.
- Unplug and plug the CBR 2 back in.
- When using an older CBR or motion detector with the Lab Cradle, you might 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



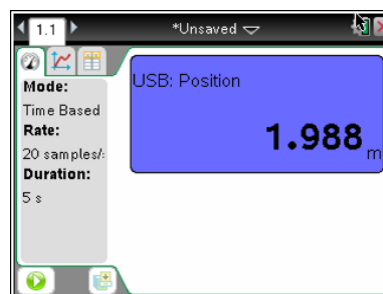
## Discussion Points and Possible Answers

**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.

**Teacher Tip:** With the Lab Cradle, you can connect multiple motion detectors to extend your exploration.

### Step 1:

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



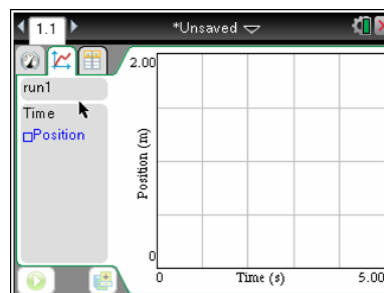
**Teacher Tip:** When the CBR 2 is first connected, it begins clicking and recording measurements. Have the students move the CBR 2 and point it at different objects. Ask them what the motion detector is doing. It should be measuring the distance from the CBR 2 to the object directly in front of it. 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 handheld 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 might 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 might also want to remind students that they must walk slowly and 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.

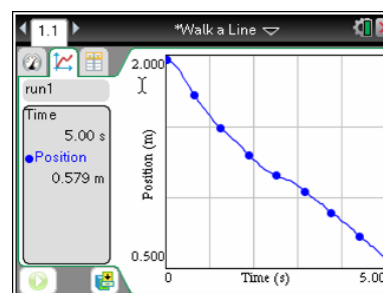
**Tech Tip:** If the students are not satisfied with their results, they can repeat the data collection by clicking the **Play** button again. This will overwrite the previous trial.

#### Step 6:

To display only the *position versus time* graph, press **Menu > Graph > 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 might 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;  $y = -0.2842x + 2$ . Equations will vary but should have  $b = 2$  and  $y$  = the slope from part c in Step 7.

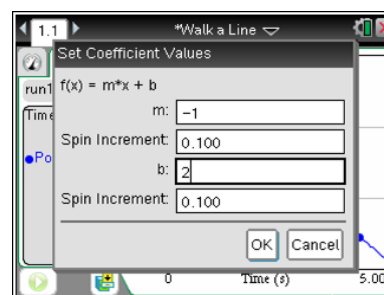
- g. What does the  $y$ -intercept represent?

**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:

Select **Menu > Analyze > Model**. Select  $m \cdot x + b$  to create a linear model, and press **OK**. Type the values for the coefficients  $m$  and  $b$  that you estimated in Step 7 in the spaces provided, and click **OK**.

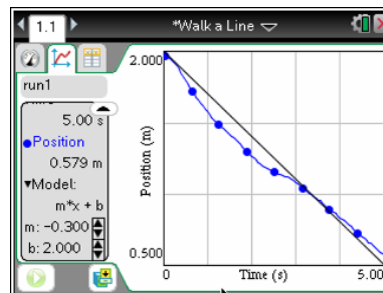


**TI-Nspire™ Navigator™ Opportunity: Live Presenter**  
See Note 1 at the end of this lesson.

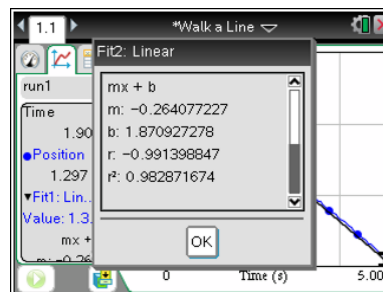
**Step 9:**

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

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

**Step 10:**

Analyzing the data with a linear regression curve, can be performed within the Vernier DataQuest application. Select **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.

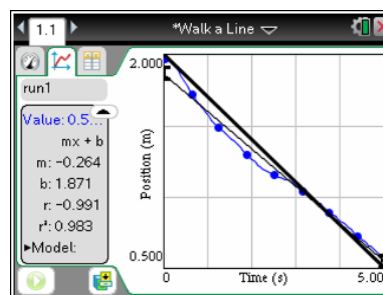


**Sample Answer:**  $m = -0.264077227$ ;  $b = 1.870927278$

**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 might appear to be a better fit because the regression equation might not go through the actual starting position.

**Discussions/Explorations**

1. As you might 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 and 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 might want to use **Live Presenter** here to allow students to share how well their equations fit the data points.



## Cool It

### Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

### How do drinks cool?

When you have a drink which is very hot, you have probably noticed that it quickly cools off to a temperature that you consider tolerable. Your drink then remains in a drinkable temperature range for quite a while until it eventually cools off too much as it approaches room temperature. When you think about how this drink cools, you are thinking about math and science. In this activity, you will explore how the temperature changes as a function of time. Because watching an entire cup of hot chocolate or coffee cool will take a long time, we will conduct our experiment by heating a temperature sensor and watching it cool. Begin by making a prediction of how the temperature will change as a function of time and sketching a graph of the prediction to the right. Begin your prediction graph at the instant the sensor is pulled from the water cup. Be sure to label your axes.



Write a sentence to explain why you think the graph will look like your prediction.

### Objectives:

- Understand how objects cool by recording temperature as a function of time for a sensor as it cools.
- Model the cooling data with the appropriate mathematical function.

### Materials:

- Vernier EasyTemp<sup>®</sup> USB temperature sensor or Vernier Go!<sup>®</sup> Temp USB temperature sensor with interface (Vernier EasyLink<sup>®</sup> USB sensor interface or TI-Nspire Lab Cradle)
- Cup of hot water with a temperature of 45°–55°C or a hair drier to heat the temperature sensor.



# Cool It

## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

### Data Collection:

1. Open a new document on the TI-Nspire™ handheld. Connect the temperature sensor directly or with the interface. You will use the default settings.
2. Place the temperature sensor in the cup of hot water and watch for the readings to become steady indicating that the sensor has reached the temperature of the water.
3. Remove the sensor from the cup of hot water, wipe it off so that evaporation is not a factor and let it sit on the edge of the table without touching anything to cool. Begin the data collection immediately by pressing the green arrow in the lower left corner of the screen (▶).
4. Once the data is collected, send the data file to each group member's handheld.

### Analysis:

1. Compare your data with your prediction. If they are different, explain why you think data does not match your prediction exactly and sketch the graph of the collected data on the same set of axes, labeling each relationship.
2. Why is the room temperature important in this activity?
3. Click on the graph to select a data point. Move the tracing cursor to find the starting temperature and then use your graph or other methods to determine the temperature of the room in °C. The room temperature should be lower than your lowest temperature recorded. Record them below

Starting Temperature (°C)	
Room Temperature (°C)	
Difference in Temperatures (°C)	

4. You may recognize that the data appears to be exponential. You will model this data with an equation in the form  $y = a \cdot b^x + c$ . Use what you know about transformations and the data points in the table above to find values for  $a$  and  $c$ . Note that  $a$  is not the starting temperature. Explain why  $a$  is different value in the table. Record the values for  $a$  and  $c$  in the table to the right.

$a$	
$c$	





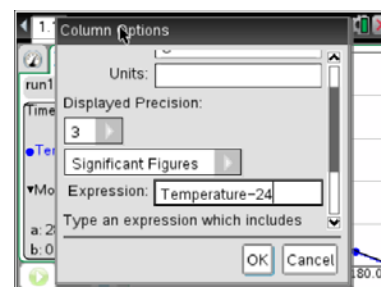
# Cool It

## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

5. You will guess a value for  $b$ . Does the graph show exponential growth or decay? Based upon this, what are the possible values for  $b$ ?
  
6. Select **MENU > Analyze > Model**. Type in the model  $y = a \cdot b^x + c$  (be sure to enter the multiplication sign between  $a$  and  $b$ ) and then enter the values for  $a$  and  $c$  along with your estimate for  $b$ . The spin increment will allow you to adjust the values in the increments you choose by the value entered. To obtain a good fit, you will need to adjust the value of  $b$  possibly  $a$  or  $c$ . Adjust the values using the up and down arrows in the details box to the left of the graph. You can also click the value of  $b$  and enter a specific value of your choice. Once the model fits the data, record the equation.
  
7. What is the physical representation of each parameter  $a$ ,  $b$  and  $c$ ?
  
8. An exponential regression can also be used to find the equation but the exponential regression is in the form  $y = a \cdot b^x$  with no vertical shift value of  $c$  from above. How could the data be transformed so that the regression model can be used on the curve?
  
9. Since the temperature levels off at room temperature rather than zero, the exponential curve is shifted upward by room temperature. Subtracting room temperature from all of the temperature values will allow the data to be analyzed with an exponential regression. Select **Menu > Data > New Calculated Column**. Name the new column *Adj Temp*. The Expression must be typed in precisely with Temperature – Room Temperature value.





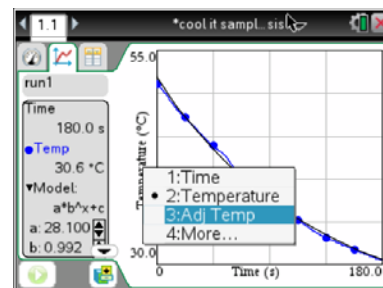
## Cool It

### Student Activity

Name \_\_\_\_\_

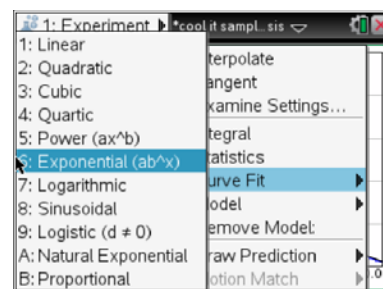
Class \_\_\_\_\_

10. To see the graph of the Adjusted Temp as a function of time, click on the *Temperature* label along the dependent axis of the graph and change it to *Adj Temp*. Or you may select it from the Graph Menu.



11. Select **Menu > Analyze > Curve Fit > Exponential**.

Record the value of the exponential regression.



12. Compare the exponential regression value with the value of the model you developed.  
Write an equation for the original data set using the exponential regression.

13. How would the graph change if the experiment were performed outside on a very cold day?

14. How would the graph change if the hot water had a higher initial temperature?

15. Write a short paragraph to summarize what you learned in this activity.



## Math and Science Objectives

- Students will first predict and then examine the relationship for temperature as a function of time for an object that is cooling.
- Students will model mathematically the relationship with the exponential equation in the form  $y = a \cdot b^x + c$ .
- Students will relate each of the parameters in the equation to a physical quantity.
- Students will draw conclusions about cooling objects and make predictions about how changes in the data collection will affect the results.
- Students will use appropriate tools strategically. (CCSS Mathematical Practice)

## Vocabulary

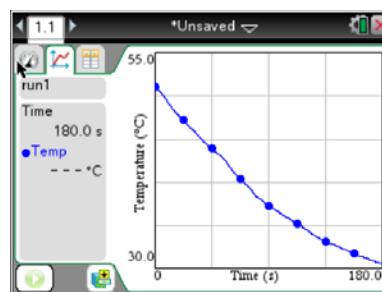
- temperature
- initial temperature
- exponential equation

## About the Lesson

- Making predictions prior to data collection is an important step in helping students to connect real world phenomena to mathematics.
- Students will heat a temperature probe either in hot water or with a hair drier and then watch it cool. They will find the mathematical equation for the data by creating their own model first and then by transforming the data so that they can run an exponential regression.
- As a result, students will:
  - Develop a conceptual understanding of how objects cool.
  - Make a real-world connection about exponential functions and transformations.

## Materials and Materials Notes

- TI-Nspire handheld or TI-Nspire computer software
- Vernier EasyTemp<sup>®</sup> USB temperature sensor or Vernier Go!<sup>®</sup> Temp USB temperature sensor with interface (Vernier EasyLink<sup>®</sup> USB sensor interface or TI-Nspire Lab Cradle)



## TI-Nspire™ Technology Skills:

- Collect temperature data with the Vernier DataQuest™ app

## Tech and Troubleshooting

### Tips:

1. The temperature sensor can be heated using hot water or a hair drier. If students use the hot water, they should wipe the sensor immediately after removing it from the water so that evaporation is not a factor in the cooling. The hair drier simply requires heating the sensor and collecting data once the drier is turned off.
2. As the temperature sensor cools, check to see that fans or air conditioners are not blowing directly on the sensor.

### Lesson Files:

*Student Activity*

Cool\_It\_Student.pdf

Cool\_It\_Student.doc




- Cup of hot water with a temperature of 45°–55°C or a hair drier to heat the temperature sensor.
- Using EasyTemp with a computer requires the use the mini-standard USB adaptor to plug the temperature sensor into a computer with TI-Nspire™ Teacher Software or TI-Nspire™ Student Software. Using the TI-Nspire™ Lab Cradle with the standard temperature sensor requires a USB cable to connect to the teacher computer.
- If you do not have the adapter, you may want to collect data with the student handheld and transfer to the computer using TI-Nspire Navigator™ System or Teacher Software.

### Discussion Points and Possible Answers

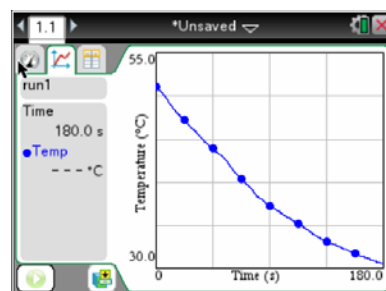
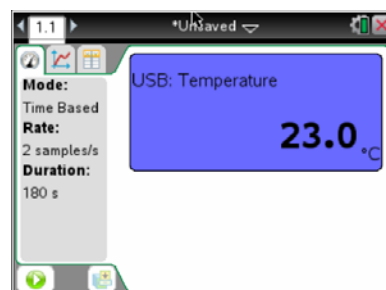
**Teacher Tip:** Making predictions is very important to helping students to connect the physical world to the mathematical world. Ask the students to make a prediction prior to collecting data and sketch it. You may then want to ask them to compare their predictions to those of other students in the class as you walk around and look at the sketches. Once the data is collected, come back to those predictions and discuss any errors. In this activity, students often show the temperature curve leveling off at a temperature of zero rather than room temperature.

### Data Collection

- To collect data with a temperature sensor, first turn on the TI-Nspire and choose **New Document**. Then, plug in the EasyTemp sensor and the Vernier DataQuest app will automatically launch. The handheld shows a meter which will change as the temperature varies. You are using the default setting which collects data for 180 seconds.

To begin the data collection, click the green **Start Collection**  arrow in the lower left corner of the screen.

- Once collection begins, the handheld will show the graph of temperature as a function of time.
- A sample graph is shown to the right





### Analysis

1. Compare your data with your prediction. If they are different, explain why you think the data does not match your prediction exactly, and sketch the graph of the collected data on the same set of axes, labeling each relationship.

**Sample answer:** Some graphs will match the prediction and some will not. The most common error is that students don't realize that the temperature levels off at room temperature, which is higher than zero.

2. Why is the room temperature important in this activity?

**Sample answer:** The graph is asymptotic to the room temperature.

3. Click on the graph to select a data point. Move the tracing cursor to find the starting temperature and then use your graph or other methods to determine the temperature of the room in °C. The room temperature should be lower than your lowest temperature recorded. Record them below.

**Sample answers:**

Starting Temperature (°C)	51.1
Room Temperature (°C)	23.0
Difference in Temperatures (°C)	28.1

4. You may recognize that the data appears to be exponential. You will model this data with an equation in the form  $y = a \cdot b^x + c$ . Use what you know about transformations and the data points in the table above to find values for  $a$  and  $c$ . Note that  $a$  is not the starting temperature. Explain why  $a$  is different value in the table. Record the values for  $a$  and  $c$  in the table to the right.

<b><math>a</math></b>	28.1
<b><math>c</math></b>	24.0

**Sample answer:** The value of  $a$  is the difference between the starting temperature and the final temperature.

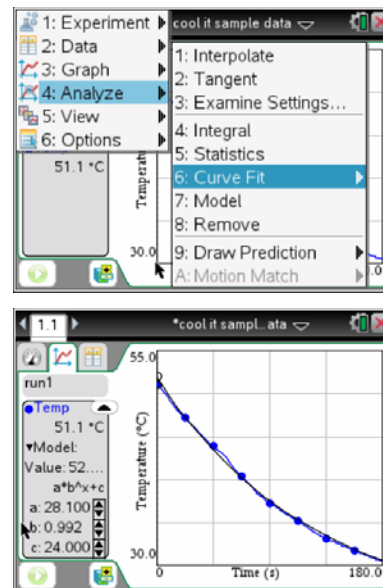
5. You will guess a value for  $b$ . Does the graph show exponential growth or decay? Based upon this, what are the possible values for  $b$ ?

**Sample answer:** The graph shows an exponential decay so the value of  $b$  must be between 0 and 1.



6. Select **MENU > Analyze > Model**. Type in the model  $y = a \cdot b^x + c$  (be sure to enter the multiplication sign between  $a$  and  $b$ ) and then enter the values for  $a$  and  $c$  along with your estimate for  $b$ . The spin increment will allow you to adjust the values in the increments you choose by the value entered. To obtain a good fit, you will need to adjust the value of  $b$  possibly  $a$  or  $c$ . Adjust the values using the up and down arrows in the details box to the left of the graph. You can also click the value of  $b$  and enter a specific value of your choice. Once the model fits the data, record the equation.

**Equation for Sample Data:**  $y = 28.1 \cdot (0.992)^x + 24.0$



**Tech Tip:** Students often become confused when they choose *Model* because a default equation appears. They should just type their model over the given one. If they have errors, they can go to the Analyze menu and remove the model and then re-enter it. One common error is to omit the multiplication sign between  $a$  and  $b$ .

7. What is the physical representation of each parameter  $a$ ,  $b$  and  $c$ ?

**Sample answer:** The parameter  $a$  represents the difference between the starting temperature and room temperature. The parameter  $b$  represents the percentage of temperature that the probe retains each second. The parameter  $c$  represents the temperature of the room.

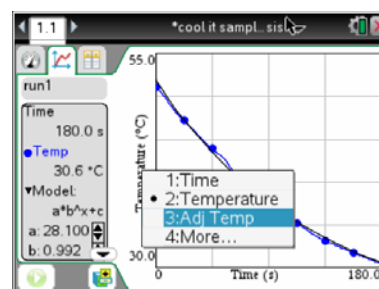
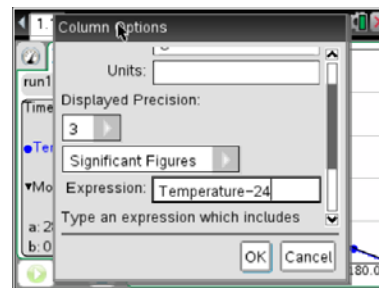
8. An exponential regression can also be used to find the equation but the exponential regression is in the form  $y = a \cdot b^x$  with no vertical shift value of  $c$  from above. How could the data be transformed so that the regression model can be used on the curve?

**Sample answer:** If the room temperature is subtracted from all of the temperature values, the graph will be shifted down so that it has a horizontal asymptote of zero and we can run the exponential regression.



9. Since the temperature levels off at room temperature rather than zero, the exponential curve is shifted upward by room temperature. Subtracting room temperature from all of the temperature values will allow the data to be analyzed with an exponential regression. Select **Menu > Data > New Calculated Column**. Name the new column *Adj Temp*. The Expression must be typed in precisely with Temperature – Room Temperature value.

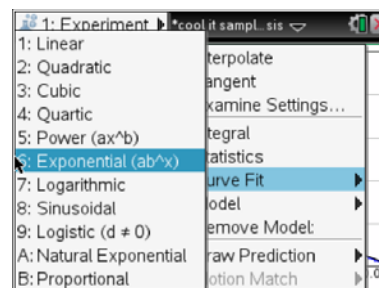
**Tech Tip:** Arrow down on the right side to access the Expression.



10. To see the graph of the Adjusted Temp as a function of time, click on the *Temperature* label along the dependent axis of the graph and change it to *Adj Temp*. Or you may select it from the Graph Menu.

11. **Menu > Analyze > Curve Fit > Exponential**. Record the value of the exponential regression.

**Sample Data Solution:**  $a = 50.0$  and  $b = 0.997$ ,  
so  $y = 50(0.997)^x$ .



12. Compare the exponential regression value with the value of the model you developed. Write an equation for the original data set using the exponential regression.

**Solution for Sample Data:** The equation  $y = 50(0.997)^x + 24$  is obtained by adding the room temperature to the exponential regression.

13. How would the graph change if the experiment were performed outside on a very cold day?

**Sample answer:** The final temperature would be lower so the horizontal asymptote will be lower and the graph may be a little steeper since the difference between the initial and final temperatures will be greater. The value for  $a$  would be larger.



14. How would the graph change if the hot water had a higher initial temperature?

**Sample answer:** The initial temperature and the value of  $a$  would be greater.

15. Write a short paragraph to summarize what you learned in this activity.





# Boyle's Law

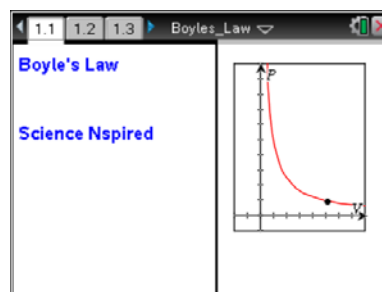
## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

Open the TI-Nspire document *Boyles\_Law.tns*.

In this activity, you will use a Gas Pressure Sensor to measure the pressure of an air sample inside a syringe. Using graphs, you will apply your results to real-world examples.



What is the mathematical relation between volume and pressure for a confined gas? To answer this question, you will perform an experiment with air in a syringe connected to a Gas Pressure Sensor. When the volume of the syringe is changed by moving the piston, the change in the pressure will be measured. It is assumed that temperature and moles of gas will be constant throughout the experiment. Pressure and volume data pairs will be collected during this experiment and then analyzed. Using the data and the graph, the type of mathematical relationship between pressure and volume of the confined gas can be determined. Historically, this relationship was first established by Robert Boyle in 1662 and has since been known as Boyle's law.

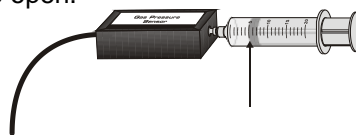
Move to page 1.6.

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

Q1. As volume increases, pressure:

- A. increases      B. decreases      C. remains the same

1. With the syringe disconnected from the Gas Pressure Sensor, move the piston of the syringe until the front edge of the inside black ring (indicated by the arrow in the picture to the right) is positioned at the 10.0 mL mark.
2. Turn on your TI-Nspire handheld, and close any documents that are open.
3. Attach the syringe to the probe as shown to the right. (Do not twist too tightly—the syringe just needs to be secure.)



4. Plug the pressure probe into the EasyLink™, and plug the EasyLink into the USB port in the top of the handheld. The DataQuest APP should open automatically.
  - What is the default unit for collection with this sensor?
5. Select **MENU > Experiment > Collection Mode > Events with Entry**.
6. Type in **volume** for Name, press **tab**, and type **mL** for Units. Press **enter**.
7. Click the green start arrow to initiate data collection.
 

Time to collect pressure and volume data. It is best for one person to take care of the syringe and for another to operate the handheld.




# Boyle's Law

## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

8. To collect your first data reading, click on the “camera” icon  in the lower left of the screen (“Keep current reading”). Enter a value of 10, since you set the syringe at 10 mL earlier. Click on OK, or press .
9. Depress and hold the plunger to the 9 mL mark. When the pressure value on the left side of the screen has stabilized, keep this reading, type in 9, and press .
10. Continue this procedure, collecting data at 8, 7, 6, and 5 mL. After you have collected data for 5 mL, click on the stop button in the lower left corner of your TI-Nspire screen.
  - Your pressure/volume graph should now be displayed.
11. Explore the various regression models to determine the best mathematical relationship for your data set.
12. Based on the graph of pressure vs. volume, decide what kind of relationship exists between these two variables—direct or inverse.
  - While on the DataQuest app page, select **MENU > Analyze > CurveFit > Power**.
  - Scroll down to see the curve fit statistics for the equation in the form  $y = Ax^B$ , where  $x$  is volume,  $y$  is Pressure,  $A$  is a proportionality constant, and  $B$  is the exponent of  $x$  (Volume).

Note: The relationship between pressure and volume can be determined from the value and sign of the exponent,  $B$ .

- If the mathematical relationship has been correctly determined, the regression line should closely fit the points on the graph (that is, pass through or near all of the plotted points).

**Move to page 2.3.**

Q2. Which variable is considered to remain constant during a Boyle's Law Experiment?

A. pressure B. volume C. temperature D. all of these

13. To linearize the data and confirm that an inverse relationship exists between pressure and volume, plot a graph of pressure vs. reciprocal of volume ( $1/\text{Volume}$ ) in DataQuest:
  - Select **MENU > Data > New Calculated Column**.
  - Type **InverseV** for Name.
  - Short Name: **1/V**
  - Units: **1/mL**
  - Expression: **1/Volume**
  - Click OK, or press .
  - Select **MENU > Graph > Select X-axis > InverseV**.



# Boyle's Law

## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

14. Calculate the regression line  $y = mx + b$  where  $x$  is  $1/\text{volume}$ ,  $y$  is pressure,  $m$  is a proportionality constant, and  $b$  is the  $y$ -intercept. On the DataQuest page, select **MENU** > **Analyze** > **Curve Fit** > **Linear**.

Q3. When a quantity of gas is compressed, the pressure of the gas is expected to \_\_\_\_\_.

- A. decrease B. remain the same C. increase D. double

Q4. The expected mathematical relationship between pressure and volume is \_\_\_\_\_.

- A. direct B. inverse C. indirect D. impossible to determine

**Move to page 3.2.**

Q5. If the volume is doubled from 5 to 10 mL, what does the data show happens to the pressure?

- A. increases B. decreases C. doubles D. cut in half

Q6. If the volume is halved from 20 to 10 mL, what does the data show happens to the pressure?

- A. increases B. decreases C. doubles D. cut in half

Q7. Based on the data, what would be expected to happen to the pressure if the volume in the syringe were increased from 10 to 40 mL?

- A. increase B. decrease C. quadruple D. cut to 1/4th

Q8. From the answers to the above three questions and from the shape of the curve of the plot, of pressure vs. volume, what is the relationship between the pressure and volume of a confined gas?

- A. inverse B. direct C. quadratic D. impossible to determine

Q9. Based on the data, what would be expected to happen to the pressure if the volume in the syringe were increased from 10 to 40 mL?

- A. increase B. decrease C. quadruple D. cut to 1/4th



# Boyle's Law

## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

Q10. What two experimental factors are assumed to be constant during this experiment?  
(select two)

- A. pressure      B. volume      C. moles of the gas      D. temperature

Q11. Using P, V, and k, write an equation representing Boyle's Law.

Q12. Which of the following produced a constant value?

- A. pressure x volume      B. pressure/volume      C. volume/pressure      D. none of these

Q13. Summarize what you have learned about the relationship between pressure and volume.

**Move to page 4.1.**

### Extension: Effect of Temperature on Boyle's Law

Follow the instructions on Pages 4.1-4.3 for the simulation, and then answer the following questions from Pages 4.4 and 4.5:

Q14. When the temperature is doubled, how does the pressure change?

- A. The pressure doubles.      B. The pressure is reduced by  $\frac{1}{2}$ .  
C. The pressure is 4X larger.      D. The pressure does not change.

Q15. At a higher temperature, the relationship between pressure and volume is a(an) \_\_\_\_\_ relationship.

- A. direct      B. inverse      C. quadratic      D. impossible to determine



### Science Objectives

- Use a Gas Pressure Sensor and a gas syringe to measure the pressure of an air sample at several different volumes.
- Determine the relationship between gas pressure and volume.
- Use the results to predict the pressure at other volumes.

### Math Objectives

- Mathematically describe the relationship between gas pressure and volume.
- Evaluate an inverse mathematical relationship.
- Generate and analyze a power regression model.
- Linearize an inverse relation.

### Materials Needed

- Vernier® EasyLink™
- Vernier Gas Pressure Sensor
- 20 ml syringe

### Vocabulary

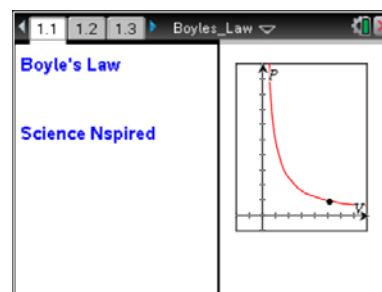
- pressure
- volume
- inverse

### About the Lesson

- This activity makes use of the Gas Pressure Sensor in an inquiry activity that enables the student to understand Boyle's Law through experimentation and data collection.
- As a result, students will:
  - Built a mathematical model to show the inverse relationship between gas pressure and gas volume.
  - Analyze that mathematical model, and make predictions from the model through interpolation and extrapolation.
  - Apply Boyle's Law to the real-life situation of human respiration.

### TI-Nspire™ Navigator™ System

- Screen Capture to monitor student progress.
- Live Presenter allows students to show their graphs to the class.



### TI-Nspire™ Technology Skills:

- Download a TI-Nspire document
- Open a document
- Move between pages
- Entering and graphing data
- Tracing and interpolating

### Tech Tips:

- Make sure the font size on your TI-Nspire handhelds is set to Medium.
- You can bring up the data collection console at any time by pressing **ctrl** **D**.
- You can hide the function entry line by pressing **ctrl** **G**.

### Lesson Materials:

#### Student Activity

- Boyles\_Law\_Student.pdf
- Boyles\_Law\_Student.doc

#### TI-Nspire document

- Boyles\_Law.tns

Visit [www.sciencenspired.com](http://www.sciencenspired.com) for lesson updates and tech tip videos.

**Activity Overview**

- Please print the student worksheet and make available to students before beginning the lab. Lab background information as well as lab procedures are included only in the student worksheet. Always remember to review any safety precautions thoroughly with your students prior to starting the lab.
- Students may answer the questions posed in the .tns file and submit for grading with TI-Nspire Navigator (optional) or students may answer directly on the student worksheet
- Ensure that students collect data on the 5 known substances and look at the graph before they actually measure the absorbance of the unknown solution. This will allow them to make predictions and to look at the graph of the data first.

**Discussion Points and Possible Answers**

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**TI-Nspire Navigator Opportunity**

Use the TI-Nspire Navigator System to monitor student progress using screen capture.

**Pre-lab Information and Questions.**

Have students read the background information on pages 1.2 – 1.5. Then, they should answer the pre-lab question on page 1.6.

Q1. As volume increases, pressure \_\_\_\_\_.

**Answer:** decreases

**Lab Procedure.**

The lab procedure is in the student worksheet and is not duplicated here. Please refer to the student handout.

**Boyles Law Lab.tns**

Have students move to pages 2.3 – 2.5 and answer the questions in the .tns file or on the worksheet.

Q2. Which variable is considered to remain constant during a Boyle's Law experiment?

**Answer:** temperature

Q3. When a quantity of gas is compressed, the pressure of the gas is expected to \_\_\_\_\_.

**Answer:** increase



Q4. The expected mathematical relationship between pressure and volume is \_\_\_\_\_.

**Answer:** inverse

Q5. If the volume is doubled from 5 to 10 mL, what does the data show happens to the pressure?

**Answer:** cut in half

Q6. If the volume is halved from 20 to 10 mL, what does the data show happens to the pressure?

**Answer:** is cut by one-third

Q7. Based on the data, what would be expected to happen to the pressure if the volume in the syringe were increased from 10 to 40 mL?

**Answer:** doubles

Q8. From the answers to the above three questions and from the shape of the curve of the plot, of pressure vs. volume, what is the relationship between the pressure and volume of a confined gas?

**Answer:** inverse

Q9. Based on the data, what would be expected to happen to the pressure if the volume in the syringe were increased from 10 to 40 mL?

**Answer:** cut into one-fourth

Q10. What two experimental factors are assumed to be constant during this experiment?  
(select two)

**Answer:** moles of gas and temperature

Q11. Using P, V, and k, write an equation representing Boyle's Law.

**Answer:**  $P = k/V$

Q12. Which of the following produced a constant value?

**Answer:** pressure times volume



Q13. Summarize what you have learned about the relationship between pressure and volume.

**Answer:** Answers will vary. Students should indicate the inverse relationship between pressure and volume

Q14. When the temperature is doubled, how does the pressure change?

**Answer:** The pressure doubles.

Q15. At a higher temperature, the relationship between pressure and volume is a(an) \_\_\_\_\_ relationship.

**Answer:** inverse (same as before)

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

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## **Wrap Up**

Use Boyle's Law to offer a practical application such as human breathing.

## **Assessment**

Formative assessment will consist of questions embedded in the pre-lab TI-Nspire document. Summative assessment questions are found in the lab and post-lab TI-Nspire document. The questions will be graded when the TI-Nspire documents are retrieved. The Slide Show can be utilized to give students immediate feedback on their assessment.

## **TI-Nspire Navigator Notes**

### **Note 1 Screen Capture**

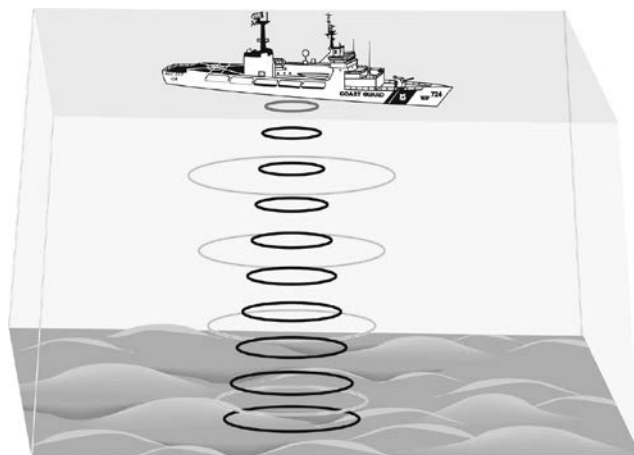
Screen Capture can be used to monitor students.



# Mapping the Ocean Floor

Oceanographers, marine geologists, and archeologists use echo sounders to investigate objects below the surfaces of bodies of water. An echo sounder consists of a transducer that sends out and receives sound waves. A signal is sent out and bounces back from a submerged surface. Scientists use the speed of sound in water and the time it takes for the signal to bounce back to calculate the depth of the object. The deeper the object, the longer it takes for the sound to return. A map of the ocean floor is made by sending out a series of “pings” in a grid pattern and recording the depths. Echo sounders use different frequencies to map different things on the ocean floor.

*Sonar*, which is short for *sound navigation ranging*, is the name given to this echo sounding system. It was invented during World War I to detect submarines. The Vernier Motion Detector works in a similar manner. In this activity, you will use a Motion Detector to map objects on a simulated ocean floor.



## OBJECTIVES

In this experiment, you will

- Use a Motion Detector to measure distances.
- Map simulated ocean floors.

## MATERIALS

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

1 m board  
masking tape  
2 or more boxes

## PRE-LAB QUESTIONS

1. What else can you think of that measures distance by sending out a sound signal?
2. What factors make it difficult to study the ocean floor directly?

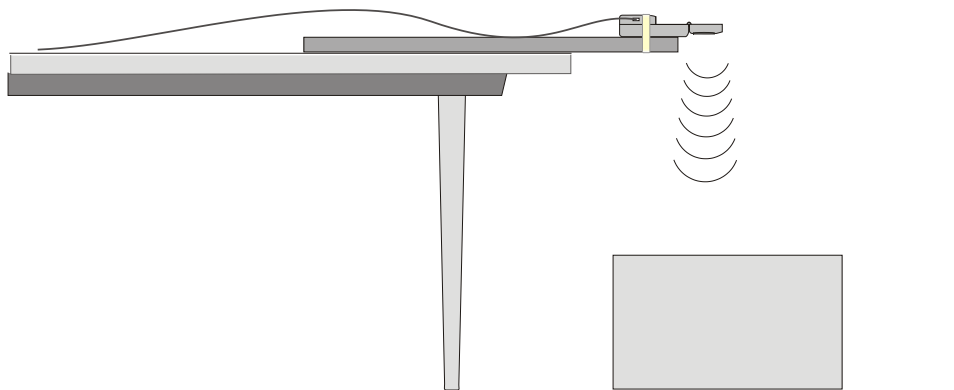












Figure 1

## PROCEDURE


### Part I Ocean Floor 1

1. Prepare the Motion Detector for data collection.
  - a. Get the board that will act as the support for your Motion Detector.
  - b. Tape or clamp the Motion Detector to one end of the board. Make sure that the round screen of the Motion Detector is not covered and is pointing downward.
  - c. Place the board with the Motion Detector flat on your table as shown in Figure 1.
2. Prepare the ocean floor for data collection.
  - a. Place the box on the floor underneath the Motion Detector. **Note:** The Motion Detector must be at least 15 cm from the top of the box.
  - b. Line up the Motion Detector so that when it is moved along the table edge it will pass over the box.
3. If your Motion Detector has a switch, set it to Normal. Connect the Motion Detector to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer. (If you are using a CBR 2 or Go!Motion, you do not need a data-collection interface.)
 


4. Set up data collection.
  - a. Choose New Experiment from the  Experiment menu.
  - b. Choose Collection Setup from the  Experiment menu.
  - c. Enter **4** as the rate (samples/second) and **15** as the experiment duration in seconds.
  - d. Select OK.
  - e. Click the Graph View tab (.
  - f. Choose Show Graph ► Graph 1 from the  Graph menu. Only the Position vs. Time Graph will be displayed.
5. Collect distance data.
  - a. Move the board to position the Motion Detector to the left of the box.
  - b. When everything is ready, start data collection (). Then, slowly slide the board across the tabletop so that the Motion Detector passes over and past the box.

6. Determine and record the distance to the floor.
  - a. Identify a flat portion of the graph that represents the floor.
  - b. Select data points in the flat portion of the graph that represents. (*Note: if you are using the TI-Nspire computer software, click and drag the cursor to select a region.*)
    - i. Move the cursor to the place you want to start the selected region.
    - ii. Press   to start the selection.
    - iii. Move the cursor to select the region.
    - iv. Press  or  to end the selection.
  - c. Choose Statistics ► Position from the Analyze menu.
  - d. Record the mean (average) distance to the floor in meters.
7. Determine and record the distance to the box.
  - a. Identify the flat portion of the graph that represents the box.
  - b. Select the region that represents the box (see Step 6b).
  - c. Choose Statistics ► Position from the Analyze menu.
  - d. Record the mean (average) distance to the box in meters.
8. Sketch and label your graph.

### Part II Ocean Floor 2

9. Prepare Ocean Floor 2.
  - a. Set up two boxes in the shape of steps. The tallest box must be at least 15 cm from the Motion Detector.
  - b. Click the Store Latest Data Set button () to save the Part I data. Repeat Steps 5–8. Be sure to record all three distances.

### Part III Hidden Ocean Floor

10. Your teacher will have a hidden ocean floor for you to measure. Click the Store Latest Data Set button () to save the Part II data. Repeat Steps 5–8 for the concealed object or objects.

## GRAPH SKETCHES

Ocean Floor 1

Ocean Floor 2

Hidden Ocean Floor

**DATA**

	Distance to floor (m)	Distance to box (m)	Box height (m)
Ocean floor 1 single box			
Ocean floor 2 box 1			
Ocean floor 2 box 2			
Hidden ocean floor box 1			
Hidden ocean floor box 2			
Hidden ocean floor box 3 (if detected)			

**PROCESSING THE DATA**

1. In the space provided in the data table above, find the height of each box. Do this by subtracting the distance to the box from the distance to the floor.
2. Which was your best result? Why do you think it was better than your other results?
3. How did the shape of your graph compare to the actual object(s) in each case? Explain.

**EXTENSIONS**

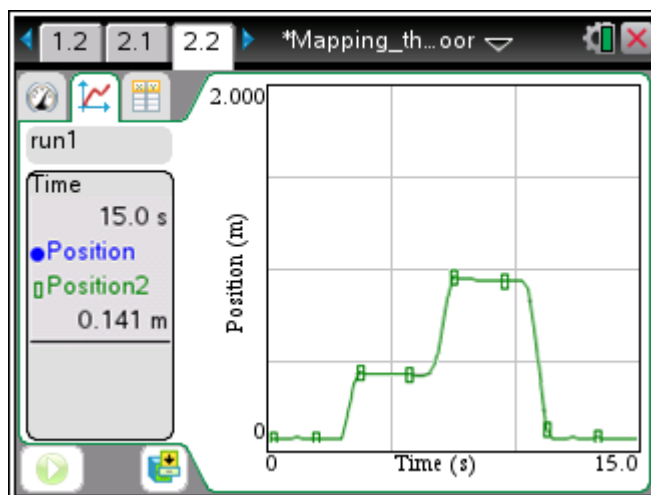
1. Try other hidden ocean-floor arrangements.
2. Research the sonar process and compare it to what you did in this activity.

## TEACHER INFORMATION

# Mapping the Ocean Floor

1. The boxes should be at least 50 cm wide.
2. Best results are obtained when the boxes are located touching each other or at least 50 cm apart.
3. The tabletops should be smooth and flat.
4. Boards longer than one meter can be used. They should provide rigid support for the Motion Detector.
5. Motion detectors without a mode switch do not properly detect objects closer than 0.5 m. As a result, such motion detectors must be farther away from the experiment than described in the student notes.
6. The hidden arrangement can be located behind a counter or demonstration table.

## SAMPLE RESULTS



*A Two-Box Simulated Ocean Floor*

## ANSWERS TO QUESTIONS

1. See the Sample Results.
2. The shape of the graph is similar to the shape of the objects.
3. Real ocean-floor mapping is affected by the water, water temperature, ocean currents, weather, and interfering objects.

**ACKNOWLEDGEMENT**

We wish to thank Don Volz and Sandy Sapatka for their help in developing and testing this experiment.



# Molecular Titration

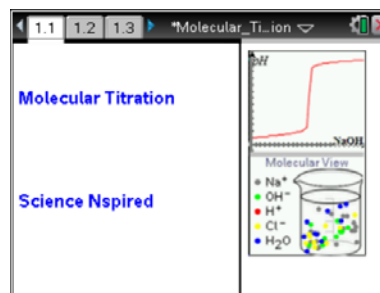
## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

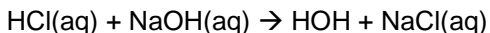
Open the TI-Nspire document *Molecular\_Titration.tns*.

What happens at the molecular level during a titration of a strong acid with a strong base? In this activity you will be able to answer this question by simulating a titration and observing the molecular view.



**Move to page 1.2.**

1. Read the introduction. This activity is a simulation of a titration of a strong acid with a strong base. The strong acid is HCl and the strong base is NaOH.



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

**Move to pages 1.3 and 1.4. Answer the following questions here or in the .tns file.**

- Q1. Referring to the titration curve on page 1.1, the equivalence point occurs \_\_\_\_\_.
  - A. in the middle of the first flat region
  - B. at the point the pH starts to rise rapidly
  - C. in the middle of the steep region
  - D. in the middle of the second flat region
- Q2. A strong acid (or a strong base) is a chemical species that \_\_\_\_\_.
  - A. produces a very low (or very high) pH
  - B. ionizes completely in water
  - C. partially ionizes in water
  - D. is a very active acid (or base)

**Move to pages 1.5 and 1.6.**

2. Read the directions and study the set-up. The beaker contains 50 mL of .10M HCl acid and the burette contains 50 mL of .20M NaOH.

**Move to pages 1.7 and 1.8. Answer the following questions here or in the .tns file.**

- Q3. Initially the beaker contains \_\_\_\_\_.
  - A.  $\text{H}^+$  and  $\text{Cl}^-$  ions
  - B. HCl,  $\text{H}^+$ , and  $\text{Cl}^-$  ions
  - C. HCl and NaOH
  - D.  $\text{Na}^+$  and  $\text{OH}^-$  ions
- Q4. How many  $\text{H}^+$  ions are present in the simulation initially?

**Move to page 1.9.**

3. Read the directions.

**Move to pages 1.10–1.12. Answer the following questions here or in the .tns file.**

- Q5. As NaOH is added the pH \_\_\_\_\_.
  - A. decreases
  - B. increases
  - C. is unchanged

**Molecular Titration****Student Activity**

Name \_\_\_\_\_

Class \_\_\_\_\_

- Q6. As NaOH is added the number of  $\text{H}^+$  ions \_\_\_\_\_.  
A. decreases                      B. increases                      C. is unchanged
- Q7. As NaOH is added the number of  $\text{Cl}^-$  ions \_\_\_\_\_.  
A. decreases                      B. increases                      C. is unchanged

**Move to pages 1.13–1.20. Answer the following questions here or in the .tns file.**

4. Read the directions on page 1.13 and look at the questions on pages 1.14–1.20. You will return to titration on page 1.6 and use the results to answer the questions.
- Q8. How many mL of NaOH are needed to reach the equivalence point?
- Q9. At the equivalence point how many  $\text{H}^+$  ions remain in the beaker?
- Q10. At the equivalence point how many  $\text{OH}^-$  ions are present in the beaker?
- Q11. Write a net ionic equation to show what happened to the  $\text{H}^+$  ions.
- Q12. At the equivalence point the number of  $\text{Cl}^-$  ions is \_\_\_\_\_ the number of  $\text{Na}^+$  ions.  
A. less than                      B. equal to                      C. greater than
- Q13. For a strong acid–strong base titration, what is the pH at the equivalence point?
- Q14. As more NaOH is added beyond the equivalence point, the pH increases because of the increase in the number of \_\_\_\_\_.  
A.  $\text{H}^+$  ions                      C.  $\text{Na}^+$  ions  
B.  $\text{OH}^-$  ions                      D.  $\text{Cl}^-$  ions





## Science Objectives

- Students will observe what happens during a titration of a strong acid with a strong base, using a simulation accompanied by a molecular view and pH graph.
- Students will determine the volume of base needed to reach the equivalence point.
- Students will see how pH is related to an excess of  $H^+$  ions or an excess of  $OH^-$  ions in a solution.

## Vocabulary

- acid dissociation constant
- aliquot
- concentration
- equivalence point
- pH
- strong acid
- strong base
- titration

## About the Lesson

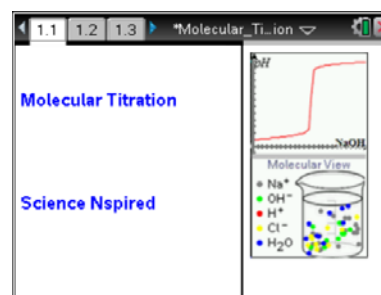
- This lesson features a simulation of a pH titration that includes a molecular view of the chemical changes that occur as a strong base (NaOH) is added to a beaker containing a strong acid (HCl) solution.
- As a result, students will have a better understanding of:
  - The nature of strong acids and strong bases.
  - The chemical species present before, after, and at the equivalence point.

## TI-Nspire™ Navigator™

- Send out the *Molecular\_Titration.tns* file.
- Monitor student progress using Screen Captures.
- Use Live Presenter to spotlight student answers.

## Activity Materials

- Molecular\_Titration.tns* document
- TI-Nspire™ Technology



## TI-Nspire™ Technology Skills:

- Download a TI-Nspire document
- Open a document
- Move between pages
- Run and pause an animation
- Use a minimized slider

## Tech Tips:

Make sure that students know how to start ►, pause ||, re-start, and reset ◀ an animation.

## Lesson Materials:

### Student Activity

- Molecular\_Titration\_Student.doc
- Molecular\_Titration\_Student.pdf

### TI-Nspire document

- Molecular\_Titration.tns

**Discussion Points and Possible Answers**

**Teacher Tip:** If you are using the TI-Nspire Navigator to pick up and evaluate the .tns file you may not need to use the student activity sheet.

**Move to page 1.2.**

1. Students should read the introduction about the titration of a strong acid with a strong base.

**Move to pages 1.3 and 1.4.**

Have students answer the questions on either the handheld, on the activity sheet, or both.

- Q1. Referring to the titration curve on page 1.1, the equivalence point occurs \_\_\_\_\_.

**Answer:** C. in the middle of the steep region

- Q2. A strong acid (or a strong base) is a chemical species that \_\_\_\_\_.

**Answer:** B. ionizes completely in water.

**Move to pages 1.5 and 1.6.**

2. After students read about the titration set up on page 1.5 they should analyze the titration set up shown on page 1.6.

**Move to pages 1.7 and 1.8.**

Have students answer the questions on either the handheld, on the activity sheet, or both.

- Q3. Initially the beaker contains \_\_\_\_\_.

**Answer:** A:  $\text{H}^+$  and  $\text{Cl}^-$  ions

- Q4. How many  $\text{H}^+$  ions are present in the simulation initially?

**Answer:** 9

**Move to page 1.9.**

3. After students read the directions on page 1.9 for running the simulation, they will move back to page 1.6 and start the titration. The first stage is to add 5 drops and observe the changes. They then answer the next set of questions.

**Move to pages 1.10–1.12.**

Have students answer the questions on either the handheld, on the activity sheet, or both.

**TI-Nspire Navigator Opportunities**

Have students take turns being Live Presenters and have them explain how the graph and the molecular view correspond to what is happening in the titration. This will enhance student understanding of the lab simulation and how to interpret the molecular view and the titration graph.

Q5. As NaOH is added the pH \_\_\_\_\_.

**Answer:** B. increases

Q6. As NaOH is added the number of  $\text{H}^+$  ions \_\_\_\_\_.

**Answer:** A. decreases

Q7. As NaOH is added the number of  $\text{Cl}^-$  ions \_\_\_\_\_.

**Answer:** C. is unchanged

**Move to pages 1.13–1.20.**

Have students answer the questions on either the handheld, on the activity sheet, or both.

4. After students read the directions on page 1.13, they will move back to page 1.6 and continue to add drops and observe the changes. They should pause the animation as needed and answer the next set of questions.

**Teacher Tip:** The model neglects the self-dissociation of water, which is a weak acid. You may wish to tell students that there is actually a very small ( $10^{-7}$  mol/l) concentration of  $\text{H}^+$  ion at the equivalence point, and review the definition of pH. You may wish to point out that the original solution has an  $\text{H}^+$  concentration one million times greater than pure water.

Q8. How many mL of NaOH are needed to reach the equivalence point?

**Answer:** 25 mL

Q9. At the equivalence point how many  $\text{H}^+$  ions remain in the beaker?

**Answer:** none

Q10. At the equivalence point how many  $\text{OH}^-$  ions remain in the beaker?

**Answer:** none



Q11. Write a net ionic equation to show what happened to the  $\text{H}^+$  ions.

**Answer:**  $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$

Q12. At the equivalence point the number of  $\text{Cl}^-$  ions is \_\_\_\_\_ the number of  $\text{Na}^+$  ions.

**Answer:** B. equal to

Q13. For a strong acid-strong base titration, what is the pH at the equivalence point?

**Answer:** 7.0

Q14. As more NaOH is added beyond the equivalence point, the pH increases because of the increase in the number of \_\_\_\_\_.

**Answer:** B:  $\text{OH}^-$  ions

**Tech Tip:** There are 2 pages at the end of Problem 1, containing a spreadsheet and a graph. These are used to capture data from the titration and create the graphs. Students should not delete these pages. They can use the pages in their lab report, if they wish.

### TI-Nspire Navigator Opportunities

If students answer the questions within the .tns file, the files can be collected at the end of class and graded electronically and added to the Portfolio.

### Wrap Up

When students are finished with the activity, pull back the .tns file using TI-Nspire Navigator. Save grades to Portfolio. Discuss activity questions using Slide Show.

### Assessment

- Formative assessment consists of questions embedded in the .tns file. The questions will be graded when the .tns file is retrieved by TI-Nspire Navigator. The TI-Nspire Navigator Slide Show can be utilized to give students immediate feedback on their assessment.
- Summative assessment consists of a lab report (optional), questions/problems on the chapter test, inquiry project, performance assessment, or an application/elaborate activity.

# Air Resistance

When you solve physics problems involving free fall, often you are told to ignore air resistance and to assume the acceleration is constant. In the real world, because of air resistance, objects do not fall indefinitely with constant acceleration. One way to see this is by comparing the fall of a baseball and a sheet of paper when dropped from the same height. The baseball is still accelerating when it hits the floor. Air has a much greater effect on the motion of the paper than it does on the motion of the baseball. The paper does not accelerate very long before air resistance reduces the acceleration so that it moves at an almost constant velocity. When an object is falling with a constant velocity, we describe it with the term *terminal velocity*, or  $v_T$ . The paper reaches terminal velocity very quickly, but on a short drop to the floor, the baseball does not.

Air resistance is sometimes referred to as a *drag force*. Experiments have been done with a variety of objects falling in air. These sometimes show that the drag force is proportional to the velocity and sometimes that the drag force is proportional to the square of the velocity. In either case, the direction of the drag force is opposite to the direction of motion. Mathematically, the drag force can be described using  $F_{drag} = -bv$  or  $F_{drag} = -cv^2$ . The constants  $b$  and  $c$  are called the *drag coefficients* that depend on the size and shape of the object.

When falling, there are two forces acting on an object: the weight,  $mg$ , and air resistance,  $-bv$  or  $-cv^2$ . At terminal velocity, the downward force is equal to the upward force, so  $mg = -bv$  or  $mg = -cv^2$ , depending on whether the drag force follows the first or second relationship. In either case, since  $g$  and  $b$  or  $c$  are constants, the terminal velocity is affected by the mass of the object. Taking out the constants, this yields either

$$v_T \propto m \text{ or } v_T^2 \propto m$$

If we plot mass versus  $v_T$  or  $v_T^2$ , we can determine which relationship is more appropriate.

In this experiment, you will measure terminal velocity as a function of mass for falling coffee filters, and use the data to choose between the two models for the drag force. Coffee filters were chosen because they are light enough to reach terminal velocity in a short distance.

## OBJECTIVES

- Observe the effect of air resistance on falling coffee filters.
- Determine how air resistance and mass affect the terminal velocity of a falling object.
- Choose between two competing force models for the air resistance on falling coffee filters.








## MATERIALS

TI-Nspire handheld **or**  
 computer and TI-Nspire software  
 CBR 2 **or** Go!Motion **or**  
 Motion Detector and data-collection interface  
 5 basket-style coffee filters

*DataQuest 13***PRELIMINARY QUESTIONS**



1. Hold a single coffee filter in your hand. Release it and watch it fall to the ground. Next, nest two filters and release them. Did two filters fall faster, slower, or at the same rate as one filter? What kind of mathematical relationship do you predict will exist between the velocity of fall and the number of filters?
2. If there were no air resistance, how would the rate of fall of a coffee filter compare to the rate of fall of a baseball?
3. Sketch your prediction of a graph of the velocity *vs.* time for one falling coffee filter.
4. When the filter reaches terminal velocity, what is the net force acting upon it?

**PROCEDURE**

1. Position the Motion Detector on the floor, pointing up, as shown in Figure 1.
2. Connect the Motion Detector to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer. (If you are using a CBR 2 or Go!Motion, you do not need a data-collection interface.)
3. Set up the DataQuest Application for data collection.
  - a. Choose New Experiment from the  Experiment menu.
  - b. For this experiment, the default collection rate of 20 samples per second for 5 seconds will be used.
  - c. Click on the Graph View tab () to display the graph.
  - d. Select Show Graph ► Graph 1 from the  Graph Menu to show only the Position *vs.* Time graph.
4. Hold a coffee filter about 1 m above the Motion Detector. Start data collection (). After a moment, release the coffee filter so that it falls toward the motion detector on the floor.
5. Examine your position graph. At the start of the graph, there should be a region of decreasing slope (increasing velocity in the downward direction), and then the plot should become linear. If the motion of the filter was too erratic to get a smooth graph, you will need to repeat the measurement. With practice, the filter will fall almost straight down with little sideways motion. If necessary, collect the data again by simply starting data collection () when you are ready to release the filter. Continue to repeat this process until you get a smooth graph.
6. The linear portion of the position *vs.* time graph is where the filter was falling with a constant or terminal velocity ( $v_T$ ). This velocity can be determined from the slope of the linear portion of the position *vs.* time graph.
  - a. Select the data in the linear region of the graph.
    - **For the handheld** – move the cursor to the start of the linear region. Press and hold the center click button () until the cursor changes to . Move the cursor to the end of the linear region by sliding your finger across the touchpad in the direction you want the

*Figure 1*






cursor to move. (For clickpad handhelds, use the left or right arrow keys to move the cursor.) Press **[esc]** to complete the selection.

- **For the computer software** – click and drag the cursor across the desired region.
- b. Choose Curve Fit ► Linear from the  Analyze menu.
  - c. Record the magnitude of the slope,  $m$ , as the terminal velocity in the data table. Select OK.
7. Repeat Steps 4–6 for two, three, four, and five coffee filters. Click the Store Latest Data Set button () before each collection with an additional filter.
  8. If desired, extend to six, seven and eight filters, but be sure to use a sufficient fall distance so that you have a large enough linear section of data.






## DATA TABLE

Number of filters	Terminal Velocity $v_T$ (m/s)	(Terminal Velocity) <sup>2</sup> $v_T^2$ (m <sup>2</sup> /s <sup>2</sup> )
1		
2		
3		
4		
5		
6		
7		
8		

## ANALYSIS

1. To help choose between the two models for the drag force, plot terminal velocity,  $v_T$ , and the square of terminal velocity,  $v_T^2$ , vs. number of filters (mass).
  - a. Disconnect all sensors from your handheld or computer.
  - b. Insert a new problem in your TI-Nspire document and insert the DataQuest App.
    - **For the handheld** – press **[doc]** (**[ctrl]** ) for clickpad handhelds) and choose Problem from the Insert menu. Press **[on]** and then select  Vernier DataQuest.
    - **For the computer software** – choose Problem from the Insert menu and then choose  Vernier DataQuest from the Insert menu.
  - c. Click on the Table View tab () to view the table.
  - d. Double-click on the x-column to open the column options.
  - e. Change the Name to **Number of Filters**. Enter **Filters** as the Short Name and leave the units blank.
  - f. Change the Display Precision to show **0 Decimal places**. Select OK.
  - g. Double-click on the y-column to open the column options.
  - h. Change the Name to **Terminal V**. Enter **V<sub>t</sub>** as the short name and **m/s** as the units.
  - i. Select OK and enter the data in the table.
  - j. Choose New Calculated Column from the  Data Menu.
  - k. Enter **Terminal V<sup>2</sup>** as the Name, **V<sub>t</sub><sup>2</sup>** as the Short Name, and **(m/s)<sup>2</sup>** as the units.

**DataQuest 13**

- l. Enter **(Terminal V)^2** as the expression. **Note:** The term “Terminal V” must exactly match the name of the column. If you are unsure how it was entered, the available column names can be found below the Expressions entry box.
  - m. Select OK. Enter the column values in the Data Table.
  - n. Click on the Graph View tab () to view the graph.
  - o. Choose Select Y-axis Columns from the  Graph menu. Select the More option and select both the Terminal V and the Terminal V<sup>2</sup> columns to graph. Select OK.
  - p. Choose Window Settings from the  Graph menu. Change the X Min and Y Min values to 0. This will scale the graph to show the origin (0,0).
  - q. Do a proportional curve fit on the **Terminal V** data. Choose Curve Fit from the  Analyze menu, select the **Terminal V** data, and choose Proportional. Select OK.
  - r. Do a proportional curve fit on the **Terminal V<sup>2</sup>** data. Choose Curve Fit from the  Analyze menu, select the **Terminal V<sup>2</sup>** data, and choose Proportional. Select OK.
2. During terminal velocity the drag force is equal to the weight ( $mg$ ) of the filter. If the drag force is proportional to velocity, then  $v_T \propto m$ . Or, if the drag force is proportional to the square of velocity, then  $v_T^2 \propto m$ . From your graphs, which proportionality is consistent with your data; that is, which graph is closer to a straight line that *goes through the origin*?
  3. From the choice of proportionalities in the previous step, which of the drag force relationships ( $-bv$  or  $-cv^2$ ) appears to model the real data better? Notice that you are choosing between two different descriptions of air resistance—one or both may not correspond to what you observed.
  4. How does the time of fall relate to the weight ( $mg$ ) of the coffee filters (drag force)? If one filter falls in time,  $t$ , how long would it take four filters to fall, assuming the filters are always moving at terminal velocity?

**EXTENSIONS**

1. Make a small parachute and use the Motion Detector to analyze the air resistance and terminal velocity as the weight suspended from the chute increases. For this extension, you may wish to hold the motion detector above the parachute when collecting data.
2. Draw a free body diagram of a falling coffee filter. There are only two forces acting on the filter. Once the terminal velocity  $v_T$  has been reached, the acceleration is zero, so the net force,  $\Sigma F = ma = 0$ , must also be zero

$$\Sigma F = -mg + bv_T = 0 \quad \text{or} \quad \Sigma F = -mg + cv_T^2 = 0$$

depending on which drag force model you use. Given this, sketch plots for the terminal velocity ( $y$  axis) as a function of filter weight for each model ( $x$  axis). (Hint: Solve for  $v_T$  first.)





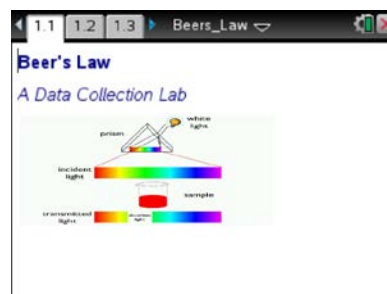
## Beer's Law Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

Open the TI-Nspire™ document *Beers\_Law\_PD.tns*.

The primary objective of this experiment is to determine the concentration of an unknown nickel (II) sulfate solution.



Move to pages 1.2–1.7.

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

### Discussion:

You will be using the colorimeter shown in Figure 1. In this device, red light from the LED light source will pass through the solution and strike a photocell. The  $\text{NiSO}_4$  solution used in this experiment has a deep green color. A higher concentration of the solution absorbs more (and transmits less) light than a solution of lower concentration. The colorimeter monitors the light received by the photocell as either an *absorbance* or a *percent transmittance* value.



Figure 1.

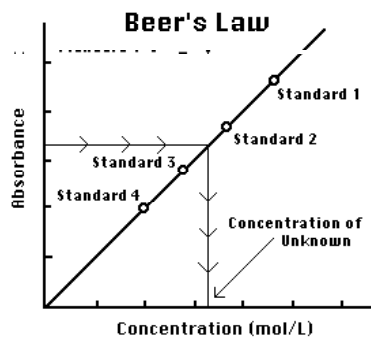


Figure 2.

You are to prepare five nickel sulfate solutions of known concentration (standard solutions). Each is transferred to a small, rectangular cuvette that is placed into the colorimeter. The amount of light that penetrates the solution and strikes the photocell is used to compute the absorbance of each solution. When a graph of absorbance versus concentration is plotted for the standard solutions, a direct relationship should result, as shown in Figure 2. The direct relationship between absorbance and concentration for a solution is known as Beer's law.

The concentration of an *unknown*  $\text{NiSO}_4$  solution is then determined by measuring its absorbance with the colorimeter. By locating the absorbance of the unknown on the vertical axis of the graph, the corresponding concentration can be found on the horizontal axis (follow the arrows in Figure 2). The concentration of the unknown can also be found using the slope of the Beer's law curve.



## Beer's Law Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

Move to page 1.8.

### Objectives:

- Prepare  $\text{NiSO}_4$  standard solution.
- Use a colorimeter to measure the absorbance value of each standard solution.
- Find the relationship between absorbance and concentration of a solution.
- Use the results of this experiment to determine the unknown concentration of another  $\text{NiSO}_4$  solution.

Move to pages 1.9–1.10.

### Materials:

TI-Nspire™ CX CAS handheld

Vernier Colorimeter

Double burette clamp

Wash bottle and distilled water

Test tube rack & Five 20 × 150 mm test tubes

30 mL of 0.40 M  $\text{NiSO}_4$

5 mL of  $\text{NiSO}_4$  unknown solution

paper towels

TI-Nspire™ Lab Cradle or Vernier EasyLink®

USB sensor interface

Two burettes

Ring stand

One cuvette

Stirring rod

KimWipes or tissues (preferably lint-free)

sink or waste basin

Move to page 1.11.

Answer the question on your TI-Nspire handheld.

Beer's Law

The wavelength of light used by the colorimeter should be \_\_\_\_\_ by the colored solution.

☐ absorbed

☐ transmitted

☐ reflected

☐ diffracted

Move to page 1.12.

Answer the question on your TI-Nspire handheld.

Beer's Law

The  $\text{NiSO}_4$  solution used in the experiment has a deep \_\_\_\_\_ color

☐ red

☐ blue

☐ yellow

☐ green



# Beer's Law

## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

**Move to page 1.13.**

Answer the question on your TI-Nspire handheld.

For this experiment, the LED of the colorimeter needs to be set to \_\_\_\_\_.

- ☐ red
- ☐ blue
- ☐ yellow
- ☐ green

**Move to page 1.14.**

Answer the question on your TI-Nspire handheld.

A higher concentration of solution absorbs \_\_\_\_\_ light.

- ☐ less
- ☐ more
- ☐ no
- ☐ twice as much

**Move to page 1.15.**

Answer the question on your TI-Nspire handheld.

The relationship between absorbance and concentration is \_\_\_\_\_.

- ☐ direct
- ☐ inverse
- ☐ indirect
- ☐ exponential

**Move to page 1.16.**

Answer the question on your TI-Nspire handheld.

The linear relationship between absorbance and concentration is called \_\_\_\_\_ Law.

- ☐ Boyle's
- ☐ Charles'
- ☐ Beer's
- ☐ Henry's

**Move to page 1.17.**

Answer the question on your TI-Nspire handheld.

The concentration of the unknown can be determined by using the \_\_\_\_\_ of the regression line on the graph.

- ☐ y-intercept
- ☐ x-intercept
- ☐ slope
- ☐ reciprocal



**Move to page 2.1.**

**Procedure:**

1. Obtain and wear goggles. CAUTION: Be careful not to ingest any nickel (II) sulfate solution or spill any on your skin.
2. Label five clean, dry, test tubes 1–5. Draw from a burette 2, 4, 6, 8, and 10 mL of 0.40 M nickel (II) sulfate solution into Test Tubes 1–5, respectively.

**Move to page 2.2.**

From the second burette, deliver 8, 6, 4, and 2 mL of distilled water into Test Tubes 1–4, respectively. Do not add any water to Test Tube 5. Thoroughly mix each solution with a stirring rod. Clean and dry the stirring rod between stirrings. Concentrations for the trials are: 0.08 M, 0.16 M, 0.24 M, 0.32 M, and 0.40 M respectively.

**Move to page 2.3.**

3. Prepare a blank by filling an empty cuvette  $\frac{3}{4}$ -full with distilled water. To correctly use a cuvette, remember:
  - All cuvettes should be wiped clean and dry on the outside with a tissue.
  - Handle cuvettes only by the top edge of the ribbed sides.
  - All solutions should be free of bubbles.
  - Always position the cuvette so the light passes through the clear sides.

**Move to page 2.4.**

4. Connect the colorimeter to the data-collection interface. Connect the interface to your TI-Nspire handheld. See Figure 3 on the following page.

**Move to page 2.5.**

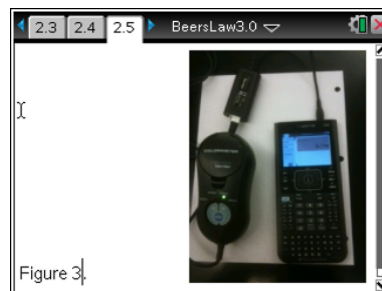


Figure 3.



## Beer's Law Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

**Move to page 2.6.**

5. Calibrate the colorimeter.
  - a. Select **Menu > Experiment > New Experiment** to reset the TI-Nspire handheld.
  - b. Place the blank in the cuvette slot of the colorimeter and close the lid.
  - c. Press the < or > buttons on the colorimeter to set the wavelength to 635 nm (Red). Then calibrate by pressing the **CAL** button on the colorimeter. When the LED stops flashing, the calibration is complete.

**Move to page 2.7.**

6. Set up the data-collection mode and change the scale options for the graph.
  - a. Select **Menu > Experiment > Collection Mode > Events with Entry**.
  - b. Enter Concentration as the Name and mol/L as the Units. Select OK.
  - c. Choose *Autoscale Settings* from the *Options* menu.

**Move to page 2.8.**

Select *Autoscale from Zero* as the *After Collection* setting. Select OK.

**Move to page 2.9.**

7. You are now ready to collect data for the five standard solutions.
  - a. **Start** data collection.
  - b. Empty the water from the cuvette. Using the solution in Test Tube 1, rinse the cuvette twice into the sink or waste basin with ~1 mL amounts and then fill it  $\frac{3}{4}$ -full. Wipe the outside with a tissue and place it in the colorimeter. Close the lid.

**Move to page 2.10.**

8. When the value displayed on the screen has stabilized, click the **Keep (Camera)** button and enter 0.080 as the concentration in mol/L. Select OK. The absorbance and concentration values have now been saved for the first solution.



**Move to page 2.11.**

9. Discard the cuvette contents as directed by your instructor. Using the solution in Test Tube 2, rinse the cuvette twice with ~1 mL amounts, and then fill it  $\frac{3}{4}$ -full. Place the cuvette in the colorimeter and close the lid. Wait for the value displayed on the screen to stabilize and click the **Keep** button. Enter 0.16 as the concentration in mol/L. Select OK.

**Move to page 2.12.**

10. Repeat the procedure for Test Tube 3 (0.24 M) and Test Tube 4 (0.32 M), as well as the stock 0.40 M NiSO<sub>4</sub>. Note: Wait until Step 9 to test the unknown.
- Stop** data collection.
  - Click *Table View* to display the data table. Record the absorbance and concentration data values in your data table.

**Move to page 2.13.**

11. Display a graph of absorbance versus concentration with a linear regression curve.
- Click Graph View.
  - Select **Menu > Analyze > Curve Fit: Linear**. The linear-regression statistics are displayed in the form:  $y = mx + b$  where  $x$  is concentration,  $y$  is absorbance,  $m$  is the slope, and  $b$  is the  $y$ -intercept.

**Move to page 2.14.**

One indicator of the quality of your data is the size of  $b$ . It is a very small value if the regression line passes through or near the origin. The correlation coefficient,  $r$ , indicates how closely the data points match up with (or fit) the regression line. A value of 1.00 indicates a nearly perfect fit.

**Move to page 2.15.**

The graph should indicate a direct relationship between absorbance and concentration, a relationship known as Beer's Law. The regression line should closely fit the five data points and pass through (or near) the origin of the graph.



**Move to page 2.16.**

12. Determine the absorbance value of the unknown  $\text{NiSO}_4$  solution.
  - a. Click Meter View.
  - b. Obtain about 5 mL of the unknown  $\text{NiSO}_4$  in another clean, dry, test tube. Record the number of the unknown in your data table.

**Move to page 2.17.**

13. Rinse the cuvette twice with the unknown solution and fill it about  $\frac{3}{4}$ -full. Wipe the cuvette and place it in the device.  
  
Monitor the absorbance value. When this value has stabilized, record it in your data table on the student activity sheet.
14. Discard the solutions as directed by your instructor. Go to Step 1 of Calculations.

**Move to page 3.1.**

Calculations:

1. To determine the concentration of the unknown  $\text{NiSO}_4$  solution, interpolate along the regression line to convert the absorbance value of the unknown to concentration.
  - a. Click Graph View.
  - b. Select **Menu > Analyze > Interpolate**.

**Move to page 3.2.**

2. Select any point on the regression curve. Use > and < to find the absorbance value that is closest to the absorbance reading you obtained in Step 9. The corresponding  $\text{NiSO}_4$  concentration, in mol/L, will be displayed.  
  
Record the concentration value in your data table on the student activity sheet.

**Move to page 3.3.**

3. Use a graphing program such as Vernier LoggerPro™ to make and print a graph of absorbance versus concentration, with a regression line and interpolated unknown concentration displayed.



# Beer's Law

## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

**Move to page 3.4.**

Answer the question on your TI-Nspire handheld.

**Move to page 3.5.**

Answer the question on your TI-Nspire handheld.

**Move to page 4.1.**

Answer the question on your TI-Nspire handheld.

**Move to page 4.2.**

Answer the question on your TI-Nspire handheld.

**Move to page 4.3.**

Answer the question on your TI-Nspire handheld.





# Beer's Law

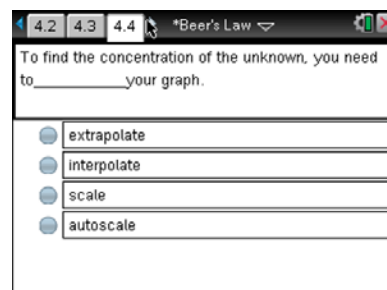
## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

Move to page 4.4.

Answer the question on your TI-Nspire handheld.



### Data Table

Trial	Concentration (mol/L)	Absorbance
1	0.080	
2	0.16	
3	0.24	
4	0.32	
5	0.40	
6	Unknown number ____	
Concentration of unknown		mol/L

**This page intentionally left blank**



## Science Objectives

- Students will make a serial dilution of a  $\text{NiSO}_4$  standard solution.
- Students will use a Colorimeter to measure the absorbance value of each standard solution.
- Students will find the relationship between absorbance and concentration of a solution.
- Students will use the results of this experiment to determine the unknown concentration of another  $\text{NiSO}_4$  solution.

## Vocabulary

- colorimeter
- transmittance
- absorbance
- slope
- y-intercept
- correlation coefficient

## About the Lesson

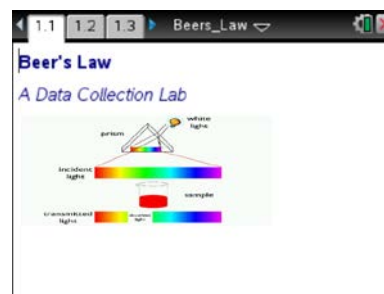
- This lesson involves absorbance data for solutions of various concentrations.
- As a result, students will...
  - Become familiar with TI-Nspire™ CX CAS technology and the Vernier DataQuest™ app for TI-Nspire.
  - Use this graph to make conclusions about the experiment.
  - Use a colorimeter to make measurements
  - Analyze a graph of the data.

## TI-Nspire™ Navigator™ System

- Send the *Beers\_Law\_PD.tns* document to students.
- Use Class Capture to monitor student progress.
- Collect and grade the *Beer's\_Law\_PD.tns* documents.

## Activity Materials

- TI-Nspire™ CX CAS handheld
- TI-Nspire™ Lab Cradle or Vernier EasyLink™ USB sensor interface
- Vernier colorimeter
- Two burettes
- Double burette clamp



## TI-Nspire™ Technology Skills:

- Download a TI-Nspire document
- Open a document
- Move between pages
- Use the Vernier DataQuest app for TI-Nspire

## Tech Tips:

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

## Lesson Files:

### Student Activity

- *Beers\_Law\_Student\_PD.pdf*
- *Beers\_Law\_Student\_PD.doc*

### TI-Nspire document

- *Beers\_Law\_PD.tns*

Visit [www.scieenspired.com](http://www.scieenspired.com) for lesson updates and tech tip videos. (Optional)



- Ring stand
- Wash bottle and distilled water
- One cuvette
- Test tube rack and five 20 × 150 mm test tubes
- Stirring rod
- Use 8–9 drops of green food coloring per liter of water to mimic 0.40 M  $\text{NiSO}_4$ . (Nickel is a carcinogen, so the green food coloring is an excellent substitute.) Check the absorbance of this stock solution to be certain it falls in the range of 0.40 to 0.80.
- KimWipes or tissues (preferably lint-free)
- 5 mL of “ $\text{NiSO}_4$ ” unknown solution; for example, 55 mL of “stock” solution and 45 mL of water, 0.22 M

## Discussion Points and Possible Answers

**Tech Tip:** Use Class Capture to monitor student progress.

### Move to page 1.11.

The wavelength of light used by the colorimeter should be \_\_\_\_\_ by the colored solution.

**Answer:** absorbed

### Move to page 1.12.

The  $\text{NiSO}_4$  solution used in the experiment has a deep \_\_\_\_\_ color.

**Answer:** green

### Move to page 1.13.

For this experiment, the LED of the colorimeter needs to be set to \_\_\_\_\_.

**Answer:** red



Move to page 1.14.

A higher concentration of solution absorbs \_\_\_\_\_ lights.

**Answer:** more

Move to page 1.15

The relationship between absorbance and concentration is \_\_\_\_\_.

**Answer:** direct

Move to page 1.16.

The linear relationship between absorbance and concentration is called \_\_\_\_\_ Law.

**Answer:** Beer's

Move to page 1.17.

The concentration of the unknown can be determined by using the \_\_\_\_\_ of the regression line on the graph.

**Answer:** slope

Move to page 3.4.

**Answer:**  $x = (y - b)/m$



Move to page 3.5.

**Answer:** (This is a sample calculation.)

$$x = [0.308 - (-0.0022)]/1.17 = 0.265 \text{ mol/L}$$

Move to page 4.1.

As the concentration of the nickel (II) sulfate solution increased, the absorbance \_\_\_\_\_.

**Answer:** increased

Move to page 4.2.

The closer the value of \_\_\_\_\_ was to zero, the better your data.

**Answer:** *b*

Move to page 4.3.

The closer the value of *r* is to \_\_\_\_\_, the better your data.

**Answer:** 1.00

Move to page 4.4.

To find the concentration of the unknown, you need to \_\_\_\_\_ your graph.

**Answer:** interpolate


**TI-Nspire™ Navigator™ Opportunity**

Use the TI-Nspire Navigator System to draw back, grade, and save the TI-Nspire document to the Portfolio. Use *Slide Show* to view student responses.

**Data Table (Sample Data)**

Trial	Concentration (mol/L)	Absorbance
1 □ 0.080 □ 0.089	0.089	52 □ 0.16 □ 0.186 □ 0.281
3	0.24	0.281
4	0.32	0.374
5	0.40	0.463
6	Unknown number ____	0.308
Concentration of unknown		0.265 mol/L

**Wrap Up**

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

- how to connect the TI-Nspire™ Lab Cradle to the TI-Nspire™ CX CAS handheld.
- how to connect sensors to the TI-Nspire Lab Cradle.
- how to gather and analyze data.
- the relationship between the absorbance and concentration of a solution.

**Assessment**

Students will complete the embedded multiple-choice questions in the *Beers\_Law\_PD.tns* document. Students will also answer questions on the student activity sheet.

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# How Much Does It Weigh?

## TI PROFESSIONAL DEVELOPMENT

### Activity Overview

*In this activity, you will navigate through a TI-Nspire™ document, answer questions, manipulate a graphic, and input values into a spreadsheet.*

### Part One—Opening the Document

#### Step 1:

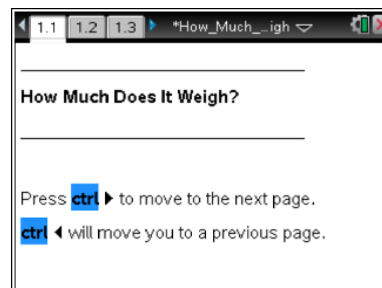
Press and select **My Documents**.

#### Step 2:

Locate *How\_Much\_Does\_It\_Weigh.tns* and press to open it. If asked whether or not you want to save the current document, choose No (unless you want to save it).

#### Step 3:

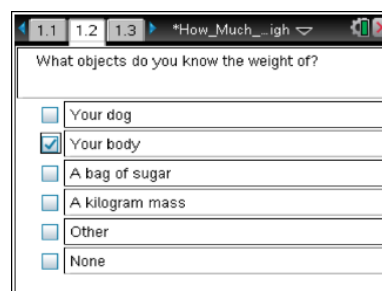
Once the document opens, press to move to page 1.2.



### Part Two—Selecting an Answer

#### Step 4:

To answer the question, press the down arrow on the bottom of the Touchpad to move to the desired response.



#### Step 5:

Press to select a response. On questions with multiple responses allowed, you deselect the answer by pressing a second time or select **Menu > Clear Answers**.

Another option for selecting an answer is to swipe your finger across the Touchpad to move the cursor, and click to make a selection.

#### Step 6:

After choosing all desired responses, press to move to page 1.3.




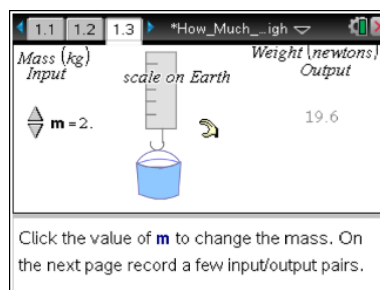
## How Much Does It Weigh?

### TI PROFESSIONAL DEVELOPMENT


#### Part Three—Changing the Input for the Mass

##### Step 7:

Move the cursor to the up and down arrows under the text *Mass (kg) Input*. Click , and use the up and down arrows on the Touchpad to change the values.





##### Step 8:

Also try clicking the number next to  $m =$  and manually change the value. Use the arrows to get to the end, press  to backspace over the previous value, and enter a new value.

##### Step 9:

Press  to evaluate this value.

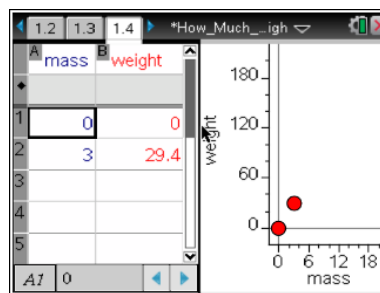
##### Step 10:

Press   to move to the next page. A scatter plot of force/weight versus mass has been set up.


#### Part Four—Editing the Spreadsheet

##### Step 11:

Record the input and output values in the spreadsheet on page 1.4, using the arrows to move to the desired cell.





##### Step 12:

Press the number on the keypad, and press .

What science concepts can be explored with this activity?

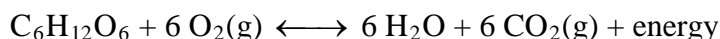
What questions can we ask to highlight the math concepts?

##### Step 13:

Press   to move to pages 1.5–1.8 to answer the open-response and multiple-choice questions. In this question document, multiple responses not allowed.

# Cell Respiration

Cell respiration refers to the process of converting the chemical energy of organic molecules into a form immediately usable by organisms. Glucose may be oxidized completely if sufficient oxygen is available and is summarized by the following reaction:



All organisms, including plants and animals, oxidize glucose for energy. Often, this energy is used to convert ADP and phosphate into ATP. It is known that pea seeds undergo cell respiration during germination. Do pea seeds undergo cell respiration before germination? Using your collected data, you will be able to answer this question concerning respiration and non-germinated peas.

Using the CO<sub>2</sub> Gas Sensor, you will monitor the carbon dioxide produced by pea seeds during cell respiration. Both germinated and non-germinated peas will be tested. Additionally, cell respiration of germinated peas at two different temperatures will be tested.

## OBJECTIVES

In this experiment, you will

- Use a CO<sub>2</sub> Gas Sensor to measure concentrations of carbon dioxide during cell respiration.
- Study the effect of temperature on cell respiration rate.
- Determine whether germinating peas and non-germinating peas respire.
- Compare the rates of cell respiration in germinating and non-germinating peas.

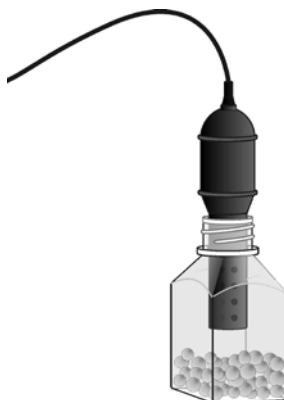


Figure 1

## MATERIALS






TI-Nspire handheld or  
computer and TI-Nspire software  
data-collection interface  
Vernier CO<sub>2</sub> Gas Sensor  
100 mL beaker

250 mL respiration chamber  
25 germinated pea seeds  
25 non-germinated pea seeds  
ice cubes  
thermometer


**DataQuest 14**

---

**PROCEDURE**

1. If your CO<sub>2</sub> Gas Sensor has a switch, set it to the Low (0–10,000 ppm) setting. Connect the sensor to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer.
2. Choose New Experiment from the  Experiment menu. Choose Collection Setup from the  Experiment menu. Enter **300** as the experiment duration in seconds. The number of points collected should be 76. Select OK.
3. Measure the room temperature using a thermometer and record the temperature in Table 1.
4. Obtain 25 germinated pea seeds and blot them dry between two pieces of paper towel.
5. Place the germinated peas into the respiration chamber.
6. Place the shaft of the CO<sub>2</sub> Gas Sensor in the opening of the respiration chamber.
7. Wait one minute, then start data collection (). Data will be collected for 300 seconds.
8. When data collection has finished, a graph of carbon dioxide gas vs. time will be displayed.
9. Remove the CO<sub>2</sub> Gas Sensor from the respiration chamber. Place the peas in a 100 mL beaker filled with cold water and an ice cube. The cold water will prepare the peas for part II of the experiment.
10. Use a notebook or notepad to fan air across the openings in the probe shaft of the CO<sub>2</sub> Gas Sensor for 1 minute.
11. Fill the respiration chamber with water and then empty it. Thoroughly dry the inside of the respiration chamber with a paper towel.
12. Determine the rate of respiration.
  - a. Examine the graph and identify the most linear region and select the data points in the most linear region.
  - b. Choose Curve Fit ► Linear from the  Analyze menu.
  - c. Record the slope,  $m$ , as the rate of respiration in ppm/s in Table 2.
13. Click the Store Latest Data Set button () to save the first run data. Repeat Steps 5–12 substituting the germinated peas with non-germinated pea seeds. In Step 9 place the non-germinated peas on a paper towel and not in the ice bath.

**Part II Germinated peas, cool temperatures**

14. Remove the germinated pea seeds from the cold water and blot them dry between two paper towels.
15. Click the Store Latest Data Set button () to save the second run data. Repeat Steps 5–12 using the cold peas.

16. Graph all three runs of data on a single graph.
- Click **run3** and select All. All three runs will now be displayed on the same graph axes.
  - Use the displayed graph and Tables 1 and 2 to answer the questions below.

## DATA

Table 1	
Room Temperature (°C)	

Table 2	
Peas	Rate of respiration (ppm/s)
Germinated, room temperature	
Non-germinated, room temperature	
Germinated, cool temperature	

## QUESTIONS

- Do you have evidence that cell respiration occurred in peas? Explain.
- What is the effect of germination on the rate of cell respiration in peas?
- What is the effect of temperature on the rate of cell respiration in peas?
- Why do germinated peas undergo cell respiration?

## EXTENSIONS

- Compare the respiration rate among various types of seeds.
- Compare the respiration rate among seeds that have germinated for different time periods, such as 1, 3, and 5 days.
- Compare the respiration rate among various types of small animals, such as insects or earthworms.

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# Barometric Pressure

## Student Activity

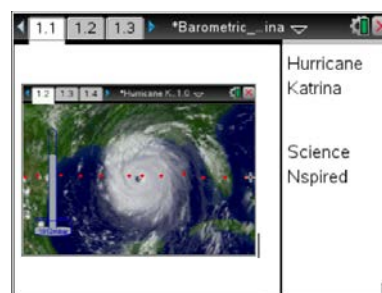
Name \_\_\_\_\_

Class \_\_\_\_\_

### Open the TI-Nspire document

#### *Barometric\_Pressure\_in\_Hurricane\_Katrina.tns.*


In this simulation, you will examine parts of a hurricane. You will discover how barometric pressure changes in relation to a hurricane.



### Launch the simulation.



When you start the simulation, you will see an aerial view of Hurricane Katrina as it approaches the East Coast of the United States.

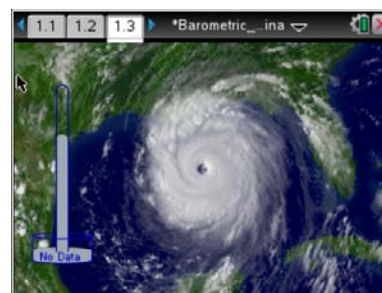
### Move to Page 1.2.

Read the Background screen on Hurricane Katrina. Then read the directions menu on page 1.3 for navigating the activity. Click  in the upper right corner to close the menu and begin the activity.

### Part 1: Exploring Barometric Pressure and Parts of a Hurricane

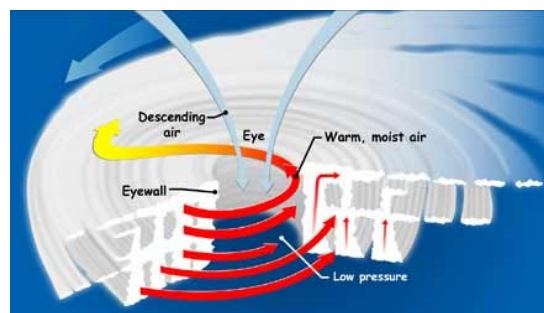
Air molecules are so tiny you cannot see them, but they still have weight and take up space. The force put on you by the weight of air molecules is called air pressure. Another name for air pressure is **barometric pressure**. The space between air molecules can vary, so the barometric pressure can also vary. In high pressure air, the air molecules are closer together than in low pressure air. Weather forecasters measure air pressure with a barometer. Barometric pressure is measured in **millibars**.

1. Slowly move the cursor using ◀ and ▶ across the image near the center of the hurricane until you see the cursor change from  to a plus sign . Notice that there is a barometer on the left side of the screen. Move the cursor in a straight line from left to right across the entire screen and observe the barometer.



Q1. Describe what happens to the barometer as you move the cursor across the screen.

2. Observe the structure of a hurricane in the diagram to the right. The **eye** is a circular area at the center of a hurricane. Just outside the eye is the **eyewall**, where the hurricane's most intense rain and wind are found.



[<http://spaceplace.nasa.gov/hurricanes/>]



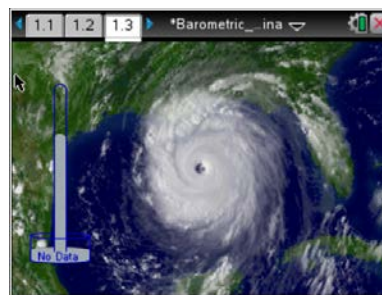
# Barometric Pressure

## Student Activity

Name \_\_\_\_\_

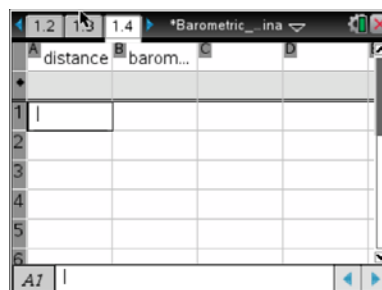
Class \_\_\_\_\_

3. Click **[esc]** to clear data points that may have previously been clicked. Move the cursor to the eye of the hurricane and click on it using . Then, move the cursor to the edge of the coast and click on it.



**Move to page 1.4.**

4. A chart shows the data you collected from the points you clicked on. The distance is measured in kilometers from an unknown location on land.



Q2. Complete the table shown below.

Location of Data Point	Distance (km) From Unknown Location
Eye of Hurricane	
Coast	

Q3. True or False: Based on your data, the eye of Hurricane Katrina is more than 1,500 kilometers away from the coast.

5. Click **[esc]** to remove data points that have previously been placed. This will also clear the spreadsheet and the scatter plot on pages 1.4 and 1.5.







# Barometric Pressure

## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

- Q4. Notice that Hurricane Katrina has a circular shape. Move the cursor and collect two data points at the outer edges of the hurricane to find its diameter. Complete the table shown below here on this activity sheet.

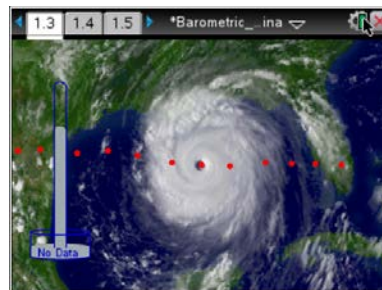
Location of Data Point	Distance (km) From Unknown Location
Right Side	
Left Side	

- Q5. Based on your data, what is the approximate diameter of Hurricane Katrina?

- A. 60 kilometers
- B. 550 kilometers
- C. 800 kilometers
- D. 1,250 kilometers

### Part 2: Analyzing Barometric Pressure

6. You've seen what happens to the barometer when you moved the cursor across the screen. Now you will collect more data and analyze what happens to the barometric pressure. Press **esc** to clear your data.
7. Move the cursor horizontally across the screen and collect 12 data points in a straight line. Start on land and move east, out into the Atlantic Ocean and across Hurricane Katrina. Be sure to collect data from the coast, the outer edges of the hurricane, and the eye of the hurricane.





# Barometric Pressure

## Student Activity

Name \_\_\_\_\_

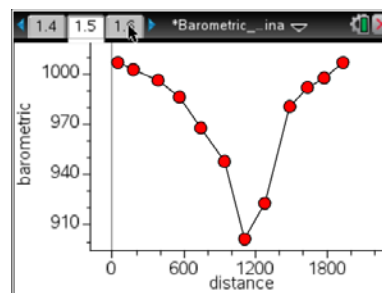
Class \_\_\_\_\_

- Q6. Go to page 1.4 that shows the spreadsheet with data you collected. Copy your data from the spreadsheet to complete the table shown below.

Data Point	Distance (km)	Barometric Pressure (mb)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Move to page 1.5.

- Q7. Look at the line graph. Describe the line graph. Where is barometric pressure highest on the graph? Where is barometric pressure lowest on the graph? In what part of the hurricane is barometric pressure lowest?



**How do hurricanes work?** Hurricanes form when warm, moist air over the ocean rises up from the surface, causing an area of lower barometric pressure below it. Higher pressure air from surrounding areas then pushes into the low pressure area, warming it and making it rise too. As the warm air rises, the surrounding air keeps rushing in to take its place. The warm air cools as it rises, and the moisture in the air forms clouds. This cycle of rising, swirling, and cooling air creates a system of clouds and wind that grows, fed by heat and moisture from the ocean.

- Q8. What causes strong winds in a hurricane?



# Barometric Pressure

## Student Activity

Name \_\_\_\_\_

Class \_\_\_\_\_

As the hurricane rotates faster and faster, an eye forms in the center. The lower the barometric pressure in the eye of the hurricane, the more intense the storm is considered.

Q9. Based on your data, what was the barometric pressure in the eye of Hurricane Katrina?

Q10. Suppose the eye of Hurricane X had a barometric pressure of 975 millibars. Which hurricane was more intense? Why?

### Part 3: Classifying a Hurricane

Hurricanes are classified according to their central pressure, wind speed, and potential to cause damage. Central pressure is the pressure in the eye of the hurricane. The table below shows the Saffir/Simpson Hurricane Scale, which is used to classify hurricanes.

SAFFIR/SIMPSON HURRICANE SCALE			
Category	Central Pressure (mb)	Winds (mph)	Damage
<a href="#">1</a>	>980	74-95	Minimal
<a href="#">2</a>	965-979	96-110	Moderate
<a href="#">3</a>	945-964	111-130	Extensive
<a href="#">4</a>	920-944	131-155	Extreme
<a href="#">5</a>	<920	155+	Catastrophic

Q11. Use the data you found in Question 9 for the central pressure of Hurricane Katrina to classify it on the Saffir/Simpson Hurricane Scale. What category is Hurricane Katrina? Explain.

Q12. Based on the Saffir/Simpson Hurricane Scale, what category is Hurricane X?

Q13. Based on the Saffir/Simpson Hurricane Scale, did Hurricane X cause more or less damage than Hurricane Katrina? Explain.

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# Barometric Pressure

## MIDDLE GRADES SCIENCE NSPIRED

## TEACHER NOTES

### Science Objectives

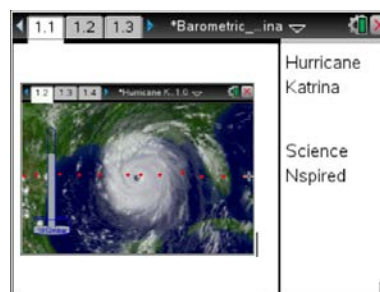
- Students will examine and describe parts of a hurricane.
- Students will discover how barometric pressure changes in relation to a hurricane.

### Vocabulary

- barometric pressure
- millibars
- eye of a hurricane
- eyewall

### About the Lesson

- This lesson is a simulation of barometric pressure measured across different points in relation to Hurricane Katrina. This provides an opportunity for students to gather data and explore parts of a hurricane and how barometric pressure changes in relation to the hurricane.
- As a result, students will:
  - Measure the distance of the eye of Hurricane Katrina from the coast and measure the diameter of the hurricane.
  - Collect data on barometric pressure across different points of an aerial view of Hurricane Katrina.
  - Use collected data to classify Hurricane Katrina on the Saffir/Simpson Hurricane Scale.



### TI-Nspire™ Technology Skills:

- Open a document
- Drag and click the cursor to collect data

### Lesson Materials:

#### Student Activity

- Barometric\_Pressure\_in\_Hurricane\_Katrina\_Student.doc
- Barometric\_Pressure\_in\_Hurricane\_Katrina\_Student.pdf
- Barometric\_Pressure\_in\_Hurricane\_Katrina.tns

### TI-Nspire™ Navigator™

- Send out the *Barometric\_Pressure\_in\_Hurricane\_Katrina.tns* file.
- Monitor student progress using Screen Capture.
- Use Live Presenter to allow students to show how they manipulate variables that effect results.

### Activity Materials

- TI-Nspire™ Technology



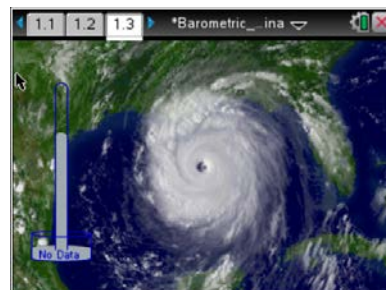
### Discussion Points and Possible Answers

#### Launch the simulation.

When students start the simulation, they will see an aerial view of Hurricane Katrina as it approaches the East Coast of the United States.

#### Move to Page 1.2.

Allow students time to read the Background on Hurricane Katrina.



#### Move to Page 1.3.

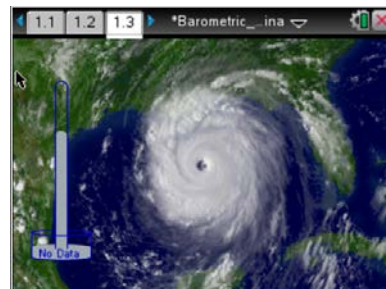
After students read the directions, they should click  (the red X) in the upper right corner to close the menu and begin the activity.

### Part 1: Exploring Barometric Pressure and Parts of a Hurricane

In this part of the lesson students explore barometric pressure and parts of a hurricane.

Allow students time to read the information in the student activity sheet explaining barometric pressure. Make sure students note where the barometer is located on the screen.

- Students will be moving the cursor across the screen using the left ◀ and ▶ right arrows. Make sure students can see that the cursor changes from an arrow ↘ to + (a plus sign) when it is on an area of the screen where data is available. Make sure students can observe that the barometer level can move up and down depending on where the cursor is located. They are not collecting data at this time.



### TI-Nspire Navigator Opportunities

Allow students to volunteer to be the Live Presenter and demonstrate areas on the screen where the cursor changes.

Students should have an intuitive understanding that the barometric pressure rises and falls depending on where the cursor is located on the screen. From their observations, students should conclude that the barometric pressure does not rise and fall randomly, but in a pattern.

Q1. Describe what happens to the barometer as you move the cursor across the screen.

**Answer:** The barometer changed levels as the cursor was dragged across the screen from left to right. It started at a high level, then dropped as it got closer to the center of the hurricane, then it rose again.

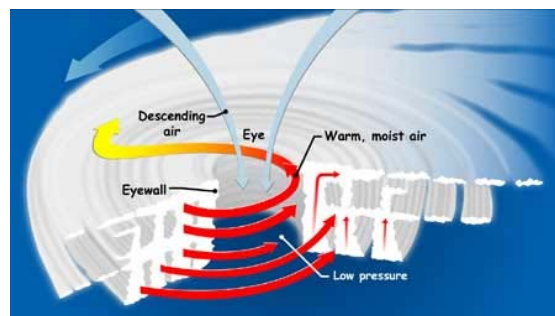


# Barometric Pressure

## MIDDLE GRADES SCIENCE NSPIRED

## TEACHER NOTES

- Allow students time to look at the diagram to the right on the activity sheet showing the structure of a hurricane. Make sure students understand where the land coast and the eye of a hurricane are located on the screen.



[<http://spaceplace.nasa.gov/hurricanes/>]

- Students will be clicking on areas of the screen to collect data points. Students need to move the cursor to the eye of the hurricane and click on it using . Then, move the cursor to the edge of the coast and click on it.



**Teacher Tech Tip:** To collect (or “save”) a data point, students should press . Make sure that they understand how to go to the next page to display the spreadsheet with the data they collected.

### Move to page 1.4.

- Data will vary from student to student and is dependent on where they placed their cursor. All students should see the same general patterns.

	distance	barom...
1	809.434	959
2	892.453	942
3	968.553	941
4	1030.82	930
5	1079.25	902
6	1112.84	900
A7	=809.43396226415	

Q2. Complete the table shown below.

### Sample answer:

Location of Data Point	Distance (km) From Unknown Location
Eye of Hurricane	1086.16
Coast	228.30

Q3. True or False: Based on your data, the eye of Hurricane Katrina is more than 1,500 kilometers away from the coast.

**Answer:** False



5. At any point, students can press **[esc]** to remove data points that have previously been placed. This will also clear the spreadsheet and the scatter plot on pages 1.4 and 1.5.
- Q4. Notice that Hurricane Katrina has a circular shape. Move the cursor and collect two data points at the outer edges of the hurricane to find its diameter. Complete the table shown below.

**Sample answer:**

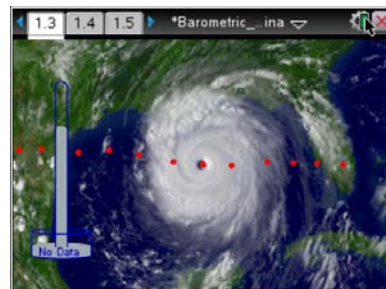
Location of Data Point	Distance (km) From Unknown Location
Right Side	1556.601
Left Side	754.088

- Q5. Based on your data, what is the approximate diameter of Hurricane Katrina?
- A. 60 kilometers  
 B. 550 kilometers  
**C. 800 kilometers**  
 D. 1250 kilometers

**Answer:** C

### Part 2: Analyzing Barometric Pressure

6. Make sure to go over that the barometer changes as the cursor is moved across the screen. Students will be collecting data from 12 points of the screen image. Students may have an intuitive understanding that barometric pressure is lowest in the central area of the hurricane, but now they will collect data to demonstrate this.
7. Students will be collecting collect data starting from inland and moving east. Make sure they use a systematic approach, spacing data points as evenly as possible. Also make sure they collect data from key points including the coast, the outer edges of the hurricane, and the eye of the hurricane.



Allow students time to analyze the line graph on page 1.5 resulting from the data collected. If they did not collect a key data point, allow them to clear their data and start over. Allow students time to read the information on the student activity sheet about how hurricanes form. Review any parts that the students do not understand.





# Barometric Pressure

## TEACHER NOTES

### MIDDLE GRADES SCIENCE NSPIRED

- Q6. Go to page 1.4 that shows the spreadsheet with data you collected. Copy your data from the spreadsheet to complete the table shown below.

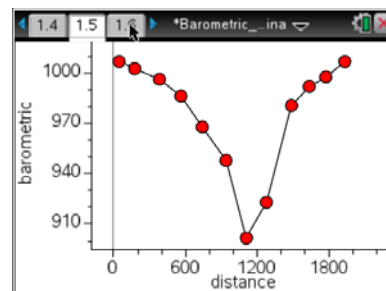
**Sample answer:**

Data Point	Distance (km)	Barometric Pressure (mb)
1	76.1006	1007
2	221.384	1001
3	408.176	996
4	574.214	986
5	726.415	968
6	830.139	950
7	961.635	941
8	1093.08	902
9	1224.53	919
10	1335.22	930
11	1487.42	981
12	1667.3	994

Move to page 1.5.

- Q7. Look at the line graph. Describe the line graph. Where is barometric pressure highest on the graph? Where is barometric pressure lowest on the graph? In what part of the hurricane is barometric pressure lowest?

**Answer:** The line graph is a V-shape. Barometric pressure is highest at the beginning and the end of the graph. Barometric pressure is lowest in the middle of the graph. Barometric pressure is lowest in the eye of the hurricane.



**Teacher Tip:** Student graphs will vary based on data.

### How do hurricanes work?

Allow students time to read the information about how hurricanes work on the student activity sheet. Go over any parts that the students do not understand.

- Q8. What causes strong winds in a hurricane?

**Answer:** Winds are the result of high pressure air rushing into the area of low pressure at the center of the hurricane.



Q9. Based on your data, what was the barometric pressure in the eye of Hurricane Katrina?

**Sample answer:** 902 mb

Q10. Suppose the eye of Hurricane X had a barometric pressure of 975 millibars. Which hurricane was more intense? Why?

**Sample answer:** Hurricane Katrina was more intense because its eye had a lower barometric pressure.

### Part 3: Classifying a Hurricane

From parts 1 and 2, students should now have a formal understanding of how barometric pressure is related to hurricanes. Central pressure is the pressure in the eye of the hurricane. Students should understand that the lower the central pressure of a hurricane, the more intense it is. Go over the Saffir/Simpson Hurricane Scale. Explain any terms students do not understand.

SAFFIR/SIMPSON HURRICANE SCALE			
Category	Central Pressure (mb)	Winds (mph)	Damage
1	>980	74-95	Minimal
2	965-979	96-110	Moderate
3	945-964	111-130	Extensive
4	920-944	131-155	Extreme
5	<920	155+	Catastrophic

Q11. Use the data you found in Question 9 for the central pressure of Hurricane Katrina to classify it on the Saffir/Simpson Hurricane Scale. What category was Hurricane Katrina? Explain.

**Answer:** Hurricane Katrina was category 5 because it had a central air pressure of less than 980 mb.

Q12. Based on the Saffir/Simpson Hurricane Scale, what category is Hurricane X?

**Answer:** Hurricane X was category 2 because it had a central air pressure between 965 and 979 mb.

Q13. Based on the Saffir/Simpson Hurricane Scale, did Hurricane X cause more or less damage than Hurricane Katrina? Explain.

**Answer:** Hurricane Katrina caused more damage than Hurricane X because a category 5 hurricane causes catastrophic damage, but a category 2 hurricane causes moderate damage.

**TI-Nspire Navigator Opportunities**

Use Quick Poll to check for understanding during the course of the activity.

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**Wrap Up**

When students are finished with the activity, pull back the .tns file using TI-Nspire Navigator. Save grades to Portfolio. Discuss activity questions using Slide Show.

**Assessment**

- Analysis questions are written into the student worksheet.

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# Getting Started with the TI-Nspire™ Family of Teacher Software

## TI PROFESSIONAL DEVELOPMENT

### Activity Overview

*In this activity, you will explore basic features of the TI-Nspire™ family of 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 Teacher Software. The Welcome Screen displays an icon for each of the eight 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 description of each option, hover the cursor over each icon. To view the Welcome Screen at any time, go to **Help > Welcome Screen**.

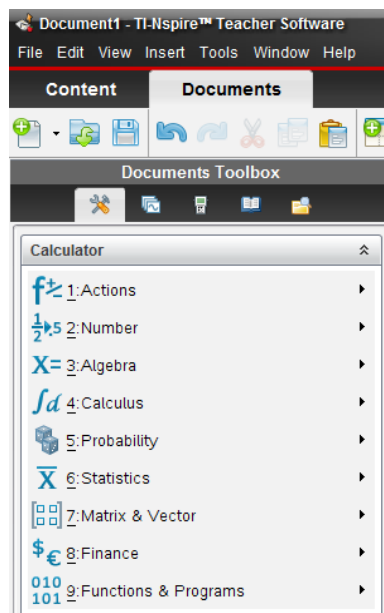
To create a new document with a Calculator application as the first page, click .

#### 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 .





## Getting Started with the TI-Nspire™ Family of Teacher Software

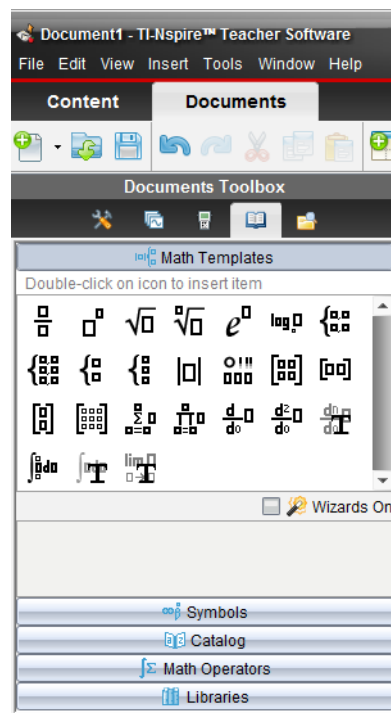
### TI PROFESSIONAL DEVELOPMENT

#### 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 on a PC, press **CTRL + Enter**. To display a decimal approximation on a Mac, press **Command + Enter**.

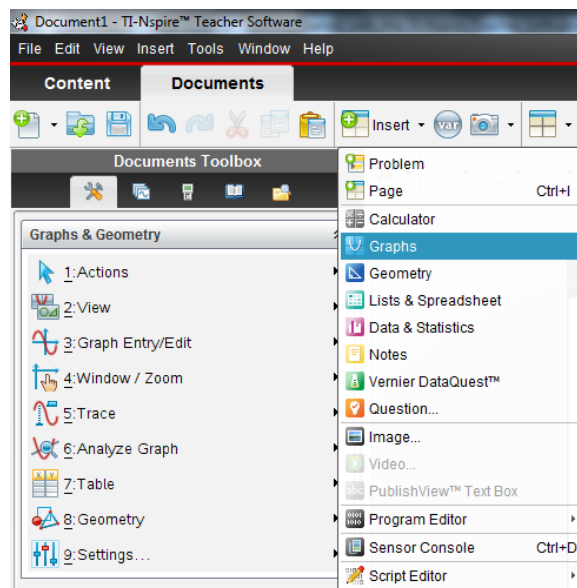


#### Step 4:

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.







## Getting Started with the TI-Nspire™ Family of Teacher Software

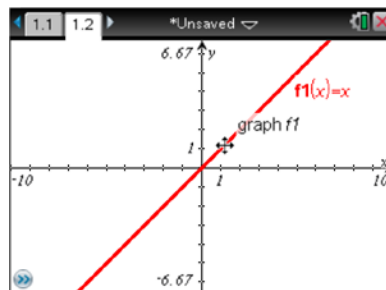
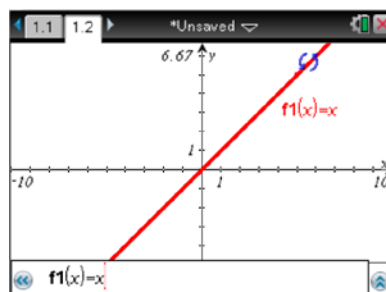
### TI PROFESSIONAL DEVELOPMENT

#### Step 5:

Graph the function  $f(x) = x$  by typing  $x$  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.

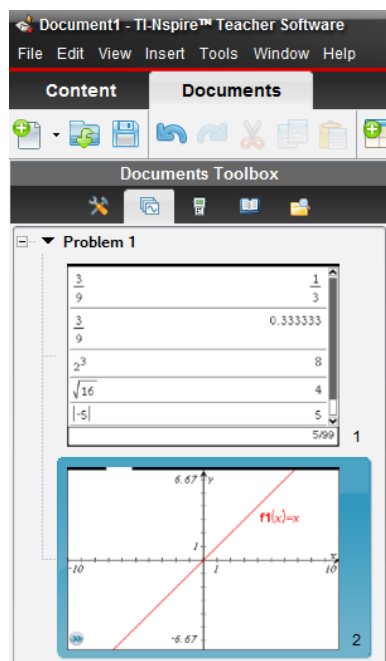


#### Step 6:

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.

**Note:** To access Page Sorter in the handheld, press **ctrl** .  
To right-click in the handheld, press **ctrl** **menu**.






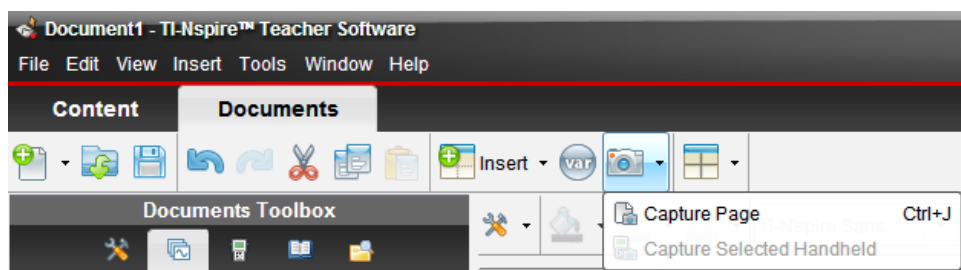
## Getting Started with the TI-Nspire™ Family of Teacher Software


### TI PROFESSIONAL DEVELOPMENT

#### 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.

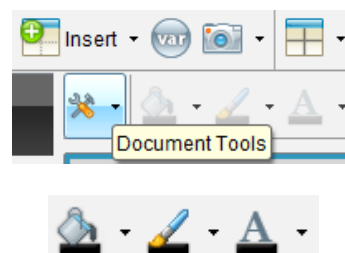
Take a Screen Capture of the current page by selecting  **Take Screen Capture > Capture Page**. This Screen Capture can be saved as an image.




Page layouts allow multiple applications to appear on one screen. Explore the various page layouts that are available by clicking  **Page Layout**.


The Document Tools menu contains tools and commands for the current application.

To change the fill color, line color, or text color, select an object and then select a color from the appropriate menu. To receive additional information about a given menu, hover the cursor over it. Not all color menus are available on all applications.



#### Step 8:

The Status Bar allows the user to access Settings, change the Document View from Handheld mode to Computer mode, and adjust the zoom of the SideScreen. Change the Document View to Computer mode by clicking  **Computer mode**.

Change the Document View back to Handheld mode by clicking  **Handheld mode**. Increase the zoom of the SideScreen to 200% by selecting 200% in the Zoom menu. The Boldness feature is enabled when using a PublishView™ document.







## Getting Started with the TI-Nspire™ Family of Teacher Software

### TI PROFESSIONAL DEVELOPMENT

#### Step 9:

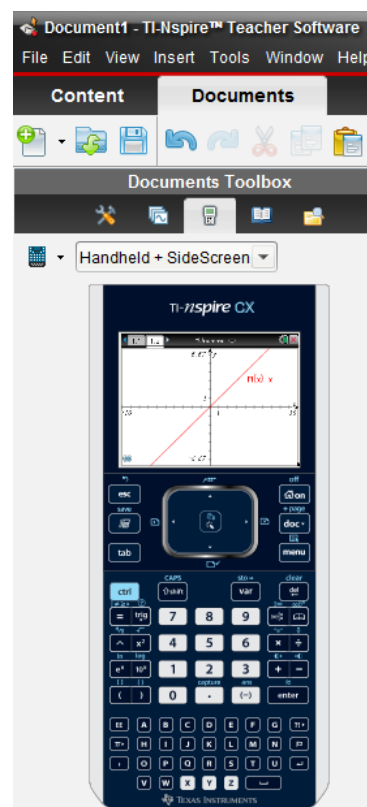
To access the TI-SmartView™ emulator for TI-Nspire, go to the Documents Toolbox and select the **TI-SmartView** tab.

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

The TI-SmartView emulator has three available keypads:

- TI-Nspire™ CX
- TI-Nspire™ with Touchpad
- TI-Nspire™ with Clickpad

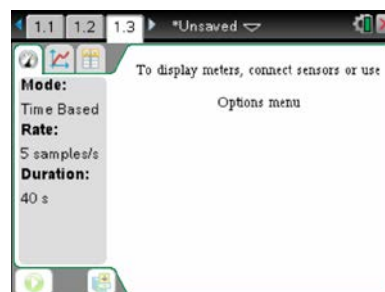
Each keypad has three available views: Normal, High Contrast, and Outline. Click the **Keypad** menu and explore each keypad and view.



#### Step 10:

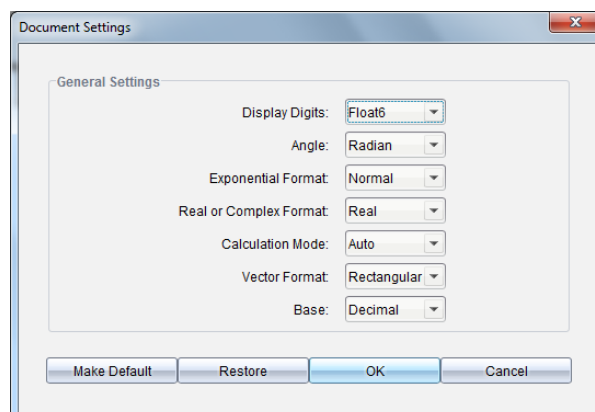
The Vernier DataQuest™ app can be used to collect, view, and analyze real-world data. Insert a page with the Vernier DataQuest app by selecting **Insert > Vernier DataQuest™**.

Though no data will be collected during this activity, the data meter will automatically launch when a Vernier sensor is connected to the computer's USB port.



#### Step 11:

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






## Getting Started with the TI-Nspire™ Family of Teacher Software

### TI PROFESSIONAL DEVELOPMENT

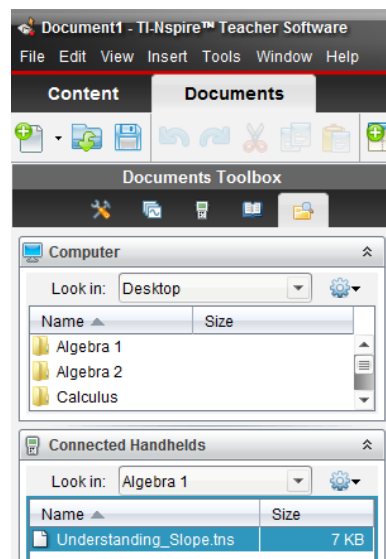
**Note:** To move across fields in the Document Settings window, press TAB. To change the setting in a given field, press the down arrow, select the desired setting, and press TAB to move to the next field. To exit the window, press ENTER.

#### Step 12:

Documents can be transferred between the computer and connected handhelds using the Content Explorer in the Documents Workspace. Explore the Content Explorer by clicking the  **Content Explorer** tab.

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



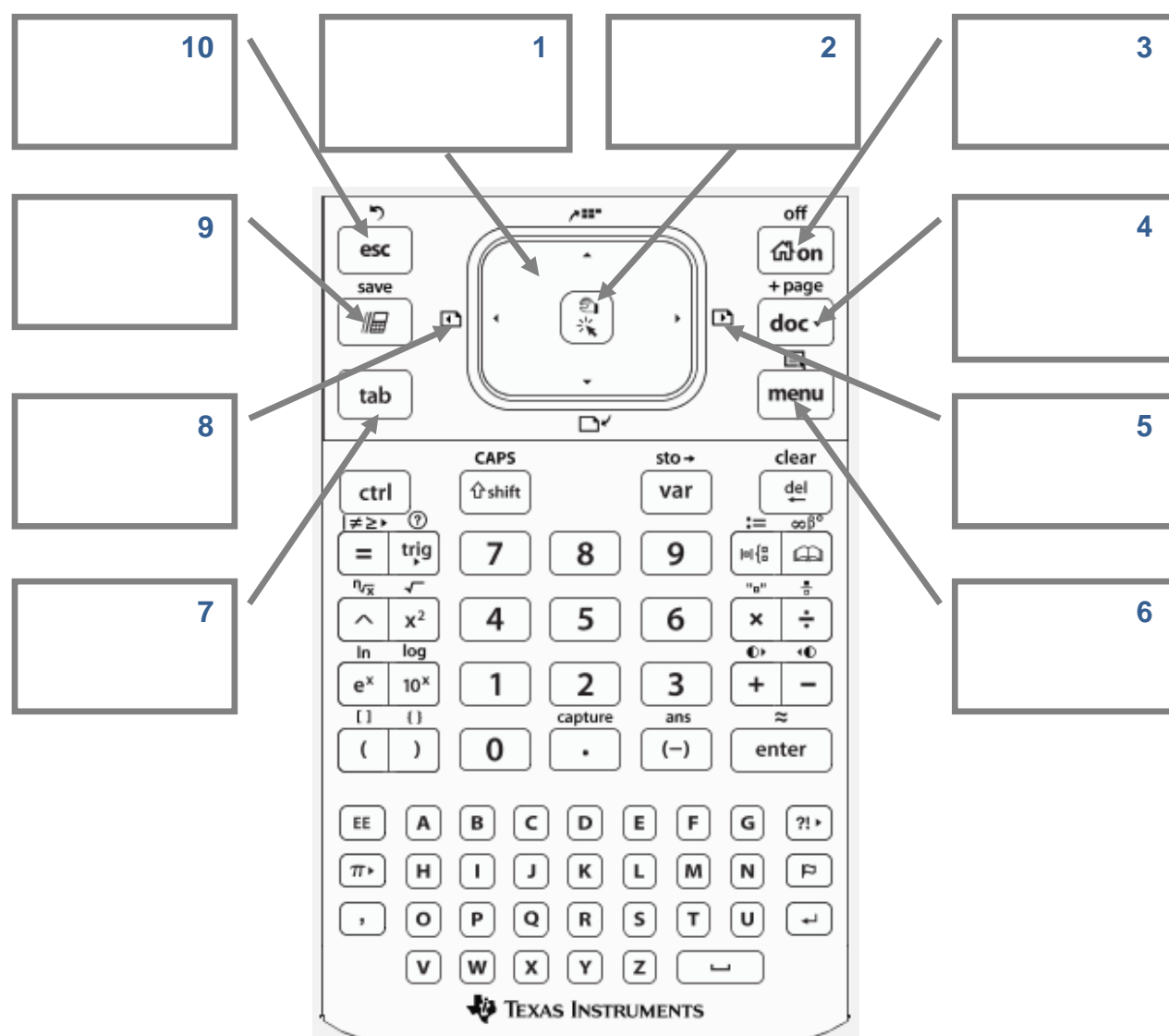


# TI-Nspire™ CX Family Overview

## TI PROFESSIONAL DEVELOPMENT

### Activity Overview

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



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## Checking and Updating the Operating System

### TI PROFESSIONAL DEVELOPMENT

#### Activity Overview

*In this activity, you will learn how to check the operating system (OS) on a TI-Nspire™ handheld and update it using the TI-Nspire™ family of Teacher Software.*

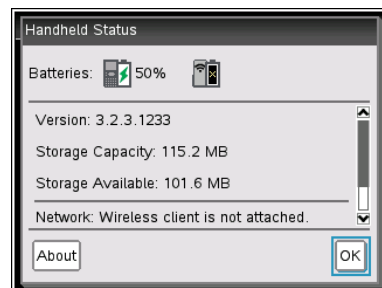
#### Materials

- 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.



**Note:** 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 the TI-Nspire™ Teacher Software or by transferring the OS from one handheld to another. OS upgrades 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. It is a good practice to back up important documents and folders before installing an updated OS.

#### Important OS Download Information

In the TI-Nspire™ family of handhelds, different handheld types require different operating systems:

- 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**.
- 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.



## Checking and Updating the Operating System

### TI PROFESSIONAL DEVELOPMENT

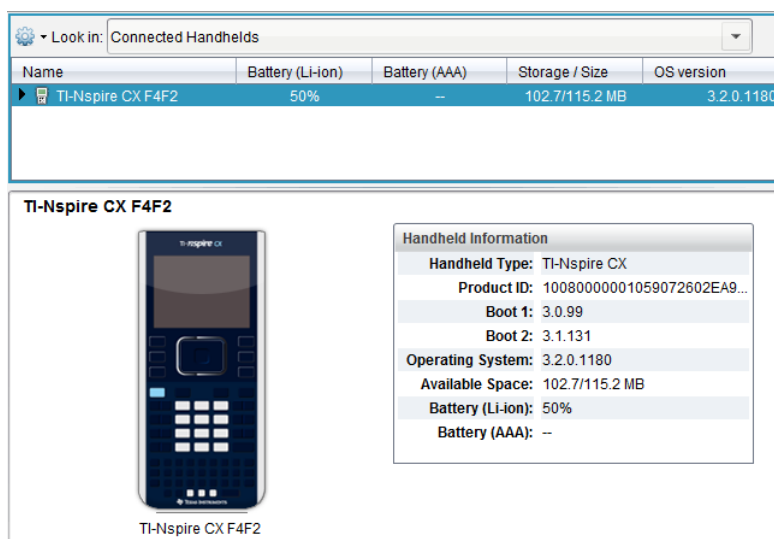
#### Finding Operating System Upgrades

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.

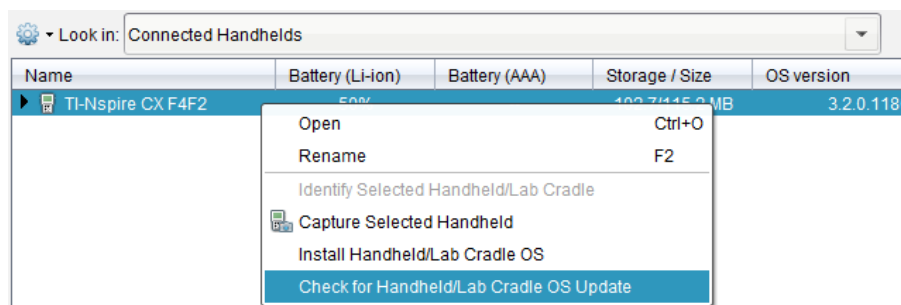
#### Using TI-Nspire Teacher Software to Update the Handheld OS

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. Select **Yes**.



## The Press-to-Test Feature TI PROFESSIONAL DEVELOPMENT

### 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. This activity enables Press-to-Test. To disable Press-to-Test, you will need to follow Steps 8-9 using either an additional TI-Nspire handheld or a computer with the TI-Nspire Teacher Software.

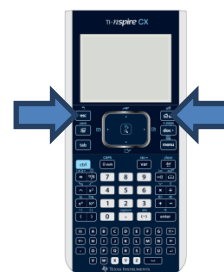
### Materials

- TI-Nspire™ handheld-to-handheld or handheld-to-computer USB connection cable

#### Step 1:

To enable Press-to-Test on the 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.

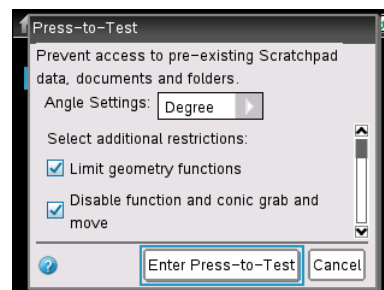
**Note:** To enable Press-to-Test on TI-Nspire™ with Clickpad, press and hold **esc**, **on**, and **off**.



#### Step 2:

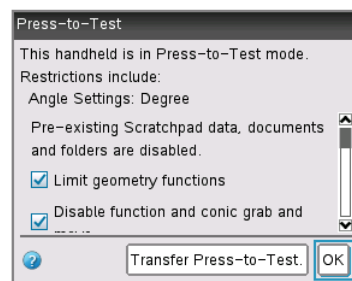
By default, Press-to-Test disables 3D graphing and pre-existing Scratchpad data, documents, and folders. The angle settings can be changed by pressing **right arrow**, selecting the appropriate setting, and pressing **right arrow** or **enter**.

By default, all of the commands and features listed are disabled. To enable a feature or command, uncheck its box. Keep all boxes checked. Enter Press-to-Test by clicking **Enter Press-to-Test**.



#### Step 3:

Once the handheld is in Press-to-Test mode, 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 in Press-to-Test mode, 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.

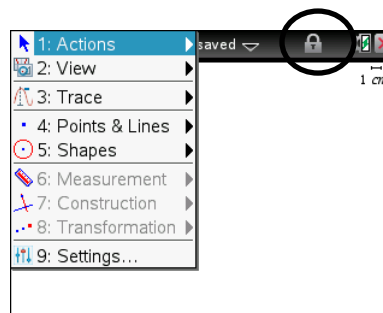


## The Press-to-Test Feature TI PROFESSIONAL DEVELOPMENT

### Step 5:

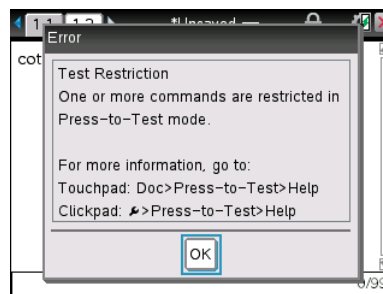
Create a new document, add a Geometry page, and press **menu**. Since geometry functions are limited, observe that the **Measurement**, **Construction**, and **Transformation** menus are not accessible.

**Note:** The lock icon at the top of the screen indicates that the handheld is in Press-to-Test mode.



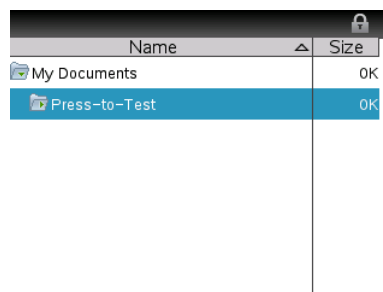
### Step 6:

Add a Calculator application by selecting **doc** > **Insert** > **Calculator**. Type **cot( $\pi/2$ )** 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. Click on OK.



### Step 7:

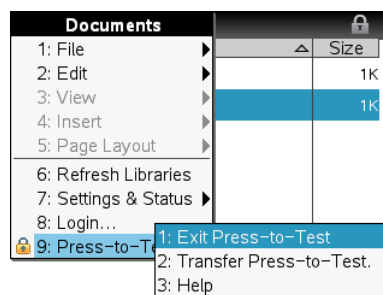
Select **on** > **My Documents**. While in Press-to-Test mode, a Press-to-Test folder appears in My Documents. All other folders and documents present on the handheld before Press-to-Test mode was entered are inaccessible.



### Step 8:

To exit Press-to-Test mode, connect two handhelds using the handheld-to-handheld USB connection cable. Then select **doc** > **Press-to-Test** > **Exit Press-to-Test**. The Exit Press-to-Test option appears regardless of whether the other handheld is in Press-to-Test mode.

Press-to-Test can also be exited with the TI-Nspire™ Navigator™ Teacher Software. Once a class has been started, students can select **doc** > **Press-to-Test** > **Exit Press-to-Test**.

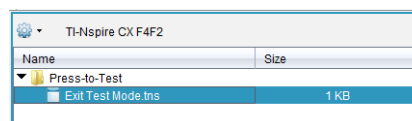


### Step 9:

Press-to-Test can also be exited 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.

**Note:** The name of the TI-Nspire document must be spelled exactly as it is above.

Go to the Tools menu and select **Transfer Tool**. Click **Add to Transfer List** and select **Exit Test Mode.tns**. In the Edit Destination Folder, select the Press-to-Test folder and click Change. Then, click **Start Transfer**.





# Transferring Documents Between Handhelds TI PROFESSIONAL DEVELOPMENT

## Activity Overview

*In this activity, you will learn how to transfer a document from one TI-Nspire™ CX handheld to another.*

## Materials

- Two TI-Nspire CX handhelds
- Unit-to-unit connection cable (Mini A to Mini B USB)

## Transferring a document or a folder

Documents can be transferred between two TI-Nspire CX handhelds by connecting them with the unit-to-unit mini USB cable. The USB A port is located at the top of the handheld on the right side.

### Step 1:

Firmly insert the ends of the mini USB unit-to-unit cable into the USB A ports of the handhelds. The handhelds will automatically turn on when the cable is plugged in.

### Step 2:

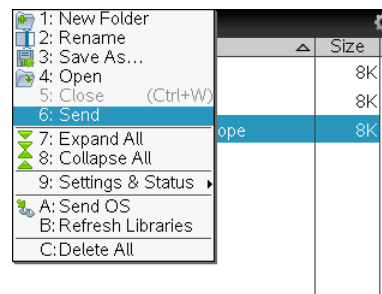
Open **My Documents** on the sending handheld.

### Step 3:

Press the ▲ and ▼ keys to highlight the document or folder to send.

### Step 4:

Press **menu** and select **Send**. No action is required by the user of the receiving TI-Nspire CX handheld. Once the transfer begins, a progress bar displays the status of the transfer. When the transfer is complete, a message displays on the receiving handheld. If the document was renamed on the receiving handheld, the new document name appears.





## Transferring Documents Between Handhelds

### TI PROFESSIONAL DEVELOPMENT

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**Note:** When sending 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.

**Note:** To cancel a transmission in progress, select **Cancel** in the dialog box of the sending handheld. To cancel a transfer from the receiving handheld, press **esc**. The receiving handheld, however, cannot cancel a transfer of folders. If an error message appears, press **esc** or **enter** to clear it.

### Guidelines for transferring documents or folders

The guidelines for sending an individual document also apply to documents within folders that are sent.

- If you send a document with the same name as an existing document on the receiving TI-Nspire CX 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 document name, including the entire path. If a transmitted document has the same name as an existing document on the receiving handheld and the document names contain 255 characters, then the name of the transmitted document 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.



# Transferring Documents Using the TI-Nspire™ Family of Teacher Software

## TI PROFESSIONAL DEVELOPMENT

### Activity Overview

*In this activity, you will use the Documents and Content Workspaces of the TI-Nspire™ family of Teacher Software to transfer TI-Nspire™ documents between the computer and the handheld.*

### Materials

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

### Transferring Documents in the Documents Workspace


#### Step 1:

Open the Teacher Software. Go to the Documents Workspace by clicking the **Documents** tab.

#### Step 2:

Connect a TI-Nspire™ handheld to the computer using the USB connection cable. Multiple handhelds can be connected using multiple USB ports, USB hubs, or the TI-Nspire™ Docking Station. If multiple handhelds are connected, then multiple handhelds appear in the Connected Handhelds panel.

#### Step 3:

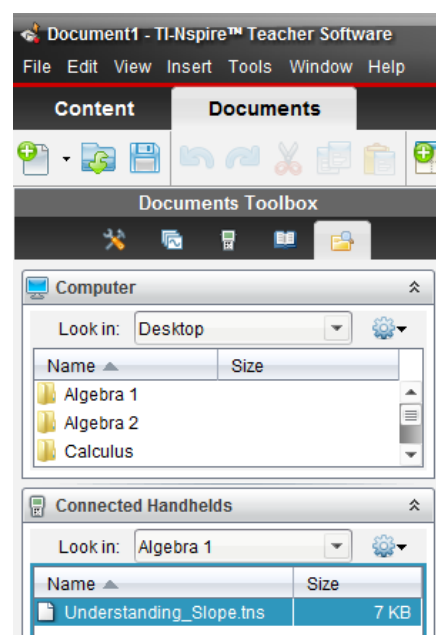
Documents can be transferred between the computer and connected handhelds using the Content Explorer in the Documents Toolbox. Open the Content Explorer by clicking the  **Content Explorer** tab.

#### Step 4:

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

#### Step 5:

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





## Transferring Documents Using the TI-Nspire™ Family of Teacher Software

### TI PROFESSIONAL DEVELOPMENT

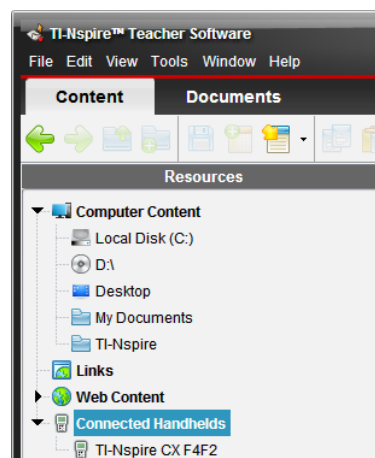
#### Transferring Documents in the Content Workspace

##### Step 6:

Go to the Content Workspace by clicking the **Content** tab. In the Resources panel, select **Connected Handhelds**.

##### Step 7:

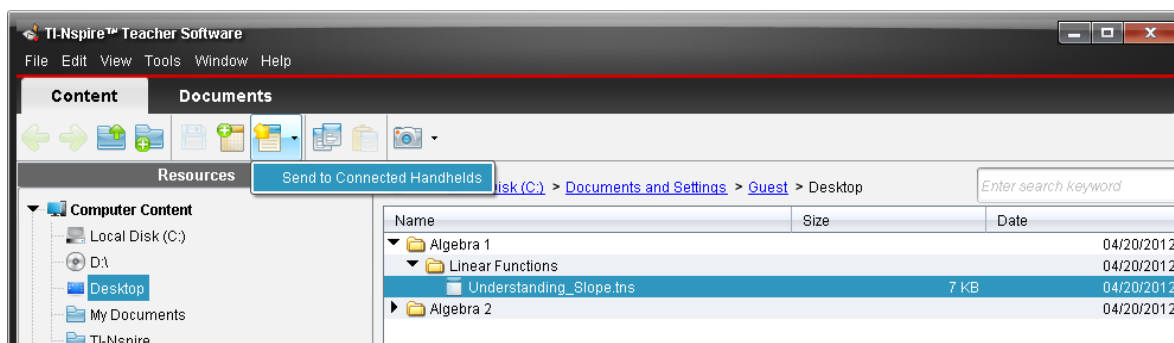
The connected handheld appears in the Content window, along with battery, storage, and OS information. To view the documents on a connected handheld, right-click it and select Open.



Look in: Connected Handhelds				
Name	Battery (Li-ion)	Battery (AAA)	Storage / Size	OS version
TI-Nspire CX F4F2	50%	—	102.8/115.2 MB	3.2.0.1180

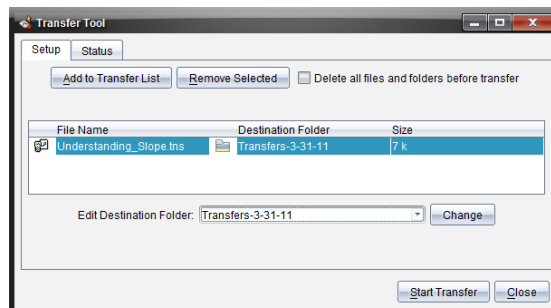
##### Step 8:

Locate a TI-Nspire™ document on your computer by browsing Computer Content in the Resources panel. Send the document by dragging and dropping it to the connected handheld. The document can also be sent by right-clicking it and selecting **Send to Connected Handhelds**.



##### Step 9:

The Transfer Tool window appears with the current document. Documents can be added to or removed from the transfer list, and the destination folder on the handheld(s) can be edited or changed. To send the document to the handheld(s), click **Start Transfer**. Once the Status tab indicates that the transfer is complete, click **Stop Transfer**.





# Inserting an Image into a TI-Nspire™ Document

## TI PROFESSIONAL DEVELOPMENT

### Activity Overview

*In this activity, you will learn how to use the TI-Nspire™ family of Teacher Software to insert images into the Graphs and Geometry 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:

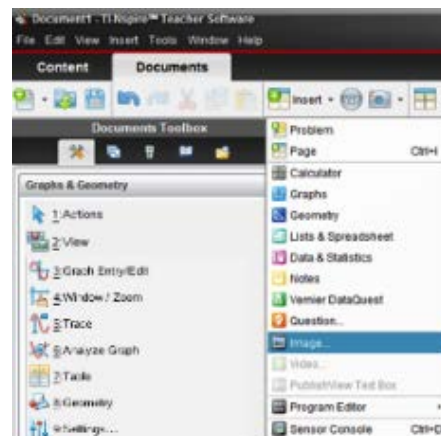
Open the Teacher Software. If the Welcome Screen appears when the software is opened, click to create a new document with a Graphs application as its first page. Otherwise, insert a Graphs application by selecting **Insert > Graphs**.

**Note:** Images can be inserted into Graphs, Geometry, Data & Statistics, Notes, and Question applications.

### Step 2:

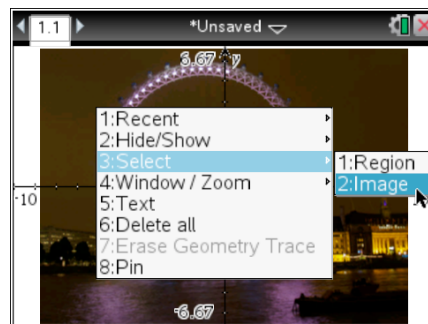
Insert an image into the Graphs application by selecting **Insert > Image**. A selection of images is preloaded in the **My Documents > TI-Nspire > Images** folder. Select **Ferris Wheel.jpg** and click Open.

**Note:** Although the Teacher Software comes with a selection of preloaded images, all jpg, jpeg, bmp, and png images are supported. The optimal format is .jpeg 560 × 240. Larger images may take the document longer to load on the handheld. Images appear in grayscale for TI-Nspire™ handhelds with Touchpads and Clickpads.



### 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 on the image and choose **Select > Image**. To select an image in the Notes application, click the image. To move the image, grab and move the image. 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.





## Inserting an Image into a TI-Nspire™ Document

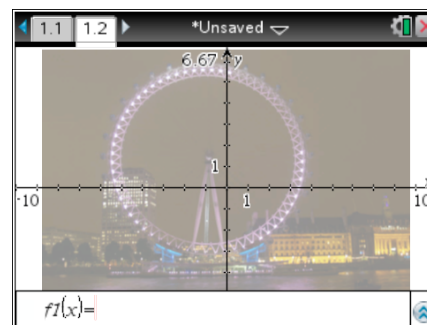
### TI PROFESSIONAL DEVELOPMENT

**Note:** To right-click an object 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 the image in a Geometry application, and then change the page to a Graphs application.

Select **Insert** > **Geometry**. Then insert an image by selecting **Insert** > **Image**. Again, choose **Ferris Wheel.jpg**. To change the Geometry application to a Graphs application, select **View** > **Graphing**.





## Online Resources

### TI PROFESSIONAL DEVELOPMENT

#### Activity Overview

*In this activity, you will explore resources available at [education.ti.com](http://education.ti.com). You will browse for activities at Math Nspired, Science Nspired, and TI-Math. You will search for activities using the Standards Search and Textbook Search, and you will explore additional information regarding professional development.*

#### Materials






- Computer with Internet connection

#### Step 1:

Go to [education.ti.com](http://education.ti.com) > **Downloads & Activities**. Select **Math Nspired** or **Science Nspired**, which can also be accessed directly at [mathnspired.com](http://mathnspired.com) and [sciencenspired.com](http://sciencenspired.com). Select a subject on the left.

#### Step 2:

Select a unit from the list. When a unit is selected, a table appears with an image from each activity. The table contains links to download, recommend, and save each activity. It also identifies each activity type:

Icon	Type	Description
	Bell Ringer	Bell ringers are short lessons designed to help transition quickly into class after the bell rings.
	Action Consequence Simulation	Interactive, engaging lessons allow students to perform actions on a mathematical object or scientific simulation, observe consequences, and make conjectures.  Each lesson contains a pre-made TI-Nspire™ document, a Student Activity, and Teacher Notes.
	Create Your Own	In addition to the Student Activity and Teacher Notes, the lesson also includes step-by-step instructions on how to create the TI-Nspire document.
	Data Collection with Probes	Data Collection Labs give students the opportunity to collect and analyze real-world data with more than 50 data collection sensors from Vernier Software and Technology™.
	TI-Nspire™ Navigator™ Compatible	The Teacher Notes identify opportunities to use the TI-Nspire Navigator System, including opportunities for Quick Polls, Class Captures, and Live Presenter.



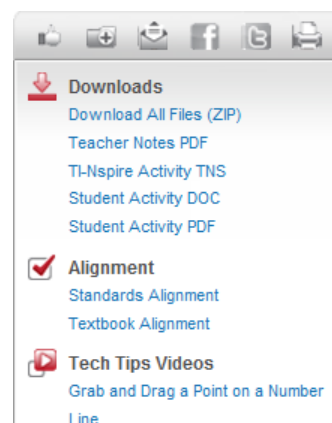
## Online Resources

### TI PROFESSIONAL DEVELOPMENT

#### Step 3:

Select an activity from the list. The activity page shows objectives, relevant vocabulary, and additional information. A video offers a preview of the lesson, and related lessons are recommended below.

Icons above the Downloads section allow you to recommend, save, email, and print an activity. Links to Facebook and Twitter are also available. The Downloads section contains links to activity files. Links for Standards Alignment, Textbook Alignment, and relevant Tech Tip Videos are also available.



#### Step 4:

Explore the Standards and Textbook Search channels on the left. Select a set of standards or a textbook from the drop-down box, select a grade, and click **Search**.

#### Standards Search

Search for lessons that align to these curriculum and assessment standards.

##### Standards Search

Standards:

Grade:

#### Textbook Search

Search for lessons that align to select textbooks from these publishers.

##### Textbook Search

Textbook:

Grade:

#### Step 6:

Go to **Downloads & Activities > TI Math**, which can also be accessed directly at [www.timath.com](http://www.timath.com).

Featured TI-Nspire™ and TI-84 Plus activities for various subjects appear in the center of the page. Links to activity archives for each subject appear on the left. Click one of the featured activities.

#### Step 7:

Go to **Professional Development > Online Learning**.

The Tutorials page contains link to free Atomic Learning video tutorials. There are video tutorials for the TI-Nspire™ handheld, the TI-Nspire™ software, and the TI-Nspire™ Navigator™ System.

The Webinars page contains links to upcoming, free PD webinars.

The Archive page contains recordings of past webinars.

Associated webinar documents are available for download.



#### Step 8:

Explore each of the following pages by clicking the appropriate tab: Products, Downloads & Activities, In Your Subject, Professional Development, Funding & Research, and Student Zone.



## AP Chemistry Lab Manual

### *A Guide to Using TI-Nspire™ for Data Collection and Analysis*

After reading this guide you will have a wealth of ideas about how you can use the TI-Nspire™ to collect and analyze data for the experiments in this AP Chemistry lab manual.

#### Data Collection – Getting Started

1. Decide what sensor(s) is(are) appropriate for your experiment. Most likely you will be using one or more of the following sensors in an AP Chemistry experiment: temperature, pH, conductivity, voltage or the colorimeter.
2. Choose the appropriate interface device (EasyTemp™, EasyLink™ cable, TI-Lab Cradle™) and attach it to the Nspire.

EasyTemp



EasyLink



TI-Lab Cradle

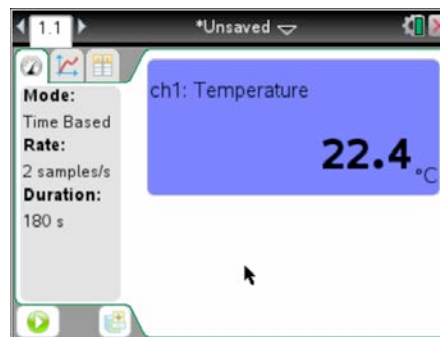


3. Connect the sensor(s) to the interface device. (When using the Lab Cradle and only one sensor, it is best to plug the sensor into Channel 1.)
4. Launch the DataQuest™ application. (Note: In most cases the DataQuest application will launch automatically. If not, from the home screen on the Nspire, select **1** for **New Document** and then choose the DataQuest application from the applications available.)

#### Data Collection – How Do I Collect Data?

There are three main methods of data collection:

1. Use the meter window.
2. Perform a “Time Based” experiment.
3. Perform an “Events with Entry” experiment.



##### Using the Meter Window

There will be some experiments in which you will need to collect only one sample of data from a chemical substance or solution. For example, maybe you need to measure the conductivity of an ionic compound in solution. In that case, using the live readout of data in the meter window (shown above) is appropriate.




##### Performing a “Time-Based” Experiment

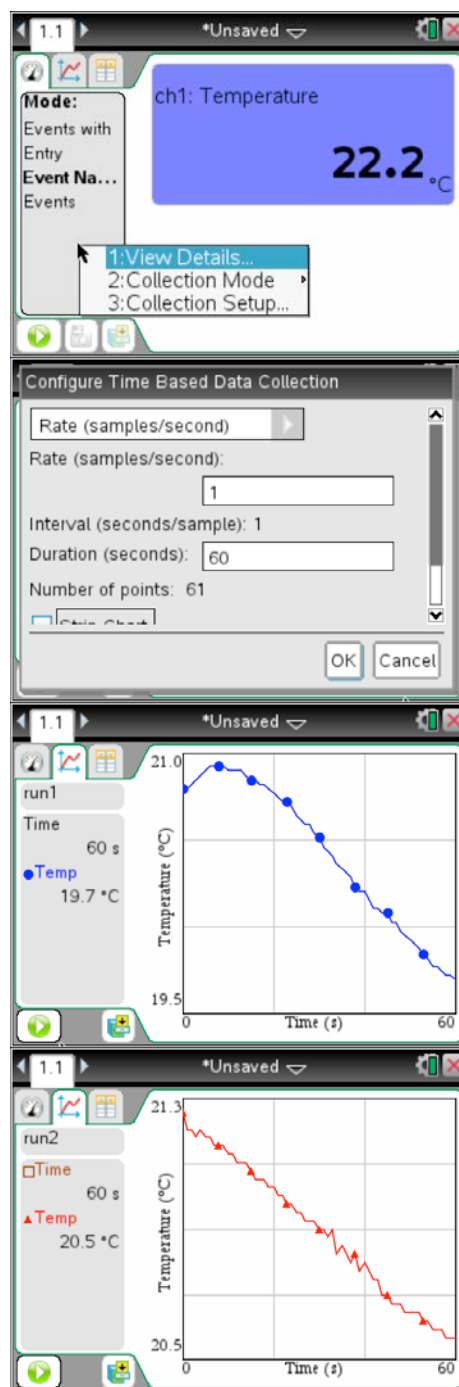
There will be some experiments in which you will want to study a variable over a certain period of time. For example, what if you were asked to determine the effect of the amount of water on the rate at which an effervescent tablet reacts in water? How would you set up the collection of data for that experiment?

On the next page you will learn about the various steps needed to carry out that process.

## AP Chemistry Lab Manual

### A Guide to Using TI-Nspire™ for Data Collection and Analysis

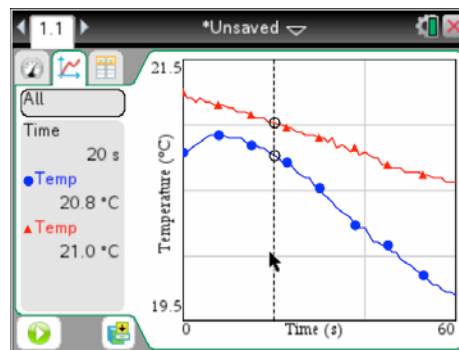
1. Be sure that the mode is set to "Time Based." (The fastest way to change the experiment mode is to "right click" on the **View Details** area on the left side of the screen. Perform a "right click" by pressing the **ctrl** button followed by the **menu** button.) Select **2:Collection Mode > 1:Time Based**.
2. Now set up the parameters of how you will collect data in your experiment. For example, in the effervescent tablet experiment, we might want to view the temperature changes over a 60 second period. The rate could be set to 1 sample/second and the duration set to 60 seconds. Click OK when you are finished.
3. Click the **Play** button  to begin collecting data. Once data collection begins the Meter view switches to the Graph view and then the graph will autoscale when data collection is complete. *(The graph at the right shows how the temperature changes as a tablet is added to 50 mL of room temperature water.)*
4. If you are finished with the experiment, press the **Stop** button . If not, store the first run of data by clicking the **Store** button . Press **Play** to collect a second run of data. *(The graph at the right shows how the temperature changes as a new tablet is added to a new sample of 100 mL of room temperature water.)*



# AP Chemistry Lab Manual

## A Guide to Using TI-Nspire™ for Data Collection and Analysis

- It is possible to see all of the runs that you collected at one time. Click on the current run at the left (**run2** in this case) and select **All**. Both runs of data will appear on the screen simultaneously and you will be able to compare temperatures at a given time by clicking somewhere in the graph. A vertical line will appear and the **View Details** area will indicate the temperatures at that time.

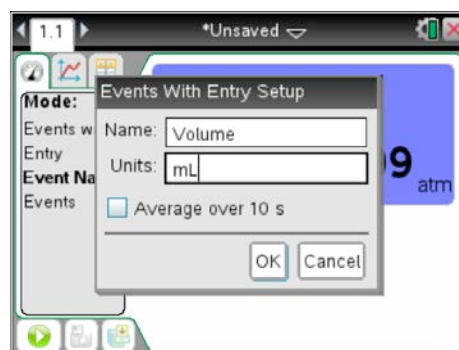
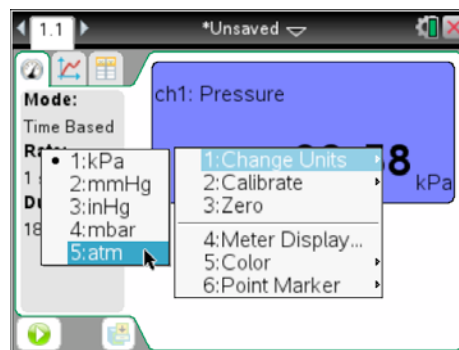


Later in this guide you will see how the Nspire can be used to analyze the data that you have collected in this mode.

### Performing an “Events with Entry” Experiment






There will be some experiments in which time is NOT an important factor when collecting data. You may wish to collect data at one set of conditions and then under a different set of conditions. For example, what if you were interested in knowing the effect of changing the volume of a specific amount of gas on the pressure of that gas? It wouldn't really matter how long it took you to change a gas from 4 mL to 20 mL (in 2 mL increments) but you might want the Nspire to record the actual pressure at each volume. “Events with Entry” would be the mode that you would want to use. Below you will see step-by-step directions on how to collect data in this manner.

- Before we set up the collection mode, it might be helpful to know that you can “right click” in other areas of the screen as well. For example, in this experiment we may want to change the default units for pressure (kPa) to atmospheres (atm). Simply press **ctrl** menu with the cursor over the **Meter** window, select **1:Change Units** followed by the preferred units.
- Okay, let's set up the data collection mode. With the cursor in the **View Details** area, press **ctrl** menu and select **2:Collection Mode > 2:Events with Entry**. The “event” is the variable that you are manipulating. Input the appropriate name and units of the event and then click OK. In this case we are changing the volume of 10 mL of air trapped in a plastic syringe. We will be studying the effect of changing this volume on the pressure of the gas.

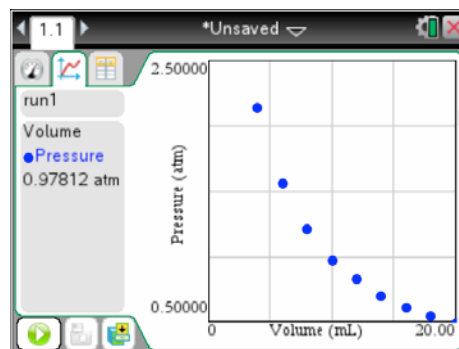
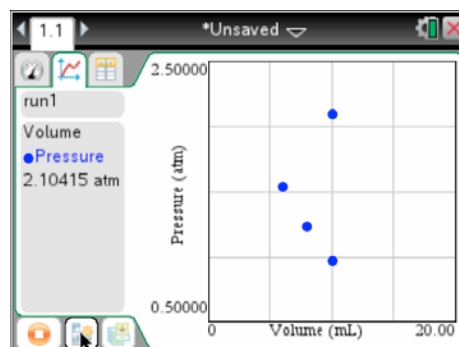
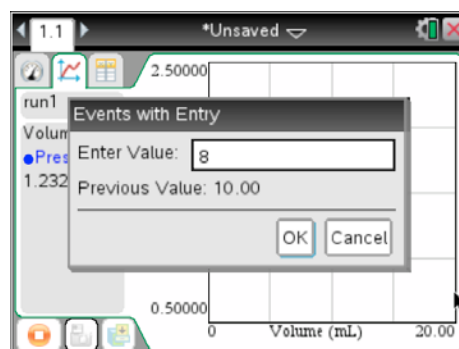
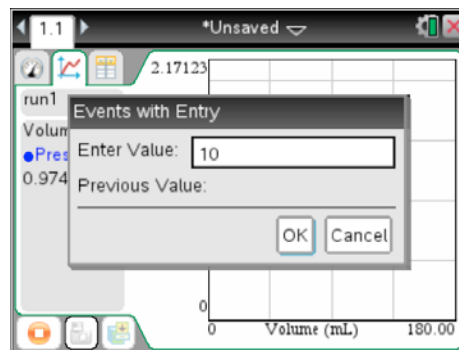


## AP Chemistry Lab Manual

### A Guide to Using TI-Nspire™ for Data Collection and Analysis

- Click the **Play** button  to begin. Once data collection begins the Meter view switches to the Graph view. Notice that in this mode a new icon  is visible. This is the **Keep** button and it allows you to take a snapshot of the data when you are ready. *(The graph at the right shows what the screen looks like when the **Keep** button is pressed. The value of 10 mL is entered to represent the 10 mL of air trapped in the syringe.)*
- When you are ready to record data at a new set of conditions press the **Keep** button  again. *(Important: Do **NOT** press the **Stop** button  !!! This is a common mistake made by new users. If you press **Stop** you will need to start the entire experiment over again.)* Notice that when you press **Keep**, the window will remind you of the previous event value that you entered.
- Continue collecting data until you are finished and then press the **Stop**  button. Notice that every time you enter a new event value, the screen returns to the graph view. It will display all of the data points that you have recorded plus the current event that you are about to record. *(The screen at the right shows blue dots for pressures recorded at 10 mL, 8 mL and 6 mL of volume. The “odd” point is the pressure of the air confined to 4 mL of space. The reason that it is in the center of the screen is that the **Keep** button has not yet been pressed and the value of 4 mL has not yet been entered.)*
- You have now finished recording data in Events with Entry mode. Notice that the button in the lower left corner of the screen has returned to the **Play** button. *(The screen at the right shows all of the Pressure and Volume data for a 10 mL sample of air.)*

Later in this guide you will see how the Nspire can be used to analyze the data that you have collected in this mode.



# AP Chemistry Lab Manual

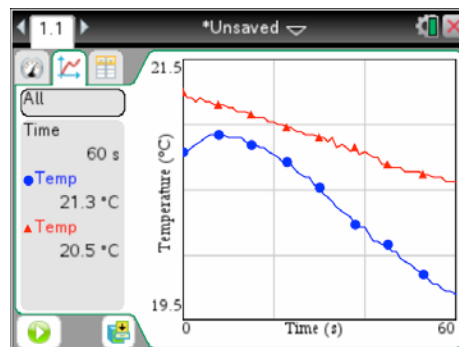
## A Guide to Using TI-Nspire™ for Data Collection and Analysis

### Data Analysis

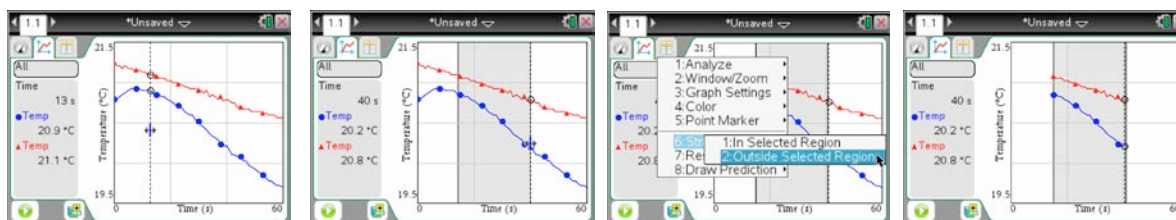
There are a few different tools available in the DataQuest application that make it very easy and quick to analyze the data that you have collected. Two important methods will be presented in this section.

#### Method 1: Striking Data

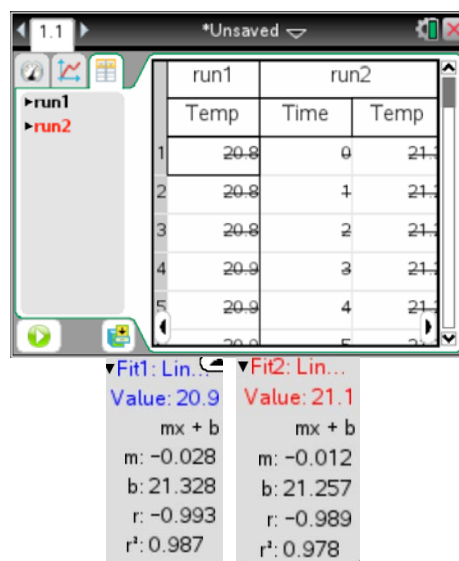
Remember the effervescent tablet experiment? Part of the graph looked very linear and it might be interesting to know the slope of the two temperature curves in the middle of the experiment. We could then compare the rate at which the temperature dropped in each situation (a tablet dropped in both 50 mL and 100 mL of room temperature water).



1. Click in the graph to create a vertical line. Click in the center of the touchpad for about 1 second until you see a double arrow appear on the line.
2. Let go of the center of the touchpad and run your finger lightly from left to right across the touchpad to select the area of the graph you would like to study.
3. Right click and select **Strike Data > Outside Selected Region**. When finished your graph will only show the portion of the data that you selected.



4. Don't worry. Your data is still there (as you can see from the Table view on the right). Striking data allows you to analyze just a portion of the data set without completing removing the information.
5. Now you are able to analyze each linear portion of the temperature graph to determine the different rates at which the temperature was dropping. Select **Menu > Analyze > Curve Fit > Run1.Temperature** and press OK. Select **Menu > Analyze > Curve Fit > Run2.Temperature** to see the other information. Now the rate information (the "m" values) can be compared in the View Details window for each graph.




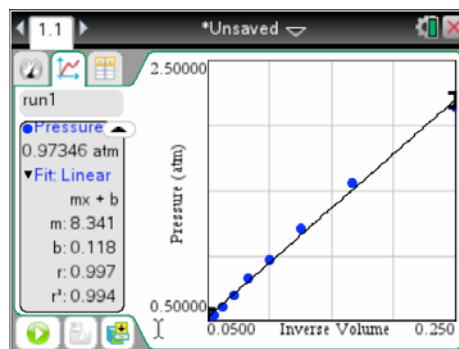
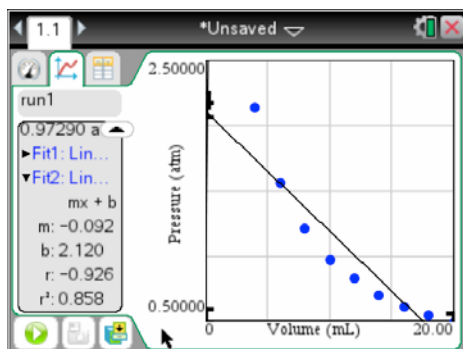
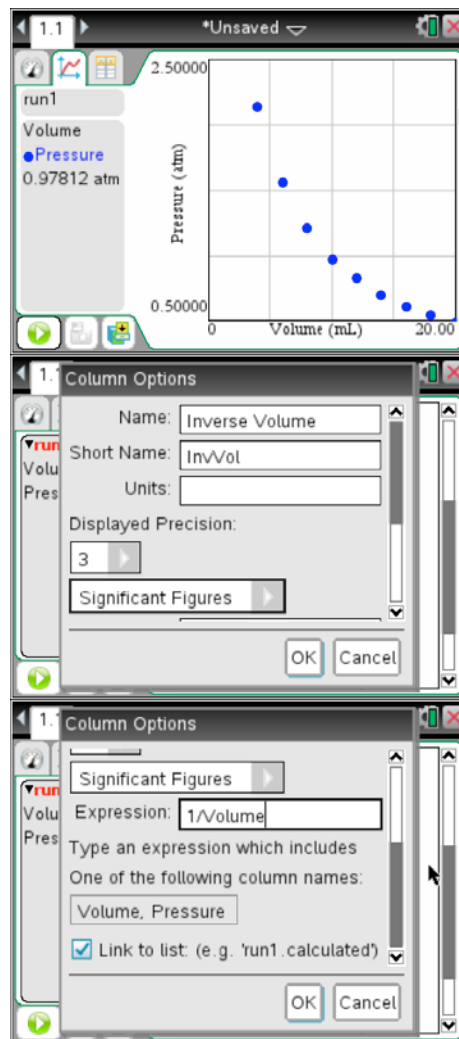
## AP Chemistry Lab Manual

### A Guide to Using TI-Nspire™ for Data Collection and Analysis

#### Method 2: Adding a Calculated Column in Table View

Getting back to the pressure/volume experiment, you'll recall that we created a curve of pressure versus volume values. To determine the equation of a graph, sometimes it is helpful to "linearize" the data. In this section we will explore how a new calculated column of data can be added in Table View and how that new variable can be selected for study in Graph view.

1. Click on the Table view tab . Then "right click" on the **View Details** area followed by **Add Calculated Column**.
2. Type in a name for the new column and any other fields that you find appropriate.
3. In the same window, scroll down until you see the **Expression** field. Enter the mathematical expression for the new column. (In this case, since it is possible to "linearize" the data by graphing Pressure vs. Inverse Volume, the expression entered is  $1/\text{Volume}$ .) When finished click OK.
4. Click on the Graph view tab to analyze the data. Press **Menu > Analyze > Curve Fit > Linear**. Obviously the data of pressure vs. volume do not fit the line created as is evidenced by the poor  $r^2$  value of 0.858. (Data points with a good linear fit show an  $r^2$  value of 1.00.)
5. Click on the x-variable at the bottom of the graph (in this case, volume) and select the calculated column variable (inverse volume). Now we have a very linear graph and we can see that  $\text{Pressure} = 8.341 * (1/\text{Volume}) + 0.118$ .





## AP Chemistry Lab Manual

### *A Guide to Using TI-Nspire™ for Data Collection and Analysis*

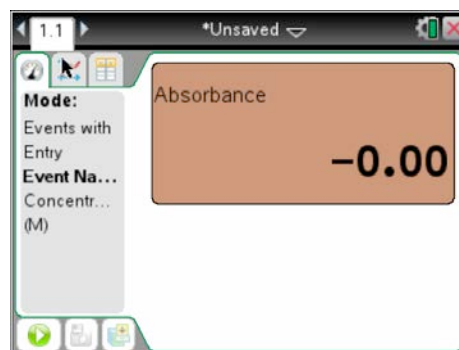
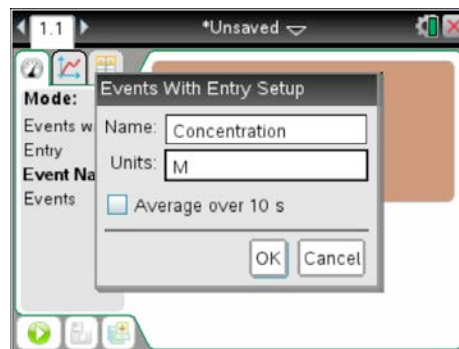
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#### Data Collection and Analysis – Using the Colorimeter

The colorimeter (shown at right) is used to collect information about how much light of a certain wavelength is absorbed by a solution. This sensor uses Events with Entry mode but has a few extra steps involved to set it up for use. The following procedure will highlight using the colorimeter to collect concentration and absorbance data using various solutions of green food coloring in water. First, data about four solutions of known concentration will be collected and then absorbance data of a solution of unknown concentration will be collected.







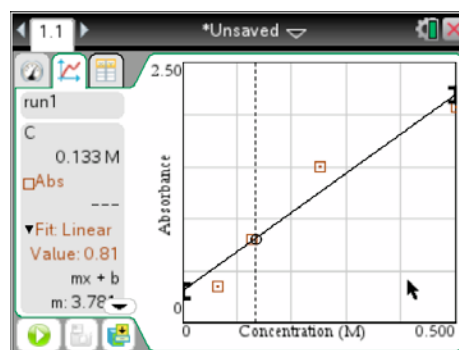
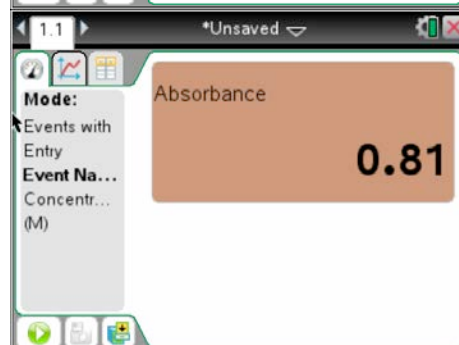
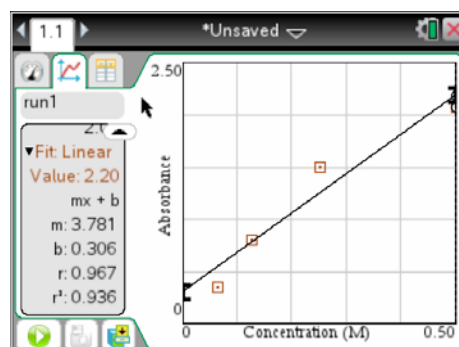
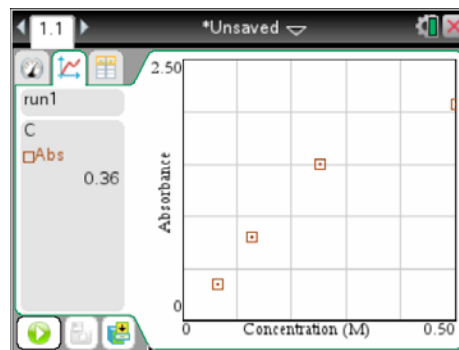
1. Connect the colorimeter to the Nspire using an EasyLink cable or a TI-Lab Cradle.
2. Select an appropriate wavelength of light to be used in the experiment by pressing the left or right arrows on the colorimeter. (You will want to use a different color other than the color of the solution. For example, if we passed green light (565 nm) through a green solution, most of it would be absorbed and we wouldn't see much difference in the data. An ideal color of light to pass through a green solution would be red (635 nm).)
3. With the cursor in the **View Details** area, press **ctrl menu** and select **2:Collection Mode > 2:Events with Entry**. Enter the variable name for the event (usually Concentration) and the appropriate units and click OK.
4. Now the device must be calibrated with the solvent being used in the solutions. Fill a plastic cuvette about  $\frac{3}{4}$  with the appropriate solvent (most likely this will be water) and place the cuvette in the holder inside the colorimeter. It is important that one of the smooth sides of the cuvette is pointed towards the white arrow at the top of the inside of the colorimeter. Also be sure that the smooth sides are free of oil or smudges from skin. Close the colorimeter door and press the CAL button until the red light stops blinking. This will take about 5 seconds. The absorbance reading in the meter view should read 0.00.



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### A Guide to Using TI-Nspire™ for Data Collection and Analysis


- When ready to begin collecting data, press **Play** . Replace the water cuvette with the first sample of known concentration being tested. Close the door, wait for the absorbance reading to stabilize, and then press **Keep** . Input the concentration of the known solution and press OK. Remove the first sample, replace it with the second sample, close the door, and press **Keep**. Repeat this process with the other samples of known concentration. When you are finished with all of the samples of known concentration, press **Stop** . (The screen to the right shows absorbance readings for known solutions with concentrations of 0.500M, 0.250M, 0.125M and 0.0625M.)
- Find the best fit line through the data points. To do this press **Menu > Analyze > Curve Fit > Linear**.
- Put the sample of unknown concentration in the colorimeter and close the door. Note the absorbance reading once it stabilizes.
- To determine the concentration at this absorbance click in the Graph view tab  (at the top left of the screen). Then press **Menu > Analyze > Interpolate**. Click somewhere in the graph to see a vertical line. Press the left or right side of the touchpad to move the line around on the graph. When you have moved the cursor to the appropriate place the Fit Linear Value will correspond to the absorbance of the solution. You will then be able to read the concentration value at the top of the **View Details** window. (Note that since the unknown solution showed an absorbance of 0.81 the vertical line was moved into place until the Fit Linear Value was also 0.81. The concentration at this absorbance was 0.133 M.)

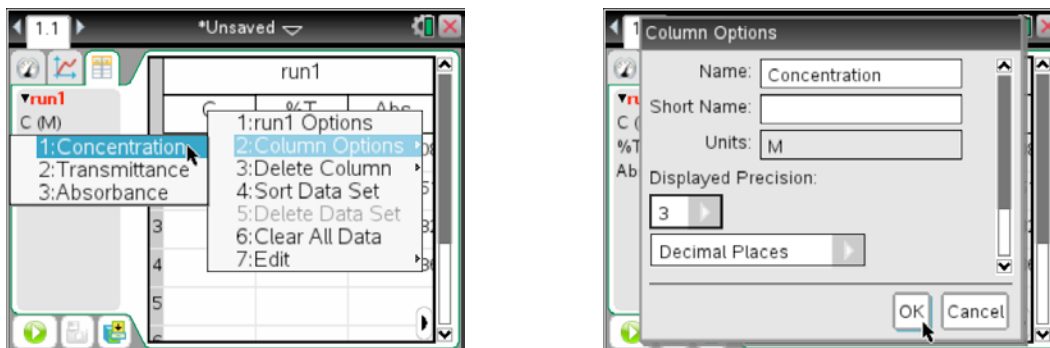




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Note: To display the concentration at a higher precision, click on the Table View icon , “right click” on the column label for concentration (C), select **Column Options > Concentration**. Change the displayed precision to an appropriate value (in this case 3 decimal places) and click OK. Now the concentration will be displayed with a higher level of precision.



#### In Conclusion:

Hopefully you have found the information in this appendix about how you can collect and analyze data using the TI-Nspire to be helpful.

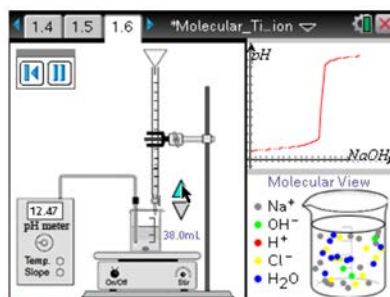
For further information about other applications within the TI-Nspire handheld, visit:

[http://www.atomiclearning.com/k12/en/ti\\_nspire](http://www.atomiclearning.com/k12/en/ti_nspire)

For further information about the Vernier sensors that you will use with these experiments, visit:

<http://www.vernier.com/products/sensors/>

You might also want to visit the Science Nspired page at Texas Instruments' website (<http://education.ti.com/calculators/tisciencespired/>) where you'll find some great simulations that can help you better understand concepts important to the AP Chemistry curriculum.



They will also determine the volume of base needed to reach the equivalence point and see how pH is related to an excess of  $H^+$  ions or an excess of  $OH^-$  ions in a solution.

Example Shown: Molecular Titration Simulator

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# TI graphing calculators are permitted on important college entrance exams.

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AP*	AP	AP	AP	AP	AP	AP	AP	AP
ACT®*		ACT		ACT	ACT	ACT	ACT	
IB®* Exam		IB Exam		IB Exam	IB Exam	IB Exam	IB Exam	
Praxis™*		Praxis		Praxis	Praxis	Praxis	Praxis	

## SAT\*

MAY 2013 4	JUN 2013 1	OCT 2013 5**	NOV 2013 2**
DEC 2013 7**	JAN 2014 25**	MAR 2014 8**	MAY 2014 3**

For deadlines and registration, visit [collegeboard.com/testing](http://collegeboard.com/testing).

\*\* These anticipated test dates are provided for planning purposes and are subject to final confirmation. The finalized, confirmed test dates, when announced, may differ from the dates shown.

## ACT®\*

JUN 2013 8	SEP 2013 21	OCT 2013 26	DEC 2013 14
FEB 2014 8***	APR 2014 12	JUN 2014 14	SEP 2014 13

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\*\*\*No test centers are scheduled in New York for the February test dates.

## AP\*

MAY 2013 6 <i>Chemistry</i>	MAY 2013 8 <i>Calculus AB/BC</i>	MAY 2013 10 <i>Statistics</i>	MAY 2013 13 <i>Physics B/C</i>
MAY 2014 5 <i>Chemistry</i>	MAY 2014 7 <i>Calculus AB/BC</i>	MAY 2014 9 <i>Statistics</i>	MAY 2014 12 <i>Physics B/C</i>

For deadlines and registration, visit [apcentral.collegeboard.com](http://apcentral.collegeboard.com).

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For information on the **IB test** and test dates, visit [ibo.org](http://ibo.org).

For information on the **Praxis test** and test dates, please visit [ets.org/praxis](http://ets.org/praxis).

Testing agencies are responsible for respective testing dates; Texas Instruments is not responsible for any testing date changes.

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**T3 Ticket Outta Here**

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I have learned ...

My question is ...

My next steps are ...

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