Getting Started with TI-Nspire™ in High School Science

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Materials for Workshop Participant*

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There are three categories of T³ Professional Development, each with a unique set of learning objectives. This workshop is focused on technology integration, and its objectives are as follows:

Technology Integration

- Emphasis on learning to use TI technology, with broad "how-to" coverage highlighting a wide range of features
- Subject/content-focused training on appropriate usage of TI technology in the classroom
  - I am comfortable with essential technology skills for exploring math and science content.
  - I can design opportunities for students to use technology as a tool to deepen their understanding of mathematics and science.
  - I can locate and download TI activities that align to my standards.
  - I can describe the role technology should play in the successful implementation of my standards, and I can implement a vision of a classroom where students routinely use technology to engage in the practice and content standards.

Workshops focused on instructional practices and content knowledge have the following objectives:

Instructional Practices

- Emphasis on classroom practices with technology as a tool to enhance student learning
- Models CCSS, TEKS, and NGSS tasks using in-depth discussions, reflective practices, and essential technology skills
  - I can demonstrate the importance of teacher actions for students' engagement in the Practices, and I can take actions that will enable students to become mathematical and scientific practitioners.
  - I can describe the role that technology should play in the successful implementation of my standards, and I can implement a vision of a classroom where students routinely use technology to engage in practice and content standards.
  - I can design tasks for students to employ the Practices, using technology as a tool to deepen their understanding of mathematics and science.
  - I can ask questions designed to make student thinking visible – to push them to think about connections, make comparisons, or probe their understanding.

Content Knowledge

- Emphasis on content with technology as support
- Addresses critical, tough-to-teach topics and new content standards for CCSS or TEKS
  - I have a deeper understanding of the mathematics and science in my content area, and I am aware of the shifts in content that affect what I teach.
  - I can design opportunities for students to use technology as a tool to deepen their understanding of mathematics and science.
  - I can locate and download TI activities that align to my standards.
  - I can describe the role technology should play in the successful implementation of my standards, and I can implement a vision of a classroom where students routinely use technology to engage in the practice and content standards.

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Conversion – Direct or Inverse Variation?

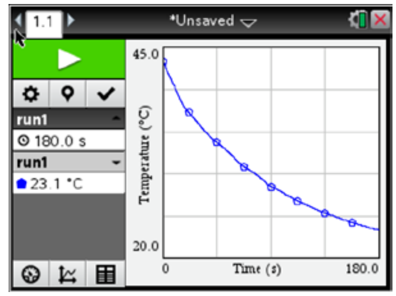
Student Activity

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.

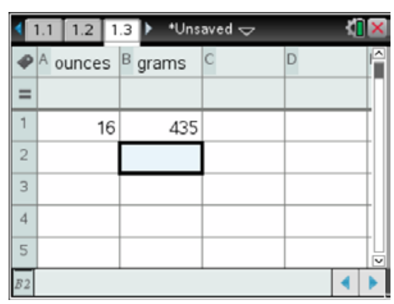
Add a Calculator Page

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 patter appear?

Add a Lists & Spreadsheet Page



6. Enter the data from the box labels into the spreadsheet.
   - Label Column A **ounces**, and enter the label values in ounces.
   - Label Column B **grams**, and enter the label values in grams.
   - Label Column C **prod** for product. In the formula cell (**=**), type **=ounces*grams** and press [enter].
   - Label Column D **quo** for quotient. In the formula cell (**=**), type **= grams/ounces** and press [enter].

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Conversion – Direct or Inverse Variation?
Student Activity

Name ________________
Class ________________

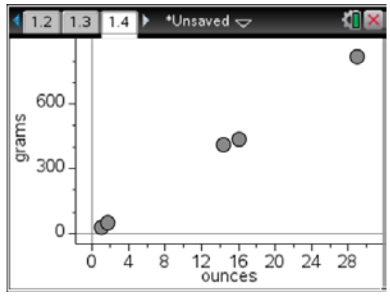
Analysis

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



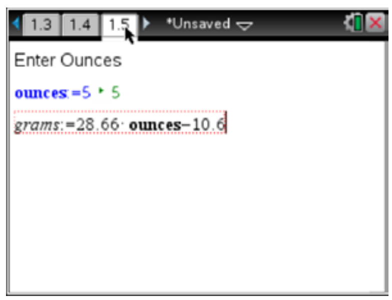
10. Place ounces on the *x*-axis and grams on the *y*-axis.
11. Determine the best fit line for this set of data by selecting **Menu > Analyze > Regression > Show Linear (mx+b)**.
12. What equation do you get when you perform the linear regression?

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.

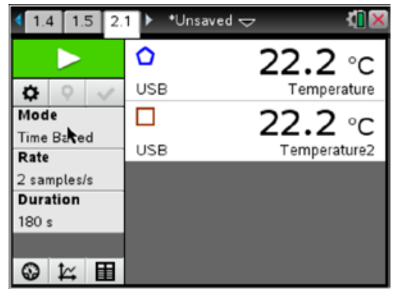
Conversion – Direct or Inverse Variation?

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 clicking on Temperature2 reading and changing °C to °F in the dialogue box.
    - Set to collect data for 5 samples per second for 30 seconds by clicking on the **Rate** area at left (set to 5) and the **Duration** area (set to 30)
    - Place both temperature probes in hot water and allow them to equilibrate to the water.
    - To begin data collection, click the green **Start Collection** ▶ arrow in the upper-left corner of the screen. Or**,** press **Tab** until the start arrow is highlighted, then press **Enter** when ready, 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.

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Conversion – Direct or Inverse Variation?

Student Activity

Name _______________

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?

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Conversion – Direct or Inverse Variation?

TEACHER NOTES

TI PROFESSIONAL DEVELOPMENT

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).

Vocabulary

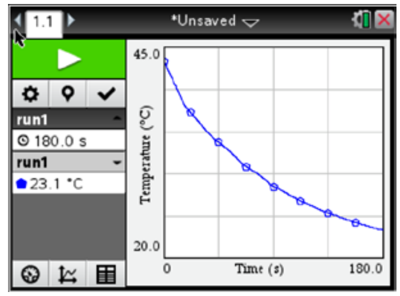
- ounces
- grams
- conversion factor

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.



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 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

TI-Nspire document

- Conversion_Solution.tns

Discussion Points and Possible Answers

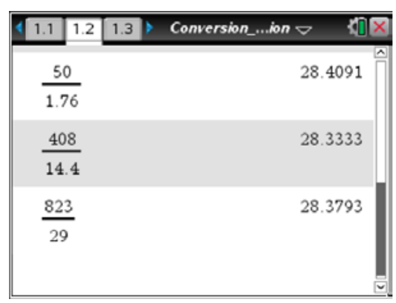
Tech Tip: Using the TI-Nspire™ Lab Cradle with the standard temperature sensor requires a USB cable to connect to the teacher computer. If you do not have the adapter, you might want to collect data with the student handheld and transfer it to the computer using TI-Nspire™ Navigator™ System or Teacher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

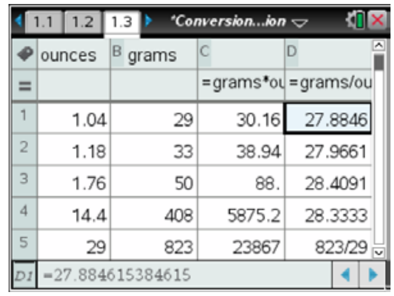
   <u>Answer:</u> Grams and ounces appear to be directly related.

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

   <u>Sample Answer:</u> 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 patter appear?

   <u>Sample Answer:</u> Each quotient is approximately 28.



Add a Lists & Spreadsheet Page

6. Enter the data from the box labels into the spreadsheet.
   - Label Column A **ounces**, and enter the label values in ounces.
   - Label Column B **grams**, and enter the label values in grams.
   - Label Column C **prod** for product. In the formula cell (**=**), type **=ounces*grams** and press [enter].

   Label Column D **quo** for quotient. In the formula cell (**=**), type **= grams/ounces** and press [enter].

> **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?

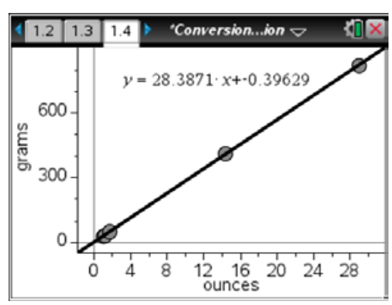
   Sample Answer: As the grams and ounces increase, their product increases. Each quotient is approximately 28.

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____ .

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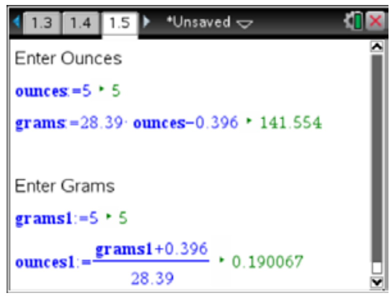
14. How does the slope of the line compare to the values in the spreadsheet on page 1.3?

    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].

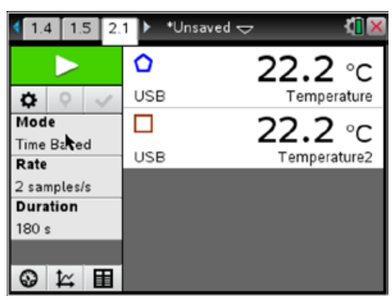
    Tech Tip: A Math Box can also be inserted by pressing [ctrl] [M].

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.

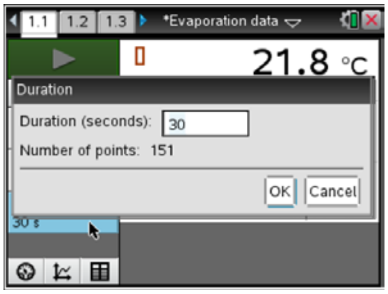
Add a New Problem to Compare Fahrenheit to Celsius

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].

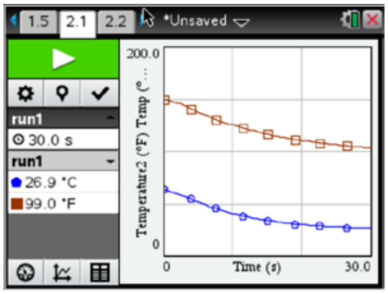


23. Two temperature readings should appear in the **Meter View**.
    - Change the units on temperature probe 2 to Fahrenheit by clicking on Temperature2 reading and changing °C to °F in the dialogue box.
    - Set to collect data for 5 samples per second for 30 seconds by clicking on the **Rate** area at left (set to 5) and the **Duration** area (set to 30).
    - Place both temperature probes in hot water and allow them to equilibrate to the water.
    - To begin data collection, click the green **Start Collection** arrow in the upper-left corner of the screen. Or, press **Tab** until the start arrow is highlighted, then press **Enter** when ready, and move both probes to ice water.



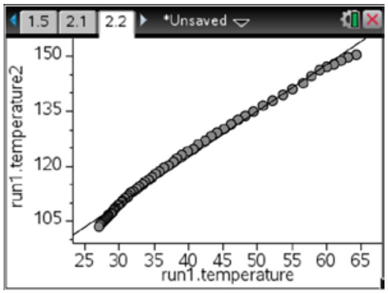
24. What happens to both temperature readings?

    <u>Sample Answer:</u> Both temperatures begin to decrease.



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

    <u>Sample Answer:</u> 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?

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

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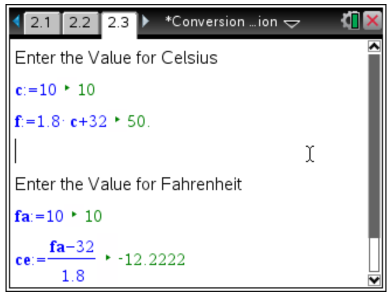
28. Create an equation for converting from Fahrenheit to Celsius.

Sample Answer: C = (F – 32)/1.8

Add a Notes Page

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



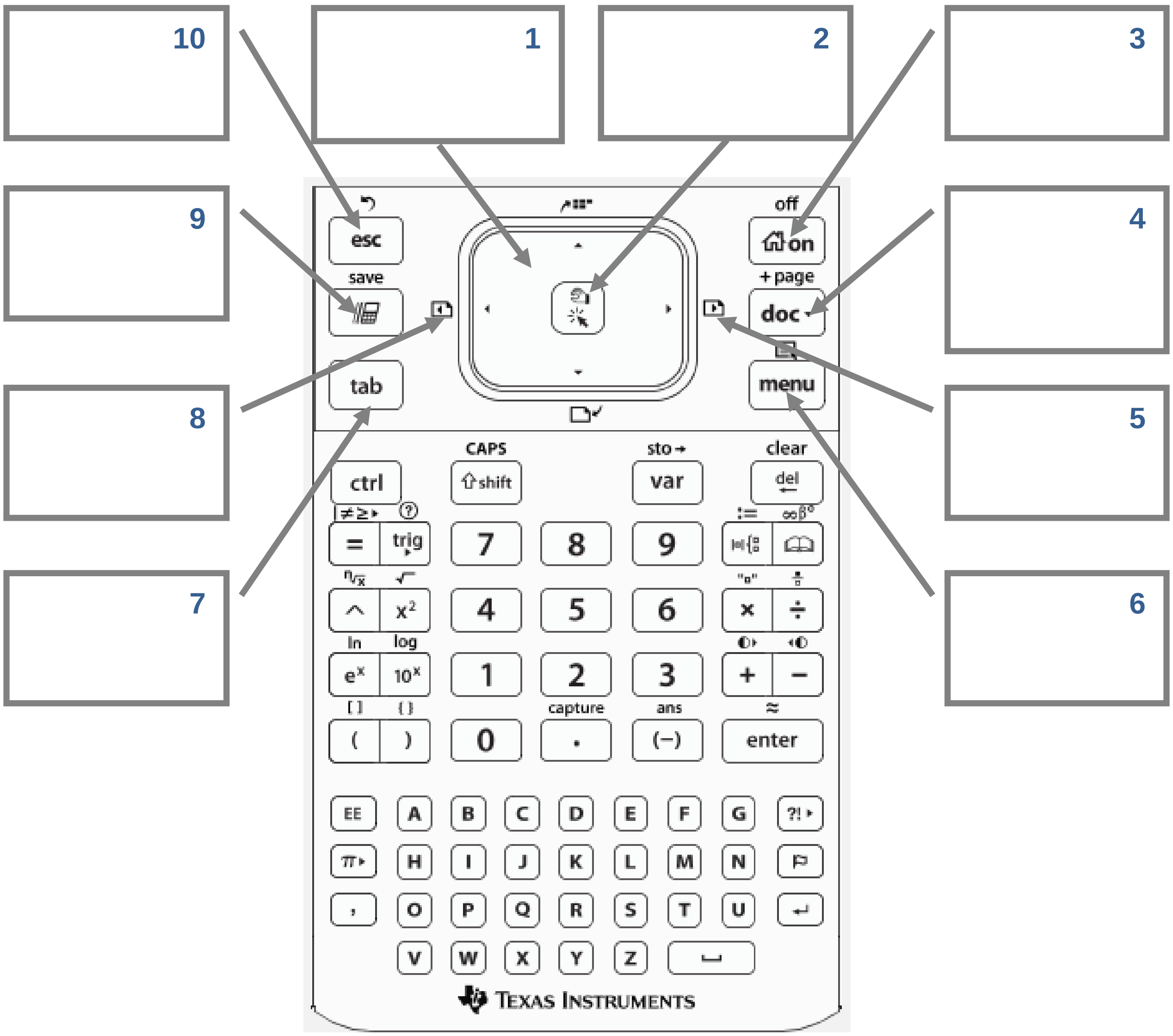
Tech Tip: Students will need to enter their expressions in Math Boxes. For the first converter, recommend that students represent Celsius with a C and Fahrenheit with an F. The variables must be different for the second converter. If they are the same, they will conflict with one another.

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 [click]. 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 [x²]. 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? ______

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Delete the current number by pressing [del]. Type in [2][8], and press [enter]. What is the answer?

____

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

____

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

____

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

____

12. Press [ctrl] and ▲. What do you see? _____________
Press [del][enter]. What does the screen say? _______________

13. Press [ctrl][0]. This is a calculator screen, but what looks different about it? __________________
Now type in [3][(][5][−][8] and [enter]. What is the answer? __________
You typed in 3(5-8, but what does the problem look like on the handheld? ________________

14. Press [ctrl][x²] to get a square root. Then type [2][3][−][7], move one space to the right, and type [+][2][enter]. 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 [(][(−)][1][7][)][x²][enter]. What is the answer? ______________
What makes the [(−)] button different from the [−] button? __________________________

16. Press [⌂ on], and open a New Document. Select 'No' when it asks if you want to save the document. Press [ctrl][⌂ on] 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?

____

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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:

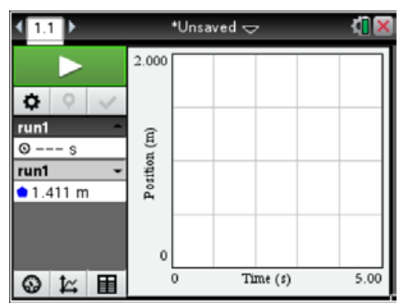
Open a New Document, and press esc.

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 Collection** arrow in the upper-left corner of the screen, <u>or</u> press **Tab** until the start arrow is highlighted, then press **Enter** when ready. 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?

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Walk a Line
Student Activity

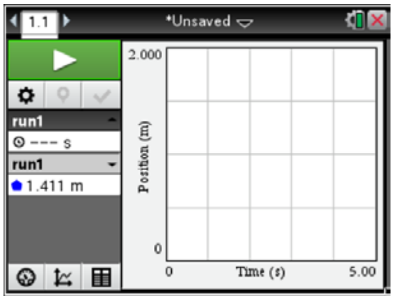
Name ________________

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

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

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

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

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

e. Why is the velocity negative?

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

g. What does the y-intercept represent?

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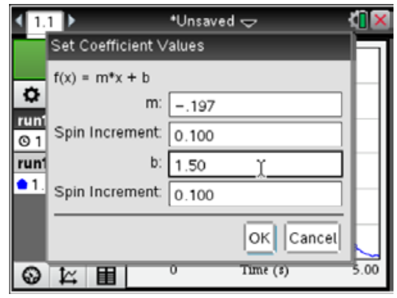
Walk a Line
Student Activity

Name ________________
Class ________________

Step 8:

Select **Menu > Analyze > Model**. Select **m*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**.

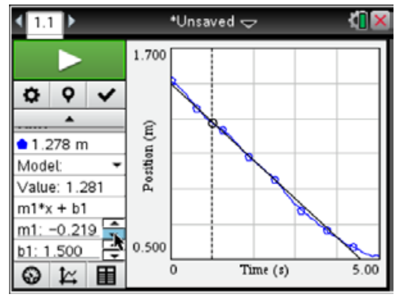


Step 9:

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 =



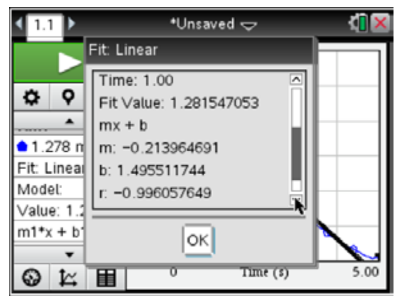
Step 10:

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.

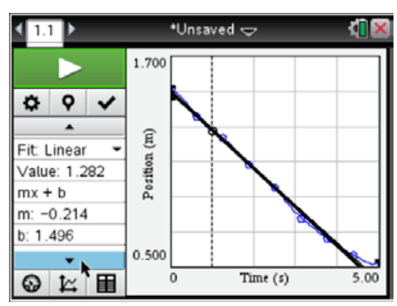
m =

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?



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Walk a Line
Student Activity

Name ________________
Class ________________

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.

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Walk a Line

Teacher Notes

TI Professional Development

Math and Science Objectives

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

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:

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

Lesson Files:
Student Activity
Walk_a_Line_Student.pdf

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Discussion Points and Possible Answers

> **Tech Tip:** The Vernier DataQuest application should launch when the CBR 2™ is connected. To begin data collection, click the green **Start Collection** arrow in the upper-left corner of the screen. Or press **Tab** until the start arrow is highlighted, then press **Enter** when ready.
>
> **Teacher Tip**: With the Lab Cradle, you can connect multiple motion detectors to extend your exploration.

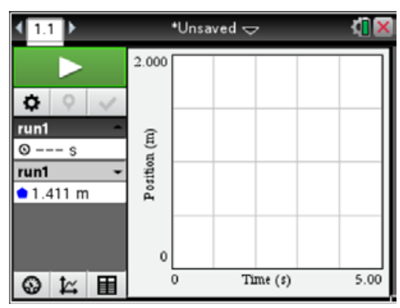
Step 1:

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 **Start** button. Making predictions and testing those predictions supports higher-level thinking.

Step 4:

The calculator operator should click the green **Start Collection** ▶ arrow in the upper-left corner of the screen, or press **Tab** until the start arrow is highlighted, then press **Enter** when ready. 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?

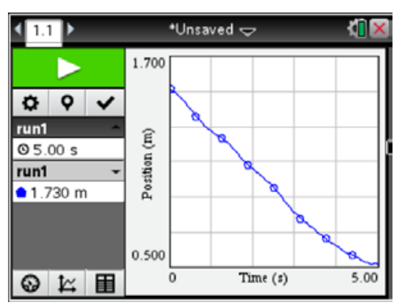
Sample Answer: Comparisons can include function type (linear, quadratic, etc.), *y*-intercept, and whether the graph is increasing or decreasing.

> **Tech Tip:** If the students are not satisfied with their results, they can repeat the data collection by Enter. 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.

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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 1.5 m. At time *t* = 5, the position was 0.514 m. 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: (0.514-1.5)/(5-0) = -.197 m/s . 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 1.5; *y* = –0.197*x* + 1.5. Equations will vary but should have *b* ≈ 2 and *y* = the slope from part c in Step 7.

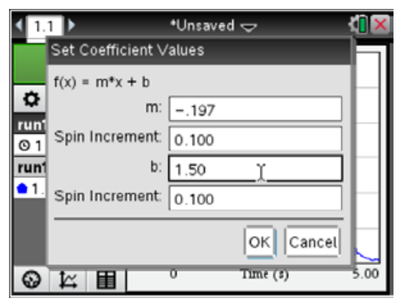
g. What does the *y*-intercept represent?

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:

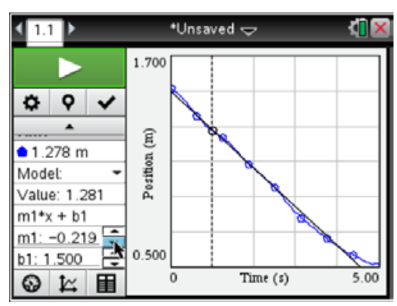
Select **Menu > Analyze > Model**. Select **m*x + b** to create a linear model, and press **OK**. Type the values for the coefficients *m* and *b* that you estimated in Step 7 in the spaces provided, and click **OK**.



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

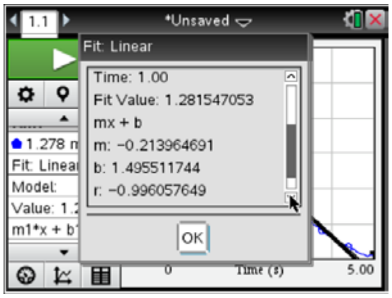
Step 9:

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* = –0.219, *b* = 1.50; *y* = –0.219*x* + 1.50

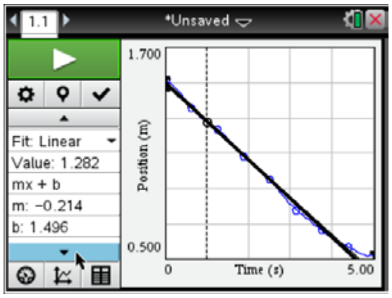
Step 10:



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.

<u>Sample Answer:</u> *m* = –0.214; *b* = 1.496

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?

<u>Sample Answer:</u> The sample linear regression is very similar to the equation from Step 9 but not quite exactly the same. Answers will vary, depending on how constant the walk actually was and how the student read endpoint values.

> **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.

   <u>Sample Answer:</u> 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.

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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 are able to 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.

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Cool It

Student Activity

Name _______________

Class _______________

How do drinks cool?

When you have a drink that 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™ USB temperature sensor or Vernier Go! ® Temp USB temperature sensor with interface (Vernier EasyLink® USB sensor interface or TI-Nspire Lab Cradle)
- Cup of hot water with a temperature of 45º–55ºC or a hair dryer to heat the temperature sensor.

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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 into 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 clicking the green **Start Collection** ▶ arrow at the upper-left top 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 the data do 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 ºC. The room temperature should be lower than your lowest temperature recorded. Record them below

Starting Temperature (ºC)	
Room Temperature (ºC)	
Difference in Temperatures (ºC)	

4. You might 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 along with 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 a different value in the table. Record the values for *a* and *c* in the table to the right.

a	
c	

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Cool It
Student Activity

Name _______________
Class _______________

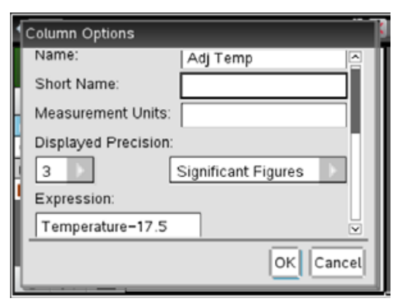
5. You will guess a value for *b*. Does the graph show exponential growth or decay? Based upon this, what are the possible values for *b*?

6. Select **Menu** > **Analyze** > **Model**. Type in the model $y = a \bullet b^x + c$ (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 $y = a \bullet b^x$ 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?

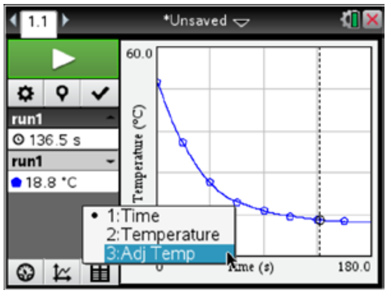
9. Since the temperature levels-off at room temperature rather than zero, the exponential curve is shifted upward by room temperature. Subtracting room temperature from all of the temperature values will allow the data to be analyzed with an exponential regression.
   - Select **Menu > Data > New Calculated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



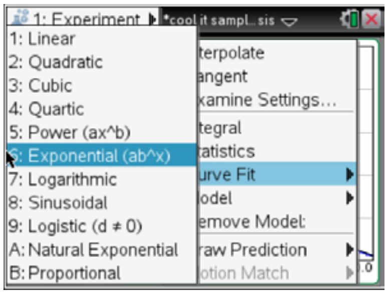
Cool It
Student Activity

Name ______________
Class ______________

10. To see the graph of the Adjusted Temp as a function of time, right-click on the *Temperature* label along the dependent axis of the graph and change it to *Adj Temp*. Alternatively, you can 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.

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Cool It

TEACHER NOTES

TI PROFESSIONAL DEVELOPMENT

Math and Science Objectives

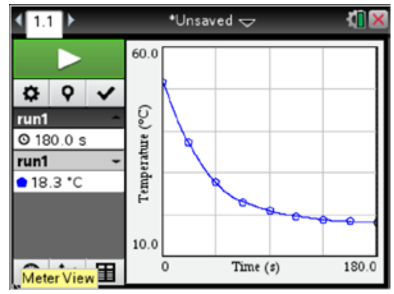
- Students will first predict and then examine the relationship for temperature as a function of time for an object that is cooling.
- Students will model mathematically the relationship with the exponential equation in the form $y = a \cdot b^x + c$.
- Students will relate each of the parameters in 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 dryer 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.



TI-Nspire™ Technology Skills:

- Collect temperature data with the Vernier® DataQuest™ app

Tech & 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

- Cool_It_Student.pdf

Materials and Materials Notes

- TI-Nspire™ handheld or TI-Nspire™ computer software
- Vernier® EasyTemp® USB temperature sensor or Vernier Go! ® Temp USB temperature sensor with interface (Vernier EasyLink® USB sensor interface or TI-Nspire Lab Cradle)
- Cup of hot water with a temperature of 45º–55ºC or a hair dryer to heat the temperature sensor.

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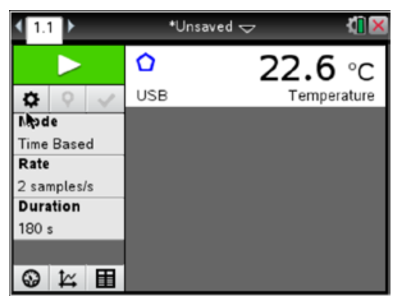
- Using EasyTemp with a computer requires the use the mini-standard USB adaptor to plug the temperature sensor into a computer with TI-Nspire™ Teacher Software or TI-Nspire™ Student Software.
- Using the TI-Nspire™ Lab Cradle with the standard temperature sensor requires a USB cable to connect to the teacher computer.
- If you do not have the adapter, you might 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

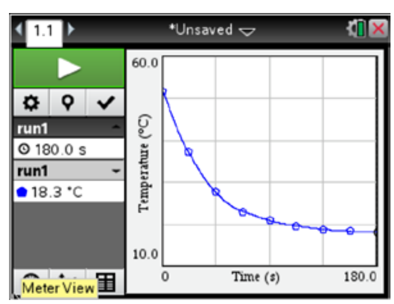
Teacher Tip: Making predictions is very important to helping students to connect the physical world to the mathematical world. Ask the students to make a prediction prior to collecting data and to sketch it. You might then want to ask them to compare their predictions to those of other students in the class as you walk around and look at the sketches. Once the data is collected, come back to those predictions and discuss any errors. 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 data collection, click the green **Start Collection** [▶] arrow in the upper-left corner of the screen. Or press **Tab** until the start arrow is highlighted, then press **Enter** when ready.



- 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 do 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 ºC. The room temperature should be lower than your lowest temperature recorded. Record them below.

   Sample Answers:

Starting Temperature (ºC)	51.8
Room Temperature (ºC)	17.5
Difference in Temperatures (ºC)	34.3

4. You might 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 along with 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	34.3
c	17.5

   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.

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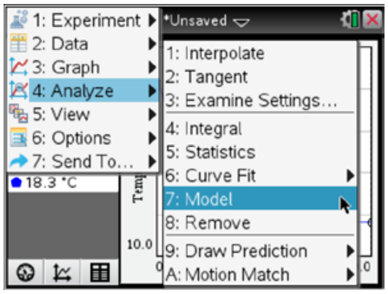
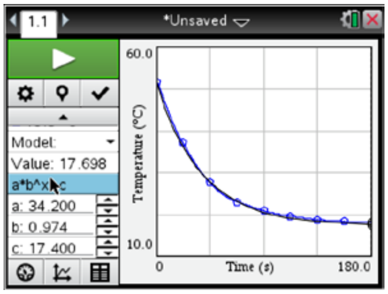
6. Select **Menu** > **Analyze** > **Model**. Type in the model $y = a \cdot b^x + c$ (be sure to enter the multiplication sign between *a* and *b*) and then enter the values for *a* and *c* along with your estimate for *b*.





- 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: $y = 34.2 \cdot (0.974)^x + 17.4$

> **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. remove the model, and 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.

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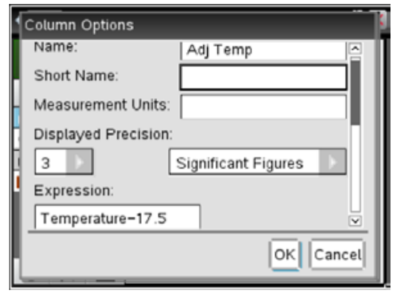
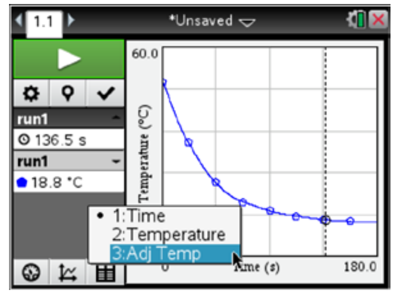
9. Since the temperature levels off at room temperature rather than zero, the exponential curve is shifted upward by room temperature. Subtracting room temperature from all of the temperature values will allow the data to be analyzed with an exponential regression.



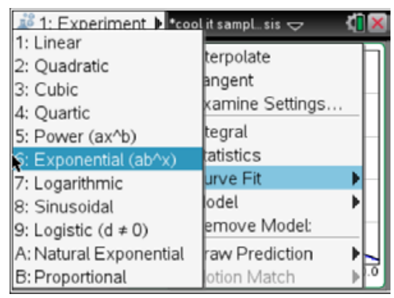
- Select **Menu > Data > New Calculated Column**.
- Name the new column *Adj Temp*. The Expression must be typed in precisely with *Temperature – Room Temperature* value.

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, right-click on the *Temperature* label along the dependent axis of the graph and change it to *Adj Temp*. Alternatively, you can select it from the Graph Menu.

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



<u>Sample Data Solution:</u> $a = 34.4$ and $b = 0.978$, so $y = 34.4(0.978)^x$.

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.

<u>Solution for Sample Data:</u> The equation $y = 34.4(0.978)^x + 17.5$ 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?

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

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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.

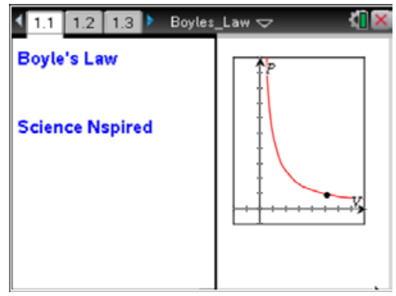
15. Write a short paragraph to summarize what you learned in this activity.

    Sample answer: Responses will vary.

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.

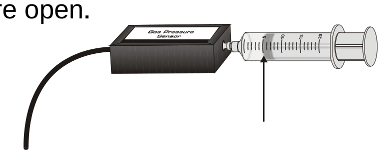
What is the mathematical relation between volume and pressure for a confined gas? To answer this question, you will perform an experiment with air in a syringe connected to a Gas Pressure Sensor. When the volume of the syringe is changed by moving the piston, the change in the pressure will be measured. 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.

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 start button to start data collection, or press tab until the start arrow is highlighted, then press enter when ready. It is best for one person to take care of the syringe and for another to operate the handheld.
8. To collect your first data reading, click on the Store Latest Data Set button to save the data. Enter a value of 10, since you set the syringe at 10 mL earlier. Click on OK, or press enter.

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Boyle's Law
Student Activity

Name ______________
Class ______________

9. Depress and hold the plunger to the 9 mL mark. When the pressure value on the left side of the screen has stabilized, click on the Store Latest Data Set button and type in 9, and press enter.
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.

- To view your data in graph form click on the Graph View button.

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/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 enter.
    - Select **MENU > Graph > Select X-axis > InverseV**.

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14. Calculate the regression line y = mx + b where x is 1/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. 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

Q10. Using P, V, and k, write an equation representing Boyle's Law.

Q11. Which of the following produced a constant value?

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

Q12. 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:

Q13. When the temperature is doubled, how does the pressure change?

A. The pressure doubles. B. The pressure is reduced by ½.
C. The pressure is 4X larger. D. The pressure does not change.

Q14. At a higher temperature, the relationship between pressure and volume is a(an) _______ relationship.

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

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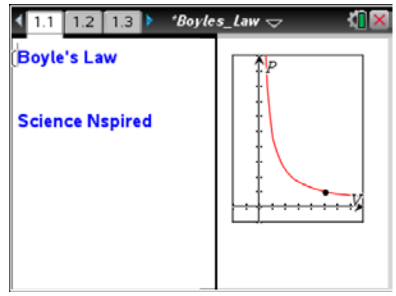

Science Objectives

- 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 Tip:

Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Files:

Student Activity

- Boyles_Law_Student.pdf
- Boyles_Law_Student.doc

TI-Nspire document

- Boyles_Law.tns

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 actual 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

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

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

Answer: moles of gas and temperature

Q10. Using P, V, and k, write an equation representing Boyle's Law.

Answer: $P = k/V$

Q11. Which of the following produced a constant value?

Answer: pressure times volume

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Q12. 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

Q13. When the temperature is doubled, how does the pressure change?

Answer: The pressure doubles.

Q14. 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.

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.

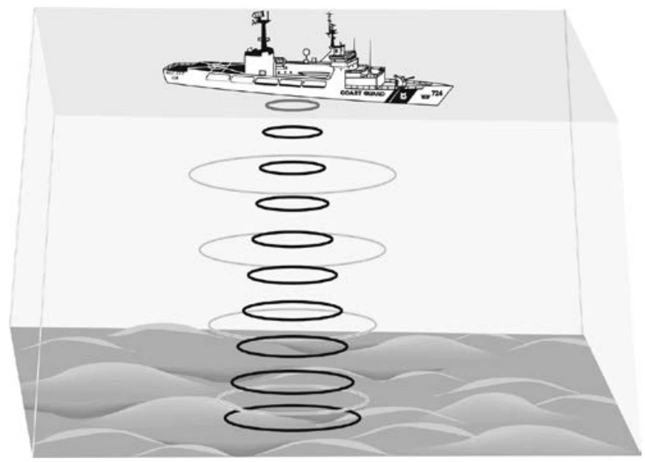
TI-Nspire Navigator Notes

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 *so*und *na*vigation *r*anging, 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	1 m board
	masking tape
Motion Detector	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?

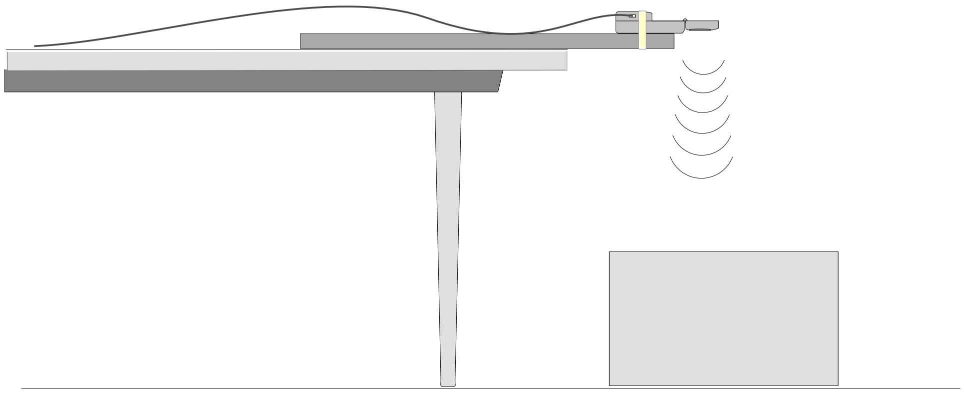


Figure 1

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 40 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. Connect the Motion Detector to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer.

4. Choose New Experiment from the Experiment menu. Choose Collection Setup from the Experiment menu. Enter **4** as the rate (samples/second) and **15** as the experiment duration in seconds. Select OK.
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 by pressing the play button ▶. 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. Click and drag the cursor across the data in the flat portion of the graph.
   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. Click and drag the cursor across the region that represents the box to select the region.
   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 40 cm from the Motion Detector.
   b. 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. 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 student pages with complete instructions for data collection using LabQuest App, Logger *Pro* (computers), EasyData or DataMate (calculators), and DataPro (Palm handhelds) can be found on the CD that accompanies this book. See *Appendix A* for more information.
2. The boxes should be at least 50 cm wide.
3. Best results are obtained when the boxes are located touching each other or at least 50 cm apart.
4. The tabletops should be smooth and flat.
5. Boards longer than one meter can be used. They should provide rigid support for the Motion Detector.
6. The hidden arrangement can be located behind a counter or demonstration table.

ANSWERS TO QUESTIONS

For Sample Answers to the questions in this lab, please contact Vernier Software and Technology at swnanswers@vernier.com

ACKNOWLEDGEMENT

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

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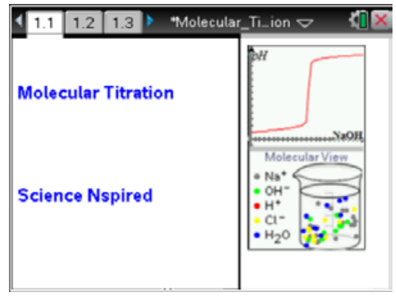
Molecular Titration
Student Activity

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.



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

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.

   HCl(aq) + NaOH(aq) → HOH + NaCl(aq)

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. H^+ and Cl^- ions
- B. HCl, H^+, and Cl^- ions
- C. HCl and NaOH
- D. Na^+ and OH^- ions

Q4. How many 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 H^+ ions _____.

A. decreases B. increases C. is unchanged

Q7. As NaOH is added the number of 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 H^+ ions remain in the beaker?

Q10. At the equivalence point how many OH^- ions are present in the beaker?

Q11. Write a net ionic equation to show what happened to the H^+ ions.

Q12. At the equivalence point the number of Cl^- ions is _____ the number of 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. H^+ ions
B. OH^- ions
C. Na^+ ions
D. Cl^- ions

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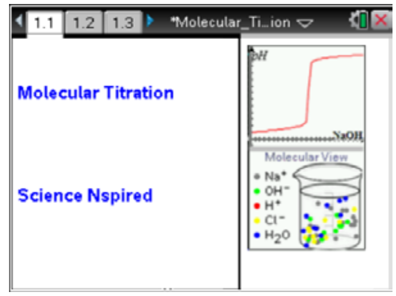
Science Objectives

- 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: H^+ and Cl^- ions

Q4. How many 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 H^+ ions _____.

Answer: A. decreases

Q7. As NaOH is added the number of 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 H^+ ion at the equivalence point, and review the definition of pH. You may wish to point out that the original solution has an 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 H^+ ions remain in the beaker?

Answer: none

Q10. At the equivalence point how many OH^- ions remain in the beaker?

Answer: none

Q11. Write a net ionic equation to show what happened to the H^+ ions.

Answer: $H^+ + OH^- \rightarrow H_2O$

Q12. At the equivalence point the number of Cl^- ions is _____ the number of 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: 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.

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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 for 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 over 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

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.

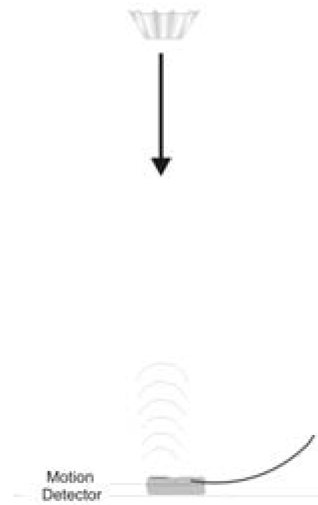


Figure 1

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 Graph View 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. Click the play button to 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 clicking the play button to start 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

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 Data 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)^2 v_T^2 (m^2/s^2)
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 home for clickpad handhelds) and choose Problem from the Insert menu. Press home 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 Table View 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 **Vt** 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^2** as the Name, **Vt^2** as the Short Name, and **(m/s)^2** as the units.

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 Graph View 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^2 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^2** data. Choose Curve Fit from the Analyze menu, select the **Terminal V^2** 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

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

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.)

TEACHER INFORMATION

Air Resistance

1. The student pages with complete instructions for data collection using LabQuest App, Logger *Pro* (computers), DataQuest (TI-Nspire Technology), EasyData or DataMate (calculators), and DataPro (Palm handhelds), can be found on the CD that accompanies this book. See *Appendix A* for more information.

2. Larger food-service size coffee filters of roughly the same proportions as consumer basket style coffee filters are available. Try to get some of these from a restaurant or your cafeteria. They make great demonstration devices.

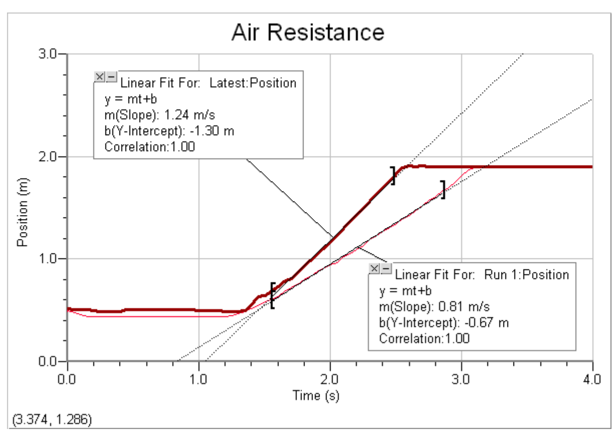
3. There are numerous articles on the physics of air resistance. Two references from The Physics Teacher are “Modeling Air Drag,” by Christopher Brueningsen, et al., Volume 32, October 1994, page 439 ff, and “Effects of Air Resistance,” Vasilis Pagonis, et al., Volume 35, September 1997, page 364 ff.

4. Students need to recognize that during free fall the drag force is equal to the weight of the filters; therefore, the weight of the filters or number of filters equal drag force during terminal velocity. Best results are obtained by allowing the filters to fall a long distance. Consider having the students stand on a chair when releasing the filters. Release the filters from underneath, and don’t hold them from the side to avoid getting a reflection from the hand.

5. Motion detectors without a mode switch do not properly detect objects closer than 0.45 m. As a result such motion detectors must be farther away from the experiment than described in the student notes. In contrast, Motion detectors *with* a mode switch will detect objects as close as 0.15 m. Ideally, an experiment will be set up so that the target is nearly this close at the point of closest approach, giving the best possible data.

SAMPLE RESULTS

Number of filters	Terminal Velocity v_T (m/s)	(Terminal Velocity)^2 v_T^2 (m^2/s^2)
1	0.80	0.65
2	1.12	1.25
3	1.37	1.88
4	1.57	2.46
5	1.87	3.50
6	2.02	4.08
7	2.23	4.97
8	2.34	5.48



Typical position vs. time graphs

ANSWERS TO PRELIMINARY QUESTIONS

1. Two filters fall more quickly than one filter. The rate of fall will increase with the number of filters nested.

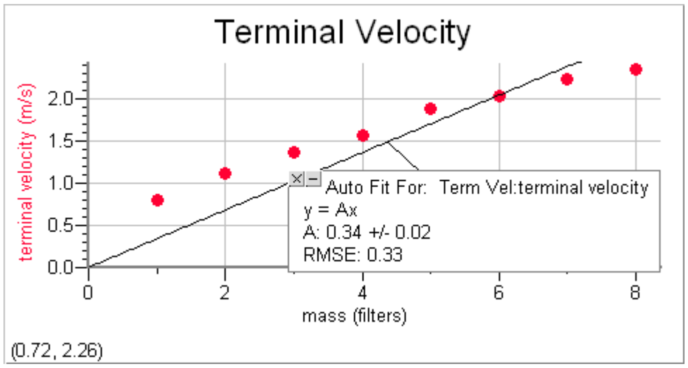
2. Without air resistance, a baseball and a coffee filter would fall at the same rate.

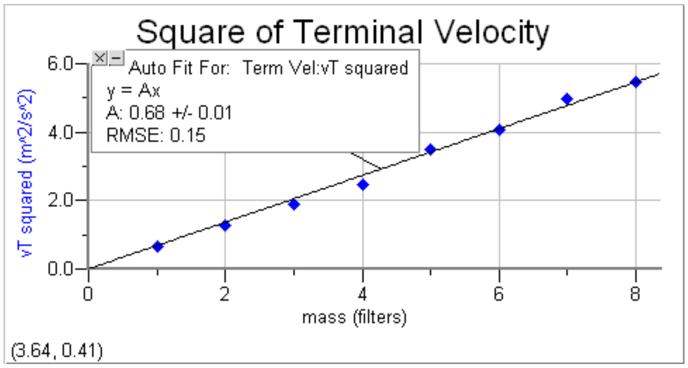
3. (sketch)

4. At terminal velocity, air resistance matches the downward force, so there is no net force.

ANSWERS TO ANALYSIS QUESTIONS

1. Two different models for the drag force:





2. The graph of v_T^2 *vs.* mass is closer to a direct relationship than is the graph of v_T *vs.* mass. In particular, the v_T^2 *vs.* mass graph points toward the origin, while the v_T *vs.* mass does not. The v_T *vs.* mass graph is also more curved than the v_T^2 *vs.* mass graph.

3. Since the v_T^2 *vs.* mass graph is close to a proportionality, it appears that the drag force is proportional to the square of velocity, or $F_{drag} = -cv^2$.

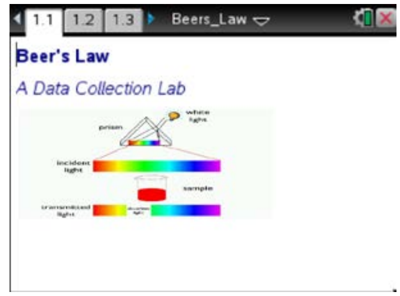
4. Since our graphs show that terminal velocity squared is directly proportional to mass, the terminal velocity of four filters is about twice as large as the terminal velocity of one filter; therefore, the fall would take half as long.

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 $NiSO_4$ 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.

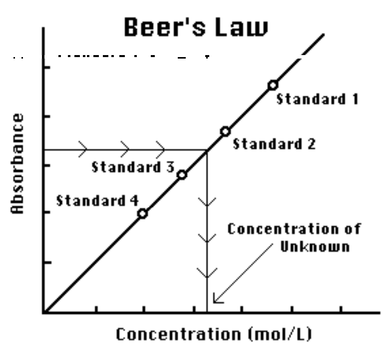


Figure 2.

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* $NiSO_4$ 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.

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Beer's Law
Student Activity

Name ______________
Class ______________

Move to page 1.8.

Objectives

- Prepare $NiSO_4$ 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 NiSO4 solution.

Move to pages 1.9–1.10.

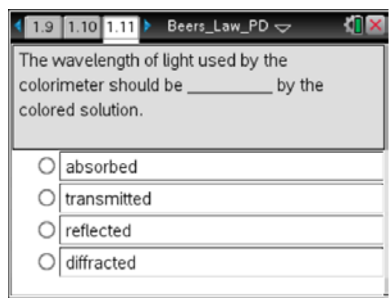
Materials

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 $NiSO_4$
5 mL of $NiSO_4$ unknown solution
paper towels

TI-Nspire™ Lab Cradle or Vernier EasyLink™ interface
Two burettes
Ring stand
One cuvette
Stirring rod
KimWipes or tissues (preferably lint-free)
sink or waste basin

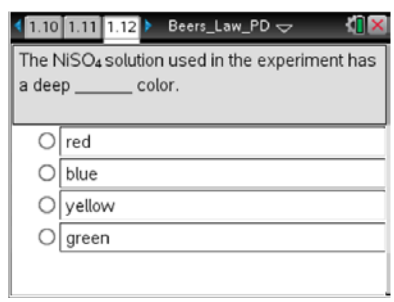
Move to page 1.11.

Answer the question on your TI-Nspire handheld.



Move to page 1.12.

Answer the question on your TI-Nspire handheld.

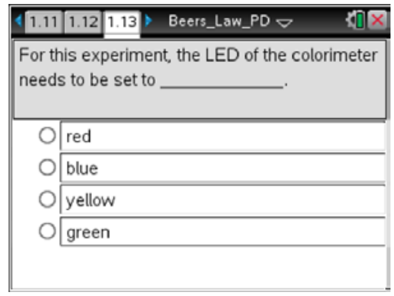


Beer's Law
Student Activity

Name ______________
Class ______________

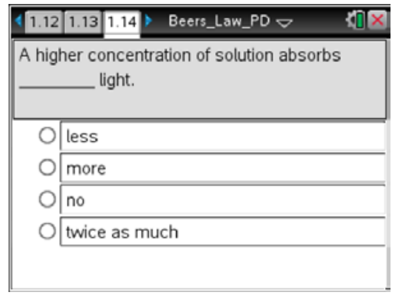
Move to page 1.13.

Answer the question on your TI-Nspire handheld.



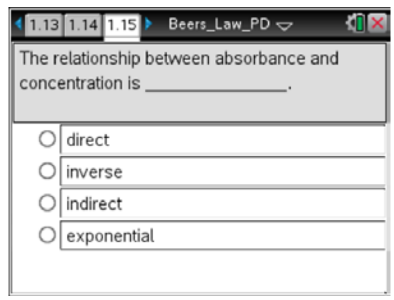
Move to page 1.14.

Answer the question on your TI-Nspire handheld.



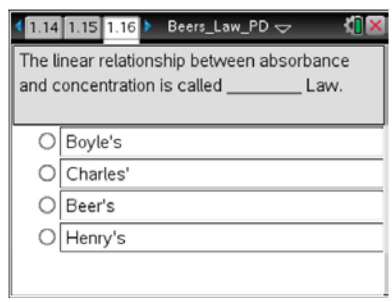
Move to page 1.15.

Answer the question on your TI-Nspire handheld.



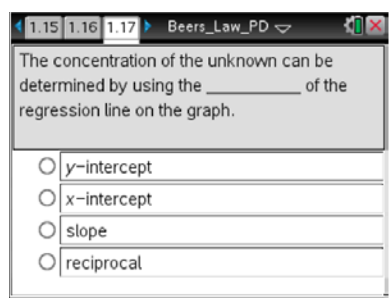
Move to page 1.16.

Answer the question on your TI-Nspire handheld.



Move to page 1.17.

Answer the question on your TI-Nspire handheld.



Beer's Law
Student Activity

Name ______________

Class ______________

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. Move to page 2.5 and see Figure 3. Then move to page 2.6 connect the colorimeter to the data-collection interface. Connect the interface to your TI-Nspire handheld.

Move to page 2.5.

Connecting the colorimeter to the TI-Nspire handheld using the EasyLink connector.

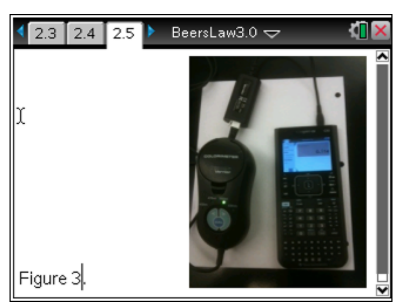


Figure 3.

Move to page 2.6.

When you connect the sensor to the handheld, this page will become active.

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.

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

   e. Select OK.

Move to page 2.9.

7. You are now ready to collect data for the five standard solutions.

   a. Click the green **Start Collection** ▶ arrow in the upper-left corner of the screen.

   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.

Beer's Law
Student Activity

Name ______________
Class ______________

Move to page 2.10.

c. When the value displayed on the screen has stabilized, click **Keep Current Reading** 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.

d. 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 **Keep Current Reading** button. Enter 0.16 as the concentration in mol/L. Select OK.

Move to page 2.12.

e. 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 $NiSO_4$. Note: Wait until Step 9 to test the unknown.

f. Press **Stop** data collection.

g. Click **Table View** tab to display the data table. Record the absorbance and concentration data values in your paper table.

Move to page 2.13.

8. Display a graph of absorbance versus concentration with a linear regression curve.
   a. Click **Graph View** tab.
   b. 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.

Beer's Law
Student Activity

Name ______________
Class ______________

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.

9. Determine the absorbance value of the unknown $NiSO_4$ solution.
   a. Click **Meter View** tab.
   b. Obtain about 5 mL of the unknown $NiSO_4$ in another clean, dry, test tube. Record the number of the unknown in your data table.

Move to page 2.17.

   c. 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.
   d. Monitor the absorbance value. When this value has stabilized, record it in your data table on the student activity sheet.

10. 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 $NiSO_4$ solution, interpolate along the regression line to convert the absorbance value of the unknown to concentration.
   a. Click **Graph View** tab.
   b. Select **Menu > Analyze > Interpolate**.

Move to page 3.2.

   c. 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 $NiSO_4$ concentration, in mol/L, will be displayed.
   d. Record the concentration value in your data table on the student activity sheet.

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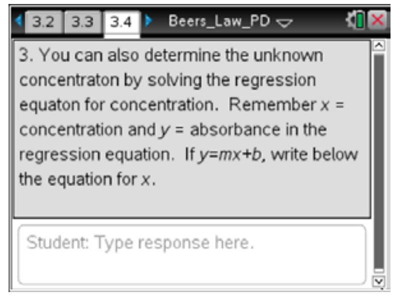
Move to page 3.3.

2. If available, 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.

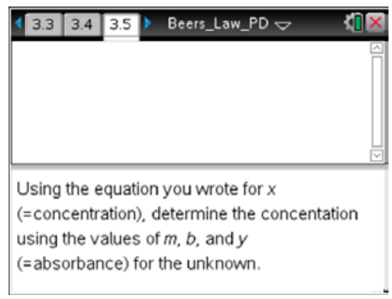
Move to page 3.4.

Answer the question on your TI-Nspire handheld.



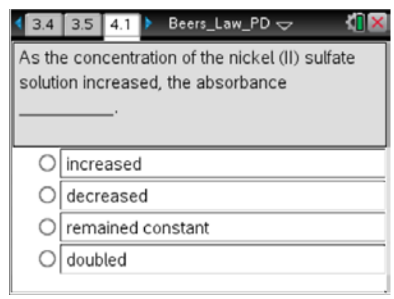
Move to page 3.5.

Answer the question on your TI-Nspire handheld.



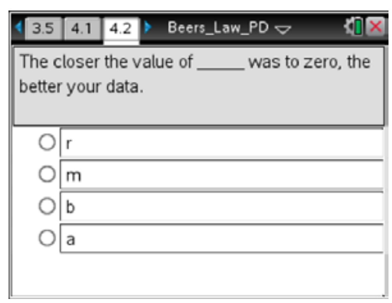
Move to page 4.1.

Answer the question on your TI-Nspire handheld.



Move to page 4.2.

Answer the question on your TI-Nspire handheld.

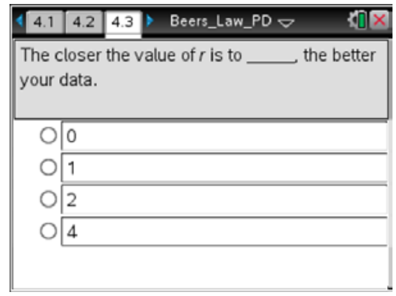


Beer's Law
Student Activity

Name ______________
Class ______________

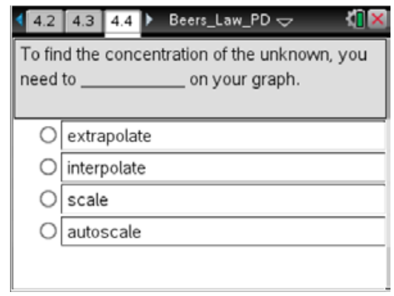
Move to page 4.3.

Answer the question on your TI-Nspire handheld.



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

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Beer's Law
TI PROFESSIONAL DEVELOPMENT

TEACHER NOTES

Science Objectives

- Students will make a serial dilution of a $NiSO_4$ 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 $NiSO_4$ solution.

Vocabulary

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

About the Lesson

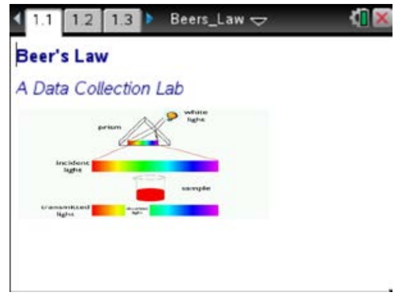
- This lesson involves absorbance data for solutions of various concentrations.
- As a result, students will...
    - Become familiar with TI-Nspire™ CX CAS technology and the Vernier DataQuest™ app for TI-Nspire.
    - Use this graph to make conclusions about the experiment.
    - Use a colorimeter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

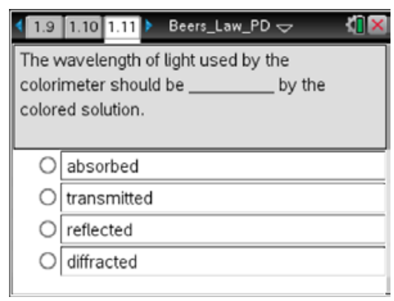
Visit www.sciecenspired.com for lesson updates and tech tip videos. (Optional)

- 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 $NiSO_4$. (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 "$NiSO_4$" 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.

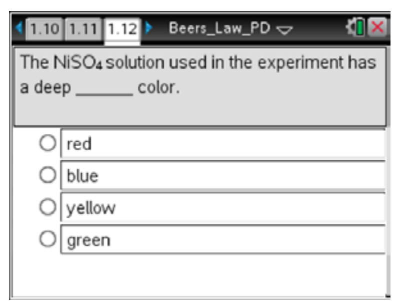
Move to page 1.11.



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

Answer: absorbed

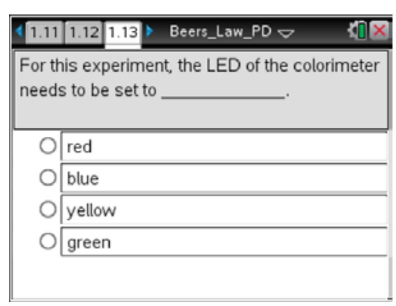
Move to page 1.12.



The $NiSO_4$ 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

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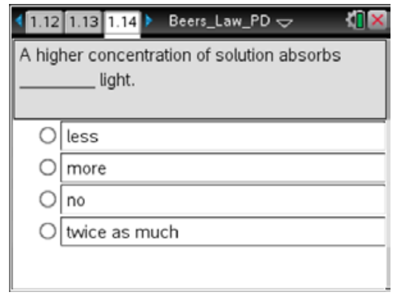
Move to page 1.14.

A higher concentration of solution absorbs _____ lights.

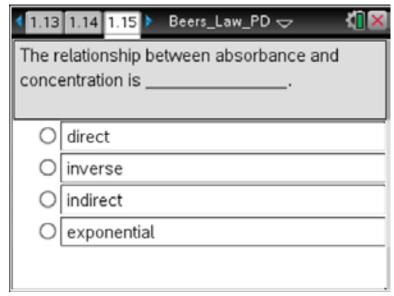
Answer: **more**



Move to page 1.15

The relationship between absorbance and concentration is _____.

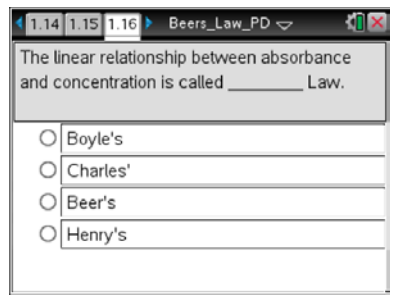
Answer: direct



Move to page 1.16.

The linear relationship between absorbance and concentration is called _____ Law.

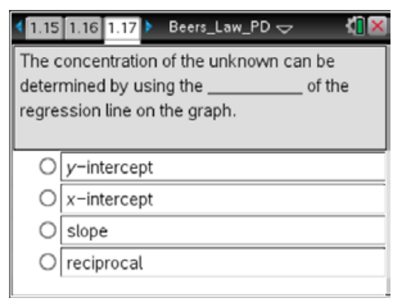
Answer: Beer's



Move to page 1.17.

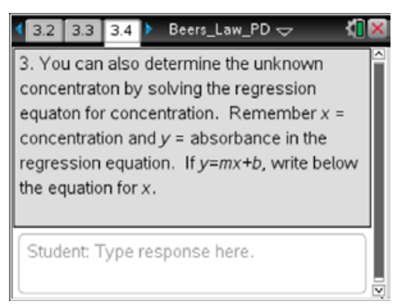
The concentration of the unknown can be determined by using the _____ of the regression line on the graph.

Answer: slope

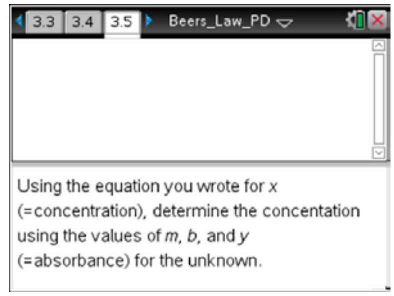


Move to page 3.4.

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



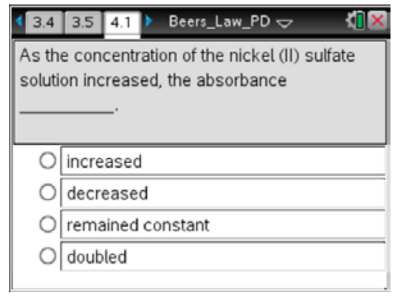
Move to page 3.5.



Answer: (This is a sample calculation.)

$x = [0.308 – (–0.0022)]/1.17 = 0.265$ mol/L

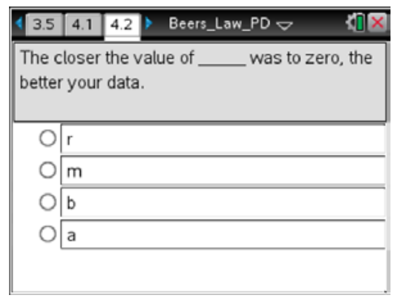
Move to page 4.1.



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

Answer: increased

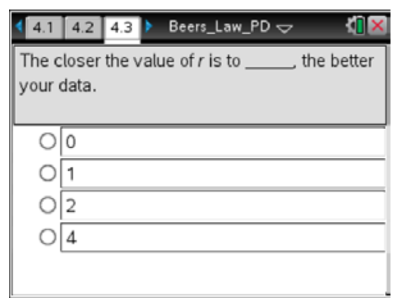
Move to page 4.2.



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

Answer: *b*

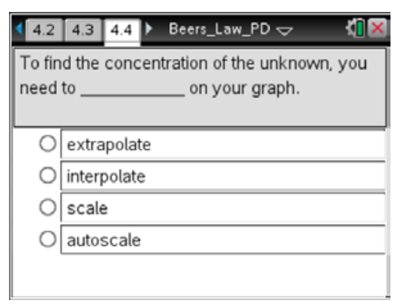
Move to page 4.3.



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

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TI-Nspire™ Navigator™ Opportunity

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

Data Table (Sample Data)

Trial	Concentration (mol/L)	Absorbance
1	0.080	0.089
2	0.16	0.186
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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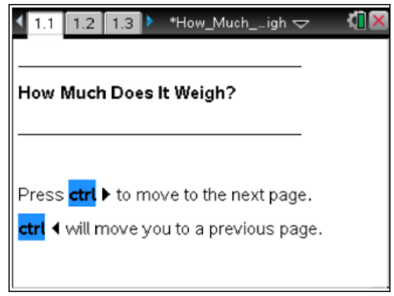
How Much Does It Weigh?

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:

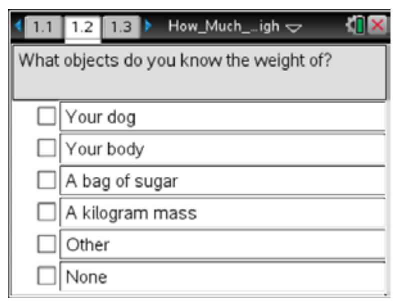
Press [on] and select **My Documents**.

Step 2:

Locate *How_Much_Does_It_Weigh.tns* and press [enter] 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 [ctrl] ▸ 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 [enter] to select a response. On questions with multiple responses allowed, you deselect the answer by pressing [enter] 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 [click] to make a selection.

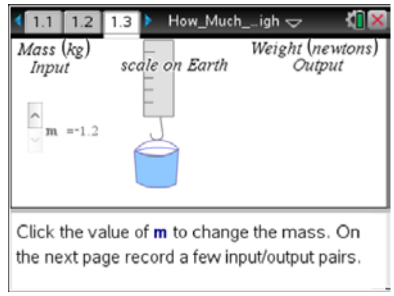
Step 6:

After choosing all desired responses, press [ctrl] ▸ 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 [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 [del] to backspace over the previous value, and enter a new value.

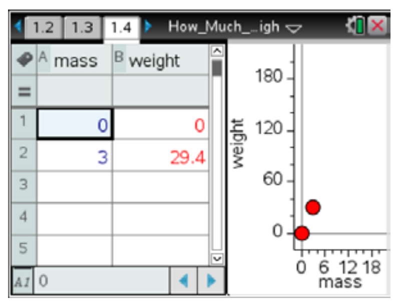
Step 9:

Press [enter] to evaluate this value.

Step 10:

Press [ctrl] ▶ 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 [enter].

What science concepts can be explored with this activity?

What questions can we ask to highlight the math concepts?

Step 13:

Press [ctrl] ▶ 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.

DataQuest
14

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:

$$C_6H_{12}O_6 + 6\ O_2(g) \longleftrightarrow 6\ H_2O + 6\ CO_2(g) + \text{energy}$$

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_2 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_2 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.

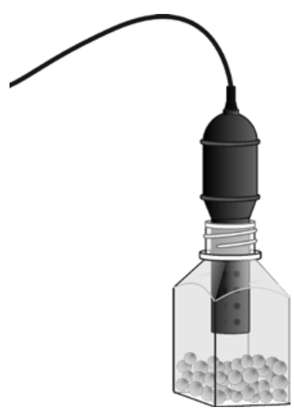


Figure 1

MATERIALS

TI-Nspire handheld **or**
computer and TI-Nspire software
data-collection interface
Vernier CO_2 Gas Sensor
100 mL beaker
250 mL respiration chamber
25 germinated pea seeds
25 non-germinated pea seeds
ice cubes
thermometer

PROCEDURE

1. If your CO_2 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_2 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_2 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_2 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 Data 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 Data 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.
    a. Click **run3** and select All. All three runs will now be displayed on the same graph axes.
    b. 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

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

EXTENSIONS

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

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Experiment
14

TEACHER INFORMATION

Cell Respiration

1. Editable Microsoft Word versions of the student pages and pre-configured TI-Nspire files can be found on the CD that accompanies this book. See *Appendix A* for more information.

2. Allow the seeds to germinate for three days prior to the experiment. Prior to the first day, soak them in water overnight. On subsequent days, roll them in a moist paper towel and place the towel in a paper bag. Place the bag in a warm, dark place. Check each day to be sure the towels remain very moist. If time is short, the peas can be used after they have soaked overnight. For best results, allow them to germinate for the full three days.

3. The CO_2 Gas Sensor has a 90 second warm-up period. Any data collected during this warm up will not be accurate. When using the TI-Nspire Lab Cradle, the text in the CO_2 sensor meter will be displayed in light gray until the sensor has warmed up. At that time, the meter text will be displayed in black.

4. Heavy condensation buildup in the respiration chamber can interfere with readings from the CO_2 Gas Sensor. This can be a source of error if the peas are very wet when placed in the respiration chamber. Before placing the peas in the respiration chamber, blot them dry with a paper towel.

5. The CO_2 Gas Sensor relies on the diffusion of gases into the probe shaft. Students should allow a couple of minutes between trials so that gases from the previous trial will have exited the probe shaft. Alternatively, the students can use a firm object such as a book or notepad to fan air through the probe shaft. This method is used in Step 10 of the student procedure.

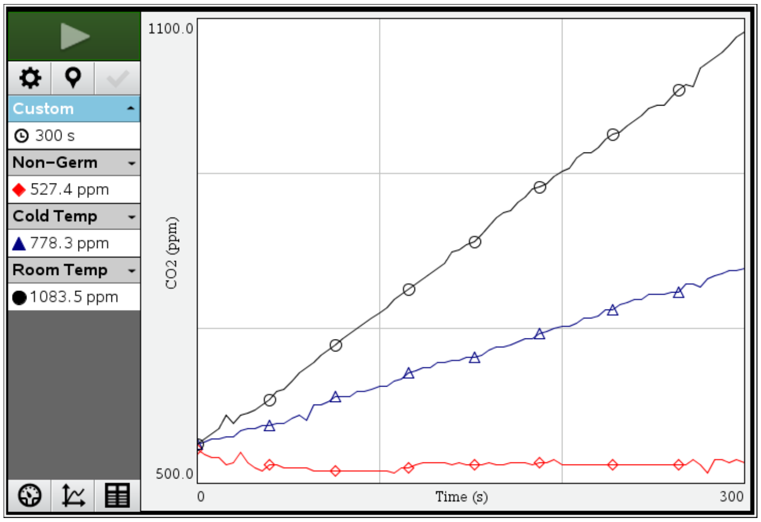
6. The morning of the experiment fill a 1 L beaker with ice and water so that students will have cold water. Students will also need access to ice.

7. When doing this experiment with a TI-Nspire handheld, your batteries will drain quickly. This is especially true when using an EasyLink or Go!Link interface. Be sure your handheld has fresh or fully charged batteries.

8. The older-style CO_2 sensor cannot be used with an EasyLink or Go!Link interface. To use this probe, you must use a multi-channel sensor interface.

9. The stopper included with the older-style CO_2 Gas Sensor is slit to allow easy application and removal from the probe. When students are placing the probe in the respiration chamber, they should gently twist the stopper into the chamber opening. Warn the students not to twist the probe shaft or they may damage the sensing unit.

SAMPLE RESULTS



CO_2 respired by germinating – room temperature (○),
non-germinating (■), and germinating – cool temperature peas (△).

Table 1	
Room Temperature (°C)	22.4

Table 2	
Peas	Rate respiration (ppm/s)
Germinating, room temperature	1.78
Non-germinating, room temperature	0.02
Germinating, cool temperature	0.78

ANSWERS TO QUESTIONS

1. Yes, the carbon dioxide concentration *vs*. time graph clearly indicates that carbon dioxide is being produced at a steady rate when germinating peas are in the respiration chamber.

2. Germination greatly accelerates the rate of cellular respiration. This reflects a higher rate of metabolic activity in germinating seeds. In most experiments, non-germinating seeds do not seem to be respiring. Occasionally, however, some respiration is detectable.

3. Warm temperatures increase the rate of respiration. This reflects a higher rate of metabolic activity in warm germinating seeds than in cool seeds.

4. It is necessary for germinating seeds to undergo cellular respiration in order to acquire the energy they need for growth and development. Unlike their mature relatives, seeds do not yet have the necessary photosynthetic abilities needed to produce their own energy sources.

Barometric Pressure

Student Activity

Name ________________

Class ________________

Open the TI-Nspire document
Barometric_Presssure_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.

Move to pages 1.2-1.3. Read the background information for this activity.

Hurricane Katrina was the deadliest and most destructive Atlantic hurricane of the 2005 Atlantic hurricane season. It is the costliest natural disaster, as well as one of the five deadliest hurricanes, in the history of the United States. Among recorded Atlantic hurricanes, it was the sixth strongest overall. At least 1,836 people died in the actual hurricane and in the subsequent floods.

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**.

Part 1: Exploring Barometric Pressure and Parts of a Hurricane

Move to page 1.4.
Read the directions for the simulation.

1. Slowly move the cursor 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.

> **Tech Tip:** To observe the pressure measurements around the eye of the hurricane, press your finger to the eye of the hurricane and drag it left and right.

Barometric Pressure

Student Activity

Name ______________

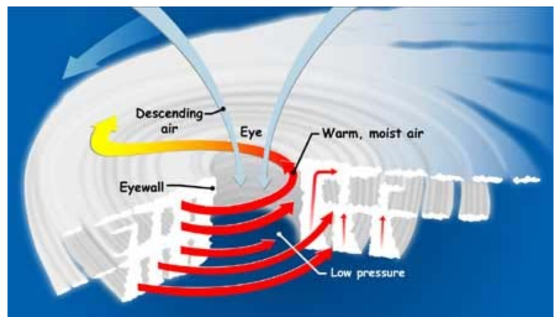
Class ______________

Tech Tip: To access the Directions again, select menu or **Document Tools ( ) > Hurricane Katrina > Directions.**

Tech Tip: To access the Directions again, select > **Hurricane Katrina > Directions.**

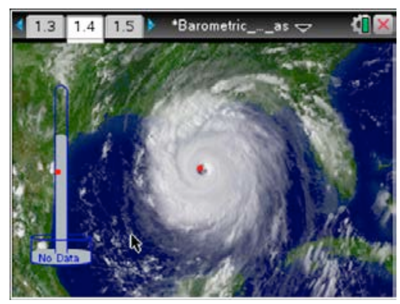
Q1. Describe what happens to the barometer as you move the cursor across the screen.

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/]

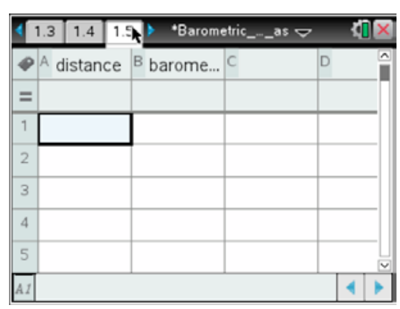
3. Select esc to clear data points that may have previously been selected. Move the cursor to the eye of the hurricane and select it using . Then, move the cursor to the edge of the coast and select it.



Tech Tip: To select data points, tap a location on the simulation. To clear data points, select > **Hurricane Katrina > Erase Measurements.**

Move to page 1.5.

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



Barometric Pressure

Student Activity

Name ________________

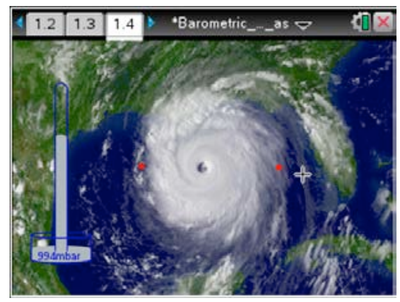
Class ________________

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. Clear the data points that have previously been placed. This will also clear the spreadsheet and the scatter plot on pages 1.5 and 1.6.



Q4. Notice that Hurricane Katrina has a circular shape. 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

Barometric Pressure

Student Activity

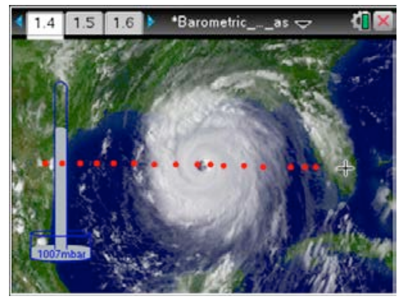
Name _______________

Class _______________

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. Clear the data points that have been collected.

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.

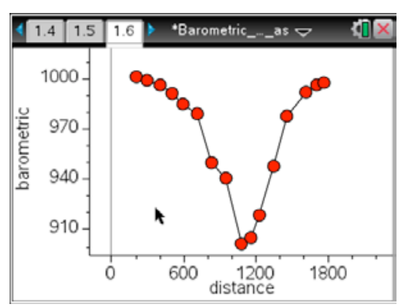


Q6. Go to page 1.5 that shows the spreadsheet with data you collected. Copy your data from the spreadsheet to complete the table shown below.

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

Move to page 1.6.

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?



Barometric Pressure

Student Activity

Name ________________

Class ________________

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 condenses to form 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?

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**
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

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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.

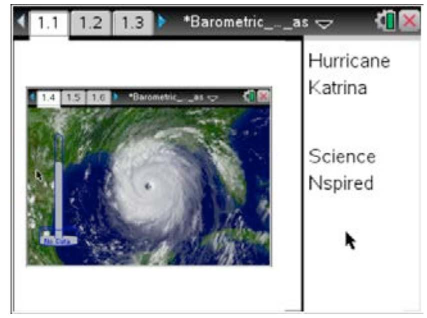
Q12. Based on the Saffir/Simpson Hurricane Scale, what category is Hurricane X?

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

Barometric Pressure

TEACHER NOTES

MIDDLE GRADES SCIENCE NSPIRED



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™ Navigator™

- Send out the *Barometric_Pressure_in_Hurricane_Katrina.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.

Activity Materials

- Compatible TI Technologies: TI-Nspire™ CX Handhelds, TI-Nspire™ Apps for iPad®, TI-Nspire™ Software

Tech Tips:

- This activity includes class captures taken from the TI-Nspire CX handheld. It is also appropriate for use with the TI-Nspire family of products including TI-Nspire software and TI-Nspire App. Slight variations to these directions may be required if using other technologies besides the handheld.
- Watch for additional Tech Tips throughout the activity for the specific technology you are using.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials

Lesson Materials:

Student Activity

- Barometric_Pressure_in_Hurricane_Katrina_Student.doc
- Barometric_Pressure_in_Hurricane_Katrina_Student.pdf

TI-Nspire document

- Barometric_Pressure_in_Hurricane_Katrina.tns

Discussion Points and Possible Answers

Move to pages 1.2–1.3.

Have students read the background information for the activity on their student activity sheets and/or on their devices.

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.

Move to page 1.4.

Have students read the directions for the simulation. Make sure students note where the barometer is located on the screen.

1. 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.

Tech Tip: To observe the barometer levels, students should press their finger to the screen and drag it across the hurricane.

TI-Nspire Navigator Opportunities

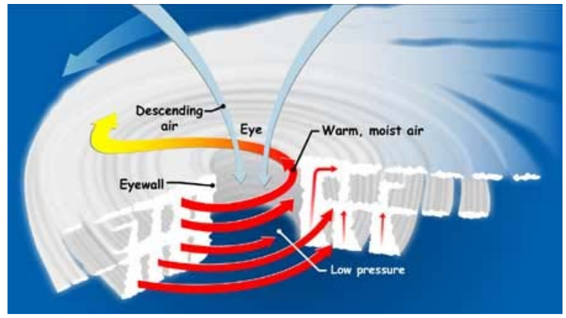
Allow students to volunteer to be the Live Presenter and demonstrate areas on the screen where the cursor changes.

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.

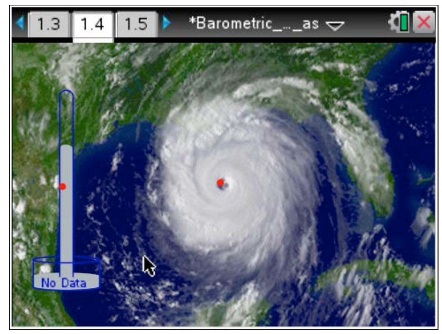
Answer: The barometer changed levels as the cursor was dragged across the screen from left to right. It started at a high level, then dropped as it got closer to the center of the hurricane, then it rose again.

2. Allow students time to look at the diagram to the right 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/]

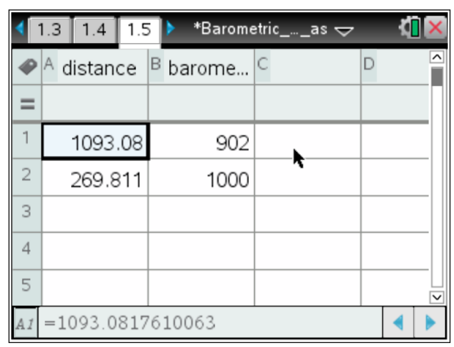
3. Students will be selecting areas of the screen to collect data points. Students need to move the cursor to the eye of the hurricane and select it using . Then, they should move the cursor to the edge of the coast and select it.



Tech Tip: To select data points, have students tap a location on the simulation.

Move to page 1.5.

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.



Q2. Complete the table shown below.

<u>Sample answer</u>:

Location of Data Point	Distance (km) From Unknown Location
Eye of Hurricane	**1093.08**
Coast	**269.811**

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 select esc to remove data points that have previously been placed. This will also clear the spreadsheet and the scatter plot on pages 1.5 and 1.6.

> **Tech Tip:** To clear data points, have students select > **Hurricane Katrina > Erase Measurements.**

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**

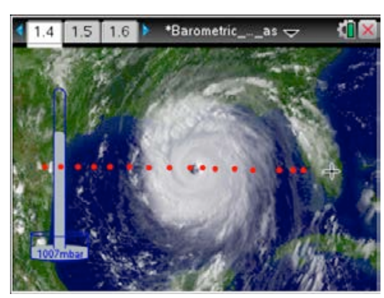
Q5. Based on your data, what is the approximate diameter of Hurricane Katrina?

A. 60 kilometers
B. 550 kilometers
C. 800 kilometers
D. 1250 kilometers

Answer: C

Part 2: Analyzing Barometric Pressure

6. Make sure to remind students 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 1.6 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.

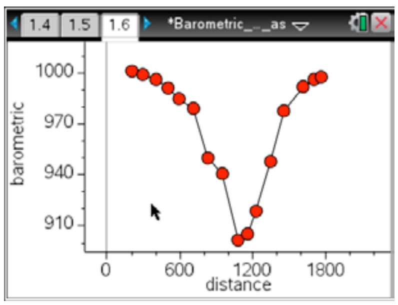
Q6. Go to page 1.5 that shows the spreadsheet with data you collected. Copy your data from the spreadsheet to complete the table shown below.

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 1.6.

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.

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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.

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™ Teacher Software

TI PROFESSIONAL DEVELOPMENT

Activity Overview

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

Materials

- TI-Nspire™ or TI-Nspire™ CAS 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**.

A new TI-Nspire™ document may be opened by clicking any of the applications on the Welcome Screen. Alternatively, a new document may be opened by going to **File** and selecting **New TI-Nspire™ Document – Handheld Page Size** or **New TI-Nspire™ Document – Computer Page Size.**

- The **Handheld Page Size** allows documents to be viewed on all platforms. The content will be scaled when viewed on a tablet or larger screen.
- In **Computer Page Size**, content will not be scaled when viewed on smaller platforms and all content may not be visible on a handheld device.

Step 2:

Go to **File > New TI-Nspire™ Document – Handheld Page Size.** Select **1:Add Calculator**.

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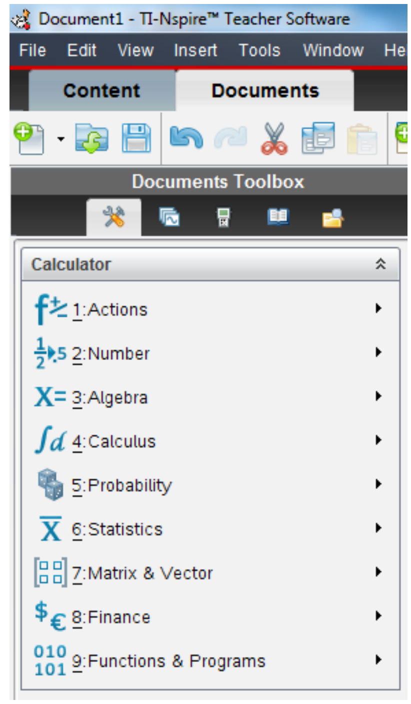
Step 3:

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

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

Explore the various menus and submenus by entering and evaluating your own expressions.

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

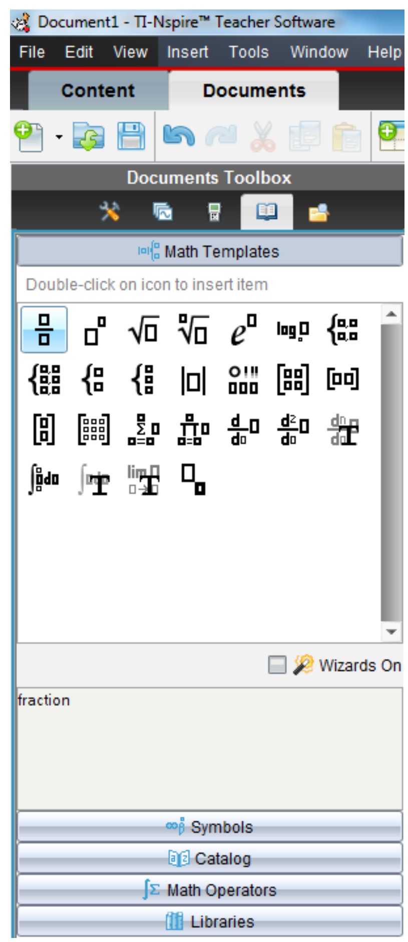


Step 4:

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**.



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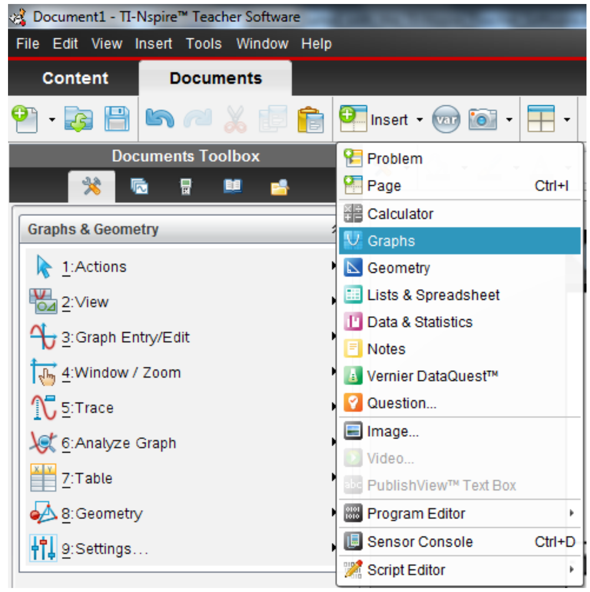
Step 5:

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

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

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

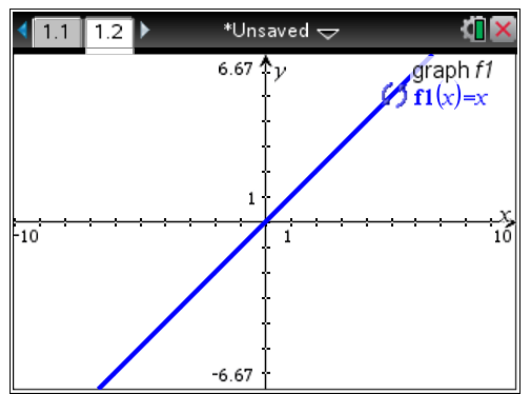


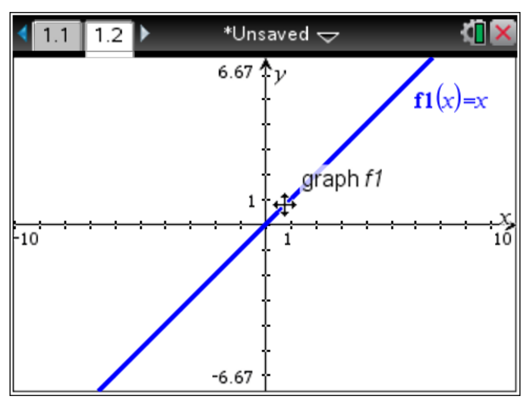
Step 6:

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 or lower-left 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 y-intercept of the graph. When the translational cursor, ✣, appears, translate the line up or down by clicking and dragging it.



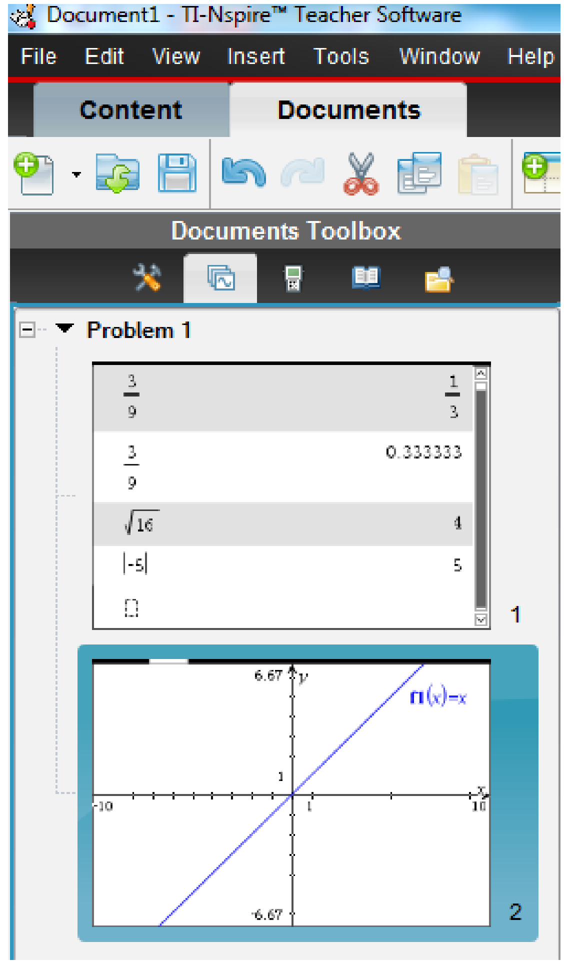


Step 7:

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.

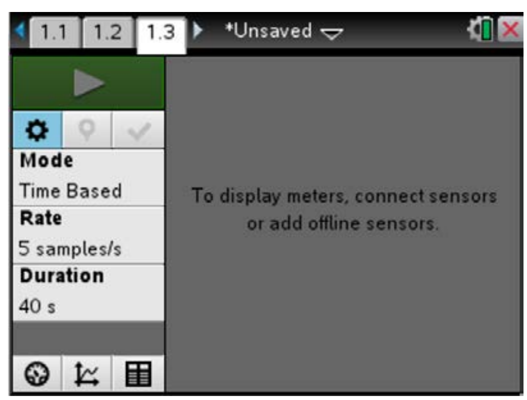
Note: To access Page Sorter in the handheld, press ctrl ▲. To right-click in the handheld, press ctrl menu.



Step 8:

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™**.

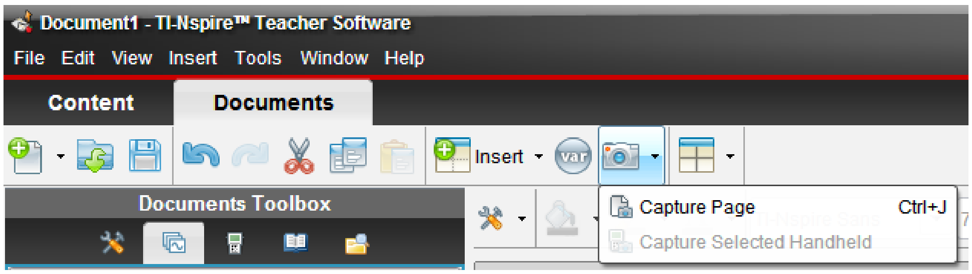
Though no data will be collected during this activity, the data meter will automatically launch when a Vernier sensor is connected to the computer's USB port.



Step 9:

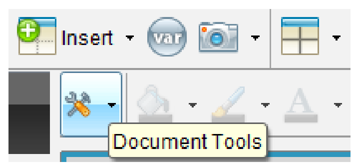
The Documents toolbar allows you to create, open, and save a TI-Nspire document. Commands such as Undo, Redo, Cut, Copy, and Paste are also available. Explore these options by hovering the cursor over each icon. Pages, problems, and applications can be inserted and variables can be stored.

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**.

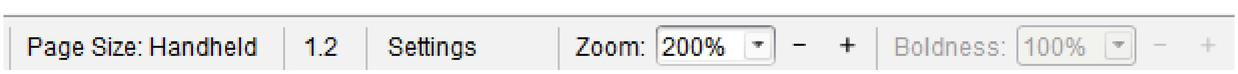
The Document Tools menu contains tools and commands for the current application.



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 10:

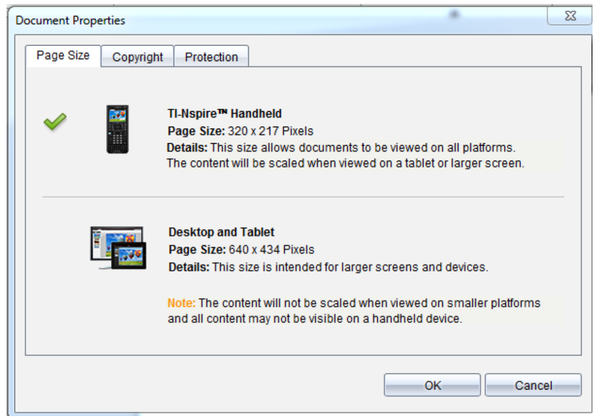
The Status Bar allows the user to access Document Properties, Settings, and to adjust the zoom of the SideScreen.



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.

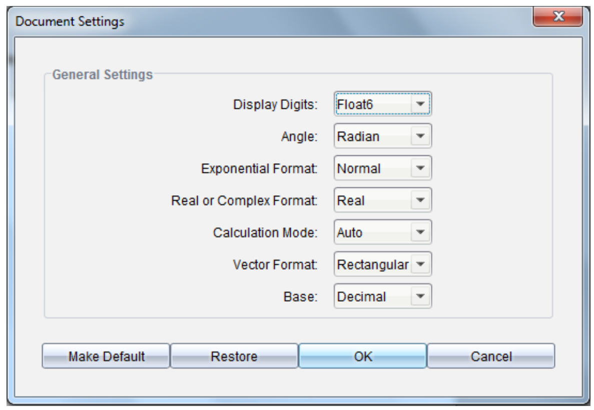
Step 11:

View the Document Properties by going to **File > Document Properties**. The Document Properties also can be viewed by going to the Status Bar and double-clicking **Page Size: Handheld** or **Page Size: Computer**. The page size displayed depends upon the type of TI-Nspire document originally opened.



Step 12:

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



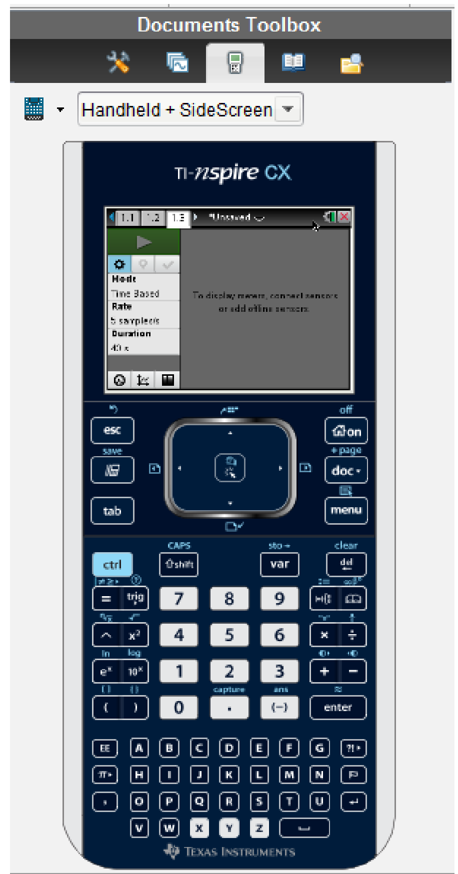
Note: To move across fields in the Document Settings window, press TAB. To change the setting in a given field, press the down arrow, select the desired setting, and press TAB to move to the next field. To exit the window, press ENTER.

Step 13:

Preview the document in Handheld or Computer view by clicking Document Preview ▾ .

Step 14:

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.

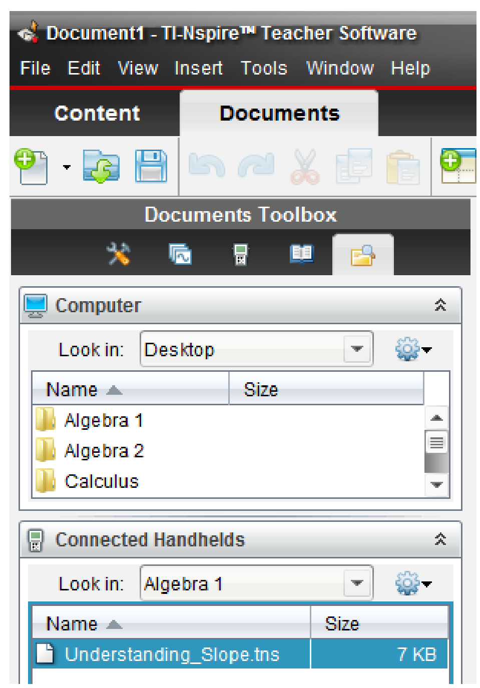
The TI-SmartView emulator has three available keypads:

- 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 Options** menu and explore each keypad and view.

Step 15:

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.

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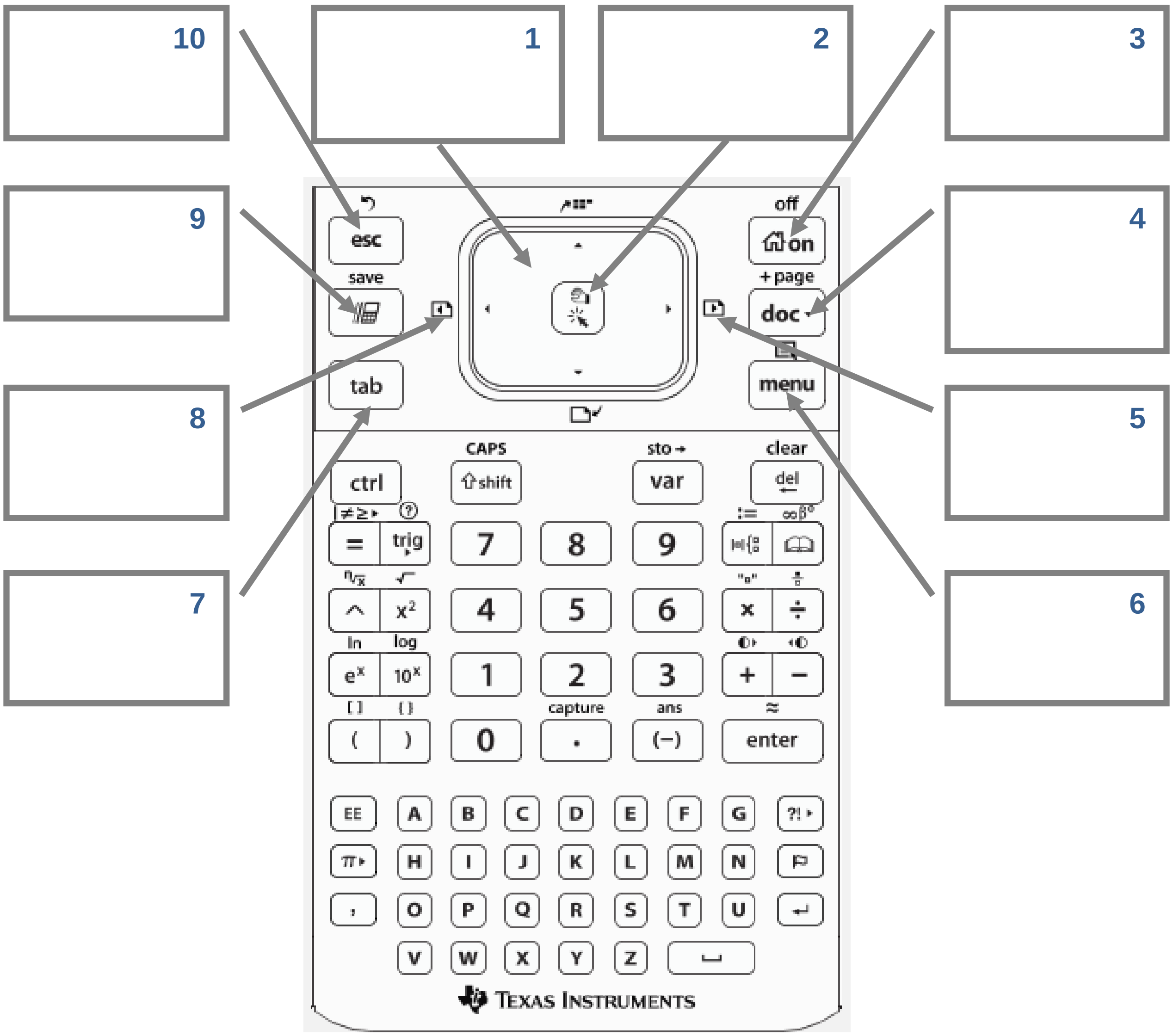
TI-Nspire™ CX Family Overview

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™ Teacher Software.

Materials

- TI-Nspire™ or TI-Nspire™ CAS Teacher Software and standard-A to mini-B USB 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 device 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 make sure the TI-Nspire CX handheld is fully charged before beginning an OS download (or, if using the TI-Nspire with Touchpad or Clickpad, install new batteries).

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 USB connection cable to download and install the updates.

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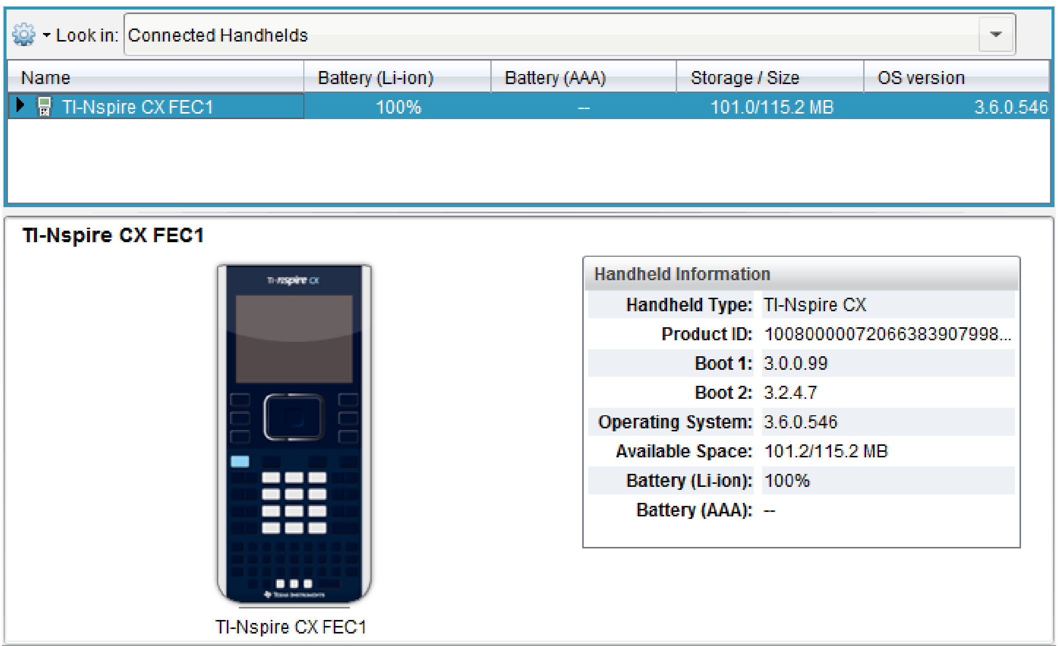
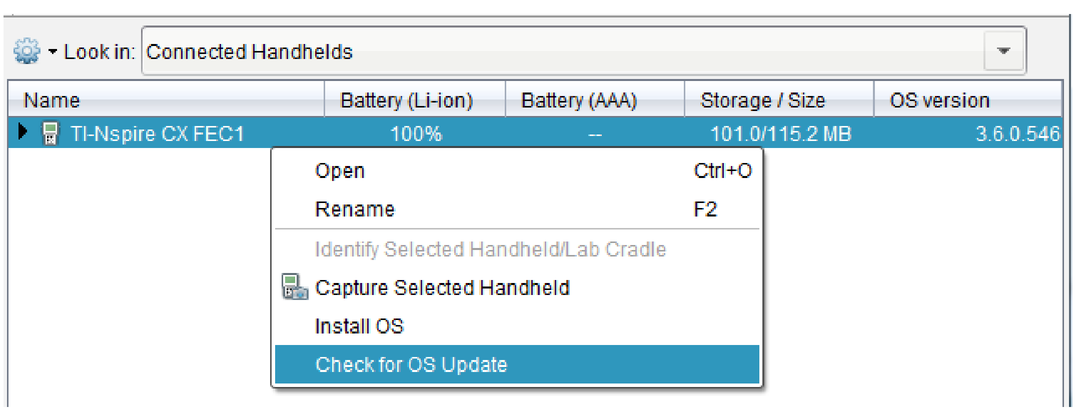
Using TI-Nspire Teacher Software to Update the Handheld OS

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 **TI-Nspire™ 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. Click on the name of the handheld to display battery, storage, and OS information. More detailed information appears in the Handheld Information window.



To see if a new OS is available, right-click on the row that includes the handheld's name. Select **Check for OS Update**. If there is a newer version of the OS available, follow the directions to install it. A window will inform you that any unsaved data will be lost. 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. Steps 1-7 in 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:

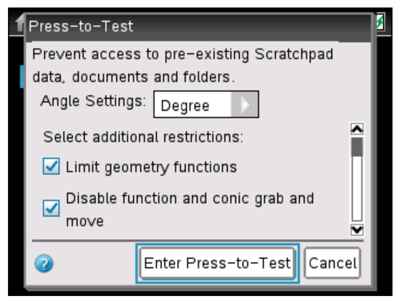
To enable Press-to-Test on the TI-Nspire™ with Touchpad and TI-Nspire CX™, first ensure that the handheld is turned off. Press and hold [esc] and [on] until the Press-to-Test screen appears.

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

Step 2:

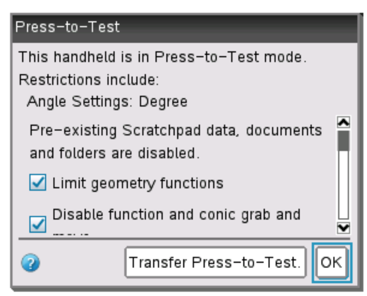
By default, Press-to-Test disables pre-existing Scratchpad data, documents, and folders as well as many other functionalities of the handheld. The angle settings can be changed by pressing ▶, selecting the appropriate setting, and pressing ▶ or [enter].

By default, all of the commands and features listed are disabled. To enable a feature or command, uncheck its box. Keep all boxes checked, and 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.

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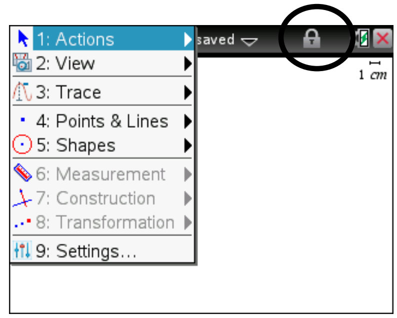
Step 5:

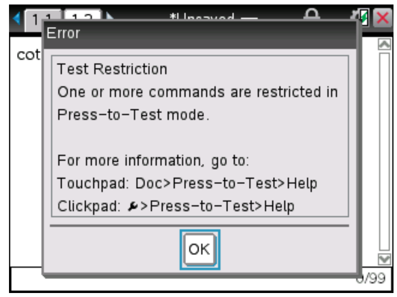
Create a new document, add a Geometry page, and press menu. Since geometry functions are limited, observe that the **Measurement**, **Construction**, and **Transformation** menus are not accessible.



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

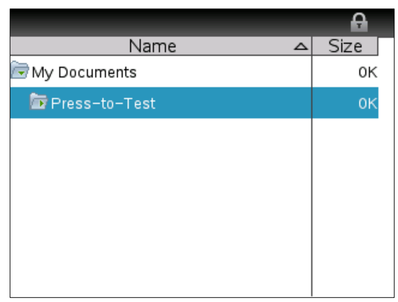
Step 6:

Add a Calculator application by selecting doc **> Insert > Calculator**. Type **cot(*π*/2)** and press enter. Since trigonometric functions are limited, an error message appears. The dialog box tells students how to access additional information about the restrictions. Click OK.



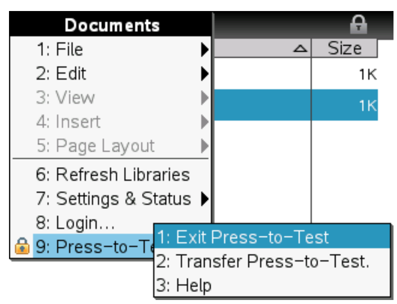
Step 7:

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:

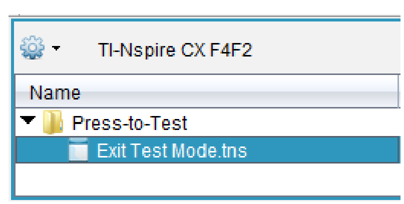
To exit Press-to-Test mode, connect two handhelds using the handheld-to-handheld USB connection cable. Then select doc **> Press-to-Test > Exit Press-to-Test**. The Exit Press-to-Test option appears regardless of whether the other handheld is in Press-to-Test mode.



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, enter the name of the folder Press-to-Test, 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:

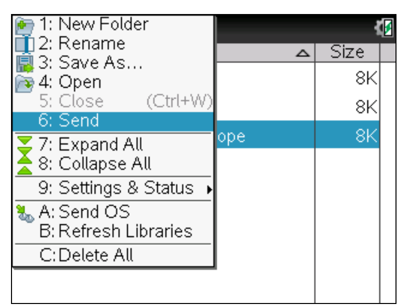
Open **My Documents** on the sending handheld.

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.



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.

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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.

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Transferring Documents Using the TI-Nspire™ Teacher Software

TI PROFESSIONAL DEVELOPMENT

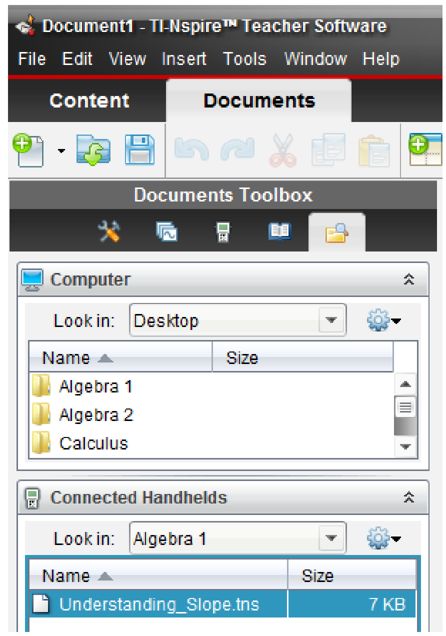
Activity Overview

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

Materials

- TI-Nspire™ or TI-Nspire™ CAS Teacher Software
- TI-Nspire™ handheld and standard-A to mini-B USB 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.

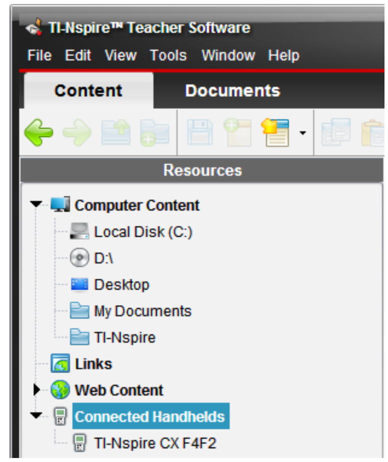
Step 5:

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 in the Content Workspace

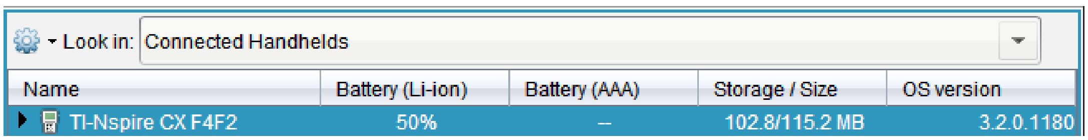
Step 6:

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



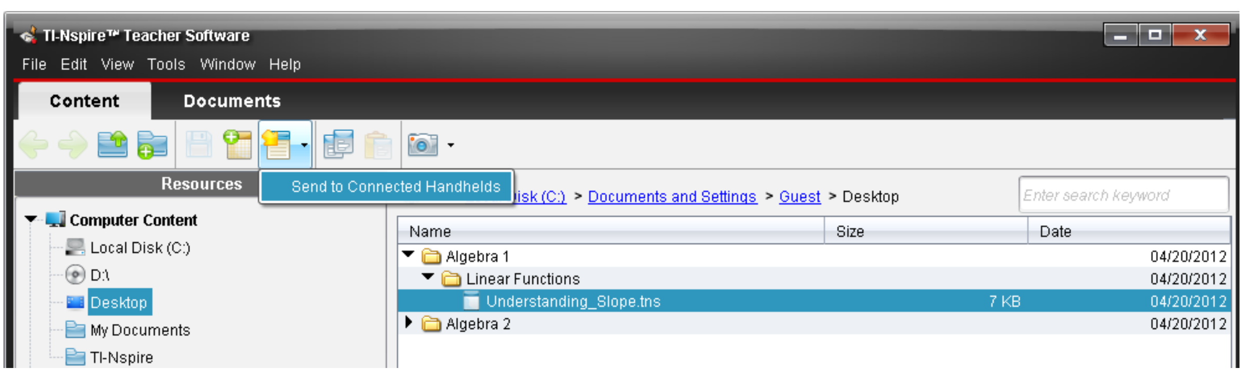
Step 7:

The connected handheld appears in the Content window, along with battery, storage, and OS information. To view the documents on a connected handheld, click the name of the handheld.



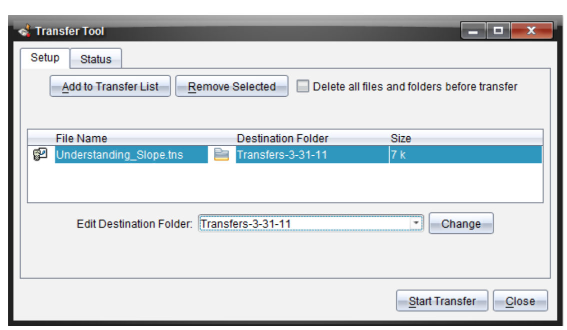
Step 8:

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**.



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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™ 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™ or TI-Nspire™ CAS Teacher Software

Step 1:

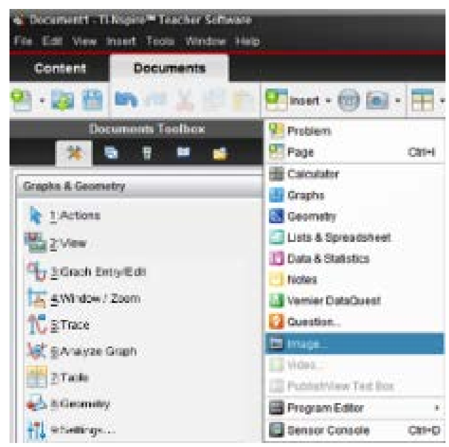
Open the Teacher Software. If the Welcome Screen appears when the software is opened, click to create a new document with a Graphs application as its first page. Otherwise, insert a Graphs application by selecting **Insert >** **Graphs**.

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

Step 2:

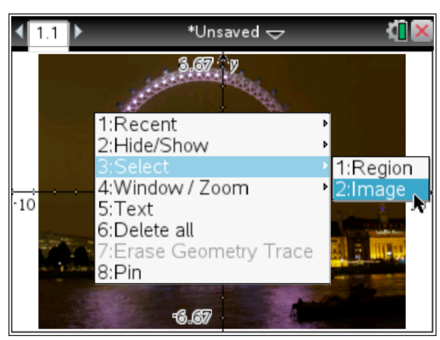
Insert an image into the Graphs application by selecting **Insert >** **Image**. A selection of images is preloaded in the **My Documents >TI-Nspire > Images** folder. Select **Ferris Wheel.jpg** and click Open.

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

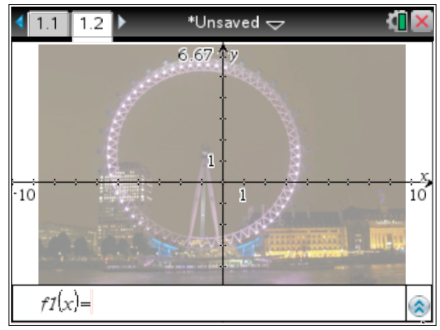
TI PROFESSIONAL DEVELOPMENT

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. You will browse for activities at Math Nspired or Science Nspired. 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 > Activities**. Select **Math Nspired** or **Science Nspired**, which can also be accessed directly at mathnspired.com and sciencenspired.com. Select a subject on the left.

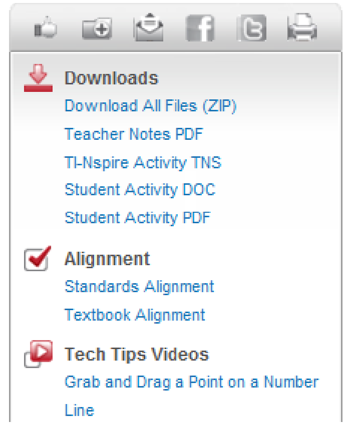
Step 2:

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.

Step 3:

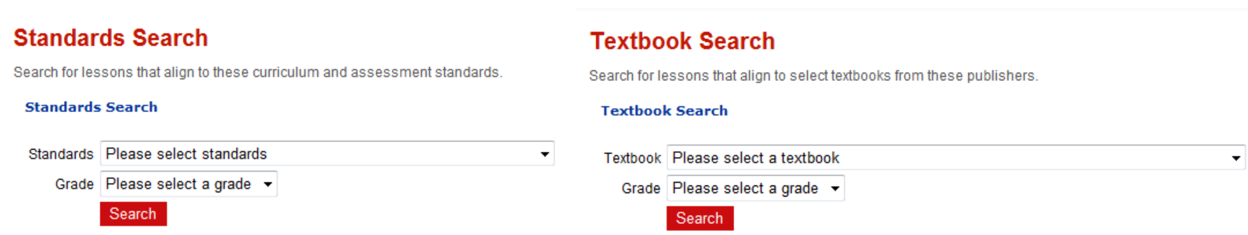
Select an activity from the list. The activity page shows objectives, relevant vocabulary, and additional information. A video offers a preview of the lesson, and related lessons are recommended below.



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**.



Step 6:

Click the **Solutions** tab and select Common Core State Standards or Science Tools. Content and activities, technology resources, and information on professional development opportunities are provided.

Step 7:

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

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

The Upcoming page contains links to upcoming, free PD webinars. The On-Demand page contains recordings of past webinars, and associated webinar documents are available for download.

Step 8:

Explore each of the following pages by clicking the appropriate tab: Products, Downloads, Activities, Professional Development, Solutions, Support, and Where to buy.

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 colorimeter.
2. Choose the appropriate interface device (EasyTemp™, EasyLink™ cable, TI-Lab Cradle™) and attach it to the TI-Nspire™ handheld.

EasyTemp

EasyLink

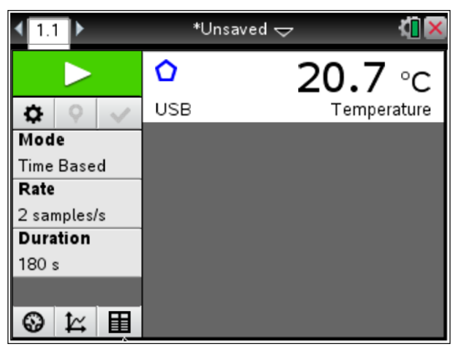
TI-Lab Cradle

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 TI-Nspire handheld, 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.



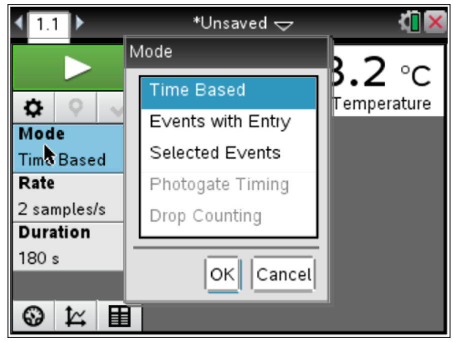
Using the Meter Window

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.

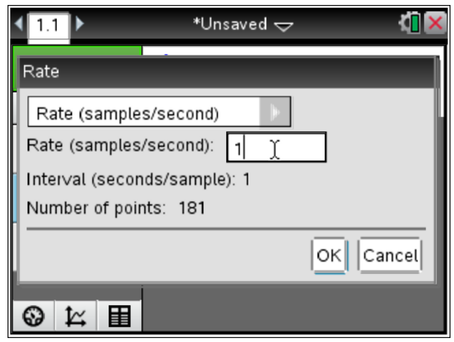
Performing a "Time-Based" Experiment

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.

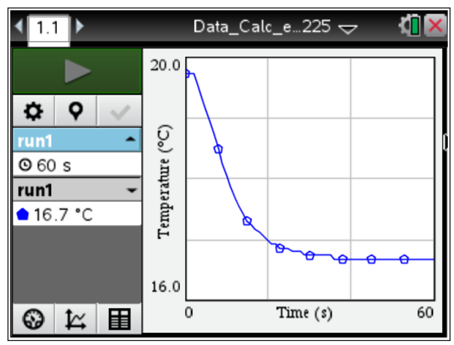
1. Be sure that the mode is set to "Time Based." (The fastest way to change the experiment mode is to click on the **Mode** area on the left side of the screen. Choose **Time Based**.



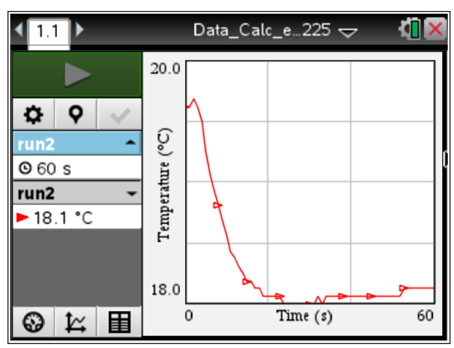
2. Now set up the parameters of how you will collect data in your experiment by clicking on the **Rate** and **Duration** areas on left. For example, in the effervescent tablet experiment, we might want to view the temperature changes over a 60-second period. The rate could be set to 1 sample/second and the duration set to 60 seconds. Click OK when you are finished.



3. To begin the data collection, click the green **Start Collection**  arrow in the upper-left corner of the screen. Or press **Tab** until the start arrow is highlighted, then press **Enter** when ready. 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, you can unplug the sensor; data is automatically saved. If not, press Store Latest Data Set  button to store the first run. Press **Enter** to collect a second run of data. *(The graph at the right shows run2: how the temperature changes as a new tablet is added to a new sample of 100 mL of room temperature water. Note how the scale automatically changed to fit the new data.)*



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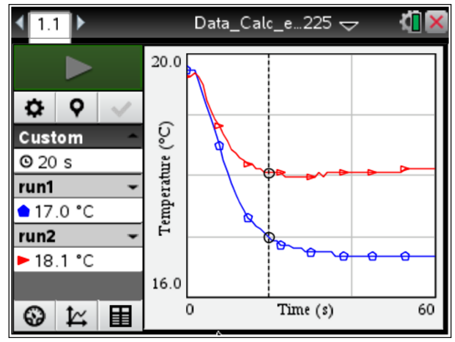
5. It is possible to see all of the runs that you collected at one time. Click on the current run at the left (**run2** in this case) and select **All.** Both runs of data will appear on the screen simultaneously, and you will be able to compare temperatures at a given time by clicking somewhere in the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

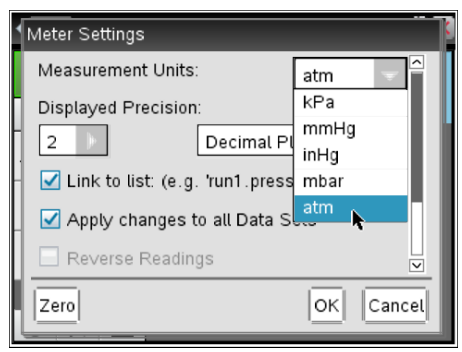


Later in this guide you will see how the TI-Nspire handheld can be used to analyze the data that you have collected in this mode.

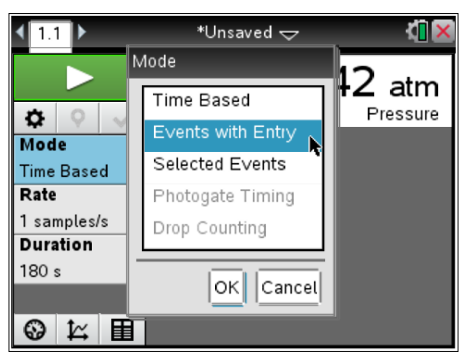
<u>Performing an “Events with Entry” Experiment</u>

There will be some experiments in which time is NOT an important factor when collecting data. You might want 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 TI-Nspire handheld 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.

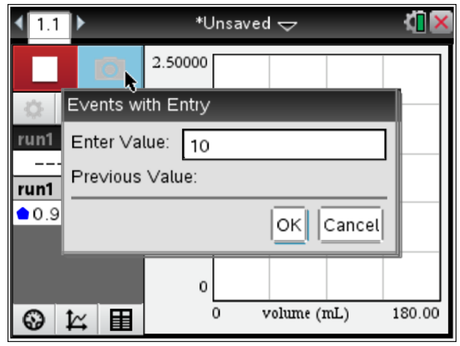
1. Before we set up the collection mode, it might be helpful to know that you can “click” in other areas of the screen as well. For example, in this experiment we might want to change the default units for pressure (kPa) to atmospheres (atm). Simply **click** on the reading window at the top, and select your preferred units from the drop-down menu. You can also click on the view buttons , , , and areas such as **Mode**.



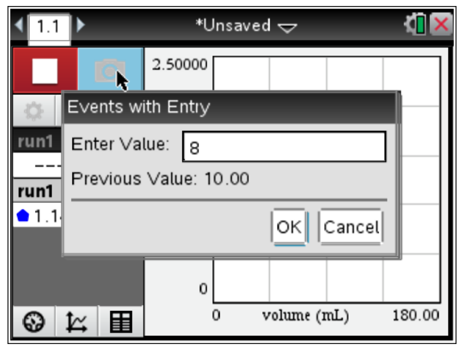
2. Okay, let’s set up the data collection mode. Click on the **Mode** area at the left, and select Events with Entry. To name the event, click on the **Event Name** area that appears below Mode. The “event” is the variable that you are manipulating. Input the appropriate name and units of the event, 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.



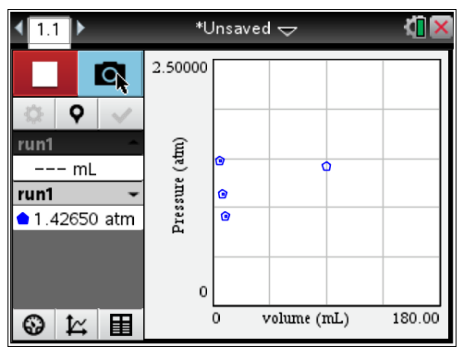
3. To begin data collection, click the green **Start Collection** arrow in the upper-left corner of the screen. Or press **Tab** until the start arrow is highlighted, then press **Enter** when ready. Once data collection begins, the Meter view switches to the Graph view. Notice that in this mode a new 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 is entered to represent the 10 mL of air trapped in the syringe.)*



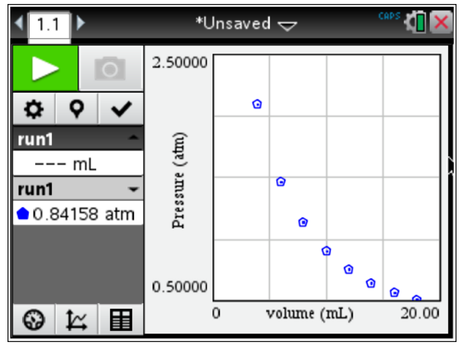
4. When you are ready to record data at a new set of conditions, press the **Keep** button again. *(Important: Do NOT press the **Stop** button!!! This is a common mistake made by new users. If you press **Stop**, you will need to start the entire experiment over again.)* Notice that when you press **Keep**, the window will remind you of the previous event value that you entered.



5. 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.)*



6. You have now finished recording data in Events with Entry mode. Notice that the button in the upper left corner of the screen has returned to the **Start** button. *(The screen at the right shows all of the Pressure and Volume data for the original 10 mL sample of air.)*



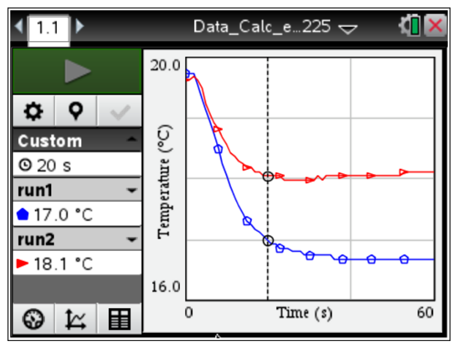
Later in this guide you will see how the TI-Nspire handheld can be used to analyze the data that you have collected in this mode.

Data Analysis

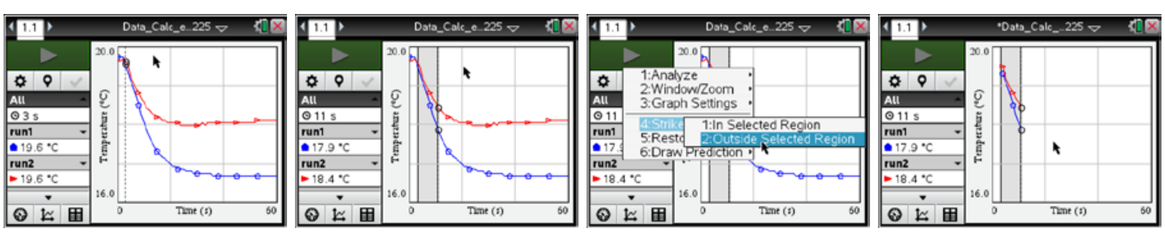
There are a few different tools available in the DataQuest application that make analysis of the data that you have collected quick and easy. Two important methods will be presented in this section.

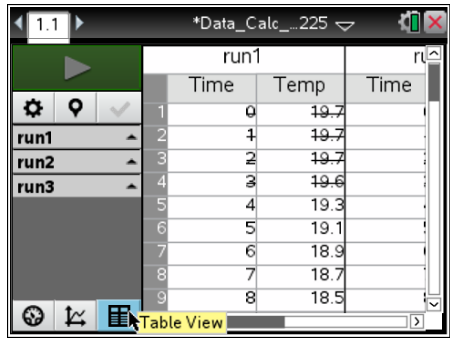
<u>*Method 1: Striking Data*</u>

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 early 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).

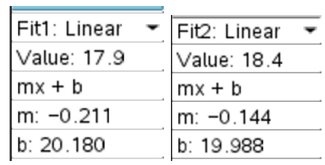


1. Click in the graph to create a vertical line. Click in the center of the touchpad for about 1 second until you see a double arrow appear on the line.
2. Let go of the center of the touchpad and run your finger lightly from left to right across the touchpad to select the area of the graph you would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



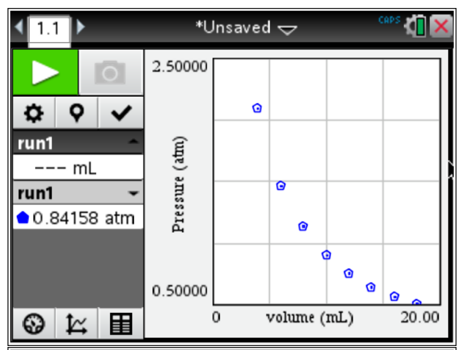


4. Don't worry. Your data is still there (as you can see from the Table view on the right). Striking data allows you to analyze just a portion of the data set without completing removing the information.
5. Return to Graph View. Now you are able to analyze each linear portion of the temperature graph 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 at left for each graph.

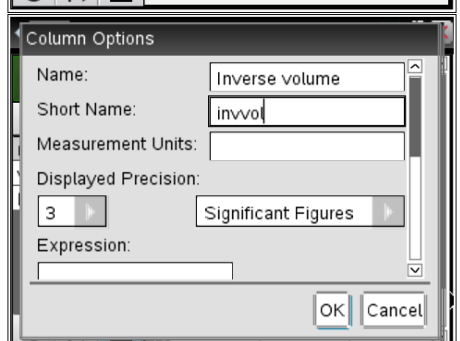


__Method 2: Adding a Calculated Column in Table View__

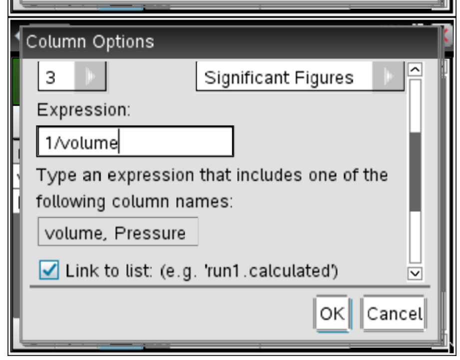
In the pressure/volume experiment, you'll recall that we created a curve of pressure versus volume values. To determine the equation of a graph, sometimes it is helpful to "linearize" the data. In this section, we will explore how a new calculated column of data can be added in Table View and how that 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 at the left; choose **New 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 to 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/volume.) When finished, click OK. The expression *variable* must match exactly the column name, including capital letters.



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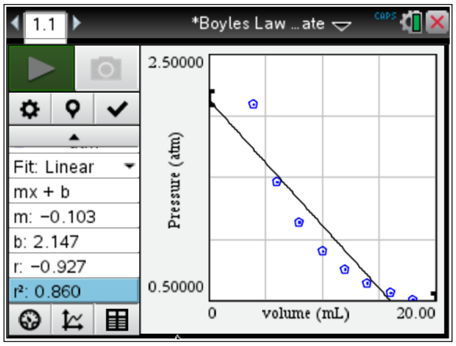
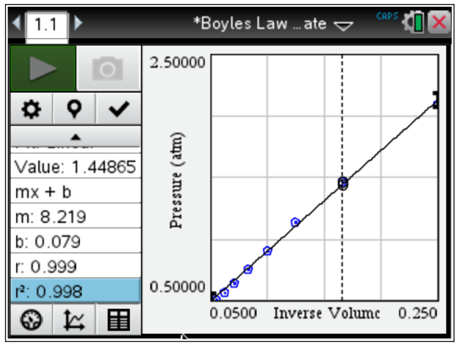
4. Click on the Graph view tab  to analyze the data. Press **Menu > Analyze > Curve Fit > Linear**. Obviously the data of pressure vs. volume do not fit the line created as is evidenced by the poor r^2 value of 0.860. (Data points with a good linear fit show an r^2 value close to 1.00.)
5. Click by the x-variable at the bottom of the graph (in this case, volume) and select the calculated column variable (inverse volume). The new graph is very linear. Redo the linear analysis. Here we see that Press = 8.219 * (1/Vol) + 0.079. (Remove the prior line with **Menu > Analyze > Remove**.)





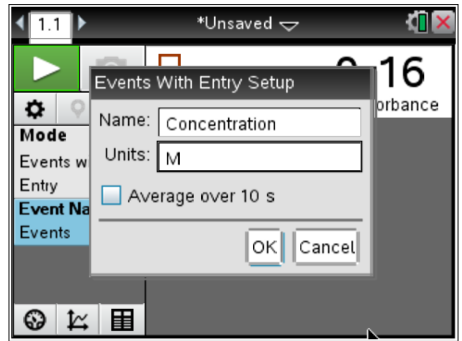
Data Collection and Analysis – Using the Colorimeter

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.

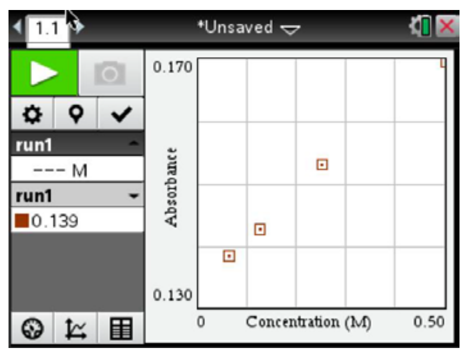
1. Connect the colorimeter to the TI-Nspire handheld using an EasyLink cable or a TI-Lab Cradle.
2. Select an appropriate wavelength of light to be used in the experiment by pressing the left or right arrows on the colorimeter. [You will want to use a different color other than the color of the solution. 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. Click on the **Mode** area at the left, and select **Events with Entry**. Click on the **Event Name** area, enter the variable name for the event (usually Concentration) and the appropriate units, and click OK.

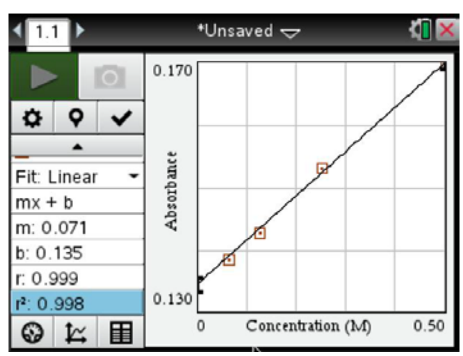


4. Now the device must be calibrated with the solvent being used in the solutions. Fill a plastic cuvette about ¾ full with the appropriate solvent (most likely this will be water) and place the cuvette in the holder inside the colorimeter. It is important that one of the smooth sides of the cuvette 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.

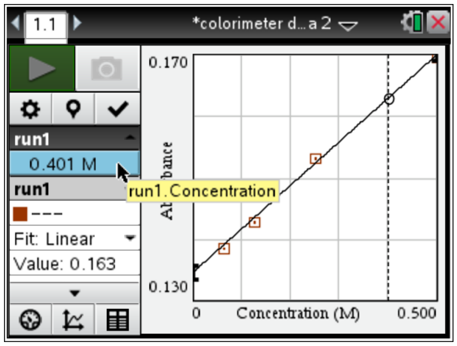
5. To begin data collection, click the green **Start Collection** arrow in the upper-left corner of the screen. Or press **Tab** until the start arrow is highlighted, and press **Enter** when ready. Replace the water cuvette with the first sample of known concentration being tested. Close the door, wait for the absorbance reading to stabilize, and then press **Keep**. Input the concentration of the known solution, and press **Enter**. 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 upper right shows absorbance readings for known solutions with concentrations of 0.500M, 0.250M, 0.125M and 0.0625M.)*



6. Find the best fit line through the data points. To do this, select **Menu > Analyze > Curve Fit > Linear**.



7. Put the sample of unknown concentration in the colorimeter, and close the door. Click Meter view; note the absorbance reading once it stabilizes.
8. To determine the concentration at this absorbance, click Graph view. Then select **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 in this example the unknown solution showed an absorbance of 0.163. The vertical line was moved into place until the Fit Linear Value was also 0.163. The concentration at this absorbance was 0.401 M.)



Note: To display the concentration at a higher precision, simply click on the concentration value as shown above and set the desired Display Precision in the pop-up window.

In Conclusion:

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

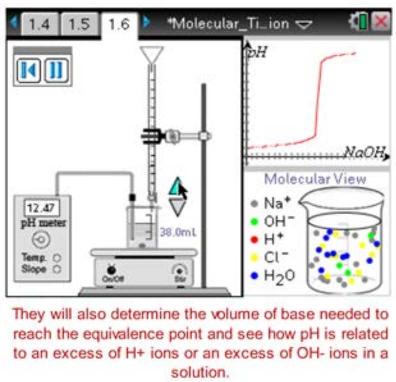
For further information about other applications within the TI-Nspire handheld, visit:

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 on Texas Instruments' website (http://education.ti.com/calculators/tisciencenspired/) where you'll find some great simulations that can help you better understand concepts important to the AP Chemistry curriculum.



Example Shown: Molecular Titration Simulator

TI Technology Exam Acceptance

TI PROFESSIONAL DEVELOPMENT

TI-Nspire™ Technology

Approved for Tests	TI-Nspire™ CX TI-Nspire™ w/Touchpad	TI-Nspire™ CX CAS TI-Nspire™ CAS w/Touchpad
SAT*	●	●
AP*	●	●
PSAT/NMSQT*	●	●
ACT*	●	
International Baccalaureate	●	
Praxis™	●	●
Texas STAAR® Grade 8	●	
Texas STAAR® Algebra	●	

Graphing Technology

Approved for Tests	TI-84 Plus C Silver Edition TI-84 Plus Silver Edition TI-84 Plus, TI-83 Plus	TI-89 Titanium
SAT*	●	●
AP*	●	●
PSAT/NMSQT*	●	●
ACT*	●	
International Baccalaureate	●	
Praxis™	●	●
Texas STAAR® Grade 8	●	
Texas STAAR® Algebra	●	

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My question is …

My next steps are …

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