Getting Started with TI-Nspire™ Technology in Connecting Science and Mathematics

Conversion – Direct or Inverse Variation?

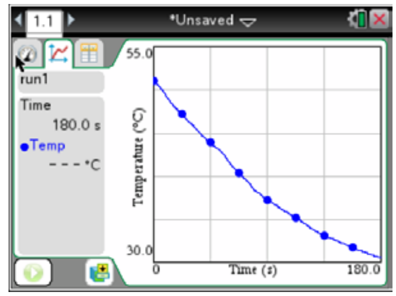
Student Activity

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.

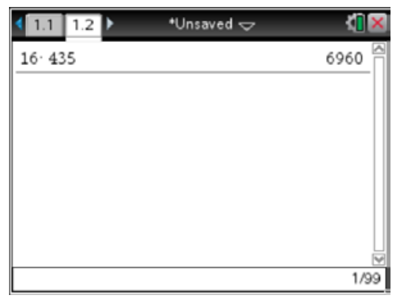
In the second part of the activity, you will collect and analyze temperature data and draw conclusions about cooling objects.



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

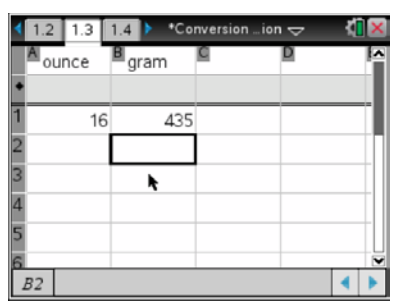


3. Compare the grams to ounces on the box labels. Do the grams and ounces appear to be directly related or inversely related?

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 **ounce**, and enter the label values in ounces.
   - Label Column B **gram**, and enter the label values in grams.
   - Label Column C **prod** for product. In the diamond cell ♦, type **=ounces*grams** and press enter.
   - Label Column D **quo** for quotient. In the diamond cell ♦, type **= grams/ounces** and press enter.

Conversion – Direct or Inverse Variation? Name _______________
Student Activity Class _______________

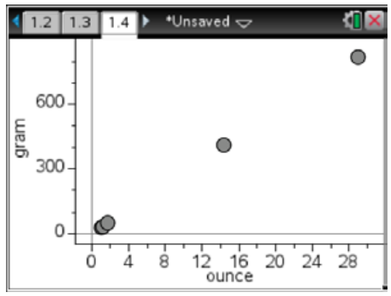
Analysis

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

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

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

Add a Data & Statistics Page



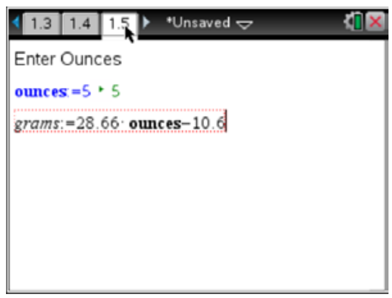
10. Place ounces on the *x*-axis and grams on the *y*-axis.
11. Determine the best fit line for this set of data by selecting **Menu > Analyze > Regression > Show Linear (mx+b)**.
12. What equation do you get when you perform the linear regression?

13. In the graph, *x* represents __________________ and *y* represents __________________.

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

15. What are the units for the slope?

Add a Notes Page

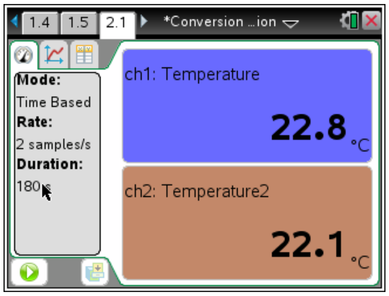


16. Type "**Enter Ounces**".
    - Insert a Math Box by selecting **Menu > Insert > Math Box**.
    - Type **ounces:=5** and press enter.
17. Insert a second Math Box, and enter the equation that you received from the prior page.
    - Change *y* to grams and *x* to ounces: **Grams:= m*ounces + b**.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

Conversion – Direct or Inverse Variation?
Student Activity

Name ______________
Class ______________

Add a New Problem to Compare Fahrenheit to Celsius



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

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

Add a Data & Statistics Page

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

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

Add a Notes Page

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

Conversion – Direct or Inverse Variation?
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?

Conversion – Direct or Inverse Variation?

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

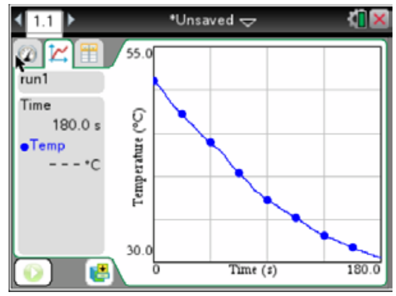
- ounces
- grams
- conversion factor

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*
- Conversion_Direct_or_Inverse_Variation_Student.pdf

Discussion Points and Possible Answers

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

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

Open a New Document and Add a Notes Page

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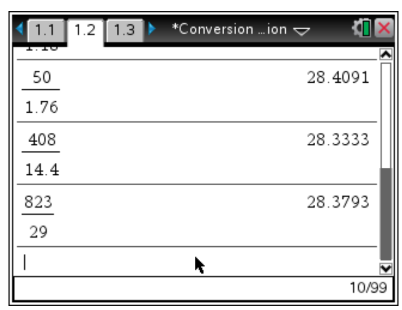
Add a Calculator Page



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.

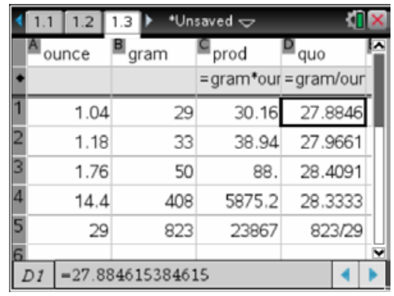
4. Calculate the product of ounces and grams for each box label. Does a consistent pattern occur when the two are multiplied together?

   <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 **ounce**, and enter the label values in ounces.
   - Label Column B **gram**, and enter the label values in grams.
   - Label Column C **prod** for product. In the diamond cell ♦, type **=ounces*grams** and press enter.

     Label Column D **quo** for quotient. In the diamond cell ♦, type **= grams/ounces** and press enter.

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

Analysis

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

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

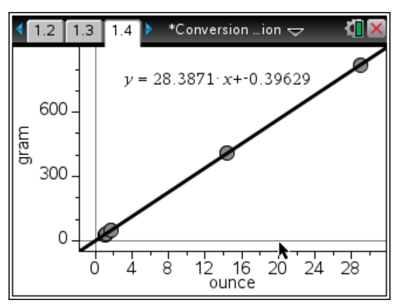
8. Do you believe the product or the quotient is most constant?

   Answer: The quotient is most constant.

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

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

Add a Data & Statistics Page



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

    Sample Answer: $y = 28.3871x - 0.39629$

13. In the graph, x represents ____ounces____ and y represents____grams____ .

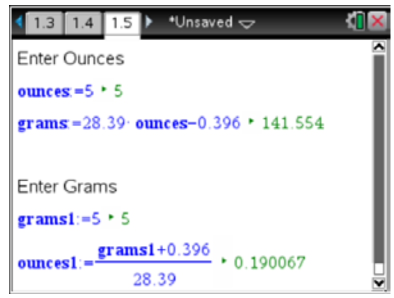
14. How does the slope of the line compare to the values in the spreadsheet on page 1.3?

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

15. What are the units for the slope?

    Answer: The units for slope are grams/ounce.

Add a Notes Page

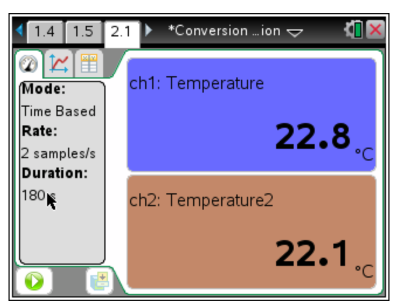


16. Type "**Enter Ounces**".
    - Insert a Math Box by selecting **Menu > Insert > Math Box**.
    - Type **ounces:=5** and press [enter].

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

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

Add a New Problem to Compare Fahrenheit to Celsius



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22. Wait for a moment for the Vernier DataQuest™ application to launch. If it does not launch, select **Add Vernier DataQuest**.
    - To set up the Vernier DataQuest app, think of variables that are being measured and how they are being measured.

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

23. Two temperature readings should appear in the **Meter View**.
    - Change the units on temperature probe 2 to Fahrenheit by selecting **Menu > Experiment > Set Up Sensors > Change Units**.
    - Selecting **Menu > Experiment > Collection Setup**. Set the **Mode** to Time graph for 5 samples per second for 30 seconds.
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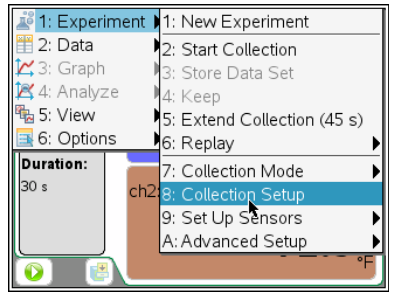
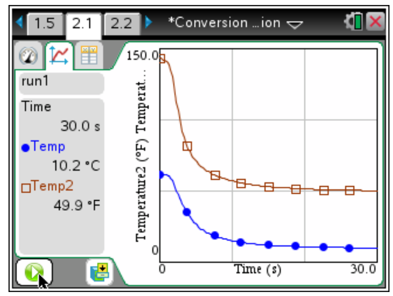


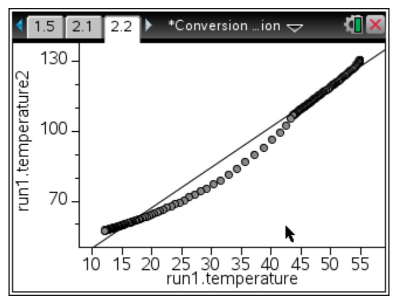
24. What happens to both temperature readings?

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



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.tempemperature** (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?

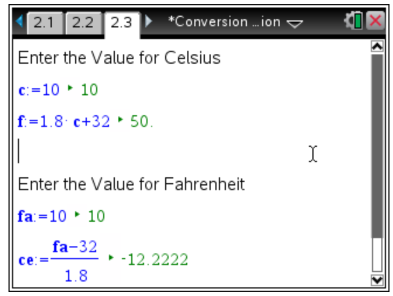
    <u>Sample Answer:</u> The equation should be around $y = 1.8x + 32$ The equation represents the relationship between Celsius and Fahrenheit.

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

    <u>Sample Answer:</u> C = (F – 32)/1.8

Add a Notes Page

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

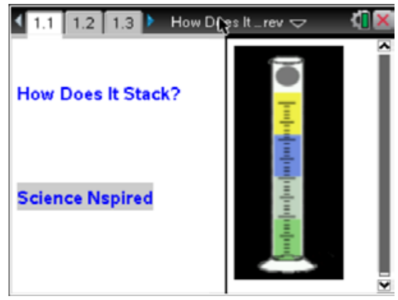


Tech Tip: Students will need to enter their expressions in Math Boxes. For the first converter, recommend that students represent Celsius with a C and Fahrenheit with an F. The variables must be different for the second converter. If they are the same, they will conflict with one another.

How Does It Stack?
Student Activity

Name ______________
Class ______________

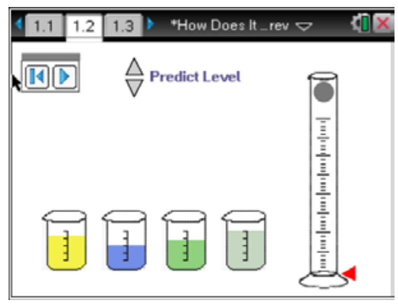
Open the TI-Nspire™ document *How_Does_It_Stack.tns.*
Have you ever wondered why ice floats in water? Do you know why a mixture of oil and vinegar eventually separates? Have you wondered why a rock sinks in water, while polystyrene foam floats? In this activity, you'll use a simulation to explore these questions.



The TI-Nspire document contains a virtual density column. Your task is to calculate the density of each of the four solutions. Then, based on the results, predict the order in which the layers will settle. Finally, you will predict where a solid object will float when dropped into the column.

Move to pages 1.2–1.3.

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



1. Hover the cursor over a beaker to reveal the mass and volume of a solution.
   a. IMPORTANT: If you click on the beaker, the liquid will be "poured" into the cylinder, forcing you to reset.
   b. When you reset, the masses and volumes of the liquids in the beaker change.
   c. You can reset the page using the reset button on the screen or the delete button on the handheld.

Container 1	Container 2	Container 3	Container 4
Mass: ____________	Mass: ____________	Mass: ____________	Mass: ____________
Volume: __________	Volume: __________	Volume: __________	Volume: __________

2. Use the calculator page 1.3 or Scratchpad to calculate the density of each solution.

   What is the formula for calculating density? ______________________________

Container 1	Container 2	Container 3	Container 4
Density: _________	Density: _________	Density: _________	Density: _________

3. Once you have determined the densities, return to page 1.2 and click on the solution containers in the order in which they will settle in a graduated cylinder.
   If you select an incorrect order, you will receive a Goat. Reset the page and try again.

How Does It Stack?
Student Activity

Name ________________
Class ________________

4. Hover the cursor over the solid ball to reveal mass and volume.

   Mass: _______________________ Volume: _______________________

5. Use the calculator page 1.3 to calculate the density of the solid ball.

   Density of Solid Ball: _______________________

6. Use the arrows beside "Predict Level" to move the red arrow next to the graduated cylinder to show where you predict the ball will float in the column.
7. Click the play button to watch the ball fall through the density column. If you correctly predicted the location of the ball, you will receive a Gold Star. If you did not predict the correct location of the ball, you will receive a Goat. Press the Reset button and try again until you receive the Gold Star.

Move to pages 2.1–2.5. Answer the following questions below or on your handheld.

Q1. When poured into the graduated cylinder, the most dense liquid will _________.

A. float on top
B. be the middle layer
C. be the bottom layer
D. chemically react

Q2. As the solid becomes more dense, it is most likely to ___________.

A. sink
B. float
C. rise to the top
D. be suspended midway in the liquids

Q3. Density is __________.

A. how heavy an object is
B. the size of an object
C. $D = \frac{V}{m}$
D. how closely packed the matter is

Q4. The density of glycerin is 1.26 g/mL. If the mass of glycerin increases from 125 g to 250. g, the volume __________.

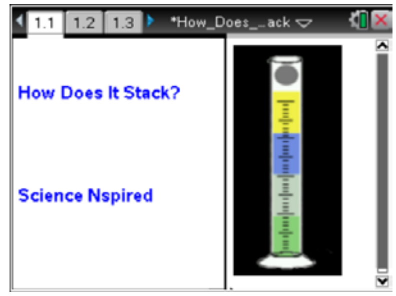
A. doubles
B. decreases by one half
C. is unchanged
D. decreases by one fourth

Q5. The density of glycerin is 1.26 g/mL. If the mass of glycerin increases from 125 g to 250. g, the density __________.

A. doubles
B. decreases by one half
C. is unchanged
D. decreases by one fourth

How Does It Stack?
SCIENCE NSPIRED — **TEACHER NOTES**

Science Objectives
- Students will calculate the density of liquids.
- Students will order the liquids in a graduated cylinder
- Students will predict at what level a solid object will float in the liquids.



Vocabulary
- density
- float
- liquid
- mass
- sink
- solid
- volume

TI-Nspire™ Technology Skills:
- Download a TI-Nspire document
- Open a document
- Move between pages
- Answer multiple choice questions

About the Lesson
- This lesson allows students to visually see the relationship between density of solutions and the relative position of an object in the solutions based on its density.
- As a result, students will:
  - Understand how solutions will separate based on their densities.
  - Predict where a solid object will stop within the given solutions based on the known densities.

Tech Tips:
Make sure that students understand how to reset the animation by clicking .

Lesson Materials:
Student Activity
- How_Does_It_Stack_Student.doc
- How_Does_It_Stack_Student.pdf

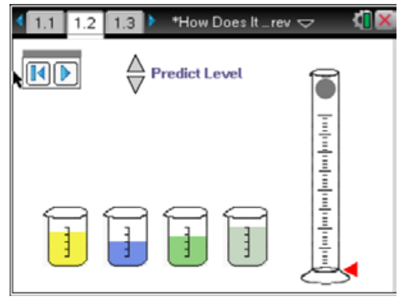
TI-Nspire document
- How_Does_It_Stack.tns

Using TI-Nspire™ Navigator™
- Send out the TI-Nspire document.
- Monitor student progress using Screen Shots.
- Use Live Presenter to spotlight student answers.

Activity Materials
- *How_Does_It_Stack.tns* document
- TI-Nspire™ Technology

Discussion Points and Possible Answers

Move to pages 1.2–1.3.



1. Students will hover over each beaker to obtain mass and volume data.
   a. IMPORTANT: If students click on the beaker the liquid will be "poured" into the cylinder and they will have to reset the page to remove the liquid from the cylinder.
   b. Make sure the students understand that when reset is pressed, the masses and volumes of ALL the liquids in the beakers change. They basically have to start over again.

c. The page can be reset using the reset button on the screen or the delete button on the handheld.

Tech Tip: Students can press to use Scratchpad instead of moving between pages 1.2 and 1.3 to perform calculations.

2. Students will use the calculator page 1.3 to calculate the density of each solution. Guide students to use dimensional analysis if they cannot remember the formula for density. The units of g/mL are units of mass divided by weight, so the formula is: $\text{density} = \frac{\text{mass}}{\text{volume}}$.
3. Next the student will back to page 1.2 and click on the solutions in the order they would be poured into the graduated cylinder—most dense first and least dense last. If the student is not successful, he/she will get a "Goat" and will have to reset the page to start over.
4. The student will then hover over the solid ball to get its mass and volume.
5. Students return to page 1.3 or use Scratchpad to calculate the solid ball's density.
6. Students then predict on page 1.2 where the solid will settle in the column. Be sure students understand which buttons are "predict" and which are "reset/play."
7. Students click the play button to test their predictions. If the prediction is incorrect, the student will have to reset the simulation and try again until they get a gold star.

Tech Tip: If students have to reset because they incorrectly predicted where the ball will fall, they will start over again with new liquids.

TI-Nspire Navigator Opportunities

Use Screen Capture to monitor for "goats" and "gold stars" as students progress through the simulation.

Move to pages 2.1–2.5.

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

Q1. When poured into a graduated cylinder, the most dense liquid will ________.

Answer: C. be the bottom layer

Q2. As the solid becomes denser, it is more likely to ________.

Answer: A. sink

Q3. Density is _____________.

Answer: D. how closely packed the matter is

Q4. The density of glycerin is 1.26 g/mL. If the mass of glycerin in the graduated cylinder is increased from 125 g to 250. g, the **volume** of the glycerin ________.

Answer: A. doubles

Q5. The density of glycerin is 1.26 g/mL. If the mass of glycerin in the graduated cylinder is increased from 125 g to 250. g, the **density** of the glycerin ________.

Answer: C. is unchanged

TI-Nspire Navigator Opportunities

TI-Nspire Navigator can be used to make screen shots to follow student progress. A visual check can be made to see which students are successful and which are struggling.

Wrap Up

When students are finished with the activity, collect the TI-Nspire document using the TI-Nspire Navigator System. Save grades to Portfolio. Discuss activity questions using Slide Show.

Assessment

- Formative assessment will consist of questions embedded in the TI-Nspire document. The questions will be graded when the document 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 will consist of questions/problems on the chapter test, inquiry project, performance assessment, or an application/elaborate activity.

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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 [home 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? _________

TI-Nspire™ Scavenger Hunt – The Calculator Application

TI PROFESSIONAL DEVELOPMENT

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?

____

Introduction to Data Collection

TI PROFESSIONAL DEVELOPMENT

Activity Overview

In this activity, you will see how easy and efficient it is to collect and analyze data using TI-Nspire™ technology and the built-in Vernier® DataQuest™ application.

Materials

- *Vernier® EasyLink™ adapter*
- *Stainless Steel Temperature probe*

Step 1:

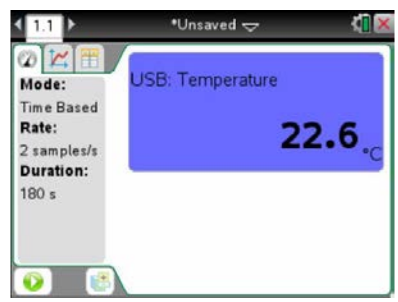
Turn on the TI-Nspire™ CX handheld, and create a new document by selecting **New Document**.

- If asked to save the current document, select "Yes" or "No."

A new document will appear. Though you have the opportunity to add one of the seven built-in TI-Nspire applications, do not select an application at this time.

Step 2:

Obtain a TI Stainless Steel Temperature probe and the Vernier EasyLink adapter.



Plug the TI Stainless Steel Temperature probe into the EasyLink adapter, and then connect the Vernier EasyLink adapter to the mini-USB port on top of the handheld.

This should launch the Vernier DataQuest application on Page 1.1.

Step 3:

Discuss the following questions with your partner:

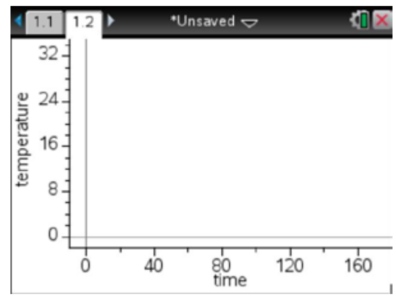
- What is the temperature? What are the units?
- How often does the temperature reading update?
- What are the default settings for the mode, rate, and duration?
- What happens as [tab] is pressed?
- What do you think each of the following icons represent? 

Step 4:

Let the temperature return to room temperature. Note your measure of the temperature of the room and compare it with others around you.

- Are the values the same?
- If not, how could one account for the differences?

Step 5:



Now we want to heat the temperature probe. Discuss with your partner how you might go about this, and share your plan with others in the room.

Predict what a plot of temperature vs. time would look like if you implemented your plan.

Step 6:

The best way to perform most temperature change experiments is to start the temperature change event and then start the data collection.

Start heating the probe. To start collecting the data, press [tab] until the Play button in the lower left of the screen is highlighted. Then press [enter]. Alternately, you can hover the cursor over the Play button and use the click button ( ) on the Touchpad.

Note: The [enter] and buttons perform slightly different commands. The click ( ) is like a left-click on a computer mouse and will activate the part of the screen that the cursor or pointer ( ) is over.

Step 7:

During the data collection, a scaled graph will appear and the Play button will change to a Stop button. After a brief period of time, end the experiment by clicking the Stop button.

When the experiment ends, the File Cabinet appears .

Step 8:

Examine your results and compare with your prediction. Discuss the following questions:

- Did you need the full time for the experiment, or did you end it early?
- We are interested in the rate at which the temperature increased. How would you describe this rate? At the start? Toward the end?
- What material did you use to warm the probe? Do you think that the material used to heat the probe matters? Why?
- Check with others in the room, and see their results. How do they compare with your results? What material did they use to warm the probe? Would that account for the differences?

Step 9:

To look at the table of data from the experiment, press tab until the Table option is highlighted and then press enter. Alternately, use the Touchpad to position the pointer over the Table icon and press .

Explore your rate of warming by looking at the change in temperature over equal increments of time.

- How could you quantify this change in rate of warming?
- How does this compare with your earlier analysis?

Step 10:

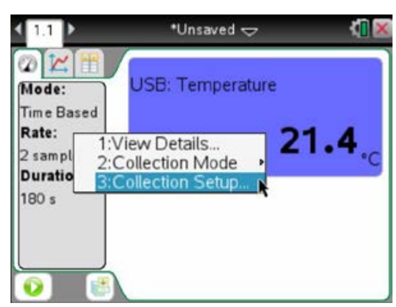
To save the results from the first experiment, place this "run" in the File Cabinet . Press tab until the File Cabinet is highlighted and press enter.

- What changes do you notice on the screen?

Step 11:

Now design an experiment that will cool the temperature probe.

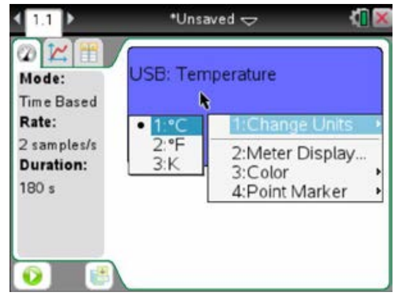
Consider changing some of the options by right-clicking (ctrl menu) an area of interest (Mode, or the Gauge reading). For example, the default settings of three minutes and the units can be changed.



Introduction to Data Collection

TI PROFESSIONAL DEVELOPMENT

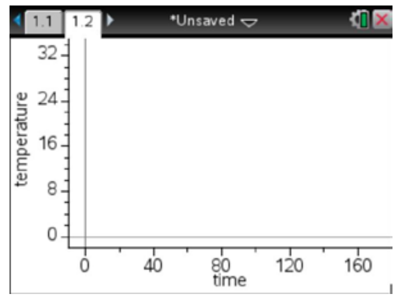
Note that these options are also under the menu. Based on what you learned in the heating experiment, adjust the settings as needed for your cooling experiment.



Step 12:

As you prepare for the cooling experiment, consider the following questions:

- What will you use to cool the probe?
- How long will it take to cool?
- What units will you use?
- What will the plot of temperature vs. time look like this time?



Step 13:

Collect the data using your design for cooling. Once the cooling begins, start the data collection as soon as possible. Highlight the play button, and press enter to start.

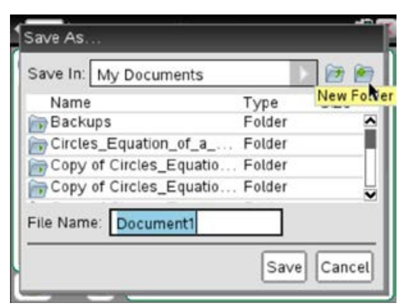
Step 14:

Explore your rate of cooling as before, and look at the table of data. Discuss the following questions:

- Were the rates of cooling or heating the same in both experiments? Explain.
- To compare the heating and cooling experiments, what variables should you control?

Step 15:

We might use this data again, so the experiment should be saved. To save the experiment, press ctrl S, name the document, and select a folder to place it in. If necessary, create a new folder.



Cool It

Student Activity

Name _______________

Class _______________

How do drinks cool?

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

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

Objectives:

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

Materials:

- Vernier EasyTemp® 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 drier to heat the temperature sensor.

Cool It

Student Activity

Name _______________

Class _______________

Data Collection:

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

Analysis:

1. Compare your data with your prediction. If they are different, explain why you think data does not match your prediction exactly and sketch the graph of the collected data on the same set of axes, labeling each relationship.
2. Why is the room temperature important in this activity?
3. Click on the graph to select a data point. Move the tracing cursor to find the starting temperature and then use your graph or other methods to determine the temperature of the room in 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 may recognize that the data appears to be exponential. You will model this data with an equation in the form $y = a \bullet b^x + c$. Use what you know about transformations and the data points in the table above to find values for *a* and *c*. Note that *a* is not the starting temperature. Explain why *a* is different value in the table. Record the values for *a* and *c* in the table to the right.

a	
c	

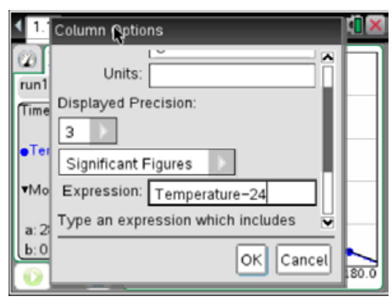
5. You will guess a value for *b*. Does the graph show exponential growth or decay? Based upon this, what are the possible values for *b*?

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.

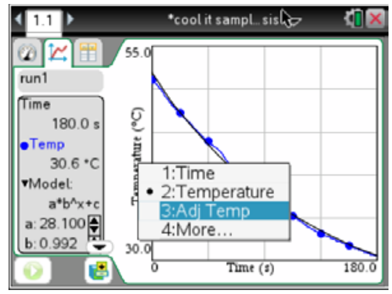


Cool It
Student Activity

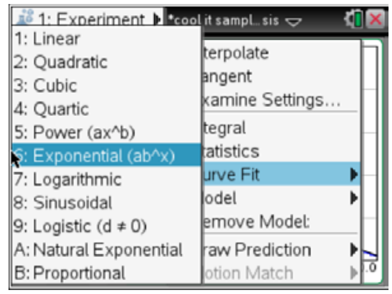
Name ______________

Class ______________

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



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



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

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

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

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

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 $y = a \bullet b^x + c$.
- Students will relate each of the parameters in the equation to a physical quantity.
- Students will draw conclusions about cooling objects and make predictions about how changes in the data collection will affect the results.
- Students will use appropriate tools strategically. (CCSS Mathematical Practice)

Vocabulary

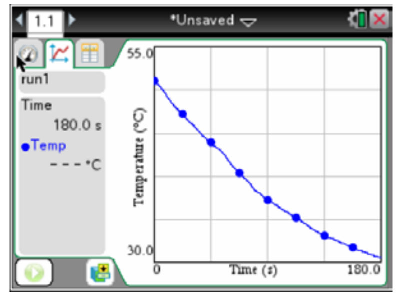
- temperature
- initial temperature
- exponential equation

About the Lesson

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

Materials and Materials Notes

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



TI-Nspire™ Technology Skills:

- Collect temperature data with the Vernier DataQuest™ app

Tech and Troubleshooting Tips:

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

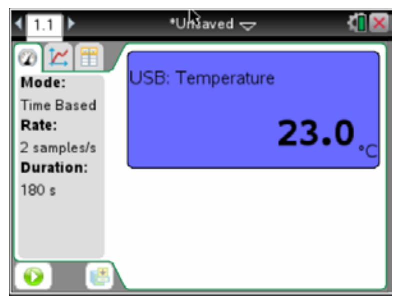
Lesson Files:
Student Activity
Cool_It_Student.pdf
Cool_It_Student.doc

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

Discussion Points and Possible Answers

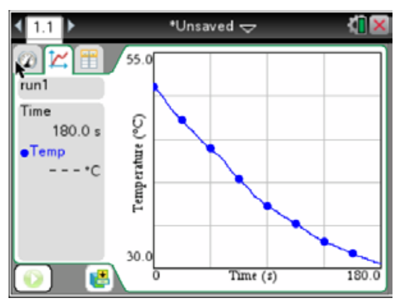
> **Teacher Tip:** Making predictions is very important to helping students to connect the physical world to the mathematical world. Ask the students to make a prediction prior to collecting data and sketch it. You may then want to ask them to compare their predictions to those of other students in the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

Data Collection



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

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



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

Analysis

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

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

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

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

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

   Sample answers:

Starting Temperature (ºC)	51.1
Room Temperature (ºC)	23.0
Difference in Temperatures (ºC)	28.1

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

a	28.1
c	24.0

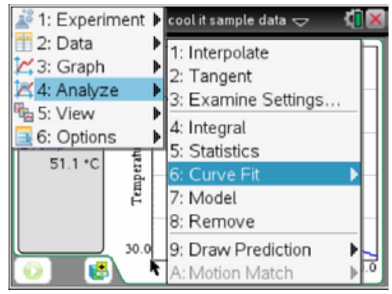
   Sample answer: The value of *a* is the difference between the starting temperature and the final temperature.

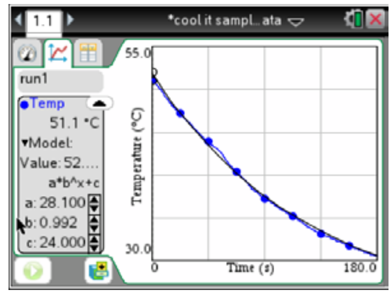
5. You will guess a value for *b*. Does the graph show exponential growth or decay? Based upon this, what are the possible values for *b*?

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

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

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





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

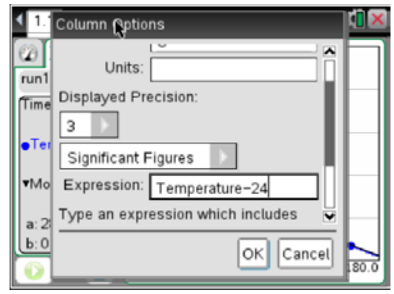
7. What is the physical representation of each parameter *a, b* and *c*?

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

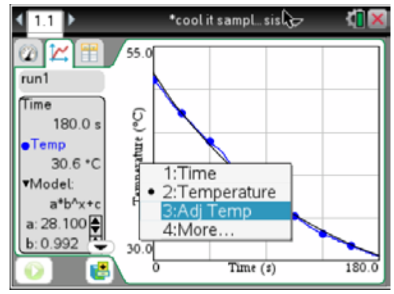
8. An exponential regression can also be used to find the equation but the exponential regression is in the form $y = a \bullet b^x$ with no vertical shift value of *c* from above. How could the data be transformed so that the regression model can be used on the curve?

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

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

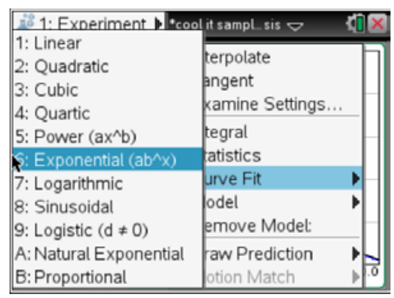


Tech Tip: Arrow down on the right side to access the Expression.



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

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



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

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

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

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

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

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

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

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

Match Me
Student Activity

Name ______________
Class ______________

Activity Overview

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

Materials

- TI-Nspire™ handheld or computer software
- Calculator-Based Ranger 2™ data collection device with USB CBR 2-to-calculator cable

  Note: If the CBR 2 is used with a computer, a mini-standard USB adaptor to plug the CBR 2 into the computer is needed.

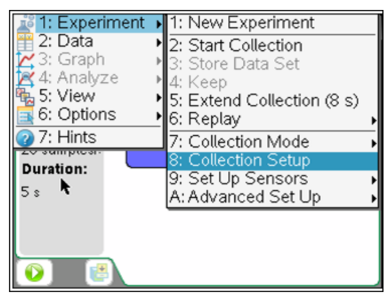
Part 1—Step-by-step setup

To utilize the built-in, easy-to-use **Motion Match** feature, first turn on the TI-Nspire handheld and choose **New Document**. Then, plug in the CBR 2 and the Vernier DataQuest™ app for TI-Nspire will automatically launch.

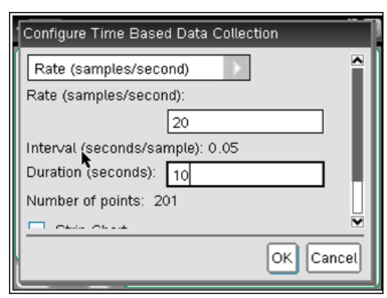
Hold the CBR 2 so that it points toward a smooth surface like the wall or door. Move forward and backward to observe the reading changes on the meter.

1. How far are you from the wall? _________

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



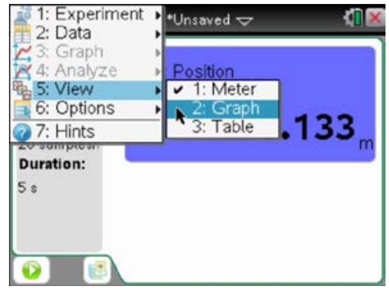
You will set up an experiment for 10 seconds. Press **Menu > Experiment > Collection Setup.** Change the duration to 10 seconds.



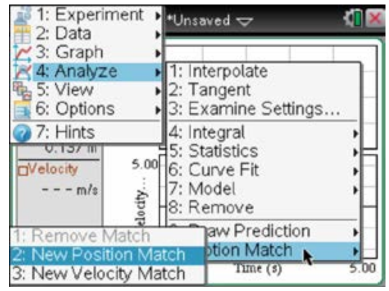
Match Me
Student Activity

Name ______________
Class ______________

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



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



2. What physical quantity is the dependent variable?

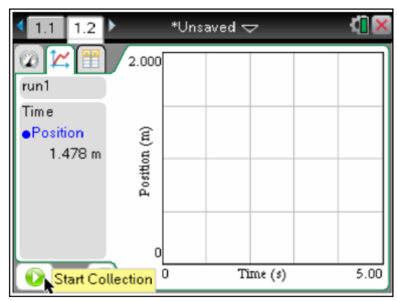
   ____

   A. velocity in meters/second
   B. position in meters
   C. time in seconds

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

   ____

Draw your Position Match on the graph to the right.



4. What is the domain? Include units. _________

5. What is the range? Include units. __________

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

   a. What is the *y*-intercept?

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

   c. At approximately what distance from the wall should the motion detector be located to match the initial position in the motion graph?

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

Match Me
Student Activity

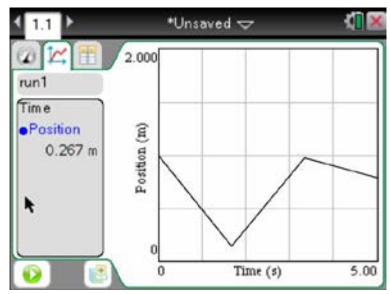
Name ______________

Class ______________

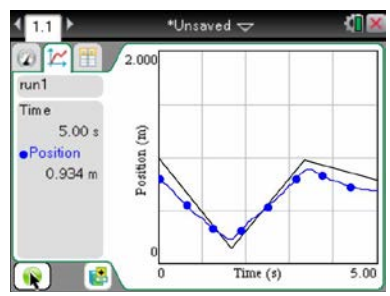
7. Press the **Start Collection** arrow in the lower-left corner of the screen. Point the CBR 2 at a wall and move back and forth until your graph matches the Position Match graph as closely as possible. If you are not pleased with your first attempt, press **Start Collection** again to repeat. You may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

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

Now, look at the graph shown at the right.



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



10. Describe the graph with the round dots that was created when **Start Collection** was pressed. Contrast the graph of position-versus-time that should have been created with what actually happened. Write at least two complete sentences. Example: *From 2 seconds to 3.5 seconds, the person moved too slowly to reach the original position – one meter from the wall.*

Part 2—Extend and Explore

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

11. Discuss your new match with a classmate.

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Match Me

TEACHER NOTES

TI PROFESSIONAL DEVELOPMENT

Math and Science Objectives

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

Vocabulary

- speed
- velocity
- initial position

About the Lesson

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

Materials and Materials Notes

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

TI-Nspire™ Technology Skills:

- Collect motion data with the Vernier DataQuest™ app for TI-Nspire.

Tech and Troubleshooting Tips:

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

Lesson Files:

Student Activity

Match_Me_Student.pdf

Match_Me_Student.doc

Discussion Points and Possible Answers

Part 1—Step-by-step setup

To utilize the built-in, easy-to-use **Motion Match** feature, first turn on the TI-Nspire™ handheld and choose **New Document**. Then, plug in the CBR 2 and the Vernier DataQuest™ app will automatically launch.

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

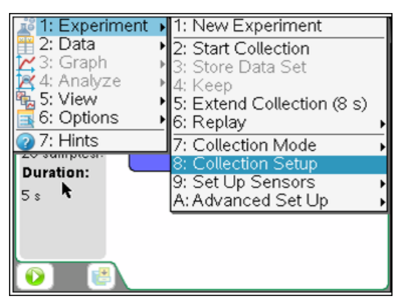
> **Tech Tip:** The Vernier DataQuest app is user-friendly. It should launch when the CBR 2 is connected. To begin the data collection, click the green **Start Collection** arrow in the lower-left corner of the screen.

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

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

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

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

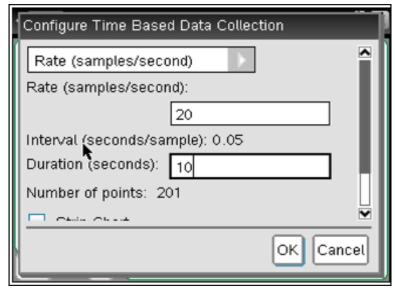


Match Me

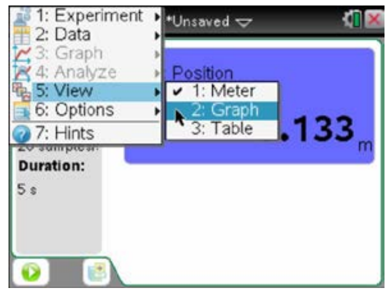
TEACHER NOTES

TI PROFESSIONAL DEVELOPMENT

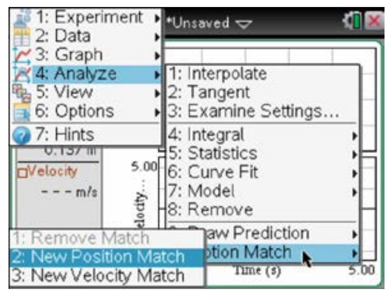
Change the duration to 10 seconds.



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



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



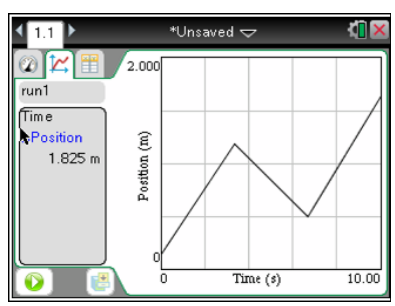
2. What physical quantity is the dependent variable?
   A. velocity in meters/second
   B. position in meters
   C. time in seconds

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

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

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

Draw your Position Match on the graph to the right.



<u>Answer</u>: Student graphs will vary because the Vernier DataQuest app randomly generates new graphs.

4. What is the domain? Include units.

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

5. What is the range? Include units.

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

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

   a. What is the *y*-intercept?

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

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

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

   c. At approximately what distance from the wall should the motion detector be located to match the initial position in the motion graph?

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

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

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

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

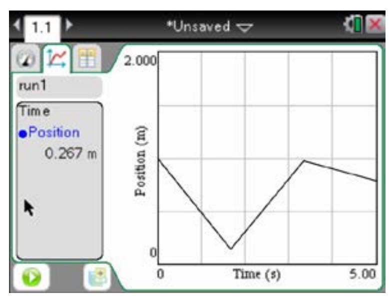
7. Press the **Start Collection** arrow in the lower-left corner of the screen. Point the CBR 2 at a wall and move back and forth until your graph matches the Position Match graph as closely as possible. If you are not pleased with your first attempt, press **Start Collection** again to repeat. You may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

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

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

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

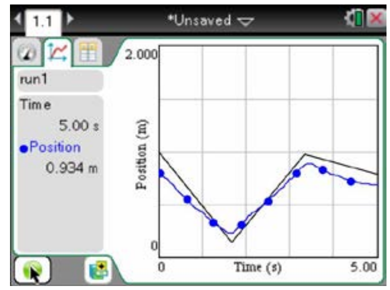
Now, look at the graph shown at the right.



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

<u>Sample answer</u>: The walker begins one meter from the wall and moves toward the wall at a constant velocity for about 1.7 seconds. The walker gets about 0.2 meters from the wall and then begins walking away from the wall at about the same rate for another 1.7

seconds, arriving back at 1.0 meters from the wall. The walker then begins to slowly move toward the wall until a total time of 5 seconds has elapsed. The slopes of the first two sections appear to indicate the same speed, but the first of these velocities is negative, while the second is positive. The walker moved slowest during the time period from 3.4 to 5 seconds.



10. Describe the graph with the round dots at the right that was created when **Start Collection** was pressed. Contrast the graph of position-versus-time that should have been created with what actually happened. Write at least two complete sentences. Example: *From 2 seconds to approximately 3.5 seconds, the person moved too slowly to reach the original position – one meter from the wall.*

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

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

Part 2—Extend and Explore

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

11. Discuss your new match with a classmate.

    <u>Sample answer</u>: Answers will vary depending upon the graph generated.

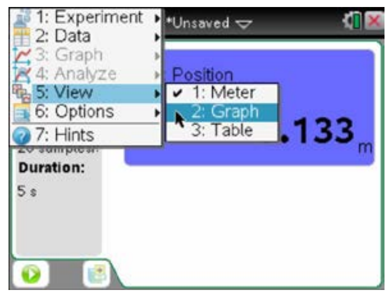
Teacher Extension

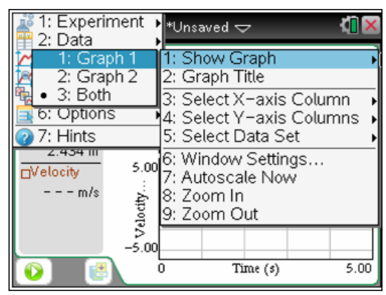
You can create your own matches for students if you want to be sure that they can match a graph with specific criteria. Follow these steps.

1. Open a new TI-Nspire document and then connect the CBR 2 data collection device.

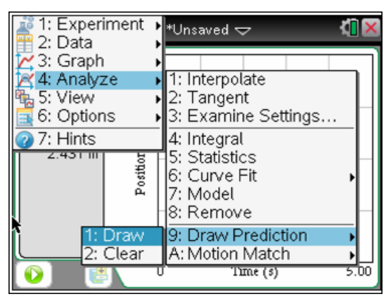
2. You will set up an experiment for 10 seconds. Press **Menu > Experiment > Collection Setup**. Change the duration to 10 seconds.

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

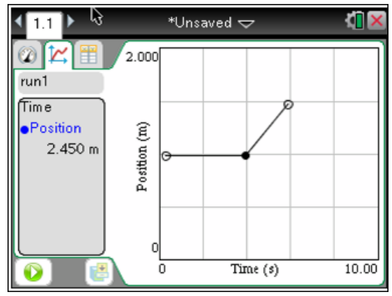




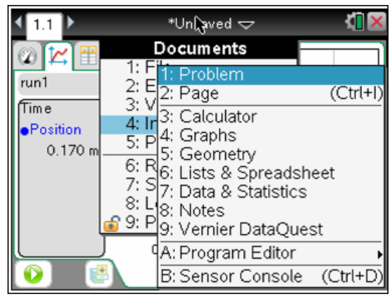
4. To draw your own graph to be matched, select **Menu > Analyze > Draw Prediction > Draw**.



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



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



How Does It Bounce?

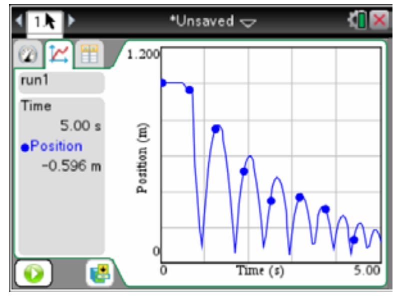
Student Activity

Name ________________

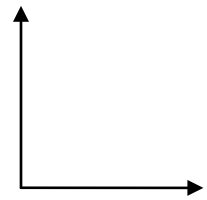
Class ________________

How do balls bounce and rebound?

When you drop a basketball, it does not rebound to the same height from which you dropped it. But how high does it bounce? The rebound height of a basketball can be used to determine whether the ball is inflated to the correct pressure. You will sometimes see basketball referees drop the ball from a certain height to see if it rebounds correctly prior to officiating a game. In this activity, you will explore how the height of a ball varies as a function of bounce number.



Before you begin, predict the graph of height as a function of bounce number. Sketch your prediction to the right. Be sure to label the axes.



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

Objectives:

- Understand how balls bounce by collecting position data for a bouncing ball and recording the height as a function of bounce number.
- Model the data with the appropriate mathematical function.

Materials:

- TI-Nspire™ handheld or computer software
- Calculator-Based Ranger 2™ data collection device (CBR 2™)
- Ball (Basketballs, racquetballs or kick balls work well. Avoid tennis balls or other fuzzy balls.)

How Does It Bounce?

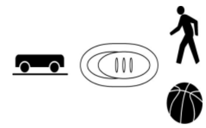
Student Activity

Name ________________

Class ________________

Data Collection:

1. Open a new document on the TI-Nspire™ handheld. Set the switch on the CBR 2 to *normal* and connect it to the handheld with the USB square-end long cable.



2. Find a good location to drop the ball. It should bounce straight up and down without going off to the side. Practice a few times before setting up the CBR 2.
3. You cannot place the motion detector on the floor and bounce the ball on it, but you can reverse the positions so that the data will appear as though it was collected with the floor as the zero height. Set the CBR 2 to a fixed height approximately 1.5 meters above the ground. Select **Menu > Experiment > Set Up Sensors > Zero**. Then select **Menu > Experiment > Set Up Sensors > Reverse**.
4. To show only the position versus time graph, click the **Graph View** tab ( ). Select **Menu > Graph > Show Graph > Graph 1**.
5. Hold the ball at least 15 cm below the CBR 2 and start data collection ( ) just before dropping the ball. You want the CBR 2 to record the initial height of the ball as well as the bounce heights.
6. The position versus time graph should contain a series of at least five parabolas. If it does not, try again. Show your graph to your teacher before proceeding to the next section of the activity. Once your graph is approved, send the document to your other group members.

Data:

Click on the graph to select a data point. Move the tracing cursor to find the starting height. Record it in the data table as the Maximum Height for Bounce Number 0. Then move the cursor to each successive maximum height and record the height in the table below.

Analysis:

1. Enter the Bounce Number and Bounce Height (round to 2 decimal places) data into the table below.

How Does It Bounce?

Student Activity

Name _______________

Class _______________

2. Divide each bounce height by the previous bounce height for each set in your data table. For example, divide the height of bounce 1 by the height of bounce 0. Write the ratio as a decimal value in the right column of the table.

Bounce Number	**Bounce Height (m)**	**Ratio of Bounce Heights**
0		
1		
2		
3		
4		
5		

3. Examine the data in the table. Is the relationship linear? How can you tell from the differences in the Maximum Height values?

4. Is the data quadratic? How can you tell from the differences in heights?

5. What do you notice about the ratios shown in the right column of the table?

6. Find the average of these values.

7. How could you use the average value and the initial height to find the height of bounce 1 using mathematics?

8. How would you then be able to predict the height of bounce 2?

9. Write the estimation of height 2, H_2 as a function of the initial height, $H_{o.}$ Now do the same for H_5, the height of the 5th bounce.

How Does It Bounce?
Student Activity

Name ________________
Class ________________

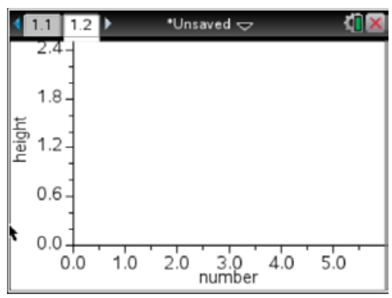
10. This type of function is an exponential function. It has the form, $y = a * b^x$ where b is the percentage of the return written as a decimal. What is the value of ***a***? Hint: think about the height for bounce zero. Explain your reasoning.

11. Write the equation for height as a function of bounce number for this set of data.

12. To check your model, create a graph of maximum height as a function of bounce number on the handheld. First, you must enter the data into the Lists and Spreadsheets application by adding a new page to your document. Name the first column Number and the second column Height. Enter the values from your data table above into the columns on the handheld.

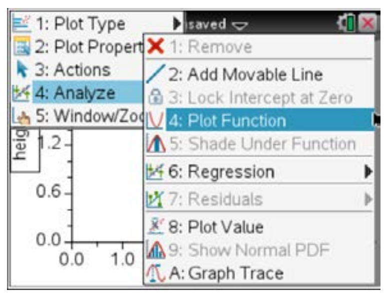
13. Add another new page and choose Data & Statistics. Click on the horizontal axis, and select **Number** for your independent variable. Click on the vertical axis, and select **Height** for your dependent variable.

14. Sketch the graph to the right.



15. How does it compare with the prediction that you made prior to the data collection?

16. Check to see how the equation you found matches with your data. From the menu on the Data and Statistics page, choose Analyze and then Plot Function. Enter the equation for the maximum height as a function of the bounce number. You must use x for the bounce number in the equation.



17. Does the function that you entered match the data? If not, make adjustments. Record the equation that matches your data and any needed adjustments.

18. An exponential equation has the form $y = a \cdot b^x$. Explain what ***a*** and ***b*** represent in this equation.

How Does It Bounce?
Student Activity

Name _______________
Class _______________

19. Use your model to predict the height of the next bounce. Show your work.

20. Why do you think the ball does not bounce as high as the previous bounce?

21. In science, you learn about kinetic and potential energy. How do the concepts of energy relate to this bouncing ball? Is mechanical energy conserved?

22. Summarize what you learned in this activity.

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How Does It Bounce?

TEACHER NOTES

TI PROFESSIONAL DEVELOPMENT

Math and Science Objectives

- Students will first predict and then examine the relationship for maximum bounce height as a function of bounce number for a ball bouncing under a motion detector.
- Students will model mathematically the relationship with the exponential equation in the form $y = ax^b$.
- Students will relate each of the parameters in the equation to a physical quantity.
- Students will draw conclusions about bouncing balls and the loss of energy in the bounce.
- Students will use appropriate tools strategically. (CCSS Mathematical Practice)

Vocabulary

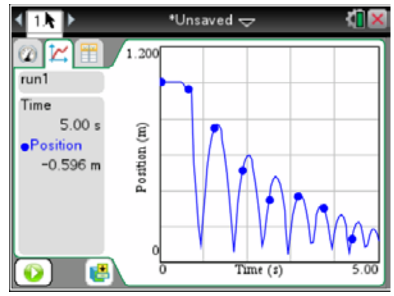
- position
- initial value
- exponential equation

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 drop a ball under a motion detector to collect position as a function of time. They will find the maximum height for each bounce and record it in a data table.
- Students will develop the mathematical equation for the data by creating their own model of an exponential function.
- As a result, students will:
  - Develop a conceptual understanding of exponential functions
  - Make a real-world connection about exponential functions and transformations.

Materials and Materials Notes

- TI-Nspire™ handheld or computer software
- Calculator-Based Ranger 2™ data collection device (CBR 2)
- Ball (Basketballs, racquetballs or kick balls work well. Avoid tennis balls or other fuzzy balls.)



TI-Nspire™ Technology Skills:

- Collect position vs. time data with the Vernier DataQuest™ application for TI-Nspire.

Tech Tips:

1. The CBR 2™ needs to be set to zero position with the floor and reversed. Once this setting is made, students must keep the CBR 2 at that same distance from the floor.
2. Have students look for a good location prior to setting up the CBR 2. Find a spot where the ball will bounce without moving horizontally.
3. Some students have the misconception that the graph represents a picture of the motion rather than the function of position versus time. Allowing the ball to move side to side contributes to this misconception.

Lesson Files:

Student Activity

- How_Does_It_Bounce_Student.pdf
- How_Does_It_Bounce_Student.Student.doc

- Using the CBR 2 USB cable with a computer requires the use of the mini-standard USB adaptor to plug the motion detector into a computer with TI-Nspire™ Teacher or Student Software. The TI-Nspire Lab Cradle also can be used with the Vernier Go!® Motion USB motion detector, which connects directly to the computer.
- If you do not have the adapter, you may want to collect data with the student handheld and transfer it to the computer using the TI-Nspire™ CX Navigator™ System.

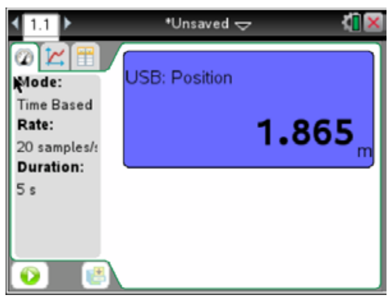
Discussion Points and Possible Answers

> **Teacher Tip:** Making predictions is very important in helping students connect the physical world to the mathematical world. Ask students to make a prediction and sketch it prior to collecting data. You then may 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 should show height decreasing with bounce number, but may not know how. Many may make a linear graph as a prediction. Stress that a prediction is just that. It should never be corrected for points, but instead be used as a place for students to correct their own thinking and conceptual understanding.

Data Collection

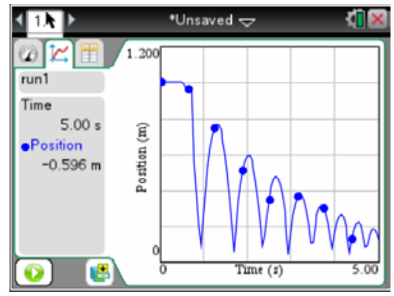
> **Teacher Tip:** Before collecting data, students should find a good spot that allows the ball to bounce straight up and down. Suggestions are: table, tile or wood floor, concrete or carpet that is not plush.

To collect data with a CBR 2, first turn on the TI-Nspire and choose **New Document**. Plug in the CBR 2 sensor and the Vernier DataQuest™ application will launch automatically. The handheld shows a meter which will change as the position varies. You are using the default setting which collects data for 5 seconds.



> **Teacher Tip**: Be sure the CBR 2 switch is set to *normal* as shown in the student handout. You may want to remind students to zero and reverse the data collection. Some also may need assistance in changing the view to show only the position graph.

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



Teacher and Technology Tips:

You may want to remind students to show you their graphs prior to proceeding. The graphs need to look like the one shown to the right, with at least 5 parabolic sections.

Some students may have trouble collecting the data. If so, you could have another group send them a data file, or you use the TI-Nspire CX Navigator System to find one good set of data, collect it, and send it out the entire class.

Each student should have a set of data to analyze on his or her handheld.

Analysis:

1. Enter the Bounce Number and Bounce Height (round to 2 decimal places) data into the table below.

2. Divide each bounce height by the previous bounce height for each set in your data table. For example, divide the height of bounce 1 by the height of bounce 0. Write the ratio as a decimal value in the right column of the table.

Sample data:

Bounce Number	Bounce Height (m)	Ratio of Bounce Heights
0	0.97	
1	0.77	0.79
2	0.60	0.78
3	0.48	0.80
4	0.39	0.81
5	0.31	0.80

3. Examine the data in the table. Is the relationship linear? How can you tell from the differences in the Maximum Height values?

   Sample answer: The data is not linear. Linear data would have a constant difference between the bounce heights. The difference in this table is decreasing.

4. Is the data quadratic? How can you tell from the differences in heights?

   Sample answer: The data is not quadratic. If the data set were quadratic, the second difference would be a constant and it is not in this case.

5. What do you notice about the ratios in right column of the table?

   Sample answer: The ratios in the sample data are all close to 0.80.

6. Find the average of these values.

   Sample answer: For the sample data, the average is 0.80.

7. How could you use the average value and the initial height to find the height of bounce 1 using mathematics?

   Sample answer: Multiply 0.80 by the initial height to estimate the height of the first bounce.

8. How would you then be able to predict the height of bounce 2?

   Sample answer: Multiply 0.80 by the first height to estimate the height of the second bounce.

9. Write the estimation of height 2, H_2 as a function of the initial height, $H_{o.}$ Now do the same for H_5, the height of the 5th bounce.

   Sample answer: $H_2 = H_0 \times (0.8)^2$; $H_5 = H_0 \times (0.8)^5$

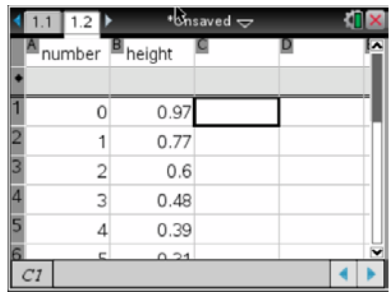
10. This type of function is an exponential function. It has the form $y = a \times b^n$,*y*=*a*∗,*b*-*x*. where *b* is the percentage of the return written as a decimal. What is the value of *a*? Hint: think about the height for bounce zero. Explain your reasoning.

    <u>Sample answer</u>: The value for *a* is the starting height before the ball was dropped.

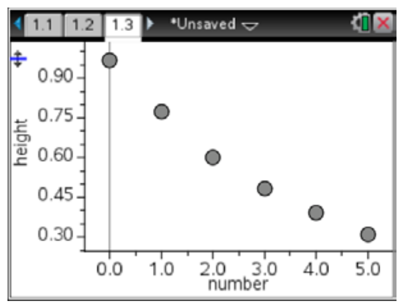
11. Write an equation for height as a function of bounce number, *n*, for this set of data.

    <u>Sample answer</u>: $H_n = 0.97 \times (0.8)^n$,

12. To check your model, create a graph of maximum height as a function of bounce number on the handheld. First, you must enter the data into the Lists & Spreadsheet application by adding a new page to your document. Name the first column *Number* and the second column *Height*. Enter the values from your data table above into the columns on the handheld.



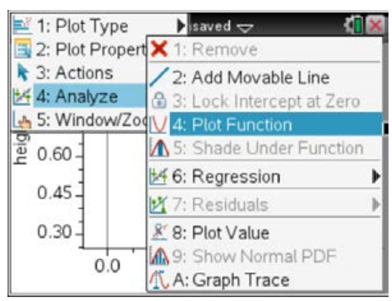
13. Add another new page and choose Data & Statistics. Click on the horizontal axis, and select **Number** for your independent variable. Click on the vertical axis, and select **Height** for your dependent variable.



14. Sketch the graph to the right.

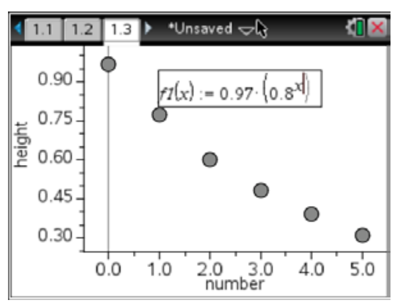
15. How does it compare with the prediction that you made prior to the data collection?

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



16. Check to see how the equation you found matches the data. Select **Menu > Analyze > Plot Function**. Enter the equation for the maximum height as a function of the bounce number. You must use *x* for the bounce number in the equation.

> **Teacher Tip:** Some students may need to make some slight adjustments, but the equation should fit the data well.



17. Does the function that you entered match the data? If not, make adjustments. Record the equation that matches your data and any needed adjustments.

    Sample answer: Answers will vary.

18. An exponential equation has the form $y = a \times b^n$. Explain what a and b represent in this equation.

    Sample answer: The value of a represents the initial height of the ball from the floor. The value of b represents the percentage of the height retained each bounce.

19. Use your model to predict the height of the next bounce. Show your work.

    Sample answer: $H_n = 0.97 \times (0.8)^n$; $H_6 = 0.97 \times (0.8)^6$; $H_6 = 0.97 \times (0.8)^6 = 0.97 \times 0.26 = 0.25$; 0.25 m

20. Why do you think the ball does not bounce as high as the previous bounce?

    Sample answer: Energy is lost each time the ball bounces.

21. In science, you learn about kinetic and potential energy. How do the concepts of energy relate to this bouncing ball? Is mechanical energy conserved?

    Sample answer: Mechanical energy is the sum of kinetic and potential energies. The ball begins with potential energy only. As the ball falls, the potential energy is converted to kinetic energy. When the ball strikes the ground, its potential energy with respect to the ground is zero because all of the energy is now kinetic. When the ball makes contact with the ground, the kinetic energy is converted to heat energy and therefore mechanical energy, but not total energy, is lost.

22. Summarize what you learned in this activity.

    Sample answer: Answers will vary.

Who's Got a Better Coffee Cup?

Student Activity

Name ________________

Class ________________

Activity Overview

In this activity, you will determine the characteristics that make a better coffee cup. After writing a hypothesis, you will design and conduct a lab to determine the heat loss or gain of a coffee cup.

Materials

- TI-Nspire™ handheld or computer software
- TI-Nspire™ Lab Cradle
- Vernier® EasyTemp™ USB temperature sensor
- Styrofoam coffee cup, paper coffee cup, or cups of your choice
- Hot plate or hot pot for heating water
- Ice

Activity Challenge

Problem: What makes the best coffee cup?

1. Create a hypothesis about which cup is best and why you believe this is true.
2. Determine the variables you need to control and observe for comparison.
3. Design a test to evaluate these variables.
4. Create a data table to store the variables that have been defined.
5. Analyze any data to support or refute your hypothesis.
6. Write a convincing statement which includes a summary of your hypothesis, how your data and calculation support your hypothesis, and any potential reasons for why a cup is better. Add notes on any future study of coffee cup design that could be considered to create a better cup.

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Who's Got a Better Coffee Cup?

TI PROFESSIONAL DEVELOPMENT

Math and Science Objectives

- Students will design a lab to determine heat loss or gain of a coffee cup.
- Students will have varying methods of determining their winner. They might use slope to look at temperature loss over time. They might look at the (amount of water) X (the change in temperature) X (specific heat) to determine energy loss.
- Students will write a summary with supporting evidence from the lab to justify their decisions.

Vocabulary

- temperature change
- slope
- specific heat
- heat
- insulation
- heat transfer
- linear
- minimum and maximum

About the Lesson

- In this lesson, students will be challenged to determine which characteristics create the best coffee cup.
- As a result, students will:
  - Devise multiple methods of solving a problem.
  - Justify why they decided on a particular cup using supporting data and analysis.

Materials and Materials Notes

- TI-Nspire™ handheld or TI-Nspire™ computer software
- TI-Nspire™ Lab Cradle
- Three Vernier® EasyTemp™ USB temperature sensors
- Hot plate and beaker or hot pot for warming water
- Ice
- Plastic tub

TI-Nspire™ Technology Skills:

- Collect temperature data using up to three different temperature probes changing time settings **Menu > Experiment > Collection Setup**.

Tech Tips:

- The Vernier® DataQuest™ app will open when a sensor is plugged in.
- An alternate method of opening the app is pressing ctrl menu and selecting **Add Vernier DataQuest**.

Lesson Files:

Student Activity

- Whos_Got_a_Better_Coffee_Cup.doc
- Whos_Got_a_Better_Coffee_Cup.pdf

Discussion Points and Possible Answers

The goal is to encourage students to first make a hypothesis. Many will focus in on the heat loss right away. Ask them how they will determine the heat loss in the coffee cup.

> **Tech Tip:** The Vernier DataQuest™ app should launch when the TI-Nspire™ Lab Cradle and EasyTemp™ sensor are connected. To begin the data collection, click the green **Start Collection** arrow in the lower-left corner of the screen. The default time setting is 180 seconds (3 minutes). Students might want to change these time parameters for their experiment by pressing **Menu > Experiment > Collection Setup**.

Activity Challenge

Problem: What makes the best coffee cup?

1. Create a hypothesis about which cup is best and why you believe this is true.

   Discuss what a strong hypothesis is with the students. They not only predict the outcome, but they need to give reasons why they believe this is true.

2. Determine the variables you need to control and observe for comparison.

   Help students define variables that will be involved in the experiment. Different groups will have slightly different variables.

3. Design a test to evaluate these variables.

4. Create a data table to store the variables that have been defined.

   Student data tables should show all variables that are being considered to support their hypothesis.

5. Analyze any data to support or refute your hypothesis.

6. Write a convincing statement which includes a summary of your hypothesis, how your data and calculation support your hypothesis, and any potential reasons for why a cup is better. Add notes on any future study of coffee cup design that could be considered to create a better cup.

   Students’ conclusions should contain information on either ‘the rate of decrease (slope) of the line is less’ if they used hot water in the cup or ‘the rate of increase is less’ if they used cold water in the cup, if they compared slopes.

   If they compared change in temperature, the cup with the least overall change under equivalent conditions would be the best for maintaining energy. There can be multiple solutions that are correct. Students’ justification must be considered and supported by their data.

Why Bigger Is Not Necessarily Better

TI PROFESSIONAL DEVELOPMENT

Name ________________

Class ________________

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

In this activity, you will investigate one consequence of an increase in volume of an object, which will be used to represent a single cell.

Move to page 1.2.

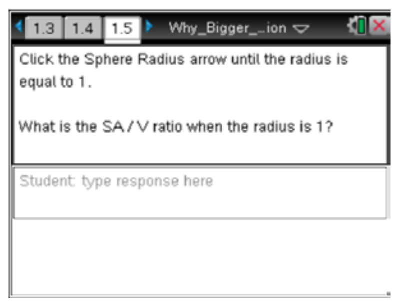
Press ctrl ▶ and ctrl ◀ to navigate through the lesson.

Did you know that the biggest cell on the planet is an ostrich egg? In contrast, most cells are FAR smaller. For example, red blood cells are only 7 or 8 MILLIONTHS of a meter in diameter, and the biggest bacterial cells are about 1/10th the size of red blood cells! Why are most cells so small? In Biology, whether you're considering tiny structures like cells, or huge animals like elephants and whales, surface area plays a key role in function and survival.

As you perform this experiment and graph the data you collect, think about how the surface area and volume of a cell affect how rapidly it can exchange materials with its environment. Also, think about the mathematical relationships that are occurring as the size of your "cell" changes. The underlying question is, "What happens to the ratio of surface area to volume as the volume increases?"

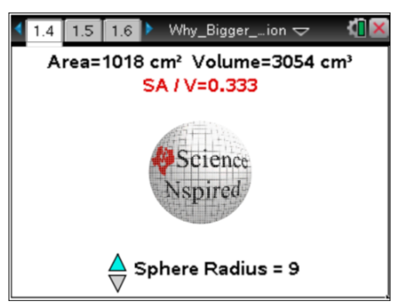
1. Follow the directions within the simulation TI-Nspire document on your handheld.

Move to pages 1.5 through 1.12.



Q1. What is the SA/V ratio when the radius is 1?

Q2. What is the SA/V ratio when the radius is 3?



Q3. What is the SA/V ratio when the radius is 5?

Q4. What is the SA/V ratio when the radius is 10?

Q5. As the radius of the sphere (cell) increased, what happened to the surface area AND the volume of the sphere (cell)?

Why Bigger Is Not Necessarily Better

TI PROFESSIONAL DEVELOPMENT

Name _______________

Class _______________

A. It increased. B. It decreased. C. It stayed the same.

Q6. If the sphere were a model for a cell, what would the "surface area" represent?

A. The nucleus B. The plasma membrane C. A ribosome D. A single cilium

Q7. As the radius of a sphere (cell) _______, the SA/V ratio of that sphere (cell) ________.

A. increases; increases B. decreases; decreases C. increases; decreases

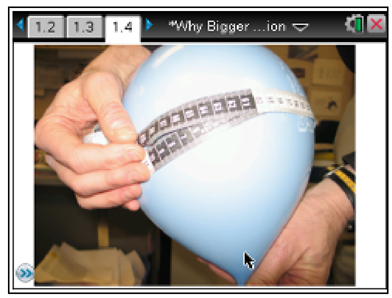
Open *Why_Bigger_Is_Not_Necessarily_Better_Data_Collection.tns* with Mathematical analysis.

Move to page 1.2.

- When asked if you want to save the simulation document, click No.

2. Work through the data collection activity in pairs. One person needs to be the “balloon inflater”, and other needs to be the “measurer”.

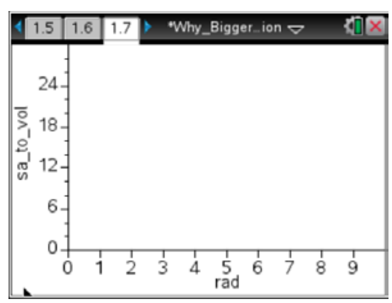
3. Inflate the balloon to six different sizes, measuring the circumference of the balloon to the nearest centimeter.



4. In the spreadsheet on Page 1.5, enter these circumferences into rows 1-6 of Column A. After entering the circumference measurement, also enter a decimal point.

5. What does the graph of volume as a function of radius look like? What does the graph of surface area as a function of radius look like?

6. Use your knowledge about the formulas for surface area and volume to predict what the graph of the ratio surface area to volume as a function of radius will look like. Sketch your prediction in the space to the right and write a sentence to explain your prediction.



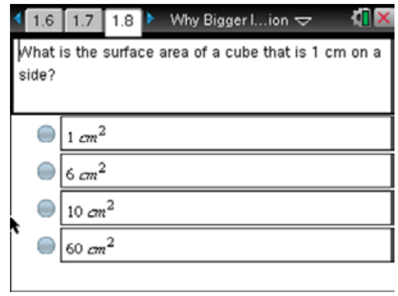
Why Bigger Is Not Necessarily Better

TI PROFESSIONAL DEVELOPMENT

Name ________________

Class ________________

Move to pages 1.8 through 1.17.



Q8. What is the surface area of a cube that is 1 cm on a side?

A. 1 cm^2 B. 6 cm^2 C. 10 cm^2 D. 60 cm^2

Q9. As your balloon got bigger, what happened to the surface area?

A. It got bigger. B. It got smaller. C. It stayed the same.

Q10. As your balloon got bigger, what happened to the volume?

A. It got bigger. B. It got smaller. C. It stayed the same.

Q11. As your balloon got bigger, what happened to the SA/V ratio?

A. It got bigger. B. It got smaller. C. It stayed the same.

Q12. If you know the circumference of a circle or a sphere, how can you calculate the radius?

A. Multiply the circumference by 2π

B. Divide the circumference by 2π

C. Multiply the circumference by πr^2

D. Divide the circumference by $2\pi r$

Q13. Measurements for _______ are expressed as units^2, while measurements for _______ are expressed as units^3.

A. volume; surface area B. surface area; volume C. surface area; diameter D. volume; radius

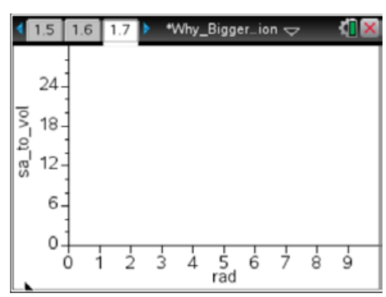
Q14. The formula for the SA of a sphere is $4\pi r^2$. The formula for the volume of a sphere is $(4/3)\pi r^3$. Plug these individual formulas into the fraction: SA/V. Then simplify the resulting fraction.

Q15. Two people are 6'3" tall. One weighs 170 pounds, while the other weighs 270 pounds. Which of these two people has a greater SA / V ratio?

A. The one weighing 170 pounds B. The one weighing 270 pounds

Mathematics Extension:

Next, you'll be graphing some of the data from the spreadsheet, so you can learn more about the relationship between the surface area and the volume of the balloon.



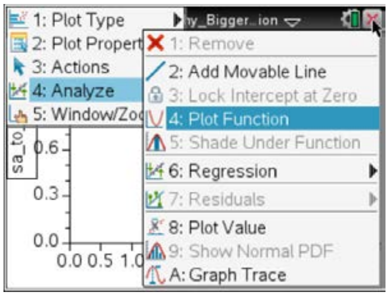
1. Move back in your document to Page 1.7, a Data & Statistics page. Click on the horizontal axis, and select **rad** for the independent variable.
2. Click on the vertical axis, and select **sa_to_vol** for the dependent variable. How does the plot compare with the prediction that you made earlier? Sketch the graph of surface area to volume as a function of radius in the space to the right.

Why Bigger Is Not Necessarily Better

TI PROFESSIONAL DEVELOPMENT

Name ________________

Class ________________



3. Once you have plotted the data, determine an equation for the ratio of surface area to volume as a funciton of radius. Select **Menu > Analyze > Plot Function**. Enter the equation for the ratio as a function of the radius. You must use *x* for the radius in the equation. Does the function that you entered match the data? If not, make adjustments. Record the equation that matches your data.

4. What type of regression would match up with your data? Select **Menu > Analyze > Regression** and choose the appropriate model from the list. Record your equation and explain why it is appropriate.

Q16. In really hot weather, which of the two people from the previous question would have a tougher time cooling off by getting rid of body heat?

A. The one weighing 170 pounds B. The one weighing 270 pounds

Q17. Mammals that live in the desert tend to be "lanky" with large, thin ears. Those that live in the arctic tend to be "round" shaped with very small, hair-covered ears. Why?

A. Managing body temperature is critical to survival in both environments.
B. It helps both be better camouflaged.
C. It helps them avoid predators.

Write a summary about the mathematics and science concepts explored in this activity. Be sure to explain why bigger is not necessarily better.

Why Bigger is Not Necessarily Better

TI PROFESSIONAL DEVELOPMENT

Science Objectives

- Students will determine the relationship between the surface area and the volume of a sphere.
- Students will use an understanding of surface area and volume to explain cellular membrane dynamics.
- Students will use a graph to interpret and analyze a biological principle.
- Students will analyze data numerically, graphically, and symbolically.
- Students will apply the relationships between the radius of a sphere and its circumference, surface area, and volume.

Vocabulary

- radius
- circumference
- surface area
- volume
- cell membrane

About the Lesson

- This lesson involves examining the relationship between surface area and volume.
- As a result, students will:
  - Use two separate TI-Nspire documents—the first for simulation, the second for data collection.
  - Draw conclusions based on the simulation and their own data collection about the Surface Area to Volume relationship and why biological cells must remain small.

TI-Nspire™ Navigator™ System

- Use Class Capture to monitor student progress.
- Use Live Presenter to allow students to show their graphs to the class.

Activity Materials

- Latex balloons
- Tape measure (or meter sticks and string)

TI-Nspire™ Technology Skills:

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

Tech Tips:

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

Lesson Materials:

Student Activity

- Why_Bigger_is_Not_Necessarily_Better_PD_Student.pdf
- Why_Bigger_is_Not_Necessarily_Better_PD_Student.doc

TI-Nspire document

- Why_Bigger_is_Not_Necessarily_Better_Simulation.tns
- Why_Bigger_is_Not_Necessarily_Better_Data_Collection.tns

Discussion Points and Possible Answers (Simulation)

Move to page 1.4.

Q1. What is the SA/V ratio when the radius is 1?

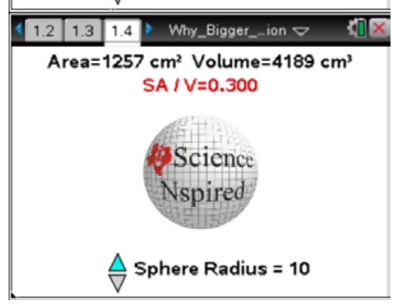
Answer: 3

Q2. What is the SA/V ratio when the radius is 3?

Answer: 1

Q3. What is the SA/V ratio when the radius is 5?

Answer: 0.6



Q4. What is the SA/V ratio when the radius is 10?

Answer: 0.3

Q5. As the radius of the sphere (cell) increased, what happened to the surface area AND the volume of the sphere (cell)?

Answer: They increased

Q6. If the sphere were a model for a cell, what would the "surface area" represent?

Answer: The plasma membrane

Q7. As the radius of a sphere (cell) _______, the SA/V ratio of that sphere (cell) ________.

Answer: increases; decreases

Discussion Points and Possible Answers (Data Collection)

Q8. What is the surface area of a cube that is 1 cm on a side?

Answer: 6 cm^2

Q9. As your balloon got bigger, what happened to the surface area?

Answer: It got bigger.

Q10. As your balloon got bigger, what happened to the volume?

Answer: It got bigger.

Q11. As your balloon got bigger, what happened to the SA/V ratio?

Answer: It got smaller.

Q12. If you know the circumference of a circle or a sphere, how can you calculate the radius?

Answer: Divide the circumference by 2π.

Q13. Measurements for _______ are expressed as $units^2$, while measurements for _______ are expressed as $units^3$.

Answer: surface area; volume

Q14. The formula for the SA of a sphere is $4\pi r^2$. The formula for the volume of a sphere is $(4/3)\pi r^3$. Plug these individual formulas into the fraction: SA/V. Then simplify the resulting fraction.

Answer: 3/r

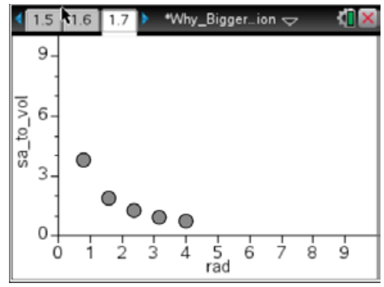
Q15. Two people are 6'3" tall. One weighs 170 pounds, while the other weighs 270 pounds. Which of these two people has a greater SA / V ratio?

Answer: The one weighing 170 pounds

Mathematics Extension:

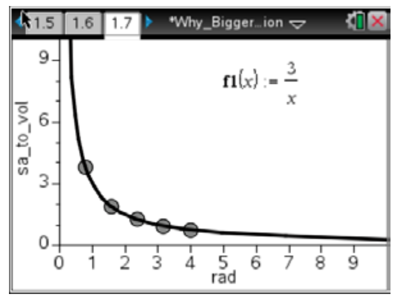
Next, you'll be graphing some of the data from the spreadsheet, so you can infer the relationship between the surface area and the volume of the balloon.

1. Move back in your document to Page 1.7, a Data & Statistics page. Click on the horizontal axis, and select **volume** for the independent variable.



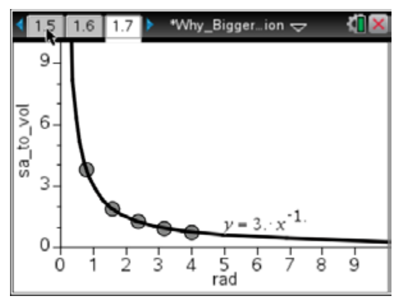
2. Click on the vertical axis, and select **sa_to_vol** for your dependent variable. How does the plot compare with the prediction that you made earlier? Sketch the graph of surface area to volume as a function of radius in the space to the right.

   Sample Answer: See sample data to the right.



3. Once you have plotted the data, determine an equation for the ratio of surface area to volume as a funciton of radius. Select **Menu > Analyze > Plot Function**. Enter the equation for the ratio as a function of the radius. You must use *x* for the radius in the equation. Does the function that you entered match the data? If not, make adjustments. Record the equation that matches your data.

   Sample Answer: Since $SA = 4\pi r^2$and $V = \frac{4}{3}\pi r^3$, the ratio is $\frac{4\pi r^2}{\frac{4}{3}\pi r^3}$, the ratio is $\frac{3}{r}$.



4. What type of regression would match up with your data? Select **Menu > Analyze > Regression** and choose the appropriate model from the list. Record your equation and explain why it is appropriate.

   Sample Answer: A power regression gives the equation $y = 3 \cdot x^{-1}$.

Q16. In really hot weather, which of the two people from the previous question would have a tougher time cooling off by getting rid of body heat?

Answer: The one weighing 270 pounds

Q17. Mammals that live in the desert tend to be "lanky" with large, thin ears. Those that live in the arctic tend to be "round" shaped with very small, hair-covered ears. Why?

Answer: Managing body temperature is critical to survival in both environments

TI-Nspire™ Navigator™ Opportunity, *Class Capture*

Class Capture can be used to monitor students' progress.

Wrap Up

Be sure to discuss the "reality" that is not inherent in this activity. That is, very few cells are actually "spherical". It is true that most animal cells are of a round-ish shape, but they tend to be flattened out, and often have projections from the membrane surface. This serves to dramatically increase surface area while having a negligible effect on the volume of the cell.

Assessment

Formative assessment will consist of questions embedded in the TI-Nspire document. The questions will be graded when the document is collected. The Slide Show can be utilized to give students immediate feedback on their assessment.

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Falling Objects and More
Student Activity

Name ________________
Class ________________

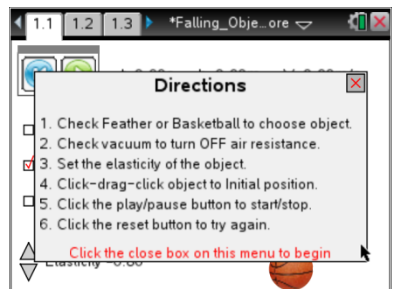
Open the TI-Nspire document *Falling_Objects_and_More.tns.*

In this simulation, you will observe differences between two objects falling to Earth. You will change variables such as height, **elasticity**, and air pressure. Then, you will observe how these changes affect **velocity** and **acceleration** over time.

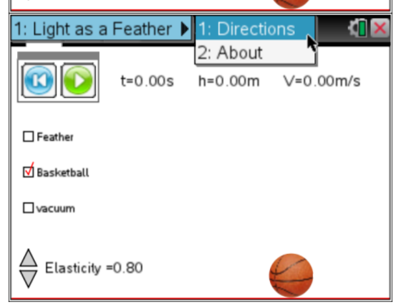
In this investigation you will drop a basketball and a feather from various heights and observe how they fall (**position**, velocity, and acceleration) under varying conditions (elasticity and air resistance). You will then analyze data displayed in a table and on various graphs in order to form conclusions about how objects fall to Earth.

Part 1: Exploring the Simulation and Identifying Variables

1. When you first open the Nspire document you will see a directions box explaining how to use the simulation. Read the directions and check with your classmates or your teacher on any items you don't understand.



2. Close the pop-up directions box when you are finished. Press menu to view the directions again.



3. Note the default settings that appear on the screen when you press the reset button. Choose an object, air resistance, and elasticity value. To position the object, hover the cursor over it and when you see the hand, press click. Move it to the height you desire and press click again to release it. Now press the play button to drop the object. You will need to press the pause button to stop the object.

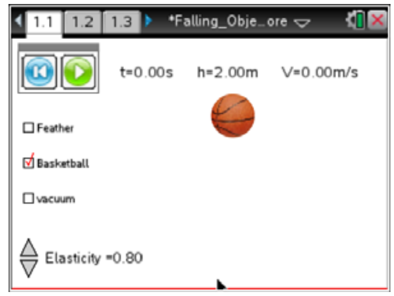
Tech Tip: Click to grab an object and click again to release.

Q1. What are the default settings for this simulation?

Falling Objects and More
Student Activity

Name ________________
Class ________________

4. Starting on page 1.1 explore the simulation. Start with the settings in the table given below. After you conduct each trial, record your observation, and move to pages 1.2 and 1.3 to see the data and the graph of the data.



   For this first round of data collection, be sure to leave the **"vacuum" box unchecked** to create air resistance.

Object	Air Resistance	Elasticity	Observation
Basketball	Yes	0.8	
Basketball	Yes	0.3	
Feather	Yes	0.0	
Feather	Yes	0.5	

5. Now try several different settings of your own. This second round of data collection includes settings when **"vacuum" is checked**.

   Take note of what patterns you see to share with your teacher, team members, and the class.

Q2. Note three things that you learned about falling objects from your exploration. Share these with the class on a Notes page as instructed by your teacher.

6. Next, identify the variables in this simulation. Then, consider how each variable affects an object falling to Earth.

Q3. In the first column of the table on the next page, list the variables that affect an object falling to Earth. In the second column of the table, describe how each variable changes the fall of the object. In the last column, indicate whether or not the variable you identified can be controlled.

Falling Objects and More
Student Activity

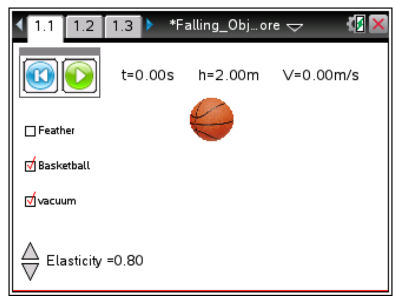
Name ____________________
Class ____________________

Variable	How does it change the falling object?	Can you control this variable?

Part 2: Exploring Falling Objects in a Vacuum

Now you can compare the patterns you have already observed with those for the same objects falling in a vacuum.

7. Go to back page 1.1. Select the basketball and check the vacuum box. Set the elasticity value to 0.80. Move the ball to a height of 2.00 meters and drop it. Pause the simulation just after it hits the ground.

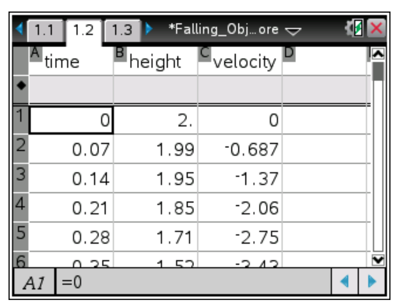


Move to page 1.2.

8. On page 1.2 you will find data in a spreadsheet for the object you just dropped. This spreadsheet contains the time, height, and velocity of the object as it falls and bounces.

   Examine the data for this drop.

   Remember: This data clears each time you reset the simulation.



Q4. Answer the following questions:

a. Using the data shown on page 1.2, approximately how many seconds did it take for the ball to fall 2.00 meters?

Falling Objects and More
Student Activity

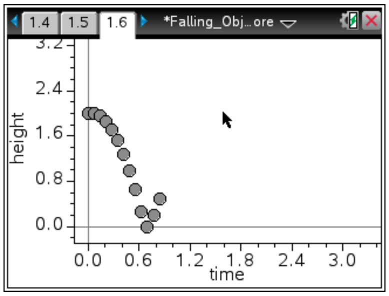
Name ________________
Class ________________

b. What was the initial velocity of the object?

c. How fast was the ball traveling right before it hit the ground?

d. Explain why some of the velocity values are positive and others are negative.

Move to page 1.6.



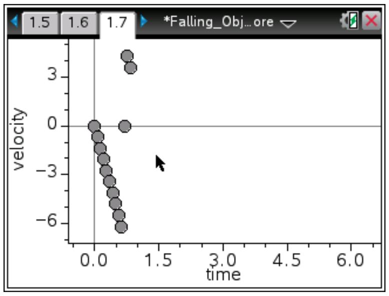
9. Look at the plot of height vs. time on page 1.6. Look at any three drop points in a row on the graph. Note that the points become further apart as the object approaches the ground.

Q5. Fill in the table below using information from the spreadsheet on page 1.2. In the first column select three points during the fall but before the bounce. Record Time 1 and Height 1 from the row *before* your selected point. Record Time 2 and Height 2 from the row *after* your selected point. Next, complete the calculations and fill in the table below using time and height data.

Data Value Row #	Time 1	Time 2	Time 2 – Time 1	Height 1	Height 2	Height 2 – Height 1

Since the time intervals are the same for the data displayed, it can be said that the object is falling a larger distance in the same time interval as it approaches the ground.

Move to page 1.7.



10. The change in distance divided by the change in time is called *speed*. *Velocity* is speed in a particular direction. On page 1.7, observe the graph of time vs. velocity.

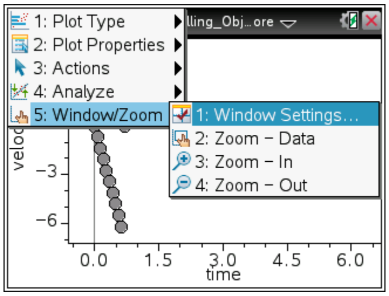
    Look at the plot and note the points that represent the time intervals you explored above.

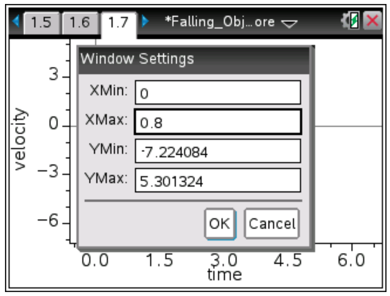
Tech Tip: You might want to adjust the Window setting so that you can focus on the drop. Press menu and the select the **Window/Zoom** option and change the **Window Setting** for the time (*x*-values).

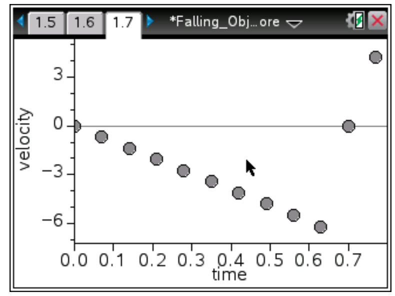
Falling Objects and More
Student Activity

Name ________________

Class ________________

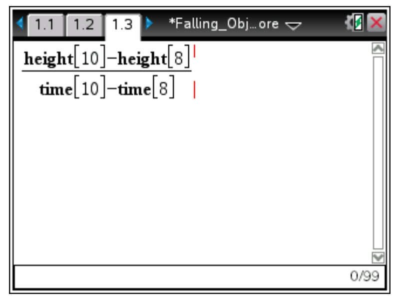






A velocity at any given instant is known as *instantaneous velocity.* The velocities given in the spreadsheet on page 1.2 are instantaneous velocities. Now you will find the average velocity for an interval and compare it to an instantaneous velocity in the middle of the interval.

11. Calculate the average velocity for the three intervals from the table in question 5 using the formula below and see if it is close to the velocity shown in the spreadsheet on page 1.2. Use the Scratchpad or insert a Calculator page (ctrl I).



$$\text{Average Velocity} = \frac{\text{Height 2} - \text{Height 1}}{\text{Time 2} - \text{Time 1}}$$

In the example shown to the right, the data value in the 9th row is selected. The data values in the 8th and 10th rows are used to determine the average velocity. On the handheld, the calculation uses the cell reference from the spreadsheet. **Height [8]** is the value in the height column, 8th row.

Q6. Fill in the table with the average velocity you calculated and the velocity on page 1.2 for each data value selected in question 5.

Data Value Row #	Average Velocity Calculated	Velocity of Data Value

Q7. How does the velocity you calculated compare to the velocity reported in the spreadsheet?

Falling Objects and More
Student Activity

Name ________________
Class ________________

Q8. Notice that the distance between the points on the velocity vs. time plot on page 1.7 is constant, but this is not the case for the height vs. time plot on page 1.6. What do you think this means?

Q9. Calculate the change in velocity over time using the formula to the right. Get an assigned time interval from your teacher. Fill in the table below.

$$\frac{\text{Velocity 2} - \text{Velocity 1}}{\text{Time 2} - \text{Time 1}}$$

Time 2 =	Velocity 2 =
Time 1 =	Velocity 1 =
Calculated change in velocity =	

A change in velocity over time is *acceleration*. On Earth the acceleration due to gravity is 9.81 m/s/s. Since the acceleration of a falling object is downward toward the Earth, it has a negative value.

Move to page 1.8.

Q10. Look at the graph of acceleration vs. time. How would you describe this graph?

Move back to page 1.1.

You will now explore a falling feather. Reset the simulation, and then check the box for “feather” and for “vacuum.” See if you can determine the differences between the falling feather and the falling basketball in a vacuum. Answer the following questions based on your exploration.

Q11. a. How much longer than the basketball did the feather take to fall to the ground?

b. How much slower than the basketball was the feather moving right before it hits the ground?

c. How much slower than the basketball was the acceleration of the feather?

Falling Objects and More
Student Activity

Name _______________

Class _______________

Part 3: Falling Objects in Air

Now see how falling objects behave when they are not in a vacuum. Objects not in a vacuum are subject to air resistance. You should have observed that objects like a basketball and a feather are different, yet in a vacuum they have the same acceleration due to gravity. In this section, you will observe the same falling objects with air resistance.

12. Your teacher will assign you both an object to drop and an initial position. This drop will NOT be in a vacuum. Record your assigned values below. Recall that you need to pause the simulation just after the object hits the ground. If you start again, be sure to reset the simulation.

    Your assigned object: ______________________

    Your assigned height: ______________________

Q12. How long did it take your object to fall to the ground? Compare this with others in the class having similar heights.

13. Look at the spreadsheet and the plot of height vs. time on page 1.6, and compare it to the plot for the objects dropped in a vacuum. Share your results with the class.

14. Now look at the velocity vs. time plot on page 1.7. Make an observation about the plot. Share your results with the class.

Q13. Terminal velocity is the constant speed that a falling object reaches. When air resistance is a factor, objects may reach different terminal velocities, and therefore, fall to the ground at different times.

a. Determine the terminal velocity for a feather.

b. What is the acceleration of the feather when it reaches its terminal velocity?

c. Why?

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Falling Objects and More

Science Objectives

- Students will explore two objects falling to Earth in a vacuum. They will modify the initial position of the drop and the elasticity of each object.
- Students will examine the object for the initial drop and for several bounces observing the position, velocity, and acceleration values.
- Students will then add air resistance to the falling objects and observe how under certain conditions, objects may reach different terminal velocities, thus falling to the ground at different times.

Vocabulary

- gravity
- position
- velocity (instantaneous and average)
- acceleration (due to gravity)
- drag
- terminal velocity
- elasticity

About the Lesson

All free falling objects fall to the Earth with the same acceleration regardless of size, shape, or weight. An object that falls through a vacuum is subject only to gravity. If an object falls through the atmosphere, there is an additional force called *drag* acting on the object.

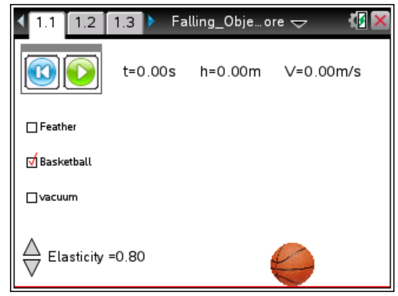
- As a result, students will:
  - Describe the variables involved in a falling object.
  - Vary the air, mass, and height of an object and examine the height, velocity, and acceleration of the object as a function of time.
  - Optional: Examine the effect of elasticity on a falling basketball as it bounces over time.

TI-Nspire™ Navigator™

- Send out the .tns file.
- Monitor student progress using Screen Capture.
- Use Live Presenter to allow students to show how they manipulate variables that affect results.

Activity Materials

- TI-Nspire™ Technology
- *Falling_Objects_and_More*.tns document



TI-Nspire™ Technology Skills:

- Open a document
- Grab and drag an object in a simulation
- Start / Stop an animation
- Add pages or use the Scratchpad
- Set up calculations
- Explore the cells of a spreadsheet

Lesson Materials:
Student Activity

- Falling_Objects_and_More _Student.pdf
- Falling_Objects_and_More _Student.doc

TI-Nspire document

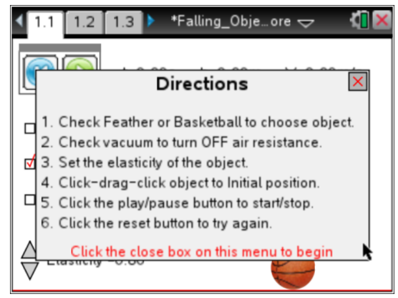
- Falling_Objects_and _More.tns

Discussion Points and Possible Answers

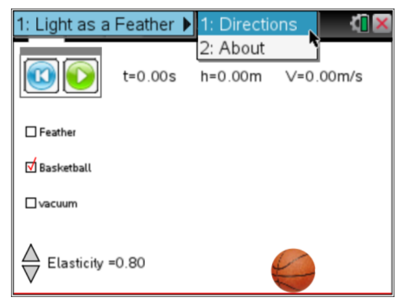
Have students read the background information stated on their activity sheet.

Part 1: Exploring the Simulation and Identifying the Variables

1. When students first open the Nspire document they will see a directions box explaining how to use the simulation. Have them look over these and then be prepared to answer any questions the students might have.



2. Students can close the pop-up directions box when they are finished. They can press menu to view the directions again.



3. Note the default settings that appear on the screen when students press the reset button. Students are to choose an object, air resistance, and elasticity value. To position the object, students hover the cursor over it and when they see the hand, press click. Move it to the height they desire and press click again to release it. Now students press the play button to drop the object. They will need to press the pause button to stop the object.

Tech Tip: Click to grab an object and click again to release.

Q1. What are the default settings for this simulation?

Answer: The basketball on the floor, not moving with an elasticity of 0.80 in air (“vacuum” unchecked).

4. Starting on page 1.1, have students explore the simulation. They will start with the settings given in the table below and should record their observation for each trial. As students conduct each trial, have them look at pages 1.2 and 1.3 to view the data and graph of the data.

   For this first round of data collection, make sure students leave the **"vacuum" box unchecked** to create air resistance.

Object	Air Resistance	Elasticity	Observation
Basketball	Yes	0.8	
Basketball	Yes	0.3	
Feather	Yes	0.0	
Feather	Yes	0.5	

5. Now students are to try several different settings of their own. This second round of data collection includes settings when **"vacuum" is checked**.

   Students should take note of what patterns they see and share.

TI-Nspire Navigator Opportunities

Allow students to volunteer to be the Live Presenter and demonstrate how to run the simulation.

Q2. Note three things that you learned about falling objects from your exploration. Share these with the class on a Notes page as instructed by your teacher.

Sample Answers:

- The patterns as shown in the graphs are the same when in a vacuum for various drop heights, elasticity values, and objects.
- The velocities are negative, then go to zero, and then become positive.
- As elasticity increases, subsequent bounces are closer to the drop height, but are always less.
- When not in a vacuum, the objects tend to slow in their increase in velocity.
- The spaces between the points in the height vs. time get father apart as it falls.

6. Next, students will identify the variables in this simulation, and then consider how each variable affects an object falling to Earth.

Q3. In the first column of the table below, list the variables that affect an object falling to Earth. In the second column of the table, describe how each variable changes the fall of the object. In the last column, indicate whether or not the variable you identified can be controlled.

Variable	How does it change the falling object?	Can you control this variable?

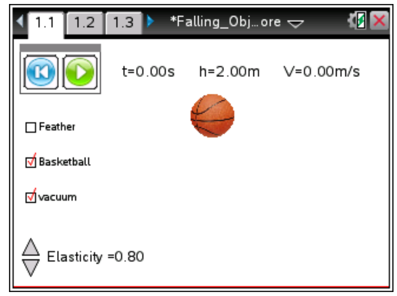
Sample Answers:

Variable	How does it change the falling object?	Can you control this variable?
Air	Slows the object	Yes
Object	None in a vacuum	Yes
Mass	None in a vacuum	No
Height	Time in air/rebound height	Yes
Elasticity	Rebound height	Yes
Wind	Depends on direction (up down, left, right)	No
Temperature	Would cause the air to be more or less dense.	No
Planet	Changes the acceleration	No
Initial Velocity	Falling time, and rebound height.	No

Part 2: Exploring Falling Objects in a Vacuum

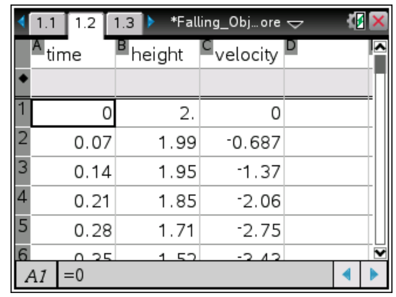
Now students can compare the patterns they have already observed with those for the same objects falling in a vacuum.

7. Have students go back to page 1.1, select the basketball, check the vacuum box, and then set the elasticity value to 0.80. They should move the ball to a height of 2.00 meters and drop it. They should pause the simulation just after it hits the ground.



Move to page 1.2.

8. On page 1.2 students will find data in a spreadsheet for the object they just dropped. The spreadsheet contains the time, height, and velocity of the object as it falls and bounces.



Have students examine the data for this drop.

Remember: The data clears each time the simulation is reset.

Q4. Answer the following:

a. Using the data shown on page 1.2, approximately how many seconds did it take for the ball to fall 2.00 meters?

Answer: 0.70 seconds

b. What was the initial velocity of the object?

Answer: 0.00 m/s

c. How fast was it traveling right before it hit the ground?

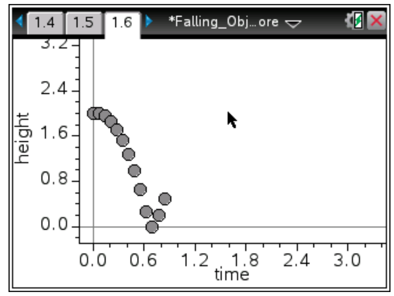
Answer: –6.28 m/s

d. Explain why some of the velocity values are positive and others are negative.

Answer: A negative velocity indicates that the basketball is falling to Earth. A positive velocity indicates that the basketball is bouncing upward.

Move to page 1.6.

9. Students should look at the plot of height vs. time on page 1.6. Note that the points become further apart as the object approaches the ground. Students need to explore this by first looking at the height drop at three points in the drop.



Q5. Fill in the table below using information from the spreadsheet on page 1.2. In the first column select three points during the fall but before the bounce. Record Time 1 and Height 1 from the row *before* your selected point. Record Time 2 and Height 2 from the row *after* your selected point. Next, complete the calculations and fill in the table below using time and height data.

Data Value Row #	Time 1	Time 2	Time 2 – Time 1	Height 1	Height 2	Height 2 – Height 1

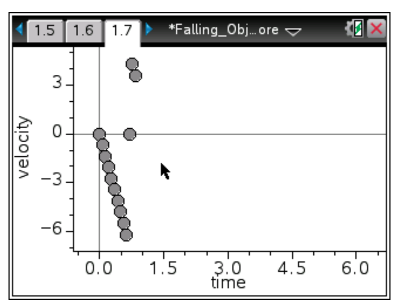
Sample Answers:

Data Value Row #	Time 1	Time 2	Time 2 – Time 1	Height 1	Height 2	Height 2 – Height 1
3	0.07	0.21	0.14 sec	1.99	1.85	–0.14 m
6	0.28	0.42	0.14 sec	1.71	1.28	–0.43 m
9	0.49	0.63	0.14 sec	0.987	0.266	–0.721 m

Since the time intervals are the same for the data displayed, it can be said that the object is falling a larger distance in the same time interval as it approaches the ground.

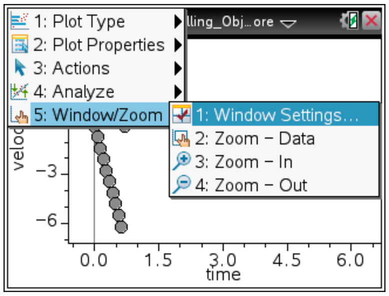
Move to page 1.7.

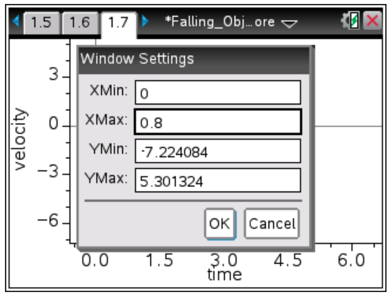
10. The change in distance divided by the change in time is called *speed*. *Velocity* is speed in a particular direction. On page 1.7, observe the graph of time vs. velocity.

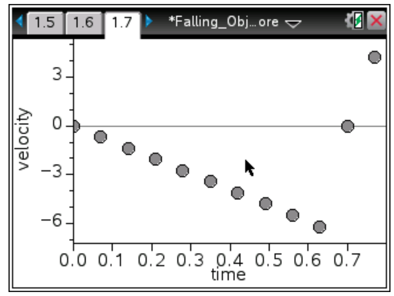


Have students look at the plot and note the points that represent the time intervals explored above.

Tech Tip: You might want to adjust the Window setting so that you can focus on the drop. Press menu and the select the **Window/Zoom** option and change the **Window Setting** for the time (*x*-values).

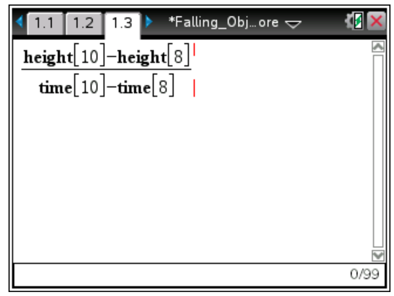






A velocity at any given instant is known as *instantaneous velocity.* The velocities given in the spreadsheet on page 1.2 are instantaneous velocities. Now students will find the average velocity for an interval and compare it to an instantaneous velocity in the middle of the interval.

11. Students will calculate the average velocity for the three intervals from the table in question 5 using the formula below and see if it is close to the velocity shown in the spreadsheet on page 1.2. Use the Scratchpad or insert a Calculator page (ctrl I).



$$\text{Average Velocity} = \frac{\text{Height 2} - \text{Height 1}}{\text{Time 2} - \text{Time 1}}$$

In the example shown to the right, the data value in the 9th row is selected. The data values in the 8th and 10th rows are used to determine the average velocity. On the handheld, the calculation uses the cell reference from the spreadsheet. **Height [8]** is the value in the height column, 8th row.

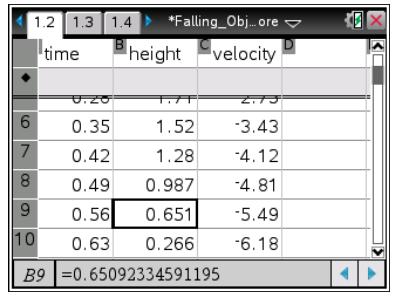
Q6. Fill in the table with the average velocity you calculated and the velocity on page 1.2 for each data value selected in question 5.

Data Value Row #	Average Velocity Calculated	Velocity of Data Value

<u>Sample Answers</u>:

Data Value Row #	Average Velocity Calculated	Velocity of Data Value
3	–1	–1.37
6	–3.07	–3.43
9	–5.15	–5.49

Q7. How does the velocity you calculated compare to the velocity reported in the spreadsheet?



Sample Answer: very close

Q8. Notice that the distance between the points on the velocity vs. time plot on page 1.7 is constant, but this is not the case for the height vs. time plot on page 1.6. What do you think this means?

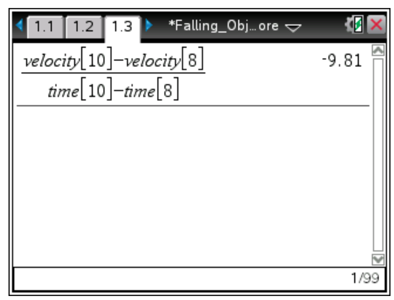
Answer: This means that the rate of change of velocity is the constant.

Q9. Calculate the change in velocity over time using the formula to the right. Get an assigned time interval from your teacher. Fill in the table below.

$$\frac{\text{Velocity 2} - \text{Velocity 1}}{\text{Time 2} - \text{Time 1}}$$

Time 2 =	Velocity 2 =
Time 1 =	Velocity 1 =
Calculated change in velocity =	

Sample Answer:



A change in velocity over time is *acceleration*. On Earth the acceleration due to gravity is 9.81 m/s/s. Since the acceleration of a falling object is downward toward the Earth, it has a negative value.

Move to page 1.8.

Q10. Look at the graph of acceleration vs. time. How would you describe this graph?

Answer: A horizontal line, a line with a slope of zero, a constant negative value.

Move back to page 1.1.

Students will now explore a falling feather. Reset the simulation, and then check the box for “feather” and for “vacuum.” They are to see if they can determine the differences between the falling feather and the falling basketball in a vacuum.

Q11. a. How much longer than the basketball did the feather take to fall to the ground?

Answer: There is no change in a vacuum.

b. How much slower than the basketball was the feather moving right before it hits the ground?

Answer: There is no change in a vacuum.

c. How much slower than the basketball was the acceleration of the feather?

Answer: There is no change in a vacuum.

Teacher Tip: Assign the students various heights and have some do the basketball and some the feather. You want the kids to share their results as we move through this part. Some heights are hard to find, so pick ones that the kids can hit, or just give them a range of heights, (ie. around 1.25 meters).

Part 3: Falling Object in Air

Now students will see how falling objects behave when they are not in a vacuum. Objects not in a vacuum are subject to air resistance. They should have observed that objects like a basketball and a feather are different, yet in a vacuum they have the same acceleration due to gravity. In this section, students will observe the same falling objects with air resistance.

12. Assign individual students or teams of students an object to drop and an initial position. This drop will NOT be in a vacuum. Have students record their assigned values below. Recall that they should pause the simulation just after it hits the ground. If students start again, be sure to reset the simulation.

Your assigned object: ______________________

Your assigned height: ______________________

Teacher Tip: Assign the students various heights and have some do the basketball and some the feather. You want the kids to share their results as we move through this part. Some heights are hard to find, so pick ones that the kids can hit, or just dive them a range of heights, like around 1.25 meters.

Q12. How long did it take your object to fall to the ground? Compare this with others in the class having similar heights.

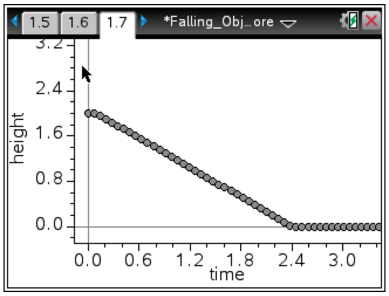
Answer: The feather will hit after the ball in air when dropped from similar heights.

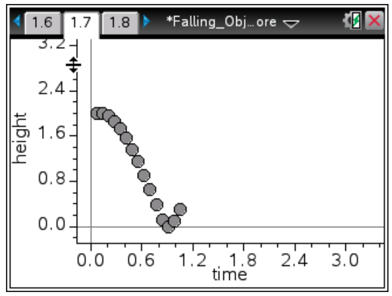
Falling Objects and More

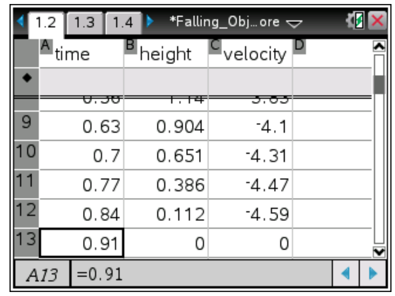
MIDDLE GRADES SCIENCE NSPIRED **TEACHER NOTES**

13. Have students look at the spreadsheet and the plot of height vs. time on page 1.6, and compare it to the plot for the objects dropped in a vacuum. Have them share their results with the class.

Possible results: The feather graph seems like a straight line now and the basketball does not seem very different but it does hit the ground later.







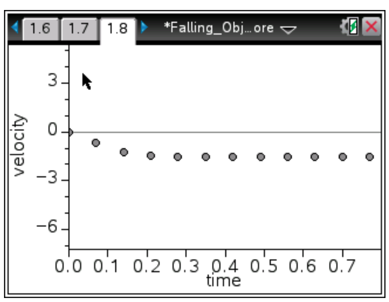
	A time	B height	C velocity	D
9	0.63	0.904	-4.1	
10	0.7	0.651	-4.31	
11	0.77	0.386	-4.47	
12	0.84	0.112	-4.59	
13	0.91	0	0	

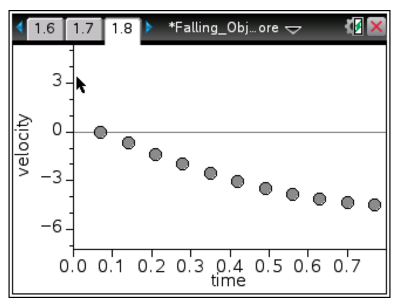
A13 =0.91

Feather ***Basketball***

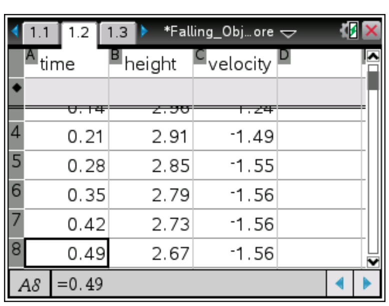
14. Now have students look at the velocity vs. time plot on page 1.7. What do they see? Have them share their results with the class.

Possible results: They both are curved now, while they were straight lines in a vacuum. The feather hits a constant velocity very quickly, while the basketball seems to be approaching this constant value (depending on the height dropped from).



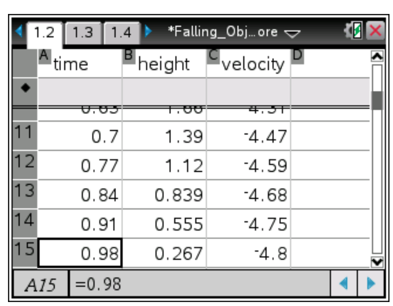


Feather ***Basketball***



	A time	B height	C velocity	D
4	0.21	2.91	-1.49	
5	0.28	2.85	-1.55	
6	0.35	2.79	-1.56	
7	0.42	2.73	-1.56	
8	0.49	2.67	-1.56	

A8 =0.49



	A time	B height	C velocity	D
11	0.7	1.39	-4.47	
12	0.77	1.12	-4.59	
13	0.84	0.839	-4.68	
14	0.91	0.555	-4.75	
15	0.98	0.267	-4.8	

A15 =0.98

Feather ***Basketball***

Q13. Terminal velocity is the constant speed that a falling object reaches. When air resistance is a factor, objects may reach different terminal velocities, and therefore, fall to the ground at different times.

a. Determine the terminal velocity for a feather.

Answer: –1.56 m/s

b. What is the acceleration of the feather when it reaches its terminal velocity?

Answer: 0

c. Why?

Answer: If the velocity is not changing, there is no acceleration.

TI-Nspire Navigator Opportunities

Allow students to volunteer to be the Live Presenter and demonstrate their results for particular questions/Scenarios.
Use Quick Poll to check for answers to some of the questions in the Student document during the course of the activity.

Wrap Up

When students are finished with the activity you may collect the individual files and examine their results or collect the Student Activity Worksheet. If you added some questions to the document, you can add this to their Portfolio and discuss the results as you Review.

Assessment

- Analysis questions are written into the student worksheet. These could be added to the tns file as Exam or Self-Check questions.
- Have the students analyze a particular setting for a second drop (after the bounce) with an assigned initial height and elasticity value.

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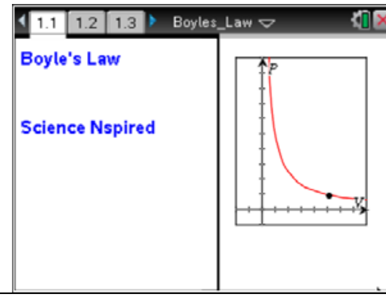
Boyle's Law
Student Activity

Name ______________

Class ______________

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

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



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

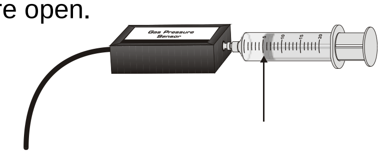
Move to page 1.6.

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

Q1. As volume increases, pressure:

A. increases B. decreases C. remains the same

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



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

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

Boyle's Law
Student Activity

Name ______________
Class ______________

8. To collect your first data reading, click on the "camera" icon in the lower left of the screen ("Keep current reading"). Enter a value of 10, since you set the syringe at 10 mL earlier. Click on OK, or press enter.
9. Depress and hold the plunger to the 9 mL mark. When the pressure value on the left side of the screen has stabilized, keep this reading, type in 9, and press 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 in the lower left corner of your TI-Nspire screen.
    - Your pressure/volume graph should now be displayed.
11. Explore the various regression models to determine the best mathematical relationship for your data set.

12. Based on the graph of pressure vs. volume, decide what kind of relationship exists between these two variables—direct or inverse.
    - While on the DataQuest app page, select **MENU > Analyze > CurveFit > Power**.
    - Scroll down to see the curve fit statistics for the equation in the form y = Ax^B , where x is volume, y is Pressure, A is a proportionality constant, and B is the exponent of x (Volume).

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

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

Move to page 2.3.

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

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

13. To linearize the data and confirm that an inverse relationship exists between pressure and volume, plot a graph of pressure vs. reciprocal of volume (1/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**.

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. 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

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

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

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

Q12. Which of the following produced a constant value?

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

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

Move to page 4.1.

Extension: Effect of Temperature on Boyle's Law

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

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

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

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

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

Boyle's Law

SCIENCE NSPIRED

Science Objectives

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

Math Objectives

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

Materials Needed

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

Vocabulary

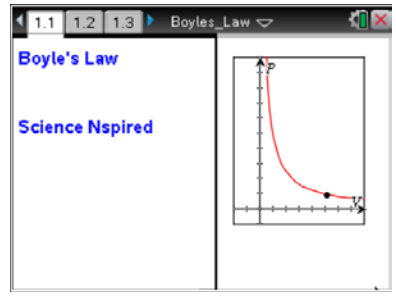
- pressure
- volume
- inverse

About the Lesson

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

TI-Nspire™ Navigator™ System

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



TI-Nspire™ Technology Skills:

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

Tech Tips:

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

Lesson Materials:

Student Activity

- Boyles_Law_Student.pdf
- Boyles_Law_Student.doc

TI-Nspire document

- Boyles_Law.tns

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

Activity Overview

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

Q4. The expected mathematical relationship between pressure and volume is __________.

Answer: inverse

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

Answer: cut in half

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

Answer: is cut by one-third

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

Answer: doubles

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

Answer: inverse

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

Answer: cut into one-fourth

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

Answer: moles of gas and temperature

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

Answer: $P = k/V$

Q12. Which of the following produced a constant value?

Answer: pressure times volume

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

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

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

Answer: The pressure doubles.

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

Answer: inverse (same as before)

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

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

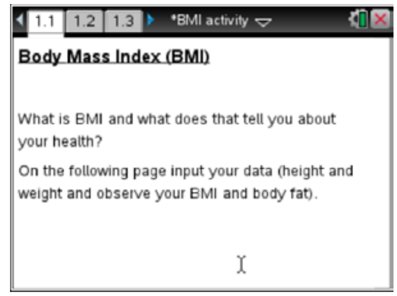
Screen Capture can be used to monitor students.

Body Mass Index
Student Activity

Name ______________

Class ______________

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

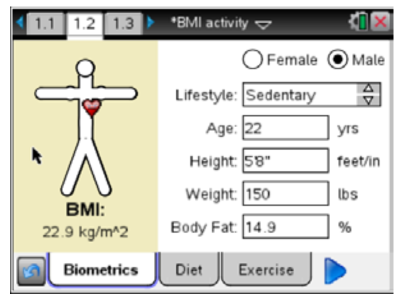


Body mass index (BMI) is a calculation related to a person's height and body weight. Percent body fat is the percentage of a person's weight that is body fat. This calculation can be made using the person's height and weight.

What is BMI and what does it tell you about your health?

Move to page 1.2.

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



Input data about your lifestyle, age, height, and weight. Observe your BMI and percent body fat.

Move to page 1.3.

When your weight increases what happens to your BMI and percent body fat?

- o BMI increases and body fat decreases.
- o BMI decreases and body fat decreases.
- o BMI increases and the body fat increases.
- o BMI decreases and percent body fat increases.

Move to page 1.4.

Does your age make a difference in your BMI or percent body fat?

- o Yes
- o No

Move to page 1.5.

If a male is the same height and weight as a female,

- o the male has more body fat.
- o the female has more body fat.
- o the male and female have the same body fat.

Body Mass Index
Student Activity

Name _______________
Class _______________

Move to page 2.3.

- Set the height to your height.
- Set the weight to 100 lb and observe the percent body fat.
- Insert a Lists & Spreadsheet page after the BMI calculator. Title the columns appropriately.
- Change the weight to 110, 120, 130, 140, 150, and 160, and enter weight and percent body fat into the spreadsheet.

Move to page 2.5.

What is the independent variable in the simulation?

Move to page 2.6.

What is the dependent variable in the simulation?

Move to page 2.7.

- Add your partner's percent body fat to the spreadsheet on page 2.4.
- Add a Data & Statistics page and plot your data appropriately.
- Create a moveable line on the graph and fit the line to your data.

Move to page 2.9.

What is the equation of the line that fits the data for your height?

Move to page 2.10.

What is the slope of your graph?

Move to page 2.11.

What is the *y*-intercept in your graph?

Body Mass Index
Student Activity

Name _______________
Class _______________

Move to page 2.12.

What does the slope represent in your graph?

- o weight
- o percent body fat
- o ratio of weight to percent body fat
- o ratio of percent body fat to weight

Move to page 2.13.

If the slope of a graph is 0.28, this means

- o for every 0.28 lb there is 1% body fat.
- o for every 0.28% body fat there is 1 lb.
- o that there is 0.28 lb.
- o that there is 0.28% body fat.

Move to page 2.14.

If you and your partner have different initial body fat percentages, what generalization can you make about body fat percentage, weight and height?

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Body Mass Index

Science Objectives

- Students will explore the body mass index (BMI) as it relates to weight, height, and age.
- Students will compare weight to percent body fat

Vocabulary

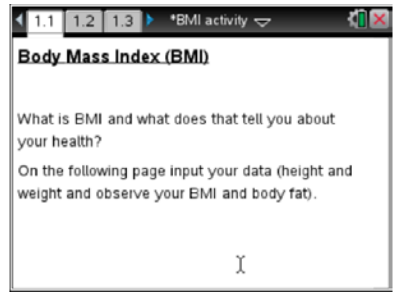
- body mass index
- percent body fat

About the Lesson

- This lesson involves students exploring the BMI calculator.
- As a result, students will . . .
    - be able to determine the relationship between their height, weight, and percent body fat .
    - plot percent body fat versus weight and determine the conversion for their weight to percent body fat.

TI-Nspire™ Navigator™ System

- Send a TI-Nspire document to students.
- Quick Poll to determine if age affects BMI.
- Make a student the Live Presenter and have him or her operate the BMI calculator as the teacher explains how to read the screen.



TI-Nspire™ Technology Skills:

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

Lesson Files:

Student Activity

- Body_Mass_Index_Student.pdf
- Body_Mass_Index_Student.doc

TI-Nspire Document

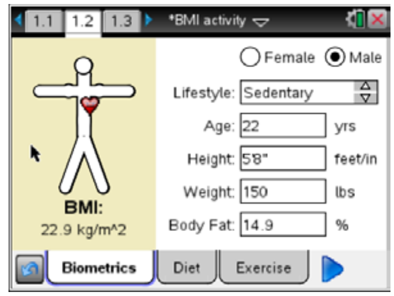
- Body_Mass_Index.tns

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

Discussion Points and Possible Answers

Tech Tip: Students can create a spreadsheet after the BMI calculator and alternate between the two pages to enter the weight and percent body fat.

Move to page 1.2.



Input data about your lifestyle, age, height, and weight.
Observe your BMI and percent body fat.

Move to page 1.3.

When your weight increases what happens to your BMI and body fat?

Answer: BMI increases and the body fat percentage increases.

Move to page 1.4.

Does your age make a difference in your BMI or body fat percentage?

Answer: No

Move to page 1.5.

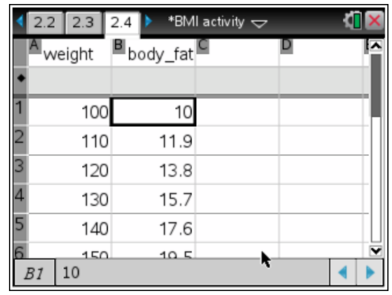
If a male is the same height and weight as a female,

Answer: The female has more body fat.

Move to page 2.3.

- Set the height to your height.
- Set the weight to 100 lb and observe the percent body fat.
- Insert a Lists & Spreadsheet page after the BMI calculator. Title the columns appropriately.
- Change the weight to 110, 120, 130, 140, 150, and 160, and enter weight and percent body fat into the spreadsheet.

Students will add a spreadsheet and record the weight and percent body fat. Title the columns **weight** and **body_fat**.



Move to page 2.5.

What is the independent variable in the simulation?

<u>Answer:</u> weight

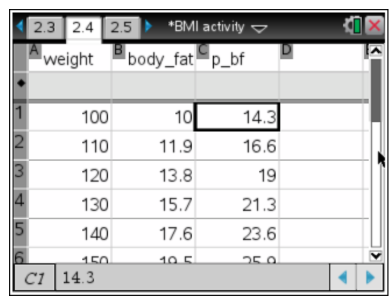
Move to page 2.6.

What is the dependent variable in the simulation?

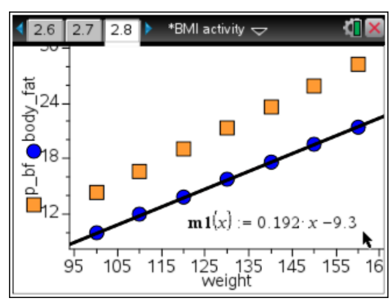
<u>Answer:</u> percent body fat

Move to page 2.7.

Add your partner's percent body fat to the spreadsheet on page 2.4.



Add a Data & Statistics page and plot percent body fat versus weight.



Move to page 2.9.

What is the equation of the line that fits the data for your height?

Sample answer: Answers will vary depending on the student's height. For a student 6 feet tall, the equation might be $y = 0.19x – 9.3$.

Move to page 2.10.

What was the slope of your graph?

Sample answer: Answers will vary depending on the student's height. For a student 6 feet tall, the slope might be 0.19.

Move to page 2.11.

What is the *y*-intercept in your graph?

Sample answer: Answers will vary depending on the student's height. For a student 6 feet tall, the *y*-intercept might be –9.3.

Move to page 2.12.

What does the slope represent in your graph?

Answer: ratio of percent body fat to weight

Move to page 2.13.

If the slope of a graph is 0.28 this means

Answer: for every 0.28% body fat there is 1 lb.

Move to page 2.14.

If you and your partner have different initial body fat percentages, what generalization can you make about body fat percentage, weight and height?

Answer: The taller a person is the heavier they can be and have a lower body fat percent.

Teacher Tip: After they have worked through the activity, talk to students about the importance of the slope being a conversion factor between body fat percent and weight. Each student's slope will be based on his or her height. The taller the student, the smaller the ratio of the percent body fat weight.

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

Wrap Up

Students should gain an understanding that the taller a student is, the heavier that student can be and have a lower percent body fat. Also, the taller the student is, the smaller the ratio between percent body fat and weight.

TI-Nspire™ Navigator™ System

Note 1
Page 2.14, *Live Presenter*
Make a student the Live Presenter and discuss the different slopes for two different people and why they are different.

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LUNAR SURFACE INSTRUMENTATION

Background

Exploration provides the foundation of our knowledge, technology, resources, and inspiration. It seeks answers to fundamental questions about our existence, responds to recent discoveries and puts in place revolutionary techniques and capabilities to inspire our nation, the world, and the next generation. Through NASA, we touch the unknown, we learn and we understand. As we take our first steps toward sustaining a human presence in the solar system, we can look forward to far-off visions of the past becoming realities of the future.

Outpost concepts are now being designed and studied by engineers, scientists, and sociologists to facilitate long-duration human missions to the surface of the Moon or other planetary bodies (Figure 1). Such outposts will include habitat modules, laboratory modules, power systems, transportation, life support systems, protection from the environment, communications for planetary surface operations, and communications back to Earth.

During past and current space missions, astronaut activity outside of the vehicle (e.g. space shuttle) is referred to as an extravehicular activity, or EVA. In a similar way, extrahabitat activities, or EHA, will be performed during a mission to accomplish exploration work. One EHA may be to place environmental sensors and instruments within the proximity of an outpost (Figure 2).

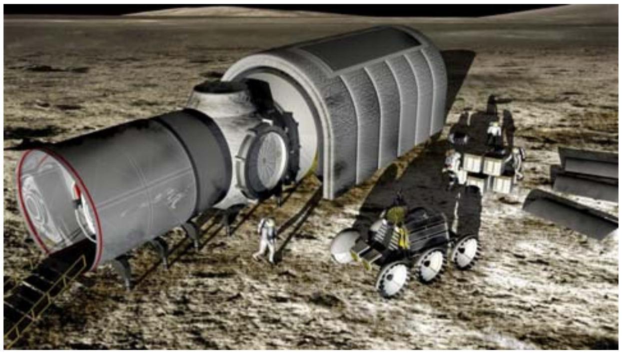


Figure 1: Habitat, airlock, and vehicles (NASA concept)

Figure 2: Astronaut services a surface instrument (NASA concept)

Such instruments may measure the radiation received from solar flares or characterize micrometeorites impacting the surface. Telescopes may also be set up for observations of Earth, other planets, and stars.

Problem

Open the TI-Nspire™ document, *Lunar Surface Instrumentation*, read through the problem set-up, and complete the questions in the document.

A. Determine the astronaut’s displacement vector (distance and direction) from the airlock when she is standing at each instrument. Include a sketch of the path taken by the astronaut.

B. Determine the astronaut's displacement (using unit-vector notation) from the airlock when she is standing at each instrument.

C. Determine the astronaut’s displacement from the first instrument and the third instrument.

D. Determine the distance she walked from the third instrument to the habitat airlock.

E. Determine the total distance she traveled on her EHA.

F. Why is it important to use vector analysis for this solution?

MATH AND SCIENCE @ WORK

AP* PHYSICS Student Edition

LUNAR SURFACE INSTRUMENTATION: Part II

Background

This problem builds from the *Math and Science @ Work Lunar Surface Instrumentation* problem. You should complete the Lunar Surface Instrumentation problem first, in order to better understand the importance of extrahabitat activities (EHA) during long-duration human missions to the surface of the Moon and other planetary bodies.

Problem

On the TI-Nspire™ handheld, open the document *Instrumentation2*. Read through the problem set-up and complete the questions embedded within the document.

A. Sketch the instrument locations with the origin at the airlock. To sketch this on TI-Nspire page 1.13, use the vector tool to draw vectors to each instrument and the measurement tool to show the location of each vector.

B. Using the sketch from Question A and the provided information:

   I. Determine the instruments' locations (x, y) from the airlock.

   II. Determine the astronaut's displacement (using unit-vector notation) from the airlock when she is standing at each instrument.

C. Subject to the constraints, determine the total distance the astronaut would walk for each of the two EHA approaches to service the instruments.

I. Utilizing a lunar surface transporter to carry all equipment.

II. Carrying loads to each instrument without use of lunar surface transporter.

D. Subject to the constraints, determine the time (in minutes) it would take for the astronaut to travel and service the instruments for each of the two EHA approaches.

I. Utilizing a lunar surface transporter to carry all equipment.

II. Carrying loads to each instrument without use of lunar surface transporter.

E. Explain which approach is more efficient in terms of:

I. The distance the astronaut walks.

II. The amount of reserve time remaining in the astronaut's life support system when she arrives back at the airlock.

MATH AND SCIENCE @ WORK

AP* PHYSICS Educator Edition

LUNAR SURFACE INSTRUMENTATION

Instructional Objectives

Students will

- add, subtract, and resolve displacement and velocity vectors to determine components of a vector along two specified, mutually perpendicular axes; and
- determine the net displacement of a particle or the location of a particle relative to another.

Degree of Difficulty

This problem is a straightforward application of vector concepts.

- For the average AP Physics student, the problem may be moderately difficult.

Background

This problem is part of a series of problems that apply math and science principles to human space exploration at NASA.

Exploration provides the foundation of our knowledge, technology, resources, and inspiration. It seeks answers to fundamental questions about our existence, responds to recent discoveries and puts in place revolutionary techniques and capabilities to inspire our nation, the world, and the next generation. Through NASA, we touch the unknown, we learn and we understand. As we take our first steps toward sustaining a human presence in the solar system, we can look forward to far-off visions of the past becoming realities of the future.

Outpost concepts are now being designed and studied by engineers, scientists, and sociologists to facilitate long-duration human missions to the surface of the Moon or other planetary bodies (Figure 1). Such outposts will include habitat modules, laboratory modules, power systems, transportation, life support systems, protection from the environment, communications for planetary surface operations, and communications back to Earth.

During past and current space missions, astronaut activity outside of the vehicle (e.g. space shuttle) is referred to as an extravehicular activity, or EVA. In a similar way, extrahabitat activities, or EHA, will be performed during a mission to accomplish exploration work. One EHA may be to

Grade Level
11-12

Key Topic
Vector Addition

Degree of Difficulty
Physics B,C: Moderate

Teacher Prep Time
5 minutes

Problem Duration
30 minutes

Technology
TI-Nspire™ Handhelds

AP Course Topics
Newtonian Mechanics:
-Kinematics

NSES
Science Standards
- Science and Technology
- History and Nature of Science

place environmental sensors and instruments within the proximity of an outpost (Figure 2).

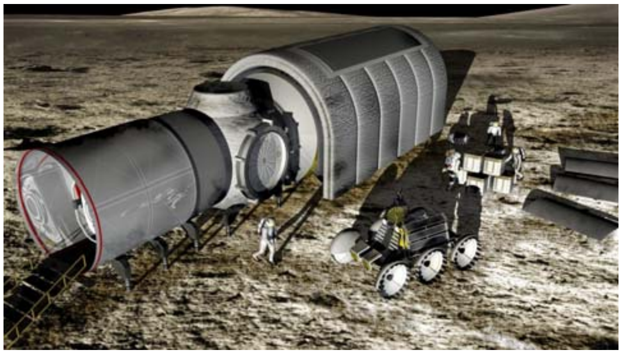


Figure 1: Habitat, airlock, and vehicles (NASA concept)

Figure 2: Astronaut services a surface instrument (NASA concept)

Such instruments may measure the radiation received from solar flares or characterize micrometeorites impacting the surface. Telescopes may also be set up for observations of Earth, other planets, and stars.

AP Course Topics

Newtonian Mechanics

- Kinematics:
  - Vectors, coordinate systems.
  - Motions in two dimensions.

NSES Science Standards

Science and Technology

Abilities of Technological Design

- Implement a proposed solution.
- Evaluate the solution and its consequences.
- Communicate the problem, process, and solution.

History and Nature of Science

Science as a Human Endeavour

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise.

Problem and Solution Key (One Approach)

Students are given the following problem information within the TI-Nspire™ document, Lunar Surface Instrumentation.tns. The questions are embedded within the TI-Nspire™ document.

An astronaut services three instruments on the relatively flat lunar surface around an equatorial lunar outpost. She starts at the lunar habitat airlock and walks 180 meters southwest to replace the sample cell in the first instrument. She then walks 140 meters due north to add a lens to a second instrument. She finishes the task by walking 100 meters 30 degrees north of east where she resets the pointing of a third instrument. The astronaut walks directly back to the same habitat airlock and reenters the habitat module. Using a Cartesian coordinate system with the *x*-axis pointed east and *y*-axis pointed north, determine the following information for her EHA. Round all answers to one decimal place.

A. Determine the astronaut’s displacement vector (distance and direction) from the airlock when she is standing at each instrument. Include a sketch of the path taken by the astronaut.

Step 1: *Sketch the path taken by the astronaut.*

Place the coordinate system origin at the airlock door.

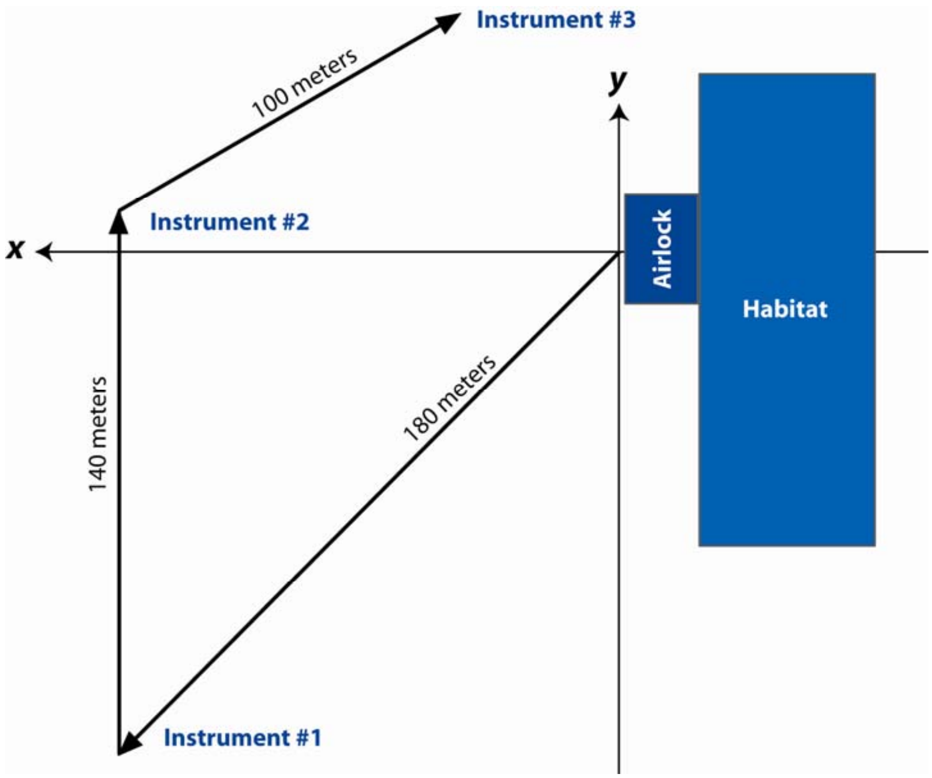
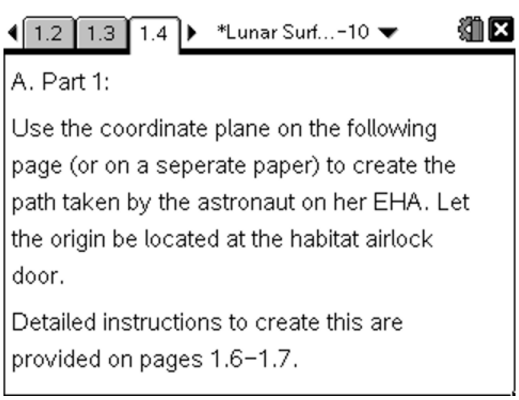


Figure 3: Locations of the lunar surface instruments

Students are also given instructions on creating this path within the TI-Nspire™ document.

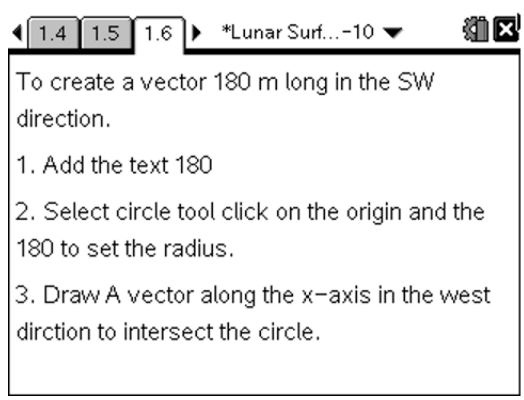


1.2 1.3 1.4 *Lunar Surf...-10

A. Part 1:

Use the coordinate plane on the following page (or on a seperate paper) to create the path taken by the astronaut on her EHA. Let the origin be located at the habitat airlock door.

Detailed instructions to create this are provided on pages 1.6-1.7.



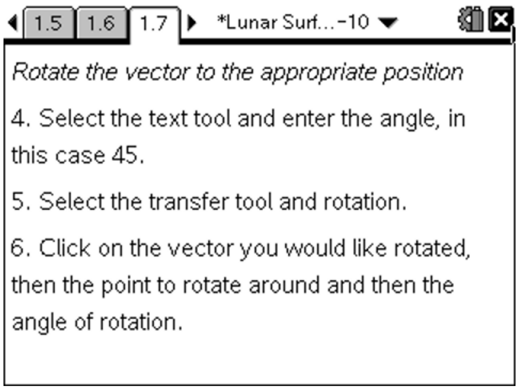
1.4 1.5 1.6 *Lunar Surf...-10

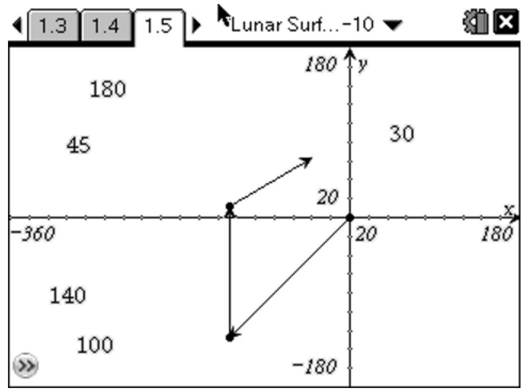
To create a vector 180 m long in the SW direction.

1. Add the text 180

2. Select circle tool click on the origin and the 180 to set the radius.

3. Draw A vector along the x-axis in the west dirction to intersect the circle.





Step 2: *Determine the (x, y) components of each leg of the trip.*

First Leg:

$$x = 180\, cos(225°) = -127.3\text{ m}$$

$$y = 180\, sin(225°) = -127.3\text{ m}$$

Second Leg:

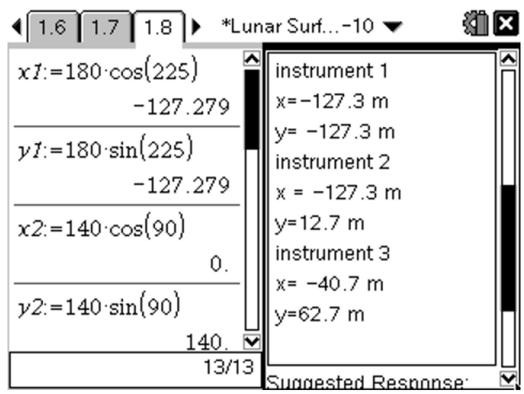
$$x = 140\, cos(90°) = 0.0\text{ m}$$

$$y = 140\, sin(90°) = 140.0\text{ m}$$

Third Leg:

$$x = 100\, cos(30°) = 86.6\text{ m}$$

$$y = 100\, sin(30°) = 50.0\text{ m}$$



Step 3: *Determine the (x, y) position of each instrument.*

Add successive legs of the trip as vector components.

First leg from the origin to instrument #1:

$$x = 0.0\text{ m} + (-127.3\text{ m}) = -127.3\text{ m}$$

$$y = 0.0\text{ m} + (-127.3\text{ m}) = -127.3\text{ m}$$

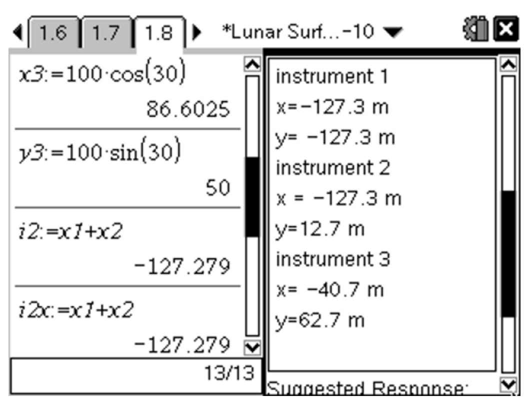
Instrument #1 location: $(-127.3, -127.3)$ m

Second leg from instrument #1 to instrument #2:

$$x = -127.3\text{ m} + 0.0\text{ m} = -127.3\text{ m}$$

$$y = -127.3\text{ m} + 140.0\text{ m} = 12.7\text{ m}$$

Instrument #2 location: $(-127.3, 12.7)$ m

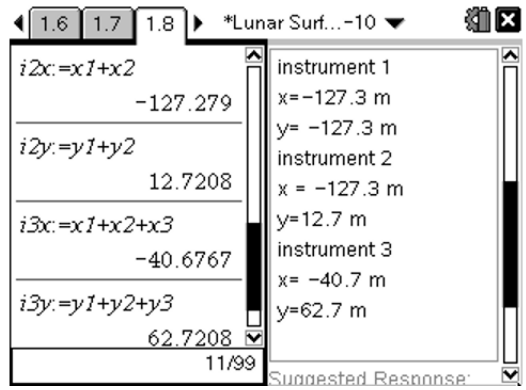


Third leg from instrument #2 to instrument #3:

$$x = -127.3\ m + 86.6\ m = -40.7\ m$$

$$y = 12.7\ m + 50.0\ m = 62.7\ m$$

Instrument #3 location: $(-40.7, 62.7)\ m$



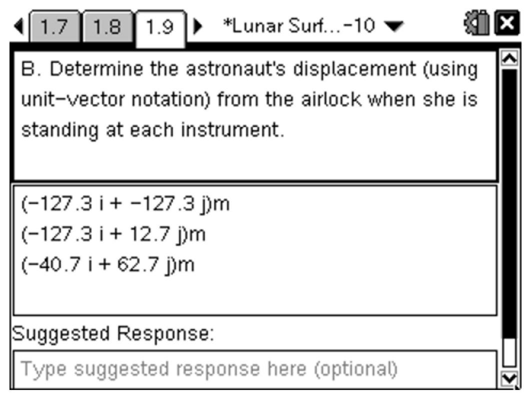
B. Determine the astronaut's displacement (using unit-vector notation) from the airlock when she is standing at each instrument.

Since the three vectors are from the origin to the three instruments, convert the position (x,y) values to vector notation using unit vectors.

Instrument #1: $(-127.3i - 127.3j)\ m$

Instrument #2: $(-127.3i + 12.7j)\,\text{m}$

Instrument #3: $(-40.7i + 62.7j)\ m$



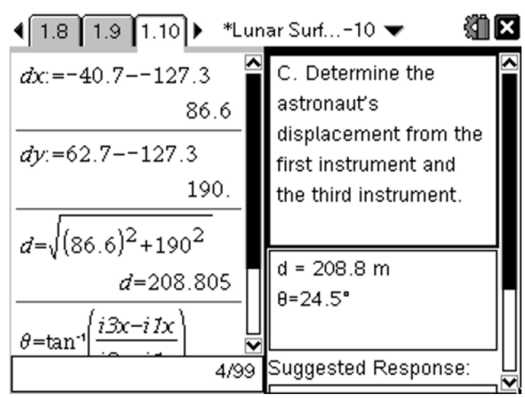
C. Determine the astronaut's displacement from the first instrument and the third instrument.

Step 1: *Find the distance between instruments #1 and #3 using the distance formula.*

$$d = \sqrt{(y_3 - y_1)^2 + (x_3 - x_1)^2}$$

$$d = \sqrt{(62.7 - (-127.3))^2 + ((-40.7) - (-127.3))^2}$$

$$d = 208.8\ m$$

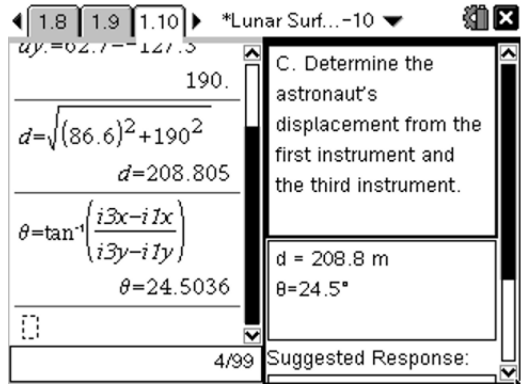


Step 2: *Find the angle between instruments #1 and #3 using the inverse tangent function.*

$$\angle\theta = \tan^{-1}\left(\frac{x_3 - x_1}{y_3 - y_1}\right)$$

$$\angle\theta = \tan^{-1}\left(\frac{-40.7-(-127.3)}{62.7-(-127.3)}\right) = 24.5°$$

Instrument #3 is 208.8 m and 24.5° east of north from instrument #1.

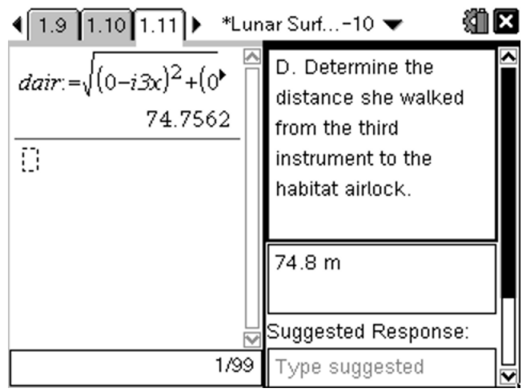


D. Determine the distance she walked from the third instrument to the habitat airlock.

$$d = \sqrt{(y_0 - y_3)^2 + (x_0 - x_3)^2}$$

$$d = \sqrt{(0-62.7)^2 + (0-(-40.7))^2}$$

$$d = 74.8\ m$$

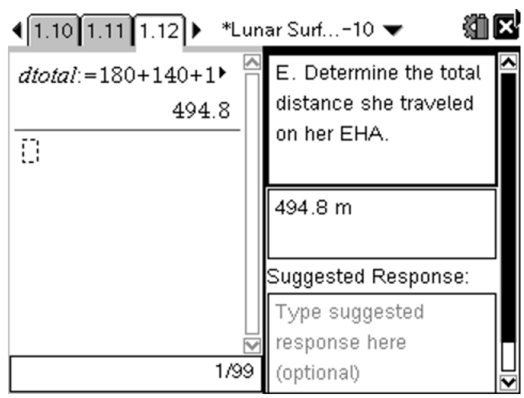


E. Determine the total distance she traveled on her EHA.

First Leg:	*180.0 m*
Second Leg:	*140.0 m*
Third Leg:	*100.0 m*
Fourth Leg:	*74.8 m*

Sum of the four individual leg lengths:

$$d = 180.0 + 140.0 + 100.0 + 74.8 = 494.8\ m$$



F. Why is it important to use vector analysis for this solution?

Answers will vary, but should include that vector analysis is an optimum way to graphically display the location of the instruments and their positions in respect to the airlock.

Contributors

Thanks to the subject matter experts for their contributions in developing this problem:

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MATH AND SCIENCE @ WORK

AP* PHYSICS Educator Edition

LUNAR SURFACE INSTRUMENTATION: Part II

Instructional Objectives

Students will
- add, subtract, and resolve displacement using unit-vector notation;
- evaluate two approaches, apply a set of constraints, and choose the best alternative to the problem.

Degree of Difficulty

This problem is a straightforward application of vector concepts.

- For the average AP Physics student, the problem may be moderately difficult.

Background

This problem is part of a series of problems that apply math and science principles to human space exploration at NASA.

This problem builds from the *Math and Science @ Work Lunar Surface Instrumentation* problem. Students should complete the Lunar Surface Instrumentation problem first, in order to better understand the importance of extrahabitat activities (EHA) during long-duration human missions to the surface of the Moon and other planetary bodies.

AP Course Topics

Newtonian Mechanics

- Kinematics (including vectors, vector algebra, components of vectors, coordinate systems, displacement, velocity, and acceleration)
  - Motion in one dimension

NSES Science Standards

Science and Technology

- Abilities of Technological Design

History and Nature of Science

- Science as a Human Endeavour

Grade Level
11-12

Key Topic
Vector Addition

Degree of Difficulty
Physics B, C: Moderate

Teacher Prep Time
5 minutes

Problem Duration
30 minutes

Technology
- TI-Nspire™ Learning Handhelds
- TI-Nspire document: *Instrumentation2.tns*

AP Course Topics
Newtonian Mechanics:
- Kinematics

NSES Science Standards
- Science and Technology
- History and Nature of Science

Problem Situation

Students are given the following problem information within the TI-Nspire document, Instrumentation2.tns. The questions are embedded within the TI-Nspire document.

NASA hopes to soon execute long-duration missions to the surface of the Moon and other planetary bodies. You are a member of the mission planning team at NASA Johnson Space Center. Your team needs to develop a plan for three instruments located around a polar region lunar outpost that need to be serviced by an astronaut resident at that lunar outpost. This servicing will be accomplished by an astronaut putting on a space suit to walk around the lunar surface in an extrahabitat activity, or EHA.

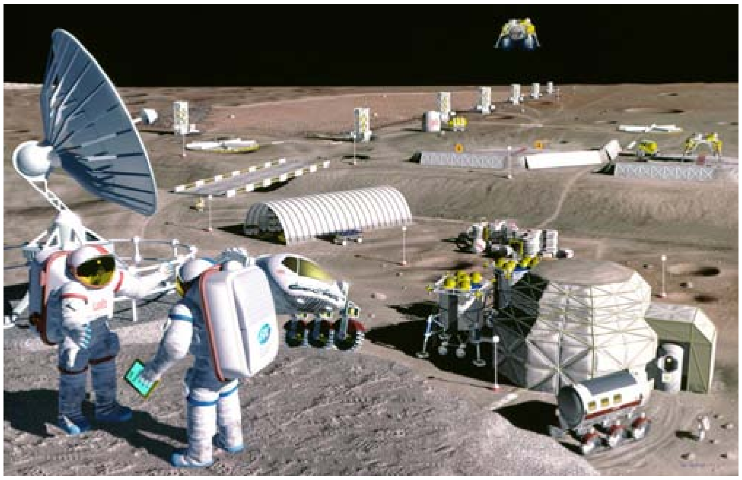


Figure 1: Astronauts on an EHA near a lunar outpost (NASA concept)

Assuming a Cartesian coordinate system where the positive *x*-axis is east and the positive *y*-axis is north, relative to the habitat airlock at the origin, the three instruments are located:

1. 200 m, southwest,
2. 175 m, 15º north of west, and
3. 150 m, 30º west of north.

Constraints

The constraints applicable to developing the plan are as follows:

1. An astronaut can carry a maximum of 25 kilograms (kg) when walking.
2. An astronaut can use a lunar surface transporter (a remote controlled, battery-powered “cart” with wheels) with a maximum load of 100 kg on it. The astronaut will walk alongside the transporter, and therefore, cannot carry anything while controlling the transporter.
3. An astronaut can walk 6 kilometers per hour (km/h) when unburdened, 4 km/h when carrying a load, and 3 km/h when controlling a lunar surface transporter (loaded or unloaded).
4. During such an activity, astronauts will carry their own life support system and supplies (e.g. water and breathable air) with total capacity for 5 hours.

5. When astronauts return to the habitat, they must have a minimum reserve life support supplies for 1 hour remaining in their life support system.

6. The equipment to be installed at the three instruments is the following:

    a. One 20 kg sample cell at Instrument #1,

    b. Two 15 kg lens component at Instrument #2, and

    c. One 25 kg camera at Instrument #3.

7. The installation times involved at the three instruments are as follows:

    a. 20 minutes to install the sample cell at Instrument #1,

    b. 15 minutes to install each lens component at Instrument #2, and

    c. 45 minutes to install the camera at Instrument #3.

Mission Planning

As a member of that mission planning team, your assignment is to examine two approaches for the astronaut's EHA. The primary selection criterion is the amount of life support supplies available at the end of the activities and whether that amount meets the constraint. The two EHA approaches are:

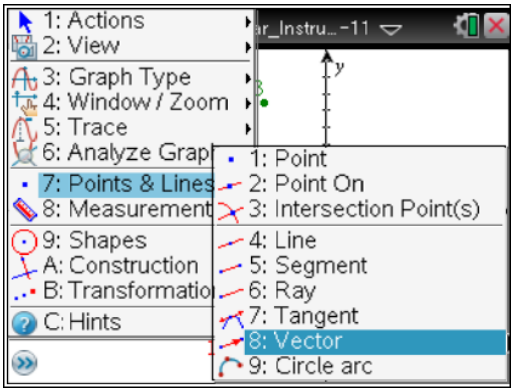
1. Use a lunar surface transporter to carry all the equipment for the three instruments; or

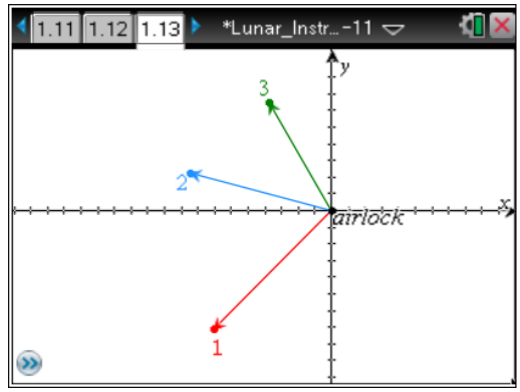
2. Carry one set of equipment at a time to each of the three instruments from the habitat airlock.

Problem and Solution Key (One Approach)

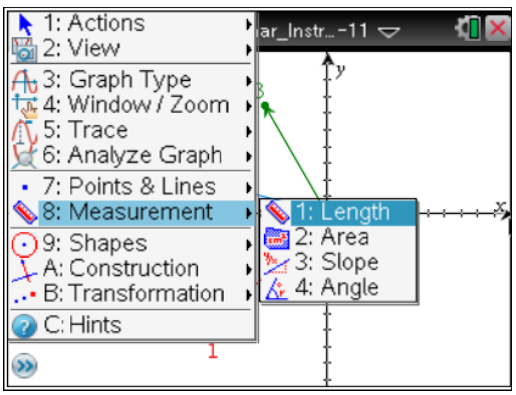
A. Sketch the instrument locations with the origin at the airlock. To sketch this on TI-Nspire page 1.13, use the vector tool to draw vectors to each instrument and the measurement tool to show the location of each vector.

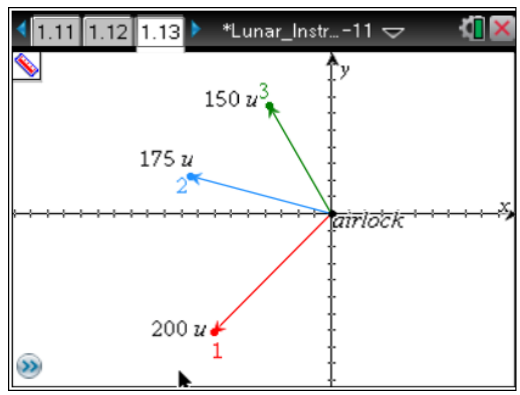
    *If students are new to using the TI-Nspire, they may need some guidance. Start on page 1.13 by pressing **menu** and then selecting **Points & Lines > Vector** as shown in the screen shot below. They can then create a vector by selecting the starting point (airlock) and then dragging the vector to the ending point (the instrument). To change the color of a vector, place the pointer on the vector, press **ctrl** and **menu**, select **Color > Line Color**, and then select the desired color.*



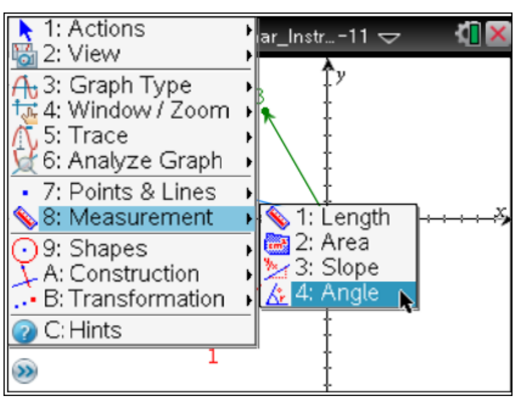


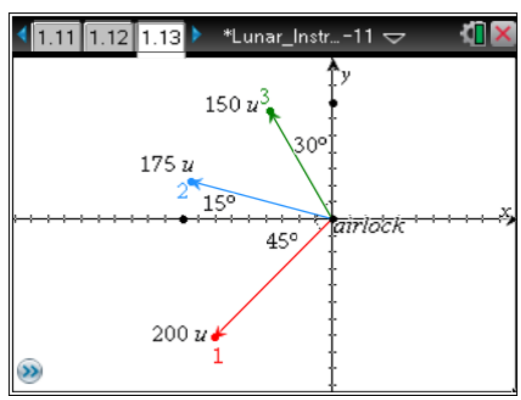
*To show the location of each instrument, first find the distance using the measurement tool. Press **menu** and select **Measurement > Length**. Move the pointer to a vector, click the center of the touchpad, move the text to the desired location, and click the center of the touchpad again.*





*To also show the angles on the diagram, press **menu** and select **Measurement > Angle**. The angle is found by clicking three points that define the angle. For instrument 1 (southwest or 45° south of west), first select a point on the negative x-axis (west), then select the origin, then select the point at instrument 1. Press esc to exit the angle mode and move the text to the desired location.*



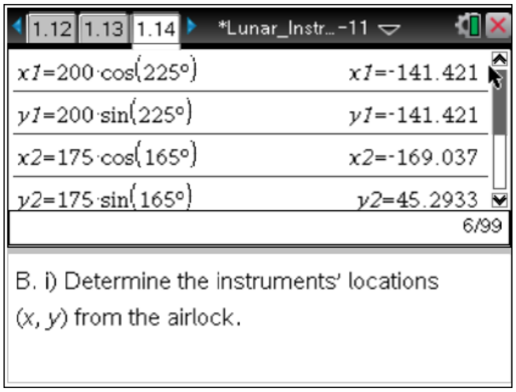


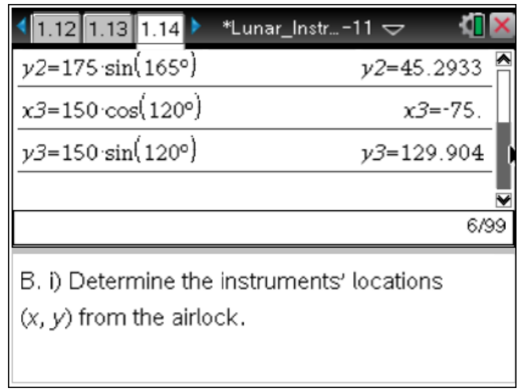
An alternative to having students sketch in the Nspire is to have them create the sketch on paper. This may be advantageous if there is little time and students are not very familiar with the technology.

B. Using the sketch from Question A and the provided information:

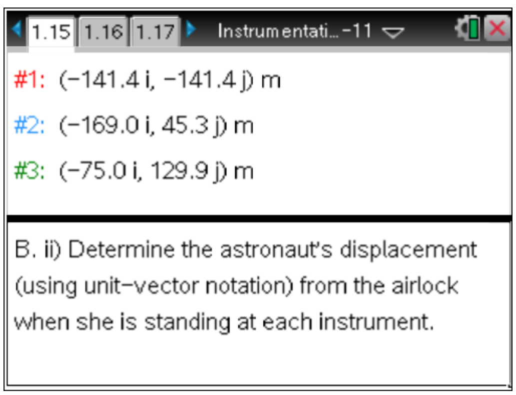
I. Determine the instruments' locations (x, y) from the airlock.

Students should find the (x, y) components of each vector in order to find the position of the instruments.





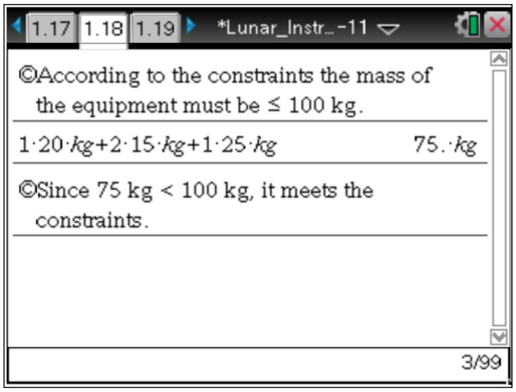
II. Determine the astronaut's displacement (using unit-vector notation) from the airlock when she is standing at each instrument.

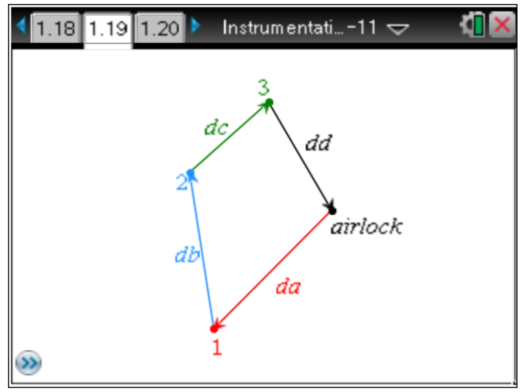


C. Subject to the constraints, determine the total distance the astronaut would walk for each of the two EHA approaches to service the instruments.

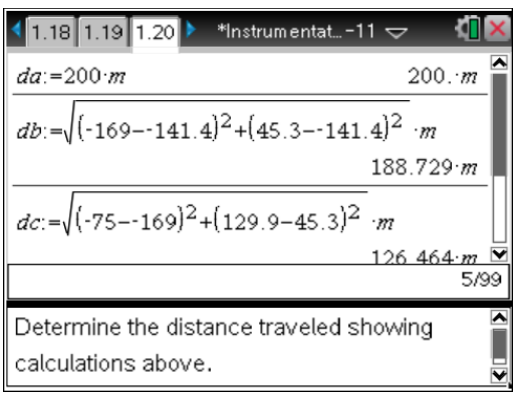
I. Utilizing a lunar surface transporter to carry all equipment.

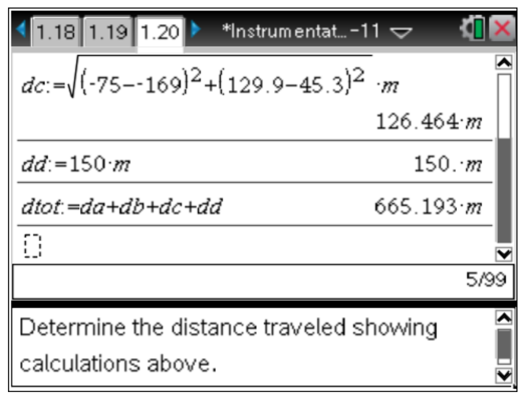
*First verify that the constraints for utilizing the lunar surface transporter are met. Then sketch the path taken on page 1.19. Draw the vectors then label each leg of the trip by selecting the vector, pressing **ctrl** and **menu**, and selecting **Label**.*



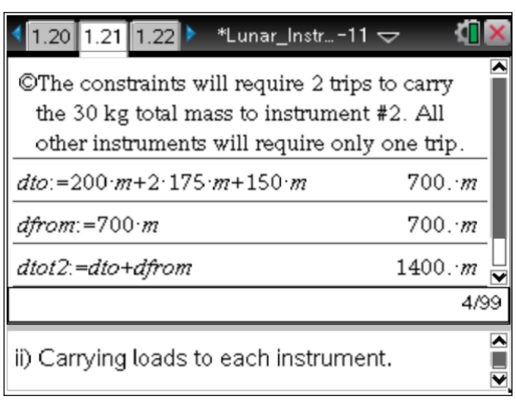


Determine the length of each segment, and then find the summation to determine total length.



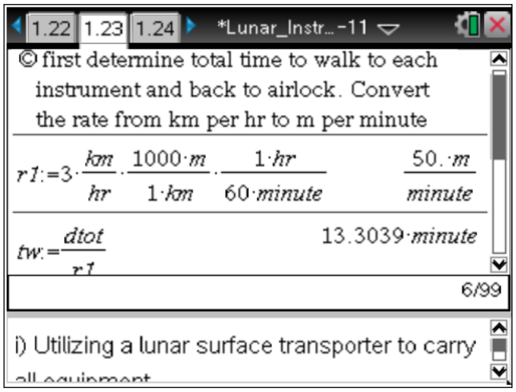


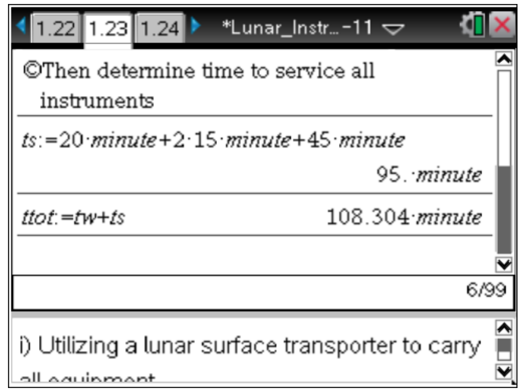
II. Carrying loads to each instrument without use of lunar surface transporter.



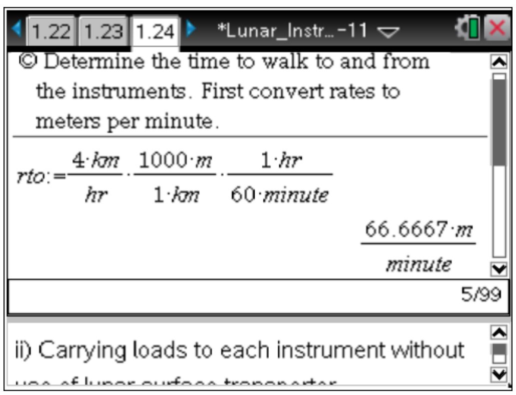
D. Subject to the constraints, determine the time (in minutes) it would take for the astronaut to travel and service the instruments for each of the two EHA approaches.

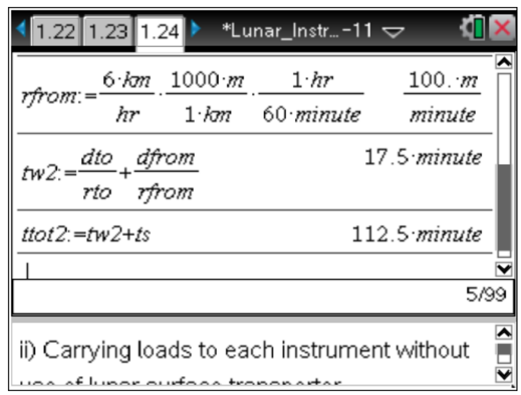
I. Utilizing a lunar surface transporter to carry all equipment.





II. Carrying loads to each instrument without use of lunar surface transporter.





E. Explain which approach is more efficient in terms of:

I. The distance the astronaut walks.

Using the lunar surface transporter, the astronaut would walk 734.8 m less than if she carried the loads to each instrument without it.

II. The amount of reserve time remaining in the astronaut's life support system when she arrives back at the airlock.

Using the lunar surface transporter is 4.2 minutes faster and would leave more reserve time remaining in the astronaut's life support system.

Scoring Guide

Suggested 15 points total to be given.

Question		Distribution of points
A	*2 points*	1 point for a sketch in the correct orientation 1 point for correct angle measurements shown on sketch
B	*3 points*	1 point for correctly using cosine function to find the *x*-coordinates of the instruments 1 point for correctly using the sine function to find the *y*-coordinates of the instruments 1 point for correct conversion to vector notation for the three instrument locations
C	*5 points*	1 point for recognizing that the constraints for mass will be met using the lunar surface transporter 1 point for correct use of distance formula or Pythagorean theorem to find the distance from instrument #1 to #2 and from #2 to #3 1 point for finding the correct total distance using the lunar surface transporter 1 point for recognizing that the constraints will require two trips to instrument #2 when carrying the loads without use of lunar surface transporter 1 point for finding total distance traveled when not using lunar surface transporter
D	*3 points*	1 point for correctly finding total time to travel from airlock to each instrument and back to the airlock when using lunar surface transporter 1 point for correctly finding the time to service each instrument 1 point for correctly finding the total time to travel to and from the instruments when not using the lunar surface transporter
E	*2 points*	1 point for correctly identifying use of the lunar surface transporter as the more efficient approach in terms of distance the astronaut walks 1 point for correctly identifying use of the lunar surface transporter as the more efficient approach in terms of the amount of reserve time remaining in life support system

Contributors

Thanks to the subject matter experts for their contributions in developing this problem:

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

TI PROFESSIONAL DEVELOPMENT

Activity Overview

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

Materials

- TI-Nspire™ Teacher Software

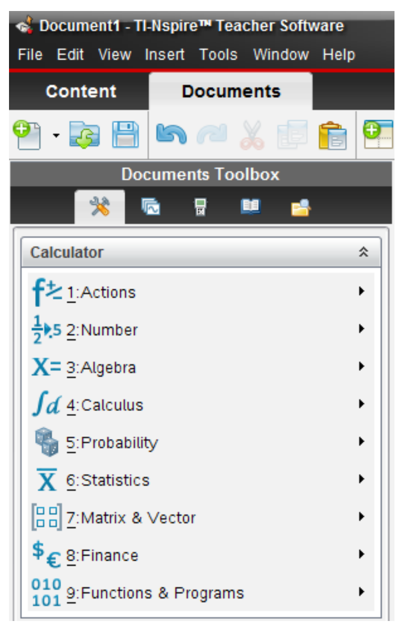
Step 1:

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

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

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

Step 2:

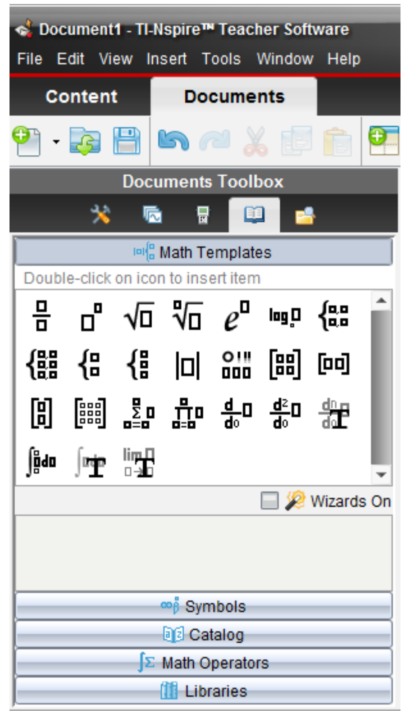


The Calculator application allows you to enter and evaluate mathematical expressions as well as create functions and programs.

In most cases, each application has a unique menu of commands and tools. To view the Calculator menu, go to the Documents Toolbox and select the **Document Tools** tab. Each item in the Calculator menu has a submenu. Explore the various menus and submenus by entering and evaluating your own expressions.

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

Step 3:

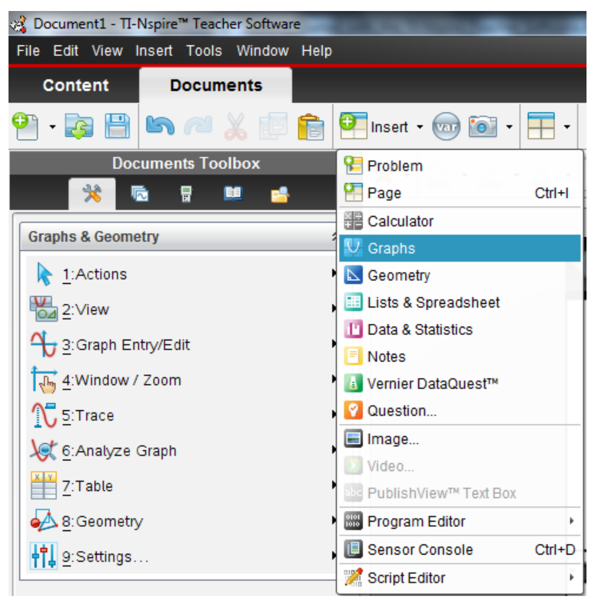


The **Utilities** tab contains Math Templates, Symbols, Catalog, Math Operators, and Libraries panes. Only one pane is displayed at a time, and the Math Templates pane is the default pane. Explore each of the other panes by clicking them.

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

Note: When evaluating expressions, the Calculator application displays rational expressions by default. To display a decimal approximation on a PC, press **CTRL + Enter**. To display a decimal approximation on a Mac, press **Command + Enter**.

Step 4:



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

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

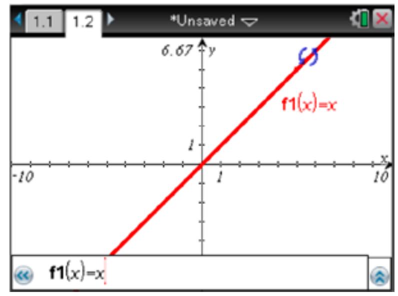
The Graphs application allows you to graph and analyze relations and functions. Explore the various menus and submenus available in the Graphs application.

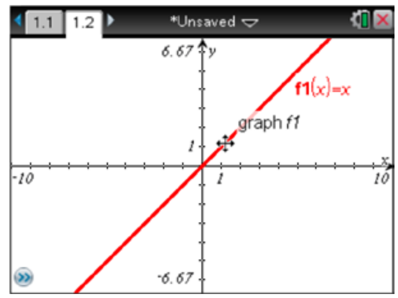
Step 5:

Graph the function *f*(*x*) = *x* by typing ***x*** into the function entry line and pressing **Enter**.

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

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



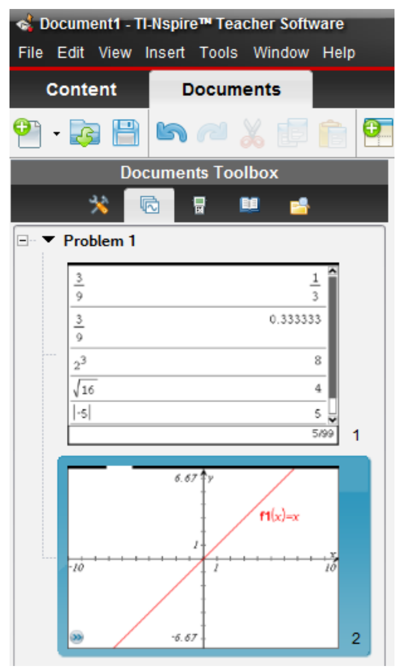


Step 6:

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

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

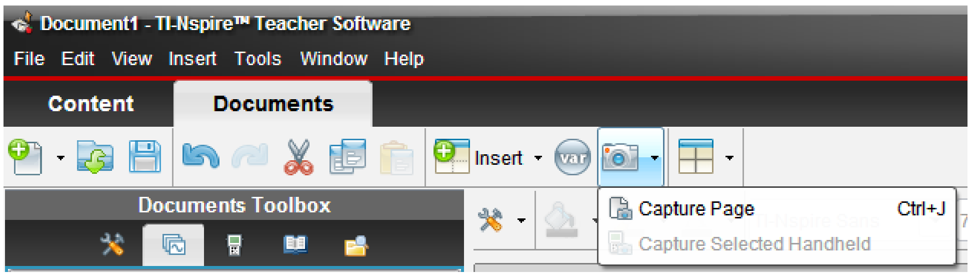
Note: To access Page Sorter in the handheld, press ctrl ▲. To right-click in the handheld, press ctrl menu.



Step 7:

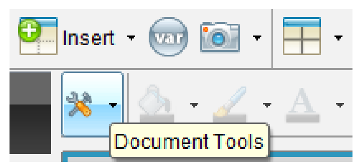
The Documents toolbar allows you to create, open, and save a TI-Nspire document. Commands such as Undo, Redo, Cut, Copy, and Paste are also available. Explore these options by hovering the cursor over each icon. Pages, problems, and applications can be inserted and variables can be stored.

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



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

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

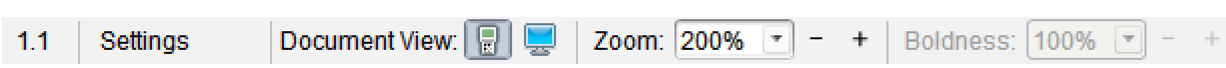


To change the fill color, line color, or text color, select an object and then select a color from the appropriate menu. To receive additional information about a given menu, hover the cursor over it. Not all color menus are available on all applications.

Step 8:

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

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



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

TI PROFESSIONAL DEVELOPMENT

Step 9:

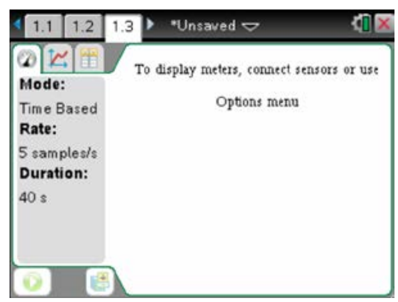
To access the TI-SmartView™ emulator for TI-Nspire, go to the Documents Toolbox and select the **TI-SmartView** tab.

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

The TI-SmartView emulator has three available keypads:

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

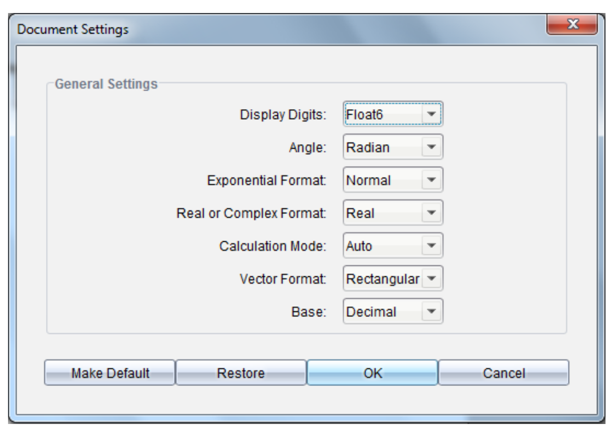
Each keypad has three available views: Normal, High Contrast, and Outline. Click the **Keypad** menu and explore each keypad and view.



Step 10:

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

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



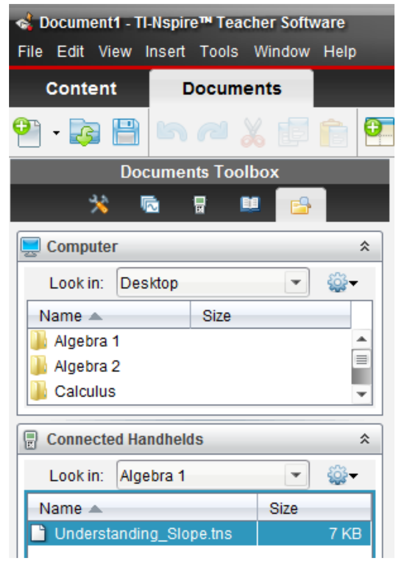
Step 11:

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

Note: To move across fields in the Document Settings window, press tab. To change the setting in a given field, press ▾, select the desired setting, and press tab to move to the next field. To exit the window, press enter.

Step 12:

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



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

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

Energy Loss of a Ball

Student Activity

Name ______________

Class ______________

How much energy is lost with every bounce?

When a ball is released and it bounces off of a solid surface, what happens to the height of the ball after every bounce? Create a method for determining the energy loss per bounce. Test different types of balls and explain why energy loss is important or not important to the bounce.

Take three balls, write a hypothesis on what will happen to the energy loss for each ball, and why you believe your hypothesis is true.

Objectives:

- Determine the energy loss for different types of balls.
- Create a mathematical model to predict the height of second and third bounces.

Materials

- TI-Nspire™ CX handheld
- CBR 2™
- 3 balls of various types

Activity

1. Define the problem.
2. Define variables that need to be measured and which will remain constant.
3. Create a data table to record your variables.
4. Show a detailed analysis of your data to support your hypothesis.
5. Summarize your results by restating the hypothesis and summarizing how your data supported or refuted your hypothesis. Elaborate on further testing that should be or could be done in this investigation.

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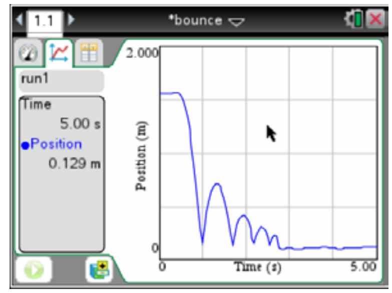
Energy Loss of a Ball

Math and Science Objectives

- Students will design a strategy to measure the energy of a bouncing ball.
- Students will calculate the energy loss between each bounce.
- Students will write a summative statement to support or refute their hypothesis using their analysis of the ball bounce.



TI-Nspire™ Technology Skills:

- Collect position vs. time data with the Vernier® DataQuest™ application

Tech Tips:

1. The CBR 2™ defaults to a 5-second sample time. This can be changed by selecting **Menu > Experiment > Collection Setup**.
2. If the students do not get a good set of bounces, just have them press start again and drop the ball again.

Lesson Files:
Student Activity

- Energy_Loss_of_a_Ball_Student.doc
- Energy_Loss_of_a_Ball_Student.pdf

Vocabulary

- kinetic energy
- potential energy
- conservation of energy
- velocity
- mass

About the Lesson

- This activity challenge students to think about the potential and kinetic energy of a ball.
- As a result, students will:
  - Strategize on their own method of measuring either type of energy.
  - Use the height and the mass of the ball on each bounce to determine the potential energy.
  - Look at the velocity of the ball as it hits the floor and leaves, comparing using the velocities to compare the kinetic energy.

Materials and Materials Notes

- TI-Nspire™ handheld or TI-Nspire™ computer software
- CBR 2™ motion sensor
- 3 different balls

Discussion Points and Possible Answers

Teacher Tip: Have students hold the CBR 2 with an arm extended and move their body, not their arm, to follow the ball. This will keep the height of the CBR 2 constant and in the sonic cone.

Discuss potential and kinetic energy.

$E_p = mhg$ $\qquad\qquad$ $E_k = ½\, mv^2$

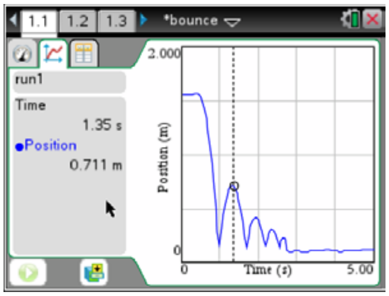
Potential Energy, E_p, is equal to mass, m, times height, h, of the object times the acceleration due to gravity, g, which is 9.81 m/s^2. Kinetic energy (E_k) is equal to one half the mass times the velocity, v, squared.

Ask students where they could measure the needed values to solve for the energy of one bounce.

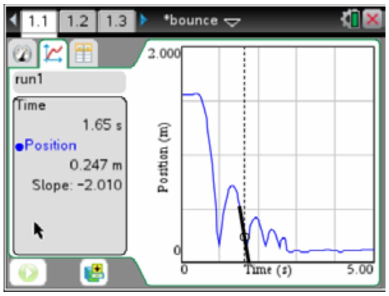
The peak of the bounce will give them the height for the potential energy, and the slope of the line (tangent) as the ball collides with the floor will produce the maximum velocity.

Potential Outcomes

If students analyze the peaks, they can scroll along the line and write down the maximum peak value. At this point, they can calculate the Potential Energy of the ball using the mass, the height, and gravity.



If the students decide to look at kinetic energy, they can move the tangent line to the bottom of a bounce to get the steepest tangent and calculate the kinetic energy by using ½ mass times the velocity squared.



To see the energy loss, they need calculate the ratio of the ball following ball bounce by the starting ball bounce or the coefficient of restitution.

DataQuest
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Evaporation and Intermolecular Attractions

In this experiment, Temperature Probes are placed in various liquids. Evaporation occurs when the probe is removed from the liquid's container. This evaporation is an endothermic process that results in a temperature decrease. The magnitude of a temperature decrease is, like viscosity and boiling temperature, related to the strength of intermolecular forces of attraction. In this experiment, you will study temperature changes caused by the evaporation of several liquids and relate the temperature changes to the strength of intermolecular forces of attraction. You will use the results to predict, and then measure, the temperature change for several other liquids.

You will encounter two types of organic compounds in this experiment—alkanes and alcohols. The two alkanes are pentane, C_5H_{12}, and hexane, C_6H_{14}. In addition to carbon and hydrogen atoms, alcohols also contain the -OH functional group. Methanol, CH_3OH, and ethanol, C_2H_5OH, are two of the alcohols that we will use in this experiment. You will examine the molecular structure of alkanes and alcohols for the presence and relative strength of two intermolecular forces—hydrogen bonding and dispersion forces.

OBJECTIVES

In this experiment, you will

- Study temperature changes caused by the evaporation of several liquids.
- Relate the temperature changes to the strength of intermolecular forces of attraction.

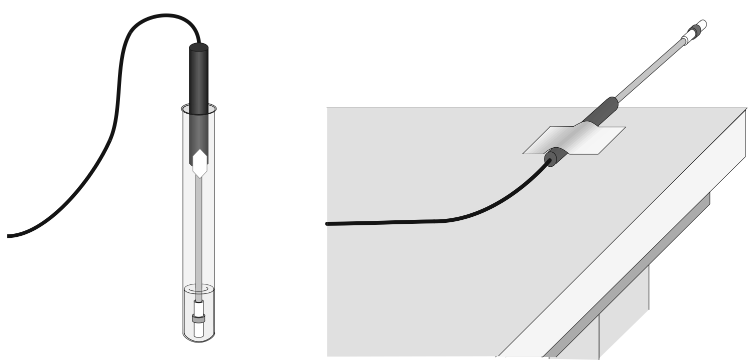

Figure 1

MATERIALS

TI-Nspire handheld **or** computer and TI-Nspire software	methanol (methyl alcohol)
data-collection interface	ethanol (ethyl alcohol)
2 Temperature Probes	1-propanol
6 pieces of filter paper (2.5 cm x 2.5 cm)	1-butanol
2 small rubber bands	n-pentane
masking tape	n-hexane

PRE-LAB QUESTIONS

Prior to doing the experiment, complete the Pre-Lab table. The name and formula are given for each compound. Draw a structural formula for a molecule of each compound. Then determine the molecular weight of each of the molecules. Dispersion forces exist between any two molecules, and generally increase as the molecular weight of the molecule increases. Next, examine each molecule for the presence of hydrogen bonding. Before hydrogen bonding can occur, a hydrogen atom must be bonded directly to an N, O, or F atom within the molecule. Tell whether or not each molecule has hydrogen-bonding capability.

Substance	Formula	Structural formulas	Molecular weight	Hydrogen bond (yes or no)
ethanol	C_2H_5OH			
1-propanol	C_3H_7OH			
1-butanol	C_4H_9OH			
n-pentane	C_5H_{12}			
methanol	CH_3OH			
n-hexane	C_6H_{14}			

PROCEDURE

1. Obtain and wear goggles! **CAUTION:** The compounds used in this experiment are flammable and poisonous. Avoid inhaling their vapors. Avoid contacting them with your skin or clothing. Be sure there are no open flames in the lab during this experiment. Notify your teacher immediately if an accident occurs.

2. Connect the Temperature Probes to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer.

3. Choose New Experiment from the Experiment menu. Choose Collection Setup from the Experiment menu. Enter **240** as the experiment duration in seconds (4 minutes). The number of points collected should be 481. Select OK.

4. Wrap Probe 1 and Probe 2 with square pieces of filter paper secured by small rubber bands as shown in Figure 1. Roll the filter paper around the probe tip in the shape of a cylinder. **Hint:** First slip the rubber band on the probe, wrap the paper around the probe, and then finally slip the rubber band over the paper. The paper should be even with the probe end.

5. Stand Probe 1 in the ethanol container and Probe 2 in the 1-propanol container. Make sure the containers do not tip over.

6. Prepare 2 pieces of masking tape, each about 10 cm long, to be used to tape the probes in position during Step 7.

7. After the probes have been in the liquids for at least 30 seconds, start data collection (▶). A live graph of temperature vs. time for both Probe 1 and Probe 2 is being plotted on the screen. Live readings are also displayed. Monitor the temperature for 15 seconds to establish the initial temperature of each liquid. Then simultaneously remove the probes from the liquids and tape them so the probe tips extend 5 cm over the edge of the table top as shown in Figure 1. **Note:** avoid moving near the sensors as air movement can affect your results.

8. Data collection will stop after 240 seconds. Click any data point and use ► and ◄ to examine the data pairs on the displayed graph. Based on your data, determine the maximum temperature, t_1, and minimum temperature, t_2 for both probes. Record t_1 and t_2 for each probe in the data table.

9. For each liquid, subtract the minimum temperature from the maximum temperature to determine Δt, the temperature change during evaporation.

10. Based on the Δ*t* values you obtained for these two substances, plus information in the Pre-Lab exercise, *predict* the size of the Δ*t* value for 1-butanol. Compare its hydrogen-bonding capability and molecular weight to those of ethanol and 1-propanol. Record your predicted Δ*t*, then explain how you arrived at this answer in the space provided. Do the same for n-pentane. It is not important that you predict the exact Δ*t* value; simply estimate a logical value that is higher, lower, or between the previous Δ*t* values.

11. Test your prediction in Step 10. Click on the Store Latest Data Set button (). Repeat Steps 5–9 using 1-butanol with Probe 1 and n-pentane with Probe 2.

12. Based on the Δ*t* values you have obtained for all four substances, plus information in the Pre-Lab exercise, predict the Δ*t* values for methanol and n-hexane. Compare the hydrogen-bonding capability and molecular weight of methanol and n-hexane to those of the previous four liquids. Record your predicted Δ*t*, then explain how you arrived at this answer in the space provided.

13. Test your prediction in Step 12. Click on the Store Latest Data Set button (). Repeat Steps 5–9, using methanol with Probe 1 and n-hexane with Probe 2.

DATA

Substance	t_1 (°C)	t_2 (°C)	Δt ($t_1 - t_2$) (°C)
ethanol			
1-propanol			
1-butanol			
n-pentane			
methanol			
n-hexane			

Predicted Δt (°C)	Explanation

PROCESSING THE DATA

Plot a graph of Δt values of the four alcohols versus their respective molecular weights. Plot molecular weight on the horizontal axis and Δt on the vertical axis.

a. Insert a new problem in the document, then Insert a new DataQuest App into problem 2. Click on the Table View tab ( ) to view the Table.
b. Double click on the *X* column to access the column options. Enter **Molecular Weight** for the Name, **Weight** for the short name, and **amu** for the units. Change the Display Precision to 0 decimal places. Select OK.
c. Double click on the *Y* column to access the column options. Enter **ΔT** for the column name. Enter **°C** as the units. Select OK.
d. Using the data recorded in the tables, enter the values in the DataQuest Table.
e. Click on the Graph View tab ( ) to view the graph.

QUESTIONS

1. Two of the liquids, n-pentane and 1-butanol, had nearly the same molecular weights, but significantly different Δt values. Explain the difference in Δt values of these substances, based on their intermolecular forces.

2. Which of the alcohols studied has the strongest intermolecular forces of attraction? The weakest intermolecular forces? Explain using the results of this experiment.

3. Which of the alkanes studied has the stronger intermolecular forces of attraction? The weaker intermolecular forces? Explain using the results of this experiment.

DataQuest
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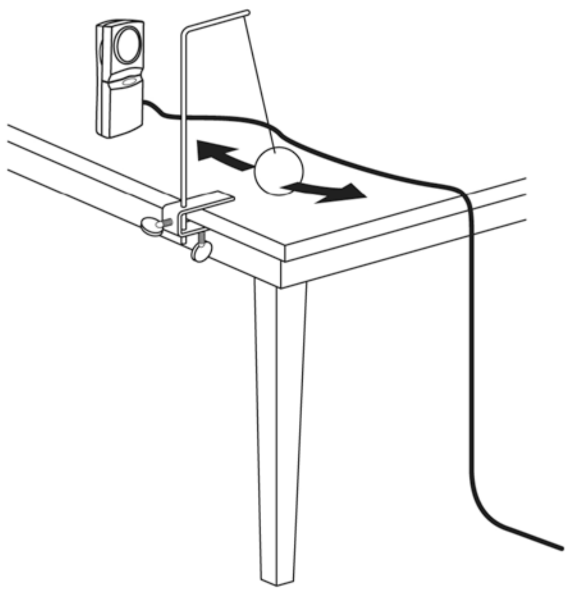
Tic, Toc: Pendulum Motion

Pendulum motion has long fascinated people. Galileo studied pendulum motion by watching a swinging chandelier and timing it with his pulse. In 1851 Jean Foucault demonstrated that the earth rotates by using a long pendulum which swung in the same plane while the earth rotated beneath it.

As long as the swing is not too wide, the pendulum approximates simple harmonic motion and produces a sinusoidal pattern. In this activity, you will use a Motion Detector to plot the position versus time graph for a simple pendulum. You will time the motion to calculate the period, and use a ruler to measure the maximum displacement. You will then use the data to model the motion with the cosine function $y = A\cos(B(x - C)) + D$ to mimic the position versus time graph.



OBJECTIVES

- Record the horizontal position versus time for a swinging pendulum.
- Determine the period of the pendulum motion.
- Model the position data using a cosine function.

MATERIALS

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

pendulum bob
string
meter stick
stopwatch

PROCEDURE

1. Hang the pendulum bob from about 50 cm of string from a rigid support. Arrange the support so the bottom of the pendulum bob clears the table by several centimeters. Position the Motion Detector about 40 cm away from the bob, pointing at the bob. Elevate the detector slightly so that it does not respond to the table or the rigid support.

2. If your Motion Detector has a switch, set it to Normal. Connect the Motion Detector to the data-collection interface. Connect the interface to the TI-Nspire handheld.

3. Choose New Experiment from the Experiment menu. For this experiment, the default data-collection parameters for a Motion Detector will be used (Rate: 20 samples per second; Duration: 5 seconds). The number of points collected should be 101.

4. Click the Graph View tab ( ). Choose Show Graph ► Graph 1 from the Graph menu. Only the position *vs*. time graph will be displayed.

5. Measure the distance from the bob to the Motion Detector; this distance must be greater than 25-30 cm. Record this distance *D*, in meters, in your data table. (Should this measurement be from the center or leading edge? Think about how the detector works!)

6. Place the meter stick under the bob, along the line between the detector and the bob. Arrange the stick so that the zero point is under the bob when it is hanging still. Determine how far you will pull back the bob before releasing it. This distance should be less than 20 cm. Record this value, in meters, as the amplitude *A* in your data table.

7. Use the stopwatch to measure the period of the pendulum. The period is the time taken by the pendulum to complete one back and forth cycle. Use the amplitude of motion you determined in the previous step. Measure the time for *ten* complete cycles, and record this time in your data table.

   Take care to count carefully: One way to do this is to start the stopwatch when the bob is farthest from the Motion Detector, and count one cycle when it returns to that spot. Keep the stopwatch running until ten cycles are completed.

8. Practice swinging the ball by pulling it back the distance you recorded above, and then releasing it so that the ball swings in a line directly away from the Motion Detector.

9. With the ball swinging properly, start data collection ( ). Data collection will run for five seconds.

10. When data collection is complete, a graph of position versus time will be displayed. Examine the graph, which should be sinusoidal. Check with your teacher if you are not sure whether you need to repeat the data collection. To repeat data collection, repeat Step 9.

11. If the graph is acceptable, save the file, and then send this file to your lab partner(s).

DATA TABLE

A (m)	
D (m)	
C (s) ***(see 2b below)***	
Time for ten cycles (s)	
Period (s) ***(see 3 below)***	
B ***(see 4 below)***	

ANALYSIS

1. Be sure your TI-Nspire software is set to perform angle calculations in **Radians**.

2. As part of your analysis, you will compare the Motion Detector data to the cosine model of $y = A*\cos(B(x - C)) + D$. Your setup measurements will allow you to determine the parameters A, B, and D. You can determine C from your graph of the Motion Detector data.
   a. Click any data point and use ► and ◄ to examine the data points on the graph.
   b. Since the cosine function starts at a maximum value when its argument is zero, you can use the location of a maximum to determine the value of C, which represents the horizontal shift of the data. Trace across your data to any maximum and read the time (x) value. Record this value as C in your data table.

3. During the procedure, you measured the time for ten complete cycles of the pendulum. Use this value to find the period (T) of the motion, which is the time for one complete cycle. Enter this value in your data table.

4. The sinusoidal model has a parameter B (called the angular frequency) that represents the number of cycles the function makes during the natural period of the cosine function. Find B by taking 2π (the natural period of the cosine function) divided by the period of the pendulum (the time for one cycle). Record the value in your data table.

5. Display a graph of the Motion Detector data and the model equation. After entering the model equation, you'll enter the values of the four parameters found in your data table.
   a. Choose Model from the Analyze menu.
   b. Enter **A*cos(B*(x–C))+D** as the equation for your model. Select OK.
   c. In the A field, enter the amplitude of your bob motion.
   d. In the B field, enter the angular frequency.
   e. In the C field, enter the horizontal time shift value.
   f. In the D field, enter the value for the offset of the cosine function from the distance axis.
   g. Select OK to view the model on your graph and answer Analysis Questions 1–4.

ANALYSIS QUESTIONS

1. How well does your model equation fit your data? If your fit is acceptable, write the model equation below, and suggest explanations for any discrepancies. If the fit of the model is not acceptable, deduce which of your parameters is producing the problem. Make changes as necessary to the parameters, and discuss why the changes were necessary. Write out the equation that produced a good fit. When you're done, select OK to close the curve fit dialog box.

2. How would the parameters A, B, C, and D change if you were to use the sine function $y = A \sin (B(x–C))+D$ instead of the cosine function? Predict the values below and explain your reasoning for each.

3. Test your predictions by storing any changed values in the four parameters using the same method you used above. Also using the same method as above, change the model equation to a sine function. Redisplay the graph to compare the data and sine model. How well does the sine model fit the data? Explain any discrepancies.
4. Give a physical interpretation of each of the parameters A, B, C, and D from the model $y = A \cos (B(x–C))+D$ in terms of the pendulum.

SCIENCE EXTENSION

1. Would it serve any purpose to replace the B in the equation above with its equivalent expression (2π / T) where T represents the time for 1 period in seconds?
   y= A*cos (2π/T(x-C)) =D

2. It is reported that the period of a pendulum can be predicted by the equation $T = 2\pi(l/g)^{.5}$ where g is the acceleration of gravity, 9.8 m/s/s. Using your pendulum, see if this statement is accurate.

3. Replace the string pendulum with a mass hanging on a spring. Place the motion detector on the floor underneath the string and set it into a vertical oscillation. Observe the resulting motion graph. Develop a similar mathematical model with the physical explanation of each variable. **Note:** The period of a spring pendulum is reported to be $T = 2\pi(m/k)^{.5}$ where m represents the mass of the hanging mass in Kg, and k represents the spring constant in N/m.

CALCULUS EXTENSION

Once you have an equation for the position versus time graph of the pendulum motion, take the derivative of the equation. This represents the velocity of the pendulum at any time *t*. How does the velocity versus time graph compare with the position versus time graph? When during the pendulum motion is the velocity zero? When is the velocity a maximum?

The derivative of velocity is *acceleration*. Take the second derivative of the position equation. Describe the position and velocity when the acceleration is a maximum. Do the same when the acceleration is zero.

Give a general description of the pendulum's position, velocity, and acceleration when the bob is passing through the at-rest position and when it is farthest from the detector.

Activity
22

TEACHER INFORMATION

Tic, Toc: Pendulum Motion

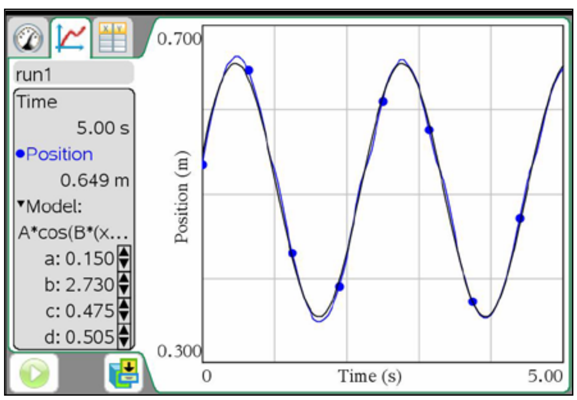
1. The student pages with complete instructions for data collection using DataQuest (TI-Nspire Technology), EasyData (TI-83/84 Plus calculators), DataMate (other TI calculators), or Logger *Pro* software can be found on the CD that accompanies this book. See *Appendix A* for more information.

2. The four different Motion Detectors that can be used to collect data are: Vernier Motion Detector, CBR, CBR 2, or Go! Motion.

3. This activity has the student measure the amplitude, period, and offset distance for a pendulum using a meter stick and a stopwatch. Although these values could be obtained from the Motion Detector graph, independent measurements show the student that the Motion Detector is using the same distance and time standards as conventional instruments.

4. Avoid using a soft or felt-covered ball for the pendulum bob, as the ultrasonic waves from the motion detector tend to be absorbed by these surfaces. A ball with a hole drilled through its center works well as a pendulum bob. Other objects such as a large fishing bobber or an empty soft drink can also work well.

SAMPLE RESULTS



Sample data with model

DATA TABLE

A (m)	0.15
B	2.73
C (s)	0.475
D (m)	0.505
Time for ten cycles (s)	23
Period (s)	2.3

ANSWERS TO ANALYSIS QUESTIONS

1. The model fits the experimental data well. $y = 0.15*\cos(2.73*(x - 0.475)) + 0.505$.

2. The values of *A*, *B*, and *D* would not change. The value of *C* would change because the horizontal shifts needed to fit a sine and cosine curve are different. Students may use a trial and error method to find the new value of *C*. Some students may reason that the sine curve is the cosine curve shifted right by one-fourth of the period. They may calculate one-fourth of the period and subtract it from the current value of *C* to find the new value of *C*. In this case, 0.475 – (0.475/4) = 0.356. This would be a good method to share in a post-activity discussion for those students who do not discover it.

3. The new sine model fits as well as the cosine model, as long as the appropriate adjustment is made in the *C* parameter.

4. *A* is the distance that the pendulum swings to either side of the stationary point. *B* is the number of cycles in the natural period of the function. *C* is the amount of time that passed between the start of the program and the time the pendulum was a maximum distance from the detector. *D* is the stationary point of the pendulum or the position of the pendulum when it is at rest.

DataQuest
21

Lights Out!
Periodic Phenomena

A rocking chair moving back and forth, a ringing telephone, and water dripping from a leaky faucet are all examples of *periodic* phenomena. That means that the phenomenon repeats itself every so often. The *period* is the time required to complete one cycle of the phenomenon. The number of times the cycle occurs per unit time is known as the *frequency*.

In the following activities, you will use a Light Sensor to collect data for two different types of periodic phenomena. You will then analyze this data to find the period and the frequency of the observed behavior.

OBJECTIVES

- Record light intensity versus time data for both fast and slow variations of intensity.
- Describe the intensity variations using the concepts of period and frequency.

MATERIALS

TI-Nspire handheld **or**
computer and TI-Nspire software
data-collection interface
Light Sensor
fluorescent light

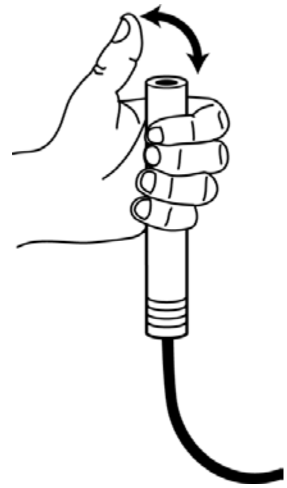
PROCEDURE I – LONG PERIOD

In this part you will point a light sensor towards a light source such as a window or an overhead lamp. To start, cover the end of the sensor with your thumb. When data collection starts, begin alternately lifting your thumb from the sensor and re-covering it. Light intensity readings will be displayed on the screen after data collection is complete.

1. Set up the Light Sensor for data collection.
   a. If you are using the Vernier Light Sensor, set it to 0–6000 lux.
   b. Connect the Light Sensor to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer.

2. Choose New Experiment from the Experiment menu. For this experiment, the default data-collection parameters for a light sensor will be used (Rate: 20 samples per second; Duration: 10 seconds). The number of points collected should be 201.

3. Once you begin data collection, you will cover and uncover the end of the light sensor using your thumb at roughly a one-covering-per-second rate. For example, you might count "one one thousand two one thousand…" and move your thumb so you cover the sensor on the start of each "thousand."



   a. Hold the sensor in your hand with your thumb ready to cover the tip. Point the sensor toward a window or other light source.
   b. Start data collection (▷).
   c. Move your thumb as described above. Data collection will run for 10 seconds.
   d. The data should show intensity levels, which start at a large value, and then alternate between this value and zero in a regular pattern. The time interval between cycles should be fairly uniform. If the data is not satisfactory, repeat this step.

DATA TABLE I

A (s)		frequency (s^{-1})	
B (s)		frequency * 60	
average ΔT (s)			
number of cycles			

ANALYSIS I

1. Begin your analysis by answering Analysis I – Analysis Question 1.
2. The function you see graphed is *periodic*. Determine the period of your cover-uncover function. To do this, click any point on the graph and use ► and ◄ to move to the first time corresponding to a transition from a plateau to zero or near zero intensity. Record this value in Data Table I as *A*.
3. Move to the last spot on your graph where the function has again gone from a plateau to a near-zero value. Count the number of cycles you traverse as you trace. Record the number of cycles in your data table. (The number of cycles corresponds to the number of times you covered and uncovered the sensor during the time interval.) Record the time of the new location in Data Table I as *B*.
4. Find the average period ΔT during the *A* to *B* time interval by dividing the time difference $B - A$ by the number of cycles during this interval. Record this value, rounded to the nearest 0.05 seconds, in Data Table I.
5. While the period represents the number of seconds per cycle, the *frequency* is the number of cycles per second. Find the frequency of the cover-uncover motion by taking the reciprocal of the period you just determined. Record this value in Data Table I as the frequency.
6. Multiply the frequency you just determined by 60, and record the value in Data Table I and then answer Analysis I – Analysis Question 2.

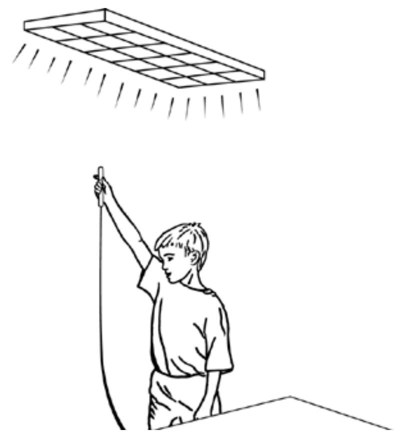
ANALYSIS I – ANALYSIS QUESTIONS

1. For this intensity plot, what do the plateaus represent? What do the minimum value regions represent?
2. What does the value you calculated in Step 6 represent?

EXTENSION I

What would happen to the graph if you repeated the cover/uncover cycle twice a second instead of the once a second rate you used before? Predict what would happen to your period and frequency values. Collect another set of data with the faster cover/uncover rate to check your prediction.

PROCEDURE II – SHORT PERIOD



In this part you will point the light sensor at a single fluorescent light and record its intensity for a very short period of time. The resulting plot of intensity versus time is interesting because it shows that fluorescent lights do not stay on continuously but rather flicker off and on very rapidly. Since the human eye cannot distinguish between flashes that occur more than about 50 times a second, the light appears to be on all the time. The data you collect will be used to determine the period and frequency at which the bulb flickers.

1. Since the rate of flickering of the lights is very fast, you need to first increase the rate of data collection. (**Note**: This part of the activity cannot be done using an Easy Link or a Go! Link.)
   a. Insert a New Problem in the TI-Nspire document.
   b. Insert a new DataQuest App.
   c. Choose Collection Setup from the Experiment menu.
   d. Enter **2000** as the rate (samples/second).
   e. Enter **0.05** as experiment duration in seconds. The number of points collected should be 101.
   f. Select OK.
2. Collect data of light intensity versus time for the fluorescent light.
   a. Hold the light sensor near the fluorescent light. Since data collection will run only 1/10th of a second, you must be ready for data collection when you click the Start button (▷).
   b. Start data collection (▷).
   c. When data collection is complete, a graph will be displayed. The data should show intensity levels that alternate between a high and low value in a regular pattern. The time interval between cycles should be relatively constant. If the data is not satisfactory, repeat this step.

DATA TABLE II

A (s)		frequency (s^{-1})	
B (s)			
average ΔT (s)			
number of cycles			

ANALYSIS II

1. Begin your analysis by answering Analysis II – Analysis Question 1.
2. Use the technique you used in Part 1 to determine the period and frequency of the pattern from the fluorescent light. Record these values in your data table, this time rounded to the nearest 0.0005 s. Then, answer Analysis II – Analysis Question 2.

ANALYSIS II – ANALYSIS QUESTIONS

1. What can you conclude about the flickering of a fluorescent light from the graph? What do the peaks represent? What do the valleys represent?
2. In North America, electric utilities use alternating current at 60 cycles/second, while in most of the world the frequency is 50 cycles/second. Is the frequency of the local current consistent with the measurement of the fluorescent light flicker rate? Note that alternating current flows first in one direction, then the other, so that the fluorescent light is bright *twice* per cycle.

EXTENSION II

The fluorescent light bulb intensity versus time data you collected in this activity can be modeled with an absolute value sinusoidal equation of the form:

$$y = A \cdot \left|\sin\left(B\left(x - C\right)\right)\right| + D$$

Can you determine appropriate values for A, B, C, and D so that this equation properly models the data? How do the frequencies of the above equation and

$$y = A\sin\left(B\left(x - C\right)\right) + D$$

compare? Be sure that the program is in radian mode before graphing these functions.

The Carousel – Exploring TI-Nspire™ Activities

TI PROFESSIONAL DEVELOPMENT

About the Activity

- You have seen a number of sources for TI-Nspire activities. To allow you to make the most relevant use of the remainder of this workshop, you will have time to explore activities that are of particular interest to you for your classroom use.
- Some activities are contained in your workshop binder, some are available online through the TI-Nspire™ Teacher Software, or you might have found something on your own that you would like to explore. You will share your findings with the whole group.

Sources for Activity Materials:

- Workshop binder
- TI-Nspire Teacher Software content links
- Math Nspired or Science Nspired websites
- Vernier books
- A lab you love and want to adapt

TI-Nspire™ Navigator™ System

- If you want, you can use the workshop's TI-Nspire Navigator System to practice enhancing your activity presentation, engage your fellow participants, and share any TI-Nspire documents you found useful. The Teachers Teaching with Technology (T^3) Instructor will be happy to help you.

Discussion Points

Work through an activity or two in the time provided. While completing the activity, consider:

- How does it add new TI-Nspire skills to your repertoire?
- What are some pedagogical implications of the activity and its technology use?
- What is the content relevance?
- How might it engage and motivate your students?
- You are encouraged to work in small groups and discuss as you go.
- Each group will give a short presentation on an activity and the results of the discussions surrounding it.

Tech Tip: Try using any TI-Nspire documents on both the TI-Nspire Teacher Software and the TI-Nspire handheld. Transfer any documents from one to the other and back again.

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Experiment **21**

Determining the Concentration of a Solution: Beer's Law

The primary objective of this experiment is to determine the concentration of an unknown nickel (II) sulfate solution. You will be using a Colorimeter. The wavelength of light used should be one that is absorbed by the solution. The $NiSO_4$ solution used in this experiment has a deep green color, so you will use the red LED on your Colorimeter. The light striking the detector is reported as *absorbance* or *percent transmittance*. A higher concentration of the colored solution absorbs more light (and transmits less) than a solution of lower concentration.

You will 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 *vs*. concentration is plotted for the standard solutions, a direct relationship should result, as shown in Figure 1. The direct relationship between absorbance and concentration for a solution is known as Beer's law.

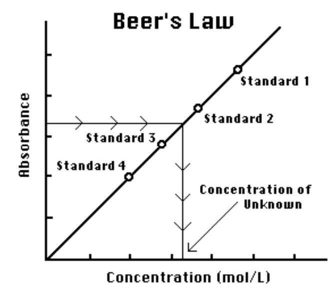


Figure 1

You will determine the concentration of an *unknown* $NiSO_4$ solution by measuring its absorbance. 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 1). The concentration of the unknown can also be found using the slope of the Beer's law curve.

OBJECTIVES

In this experiment, you will

- Prepare $NiSO_4$ standard solution.
- Measure the absorbance value of each standard solution.
- Find the relationship between absorbance and concentration of a solution.
- Determine the concentration of an unknown $NiSO_4$ solution.

MATERIALS

TI-Nspire handheld **or**
  computer and TI-Nspire software
data-collection interface
Vernier Colorimeter
one cuvette
five 20 x 150 mm test tubes
30 mL of 0.40 M $NiSO_4$
5 mL of $NiSO_4$ unknown solution

two 10 mL pipets (or graduated cylinders)
two 100 mL beakers
pipet or pipet bulb
distilled water
test tube rack
stirring rod
tissues (preferably lint-free)

PROCEDURE

1. Obtain and wear goggles. **CAUTION:** *Be careful not to ingest any $NiSO_4$ solution or spill any on your skin. Inform your teacher immediately in the event of an accident*.

2. Add about 30 mL of 0.40 M $NiSO_4$ stock solution to a 100 mL beaker. Add about 30 mL of distilled water to another 100 mL beaker.

3. Label four clean, dry, test tubes 1–4 (the fifth solution is the beaker of 0.40 M $NiSO_4$). Pipet 2, 4, 6, and 8 mL of 0.40 M $NiSO_4$ solution into Test Tubes 1–4, respectively. With a second pipet, deliver 8, 6, 4, and 2 mL of distilled water into Test Tubes 1–4, respectively. *Thoroughly* mix each solution with a stirring rod. Clean and dry the stirring rod between stirrings. Keep the remaining 0.40 M $NiSO_4$ in the 100 mL beaker to use in the fifth trial. Volumes and concentrations for the trials are summarized below:

Trial number	0.40 M $NiSO_4$ (mL)	Distilled H_2O (mL)	Concentration (M)
1	2	8	0.08
2	4	6	0.16
3	6	4	0.24
4	8	2	0.32
5	~10	0	0.40

4. Prepare a *blank* by filling an empty cuvette 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.

5. Connect the Colorimeter to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer. Choose New Experiment from the Experiment menu.

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

7. Calibrate the Colorimeter.
   a. Place the blank in the cuvette slot of the Colorimeter and close the lid.
   b. 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.

8. You are now ready to collect absorbance-concentration data for the five standard solutions.

   a. Start data collection.
   b. Empty the water from the cuvette. Using the solution in Test Tube 1, rinse the cuvette twice with ~1 mL amounts and then fill it 3/4 full. Wipe the outside with a tissue and place it in the Colorimeter. Close the lid.
   c. When the value displayed on the screen has stabilized, click the Keep 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.
   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 3/4 full. Place the cuvette in the Colorimeter and close the lid. Wait for the value displayed on the screen to stabilize and click the Keep button. Enter **0.16** as the concentration in mol/L. Select OK.
   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 10 to test the unknown.
   f. Stop data collection.
   g. Click Table View to display the data table. Record the absorbance and concentration data values in your data table.

9. Display a graph of absorbance *vs.* concentration with a linear regression curve.

   a. Click Graph View.
   b. Choose Curve Fit ► Linear from the Analyze menu. The linear-regression statistics for these two data columns are displayed for the equation in the form

   $$y = mx + b$$

   where x is concentration, y is absorbance, m is the slope, and b is the y-intercept. **Note:** 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. 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.

10. Determine the absorbance value of the unknown $NiSO_4$ solution.

    a. Click Meter View.
    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.
    c. Rinse the cuvette twice with the unknown solution and fill it about 3/4 full. Wipe the outside of the cuvette and place it into the device.
    d. Monitor the absorbance value. When this value has stabilized, record it in your data table.

11. Discard the solutions as directed by your instructor.

DATA AND CALCULATIONS

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)	

PROCESSING THE DATA

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.
   b. Choose Interpolate from the Analyze menu.
   c. Select any point on the regression curve. Use ► and ◄ to find the Linear Fit value that is closest to the absorbance reading you obtained in Step 10. The corresponding $NiSO_4$ concentration, in mol/L, will be displayed.
   d. Record the concentration value in your data table.
2. (optional) Print a graph of absorbance *vs.* concentration, with a regression line and interpolated unknown concentration displayed.

Experiment
21

TEACHER INFORMATION

Determining the Concentration of a Solution: Beer's Law

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. The light source for the nickel (II) sulfate solution is the red LED (635 nm). Since the $NiSO_4$ is green in color, the nearly monochromatic red light is readily absorbed by the solution.

3. The 0.40 M $NiSO_4$ solution can be prepared by using 10.51 g of $NiSO_4 \cdot 6H_2O$ per 100 mL. **HAZARD ALERT:** Toxic; avoid dispersing this substance; dispense with care; Nickel dust is a *possible carcinogen*. Hazard Code: B—Hazardous.

   The hazard information reference is: Flinn Scientific, Inc., *Chemical & Biological Catalog Reference Manual*, (800) 452-1261, www.flinnsci.com.

4. Solutions of $Ni(NO_3)_2$ also work well, and can be prepared by using 11.63 g of solid $Ni(NO_3)_2 \cdot 6H_2O$ per 100 mL of solution.

5. Unknowns can be prepared by doing dilutions starting with the 0.40 M $NiSO_4$ stock solution. For example, to prepare a 0.22 M unknown, use 55 mL of the standard plus 45 mL of water:

$$(55 \text{ mL} / 100 \text{ mL})(.40 \text{ M}) = 0.22 \text{ M}$$

6. This experiment works well using solutions of green food coloring. A solution with an absorbance similar to 0.40 M $NiSO_4$ can be prepared by dissolving 8–9 drops of green Schilling Food Coloring in 1 liter of distilled water. Check to see that the absorbance of this stock solution falls in the range of 0.40 to 0.80. Assign this solution a concentration of 100%. Students will follow the same procedure to dilute the stock solution to 80%, 60%, 40%, and 20%. Make the solutions fresh as they can discolor over time.

7. The cuvette must be from 55% to 100% full in order to get a valid absorbance reading. If students fill the cuvette 3/4 full, as described in the procedure, they should easily be in this range. To avoid spilling solution into the cuvette slot, remind students not to fill the cuvette.

8. Since there is some variation in the amount of light absorbed by the cuvette if it is rotated 180°, you should use a water-proof marker to make a reference mark on the top edge of one of the clear sides of all cuvettes. Students are reminded in the procedure to align this mark with the white reference mark at the top of the cuvette slot on the Colorimeter.

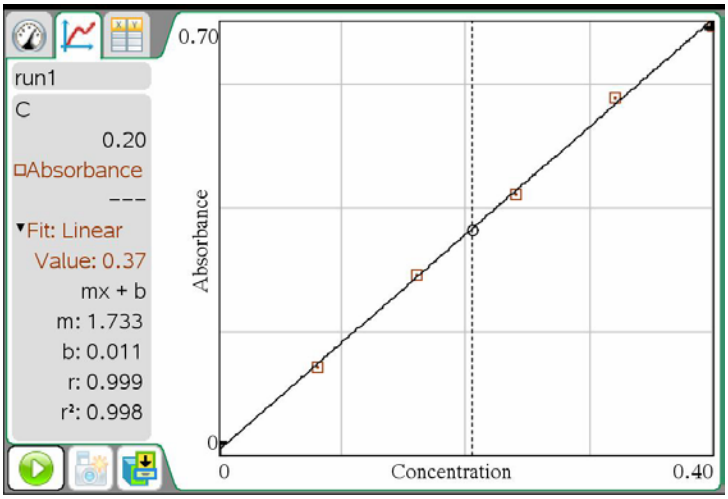
9. The use of a single cuvette in the procedure is to eliminate errors introduced by slight variations in the absorbance of different plastic cuvettes. If one cuvette is used throughout the experiment by a student group, this variable is eliminated. The two rinses done prior to adding a new solution can be accomplished very quickly.

10. There are two models of Vernier Colorimeters. The first model (rectangular shape) has three wavelength settings, and the newest model (a rounded shape) has four wavelength settings. The 635 nm wavelength of either model is used in this experiment. The newer model is an auto-ID sensor and supports automatic calibration (pressing the CAL button on the Colorimeter with a blank cuvette in the slot). If you have an older model Colorimeter, see www.vernier.com/til/1665.html for calibration information.

11. This experiment gives you a good opportunity to discuss the relationship between percent transmittance and absorbance. At the end of the experiment, students can click the Absorbance vertical-axis label of the graph, and choose Transmittance. The graph should now be transmittance *vs.* concentration. You can also discuss the mathematical relationship between absorbance and percent transmittance, as represented by either of these formulas:

$$A = \log(100 / \%T) \quad \text{or} \quad A = 2 - \log\%T$$

SAMPLE RESULTS



Absorbance vs. concentration for $NiSO_4$
with interpolation of the unknown displayed

Trial	Concentration (mol / L)	Absorbance
1	0.080	0.14
2	0.16	0.29
3	0.24	0.42
4	0.32	0.58
5	0.40	0.69
6	Unknown number 1	0.37

Linear Fit Equation:	Absorbance = 1.733*Concentration + 0.011
Concentration of the unknown	0.20 mol/L

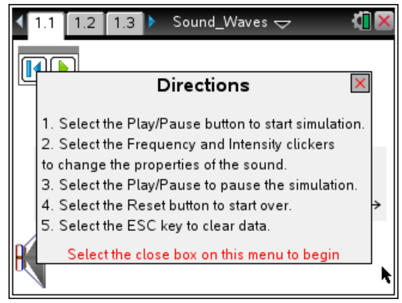
Sound Waves

Student Activity

Name ______________

Class ______________

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

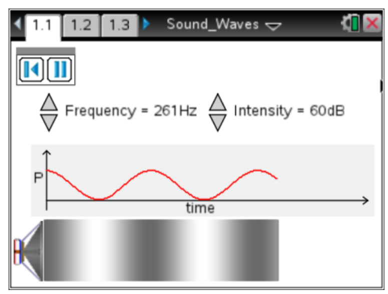


In this investigation you will explore a simulation of a sound wave. Sound waves are longitudinal waves, also called compression waves. The waves oscillate between high and low pressure and the vibration of the medium through which the wave is traveling causes the sound we hear. Sound travels differently depending upon the material it vibrates in (metal, water, air, etc.) as well as the **frequency** and the intensity of the vibration.

You will take note of changes in the sound wave as you modify the frequency or intensity of the sound. You will then calculate the **period** and determine the **wavelength** of the sound from its graph.

As you explore the sound waves, you will determine the relationship between the frequency, wavelength, and period of a wave as well as the relationship between the **pressure**, intensity, and **amplitude**.

Part 1: Exploring Sound Waves



1. After reading the instructions on page 1.1, close the directions box by selecting .

2. The graph will show the pressure (vertical axis) of the sound wave over time (horizontal axis). Select the Play button and observe the sound wave. To pause the simulation select . To reset select .

Q1. What do you observe as you run the simulation? Write down your answer and share this with a neighbor and the class as requested.

3. Now explore the simulation of the sound wave by holding the frequency constant and adjusting the intensity. Get your assigned frequency from the teacher and run the simulation with different values for the intensity. Answer the question below and then check your answer with other students that have the same assigned frequency as you.

Q2. How do the two plots change as you change the intensity of the sound?

Sound Waves

Student Activity

Name ______________

Class ______________

Q3. Now check with students who had a different frequency as you and explain how their results differ from yours.

4. Now explore the changes in the sound when holding the intensity constant but adjusting the frequency. Get your assigned intensity from the teacher and explore the simulation. Answer the question below and then check your answer with other students that have the same assigned intensity as you.

Q4. How did the two plots change as you held the intensity constant and adjusted the frequency?

Q5. Now check with other students that had a different assigned intensity as you and explain how their results differ from yours.

Q6. Summarize the way sound travels in relation to the intensity and frequency settings.

Q7. What are the units used to report the frequency of a wave, and what exactly do they measure?

Q8. Can you determine the time that is shown before the simulation clears and repeats? Explain.

Part 2: The Wavelength and Period

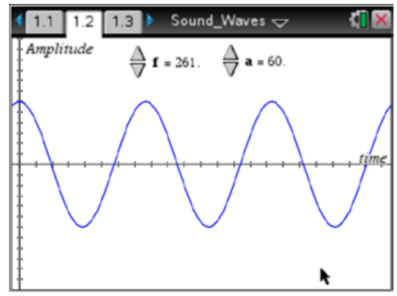
Sound Waves

Student Activity

Name ______________

Class ______________

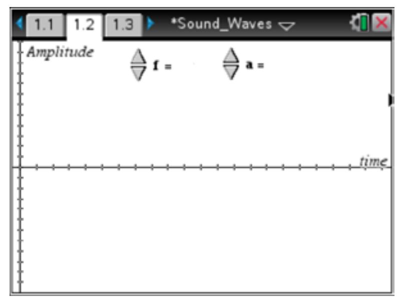
Move to page 1.2.



5. Examine the graph. You may change the values for ***f*** and ***a*** to get different graphs. Explore this and share with the class as requested.

Q9. What do you think the ***a*** and ***f*** stand for? Why?

6. Now your teacher will assign you a value for ***a*** and ***f***. Adjust your settings to create the assigned wave.



Q10. Sketch your graph and draw lines on it showing a horizontal line at the peak and vertical lines at two successive peaks or troughs. Label these lines. To get the values for the times off of the graph select **Menu > Trace > Graph Trace** and use the right and left arrows (◀ and ▶) to move along the wave. Select enter to leave a set of coordinates on the screen.

Tech Tip: To obtain values for time, select **> Trace > Graph Trace**. You may need to back-out to the main Tools Menu to see the desired menu option. To move along the wave, select the cursor and drag it left or right along the wave.

7. To determine the wavelength (λ) of this sound wave, you can subtract the two successive times from your graph to calculate how long it takes to complete one cycle. If you know the speed of sound, you can just multiply this time by the speed of sound to get the wavelength, (distance = rate X time). Since the speed of sound changes depending on the material it vibrates in and the temperature, we will assume that we are in air at 20 degrees Celsius and that the times reported are in seconds. This makes ***s*** = 343 meters/second.

Q11. What is the wavelength of your sound wave in meters? (Calculate using the Scratchpad or insert a *Calculator* page.)

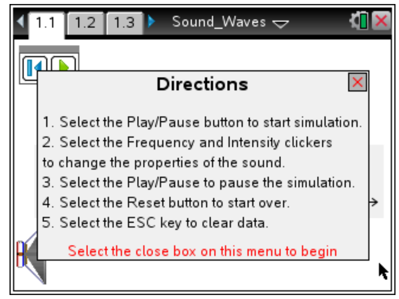
Tech Tip: To insert a *Calculator* page, select **> Calculator.**

8. You may also use the formula $\lambda = \frac{s}{f}$ where ***s*** is the speed of sound and ***f*** is the frequency to determine the wavelength (λ).

Q12. What is the wavelength of your sound wave using this formula? (Calculate using the Scratchpad or insert a *Calculator* Page.)

Q13. How do the two wavelength values, from questions 11 and 12, compare? How can one account for any differences?

Sound Waves



Science Objectives

- Students will explore an animation of a sound wave in air.
- Students will vary the frequency and intensity, or amplitude, of the wave and determine the relationship between the two.
- Students will determine the amplitude and frequency of a sound wave from a graph.
- Students will explore the relationship between the wavelength and frequency of a sound wave as it relates to the wave's period.
- Students will describe the relationship between the sound pressure (Intensity) and the simulation of a compression wave.
- Students will discover the relationship between intensity, pressure and amplitude.

Vocabulary

- Frequency
- Period
- Hertz
- Compression Waves
- Wavelength
- Amplitude
- Decibels
- Pressure
- Longitudinal Waves

About the Lesson

This lesson addresses the relationship between the points of high or low pressure in a sound wave as shown by the graphs as well as the pattern of the repetition of the points as related to frequency.

As a result, students will:

- Explore the simulation of a sound wave.
- Discover the connection between frequency and pressure.
- Calculate the period of a wave and determine the corresponding frequency and wavelength.
- Explore the peaks and troughs of a wave and relate them to the amplitude of a wave.

TI-Nspire™ Navigator™

- Send out the *Sound_Waves.tns* file.
- Monitor student progress using Class Capture.
- Use Live Presenter to spotlight student answers.
- Quick Poll students for Formative Assessment.

Activity Materials

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

Tech Tips:

- This activity includes screen 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 Files:

Student Activity

- Sound_Waves_Student.doc
- Sound_Waves_Student.pdf

TI-Nspire document

- Sound_Waves.tns

Discussion Points and Possible Answers

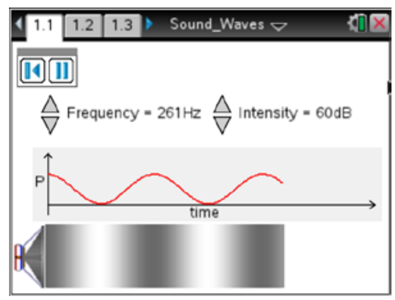
Have students read the background information stated on their activity sheet.

In this investigation students will explore a simulation of a sound wave.

Students will take note of changes in the sound wave as the frequency or intensity of the sound is modified. Then, they will determine the period and wavelength of the sound from its graph.

As students explore the sound waves, they will discover the relationship between the frequency, wavelength, and period of a wave as well as the relationship between the pressure, intensity, and amplitude.

Part 1: Exploring Sound Waves



1. After reading the instructions on page 1.4, close the directions box by selecting .

2. The graph shows the pressure (vertical axis) of the sound wave over time (horizontal axis). Students select the Play button and observe. To pause the simulation select . To reset select .

Q1. What do you observe as you run the simulation? Write down your answer and then share this with a neighbor and the class as requested.

Answer: As time goes by, the top part shows a wavy line that goes up and down, for P. The sound coming out of the speaker at the bottom shows dark and then light areas that correspond to the high and low points of the graph.

3. Now students should explore the simulation of the sound wave when holding the frequency constant but adjusting the intensity.

   Assign frequency values to individuals or groups of students, and have them run the simulation with different values for the intensity. Note the frequency steps in the slider.

Q2. How do the two plots change as you change the intensity of the sound?

Answer: As the intensity gets larger, the peaks get higher in the top plot and the bottom plot has darker parts corresponding to the peaks above and lighter parts at the low points in the top graph. The peaks and troughs appear to occur at the same times for all intensities.

Q3. Now check with students who had a different frequency as you and explain how their results differ from yours.

Answer: The other groups found the same results. Some students might note that the peaks and troughs occurred at different times for different frequencies.

4. Now students should explore the changes in the sound when holding the intensity constant but adjusting the frequency. Assign frequency values to individuals or groups of students, and have them explore the simulation.

Q4. How did the two plots change as you held the intensity constant and adjusted the frequency?

Answer: The peaks and troughs stayed at the same levels, but as the frequency got larger the peaks occurred more often, were closer together over the time period. In the bottom plot, the dark regions occurred more often and were closer together.

Q5. Now check with other students that had a different assigned intensity as you and explain how their results differ from yours.

Answer: They all had similar results with the peaks and troughs being darker/lighter and higher/lower based on their assigned intensity.

Q6. Summarize the way sound travels in relation to the intensity and frequency settings.

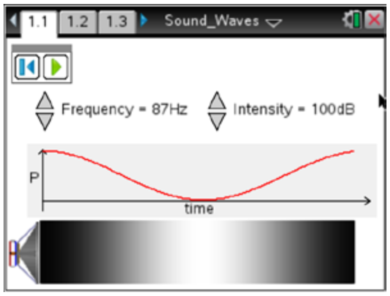
Answer: As the intensity is increased, the peaks get higher and the areas of the compressed wave get darker. As the frequency increases, the rate at which the peaks occur increases.

Q7. What are the units used to report the frequency of a wave, and what exactly do they measure?

Answer: Frequency of a wave is measured in Hz, which are Hertz. Hertz measures cycles per second and is the time it takes to complete one cycle (peak to peak trough to trough).

Q8. Can you determine the time that is shown before the simulation clears and repeats? Explain.

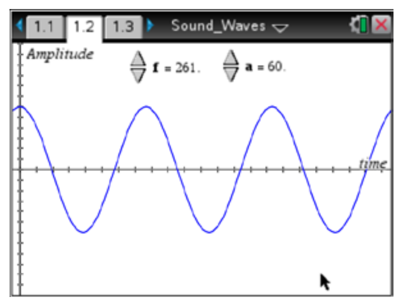
Answer: For any frequency, the student should determine how many times the pattern repeats. For example at 87 Hz you get this plot:



It appears that you get 1 cycle so at 87 cycles/sec we have 0.0115 seconds per cycle.

Part 2: The Wavelength and Period

Move to page 1.2.



5. Have students examine the graph. They may change the values for ***f*** and ***a*** to get different graphs. Explore this and share with the class as requested.

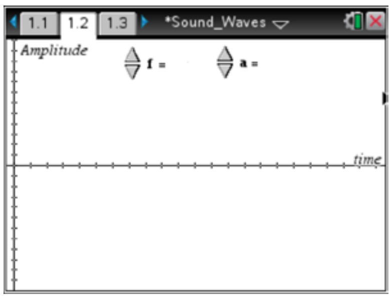
Q9. What do you think the ***a*** and ***f*** stand for? Why?

Answer: The variable ***a*** appears to be like the intensity from the first page. It makes the graph have higher or lower peaks. The variable ***f*** acts like the frequency in that it makes the number of peaks increase or decease.

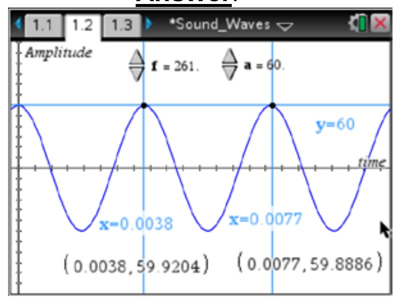
6. Assign students values for ***a*** and ***f***. Have them adjust their settings to create the assigned wave.

Q10. Sketch your graph and draw lines on it showing a horizontal line at the peak and vertical lines at two successive peaks or troughs. Label these lines. To get the values for the times off of the graph select **Menu > Trace > Graph Trace** and use the right and left arrows (◀ and ▶) to move along the wave. Select enter to leave a set of coordinates on the screen.

Tech Tip: To obtain values for time, students will need to select > **Trace > Graph Trace**. Note that in some cases, a student may need to back-out to the main Tools Menu to see the desired menu option. To move along the wave, have students select the cursor and drag it left or right along the wave.



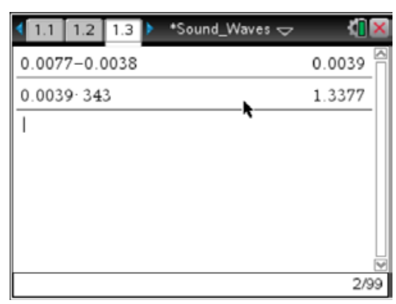
Answer:



Teacher Note: You can have the students place the horizontal and vertical lines on the graph in the Nspire by creating Text boxes such as: x = 0.0038 and y = 60. In each case you then drag the Text box to the x- or y-axis to get the graph.

7. To determine the wavelength (λ) of this sound wave, students can subtract the two successive times from their graph to calculate how long it takes to complete one cycle. If the speed of sound is known, they can just multiply this time by the speed of sound to get the wavelength (distance = rate X time). Since the speed of sound changes depending on the material it vibrates in and the temperature, we will assume that we are in air at 20 degrees Celsius and that the times reported are in seconds. This makes ***s*** = 343 meters/second.

Q11. What is the wavelength of your sound wave in meters? (Calculate using the Scratchpad or insert a *Calculator* page.)

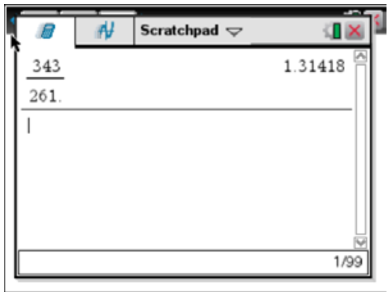


Answer: For the example in Q10 we have a change in time of 0.0039 seconds which yields 1.34 meters at 261 Hz.

Tech Tip: To insert a *Calculator* page, have students select **+** > **Calculator.**

8. Students also use the formula $\lambda = \frac{s}{f}$ where *s* is the speed of sound and ***f*** is the frequency to determine the wavelength (λ).

Q12. What is the wavelength of your sound wave using this formula? (Use the Scratchpad to calculate or insert a *Calculator* Page.)



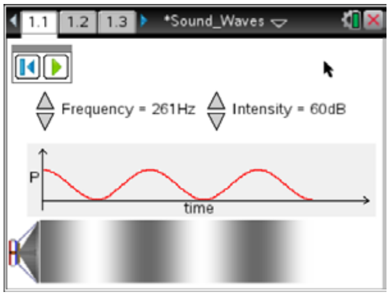
Answer: Again from Q10 we have 1.31 meters

Q13. How do the two wavelength values, from questions 11 and 12, compare? How can one account for any differences?

Answer: The two values are a very close match. When you trace the graph, you get a time close to the peak, but not the exact times, so there should be some variation from the second exact calculation.

TI-Nspire Navigator Opportunities

Allow a student to volunteer to be the Live Presenter and demonstrate how they created the horizontal and vertical lines and how they determined the times at which the wave started to repeat (Graph Trace). Pick questions from the Student sheet and Quick Poll them. Have the students show their calculations and graphs with Class Capture or make Presenter. Include an Image - Point on Question to determine if students know where the high and low pressure points are in the Compression wave.



Wrap Up

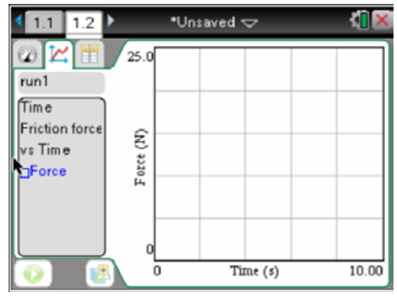
When students are finished with the activity, collect the .tns files using TI-Nspire Navigator or Connect-to-Class. If you Quick Poll the class or if you added Questions into the tns file, save to the Portfolio. Discuss the class answers using the Review and explore individual files as a class.

Friction - A Sticky Subject
Student Activity

Name ______________

Class ______________

In this activity, you will explore the concept of friction as it applies to different types of shoes. You will collect data using a force sensor and share results with your class. Different groups will use different types of shoes on different surfaces and consider the impact of friction in different situations.



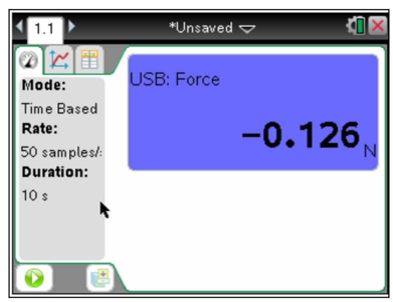
- How many different types of shoes can you name?
- Why are they designed differently?
- What different types of surfaces are they designed for?

Begin this activity by choosing two different types of shoes and obtaining a mass for each as directed by your teacher.

Problem 1
Turn on your TI-Nspire™ handheld.

1. Open a new document by pressing [⌂ on] and selecting **New Document.** A *Save* message box might appear. Press [enter] to save, or press [tab] and [enter] to not save. Ask your teacher which you should do.

2. Obtain a Dual Range Force Sensor and Vernier EasyLink™ USB sensor interface. Set the switch on the force sensor to the 50 N range. Connect the sensor cable to the EasyLink, and the EasyLink to your TI-Nspire handheld. Make sure the cables are pushed in securely.
   - What happens to your handheld?



Note the force reading on the meter display on the screen. Gently pull and push on the hook of the force sensor. What happens to the readings? Note the sensor reading when it is placed flat on a table and again when you hold the sensor with the hook vertically down. Because of these differences, the sensor needs to be zeroed for the position in which it is being used.

3. Hold the sensor <u>vertically</u> with the hook down. Select **Menu > Experiment > Set Up Sensors > Zero.**

Friction - A Sticky Subject

Student Activity

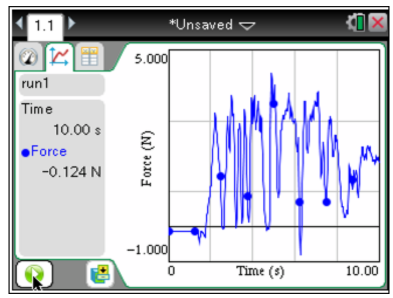
Name ______________

Class ______________

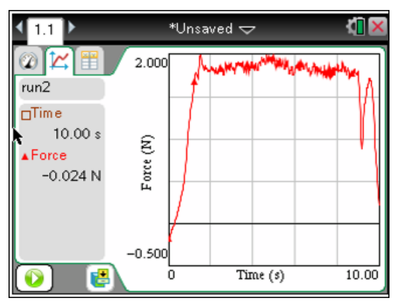
4. Hang a shoe from the sensor, and note its weight in the table below (or on Scratchpad) (Press esc to exit Scratchpad.) Repeat with the other shoe. Weigh the mass as directed by your teacher, and record the weight.

5. Next, you will pull your shoe across a horizontal surface. With some slack in the string, you will gradually increase your pull until the shoe starts to move uniformly.
   - What do you think the graph of force versus time will look like? Sketch your ideal graph in the screen at the top of the first page of this worksheet.

6. Place the force sensor flat on a <u>horizontal</u> surface as assigned by your teacher and <u>again zero the sensor</u>. Place shoe A on the surface, and loop the string on the shoe so that you can pull the shoe horizontally. Loop the other end of the string over the hook of the force sensor with a little slack in the string.
   Note the information on your handheld screen. The default settings for the force sensor are to collect time-based data at a rate of 50 samples per second for 10 seconds. This is suitable for this experiment.



Do not store this data. Click start to overwrite.

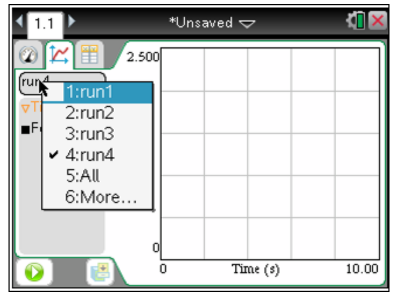


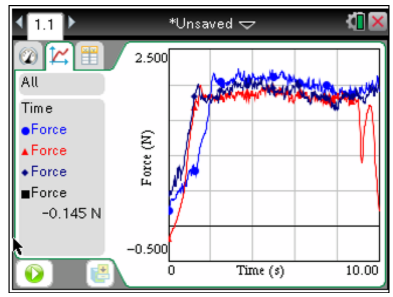
Store this data and then complete another run.

7. When you are ready to pull the shoe, move your cursor to the **Start** button and click on it. Slowly take up the slack, and gently increase force until you are pulling the shoe at a slow, constant speed across the surface. Data will collect automatically for 10 seconds, and then stop. Look at the data that is displayed in the graphing window.
   - If you do not think your trial was suitable (too fast, too rough, ran out of time…) then just click the start button again and redo the trial.
   - If your data seems reasonable, press tab to highlight the Store button (file cabinet), and press enter to store the data (or just click the **Store** button).

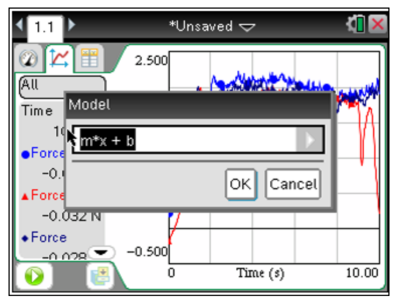
8. Repeat by clicking the **Start** button and then storing until you have collected at least three good runs with that shoe.

9. Move your cursor, and click on the small window near the top-left of your screen that says “run4” (or “run5” or “run6,” depending on how many you did). Select **All,** and all of your stored runs will be displayed. You might see an initial peak force.
   - What does this represent?
   - There also will be a section of relatively constant data values representing the dynamic friction of that shoe sliding on that surface. Estimate a reasonable average value for this data.

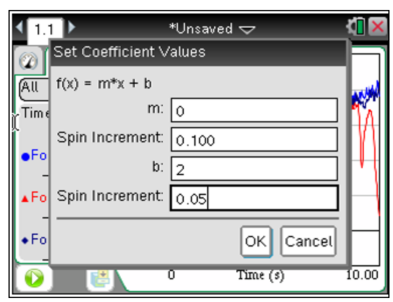




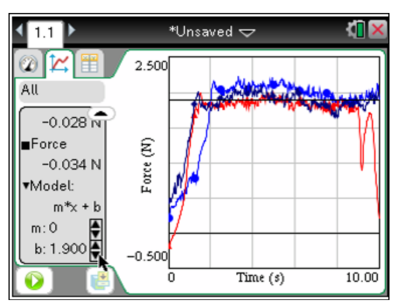
10. Select **Menu > Analyze > Model**. A linear model ($m1*x+b1$) is the default. Press enter.



11. Tab through the field cells to make $m1 = 0$, $b1$ = your estimate, and the bottom *Spin Increment* = 0.05, and again press enter.

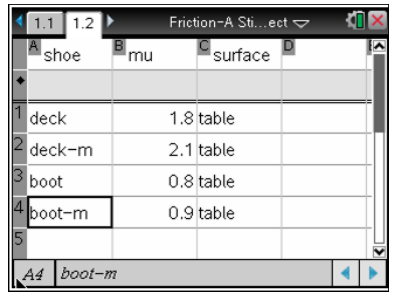


12. In the *Graph Details* window on the left, use your cursor to scroll down to the Model1 information and click on the up or down arrows to change the value of $b1$. When your model line on the graph best matches the linear portion of the data, note the value of $b1$.
    - What is your best value of dynamic friction for this shoe on this surface ($b1$)?



13. The coefficient of friction between an object and surface (μ) is defined as the force of friction divided by the normal force (the weight of the object). Press to open the Scratchpad and calculate your "shoe μ."

14. Add a new Lists & Spreadsheet page by Selecting doc▾ **> Insert > Lists & Spreadsheet**. Label Column A *shoe*, Column B *mu*, and Column C *surface*. Enter your information for shoe type, the value of the coefficient of friction, and the surface into the spreadsheet and into the table at the end of this worksheet.



Problem 2

15. Start a new problem by pressing doc▾ **> Insert > Problem > Add Vernier DataQuest**.

16. Add the extra mass to the shoe according to your teacher's directions, and repeat steps 5–8 with the same shoe on the same surface to find the coefficient of dynamic friction for the shoe with some weight in it. Don't forget to use the total weight of the shoe and mass for the final calculation.

17. Enter your values into the table at the end of this activity and into the spreadsheet on page 1.2 of the .tns file. Use the same shoe name with *–m* appended to it to indicate the shoe had mass in it. (e.g., *boot* and *boot-m*).

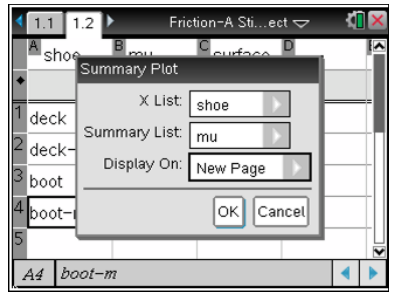
Problems 3 & 4

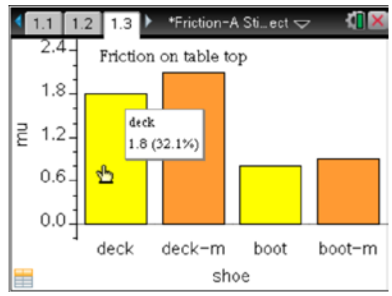
18. Start a new problem by selecting doc▾ **> Insert > Problem > Add Vernier DataQuest**. Repeat steps 3–12 for a different shoe on the same surface. When you are finished, enter your information into the table below and on page 1.2. Gather results from other groups using the same surface and enter that data into your spreadsheet as well.

Friction - A Sticky Subject
Student Activity

Name ________________
Class ________________

19. Go to your results spreadsheet on page 1.2. Select **MENU > Data > Summary Chart**. For X List, choose *shoe*; for Summary List, choose *mu*; and for Display On, choose *New Page.* Click **OK**. Discuss and compare results with other groups before answering the questions below.





Results Table

Shoe	Mu (μ)	Surface

Questions:

1. What is the meaning of the coefficient of friction?

2. What are the units of the coefficient of friction? Why?

3. Do all the shoes have the same coefficient of friction on all surfaces? What does this mean?

Friction - A Sticky Subject
Student Activity

Name ________________
Class ________________

4. Does adding mass to the shoe change its coefficient of friction? How? Why?

5. Why would you want different types of shoes with different coefficients of friction? Where would you use shoes A or B?

6. Give several pairings of shoe types to the surface on which they are meant to perform best. Are they meant to be sticky (lots of grip) or is sliding important?

7. Can you think of any extreme shoe designs (to be very slippery or sticky)? Can you try them?

8. Research some values of coefficient of friction for your extreme situations. How large and how small can the value of μ be? What would that mean?

Interesting Fact: the study of friction is called “tribology” and is very important to many industries.

Friction—A Sticky Subject

TI PROFESSIONAL DEVELOPMENT

Science Objectives

- Students will set up a data collection experiment.
- Students will zero a sensor.
- Students will collect, evaluate, and interpret data.
- Students will determine the coefficient of dynamic friction.
- Students will consider applications of friction.
- Students will see and discuss some of the variabilities of friction.

Math Objectives

- Students will interpret the data they collect.
- Students will use a zero-slope line to estimate mean values of data.
- Students will use measured values in a formula with units.
- Students will compare results from a table and from a summary bar graph.

Materials & Advance Preparation

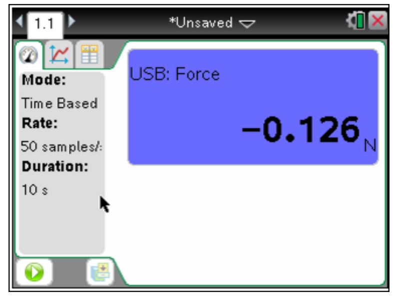
- *Friction—A Sticky Subject* Student Activity sheet
- Dual Range Force Sensor and Vernier EasyLink™ USB sensor interface
- Pieces of string or cord, about 40 cm
- Masses up to 0.5 kg per group (sand, water, rice, or mass set)
- Bags to seal mass as needed

About the Lesson

- This lesson involves students' investigating friction by measuring the force of friction as a shoe is pulled across a surface.
- As a result, students will:
  - Weigh the shoe and use their data to calculate the coefficient of friction for that case (their "Shoe μ").
  - Repeat the experiment with added mass in their shoe and again determine the coefficient of dynamic friction.

TI-Nspire™ Navigator™ System

- Use Class Capture to show results from different groups.



TI-Nspire™ Technology Skills:

- Open a new document
- Set up a data collection experiment
- Zero a sensor
- Collect data with a sensor
- Use the Scratchpad for calculations

Tech Tips:

- Data collection occurs in the Vernier DataQuest™ app for TI-Nspire, which can be viewed as a meter, a graph, or as a data table.

Lesson Materials:

Student Activity

- Friction_A_Sticky_Subject_Student.doc
- Friction_A_Sticky_Subject_Student.pdf

Discussion Points and Possible Answers

> **Tech Tip:** Ensure that the sensor reads zero before each run. Start with a little slack and pull slowly and evenly until the shoe moves at uniform speed.

Begin the lesson by having students show a variety of different styles of shoes they are wearing. Ask how they differ in use. Consider different sport shoes and the surfaces they are designed to be used on: basketball, soccer, hiking, running, dancing, bowling, curling, etc. Assign half the groups to perform the data collection on a smooth surface such as a tabletop or linoleum-covered floor, and the rest to perform the data collection on a rougher surface such as a carpeted floor or a clean outdoor sidewalk (or grass or packed snow).

1. When opening a new document, the system might give a warning message about saving the previous document. Decide ahead of time what might have been open on the handheld, and whether it should be saved or discarded.

2. What happens to your handheld?

   Answer: The handheld automatically detects the force sensor and opens the Vernier DataQuest app for TI-Nspire.

   > **Tech Tip:** If a student does not automatically see the Vernier DataQuest app, make sure the force sensor and the EasyLink™ are completely plugged in and that a New Document was created. Choose *New Experiment* from the Experiment menu if old sensor information appears.

3. Pushing and pulling will give negative and positive force readings. Make sure students zero the sensor in the orientation that it will be used—vertical or horizontal.

4. The second part of the experiment requires students to add some mass to the shoe. You might decide to use known lab masses, in which case their weight can be calculated by using the expression $m \times g$. If you are using some other convenient material such as sand, water, or rice, students will need to seal it well in a bag. Hang another larger bag from the sensor and put the mass bag in it. Weigh it all, and put it all in the shoe when needed.

5. Have students discuss and make a prediction of what the graph of force versus time will look like before beginning to pull the shoe. Prediction is a valuable learning process as it gives the students ownership of what they do and motivation to follow through to find out how well they did in their predictions. There is no right or wrong prediction; it is the process that is important.

6. Students need to run several trials and look at their data critically before storing or overwriting. Some students might have difficulty pulling the shoe consistently. Adjusting the direction of the shoe helps. This is a time when interesting results might occur, so encourage students to share what they get and ask questions about what they see. Use some of their examples to illustrate static friction, good data, poor data, chatter, etc.

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

7. Students might have a blank run (the last one which was not run) or have stored a poor one. They should look at them all, and then display only the good ones.

8. Help the students understand that the model function with a slope of zero is a horizontal line and represents one method of estimating an average value for the force of friction. This is not a statistical calculation but is good enough in this case because friction is quite variable in this scenario.

9. Students can perform their calculations on the Scratchpad and write the results in the table provided. Exit Scratchpad by pressing esc. The calculation will remain in Scratchpad and can be viewed again just by returning to Scratchpad.

> **Tech Tip:** The results will be saved in a spreadsheet on student handhelds. With the wireless TI-Nspire Navigator System, it is possible to collect and aggregate these results and send them back to the students' handhelds. This is beyond the scope of this workshop.

10. Students will enter all their results from each problem into the spreadsheet they create as page 1.2, and will manually write them in the worksheet results table. At this point everyone will have individual copies of their results. Later, they will add other groups' results to the spreadsheet for comparison.

11. Plan ahead for how you want the students to add mass to the shoe. Any convenient mass will do; approximately 1 kg is adequate. If the mass changes the shoe contact area or profile by even a small amount, then the coefficient of friction will probably change as well.

> **Teacher Tip:** It is unlikely that the second value of the coefficient of friction will be the same as the first because the added mass will likely bend the shoe a little and change the contact area with the surface.

12. As time permits, have students experiment with a completely different type of shoe on the same surface, or share results with other groups using the same surface.

13. Discuss with students why it is important to share data from the same surface type. They may then compare their summary charts with those from different surfaces.

> **Teacher Tip:** There likely will be a number of interesting results which can lead to more in-depth discussion of friction: wide variation in the value of shoes' coefficients of friction, an initial peak for static friction, and highly variable periodic data indicating chatter.

TI-Nspire Navigator Opportunity: *Class Capture*
See Note 2 at the end of this lesson.

> **Tech Tip:** The default order of the bars in the summary chart is alphabetical. It can be changed to value order or list order by pressing ctrl menu and selecting an option from **Sort**. Colors and labels can be added.

Questions:

1. What is the meaning of the coefficient of friction?

   Answer: The coefficient of friction is a measure of how hard it is to slide an object on a surface. The lower the coefficient of friction, the slipperier the surface.

2. What are the units of the coefficient of friction? Why?

Answer: The coefficient of friction is a dimensionless quantity; it has no units. This is because it is a ratio of two forces and the units divide out, or it is just a comparison number between how hard it is to slide an object compared to the force between the object and surface (normal force).

3. Do all the shoes have the same coefficient of friction on all surfaces? What does this mean?

   Sample answer: Different shoes might have different coefficients of friction on the same surface, and the same shoe might have different coefficients on different surfaces. You should choose the shoes for a particular situation based on how much friction you need.

4. Does adding mass to the shoe change its coefficient of friction? How? Why?

   Sample answer: Adding mass will likely increase the apparent value of the coefficient of friction for most shoes because it will change the contact area or contact profile with the surface. Very stiff boots, like ski boots, likely would not show this effect.

5. Why would you want different types of shoes with different coefficients of friction? Where would you use shows A or B?

   Sample answer: Shoes are designed to have a certain amount of friction on a particular type of surface. Sometimes you might want your feet to be able to slide easily so you don’t trip; other times you want your footwear to have a really good grip so you don’t slip.

6. Give several pairings of shoe types to the surface in which they are meant to perform best. Are they meant to be sticky (lots of grip) or is sliding important?

   Sample answer: You would want relatively low friction for dancing shoes on a wooden floor to slide easily, but you wouldn’t want to wear them playing soccer on a grass field. You want high friction for court shoes to play basketball, but you would probably stumble around if you were to try wearing them while learning some ballroom dance steps.

7. Can you think of any extreme shoe designs (to be very slippery or sticky)? Can you try them?

   Sample answer: Bowlers wear shoes that have very low friction to let them slide easily on the wood floor of a bowling alley; rock climbers have shoes with very high friction to get a good grip on rock faces.

8. Research some values of coefficient of friction for your extreme situations. How large and how small can the value of μ be? What would that mean?

   Sample answer: μ can be very low—close to zero—in very slippery situations. Some types of polybutylated rubber can have values in the thousands on some surfaces, such as the "sticky hand" toy that you throw at the wall and it slowly flops down the wall but does not slip.

Wrap Up

This activity provides students with an opportunity to think, talk, and work with experimental design issues while learning some basic concepts about friction and its applications. Discussions around different situations relating to friction will engage students and provide reinforcement for vocabulary and concept understanding. Note the **Interesting Fact:** the study of friction is called "tribology" and is very important to many industries. This could lead into many student projects or interests.

Assessment

Students can self-asses their understanding of their experimental set-up and data quality by sharing in their group and with other groups. Students also should be given the opportunity to show and explain their results to the class, another group, or the teacher.

TI-Nspire Navigator System

Note 1

Step 6, *Class Capture*

Here is an ideal place to display screen captures to focus student attention and discussion. Screen captures can be displayed with or without student names. Decide whether you want to praise someone's work, or just display some representative work anonymously.

Note 2

Step 13, *Class Capture*

Showing the class comparable summary charts from different surfaces is a good focus for discussion.

This activity promotes the following **Common Core State Standards Mathematical Practices:**

2. Reason abstractly and quantitatively
4. Model with mathematics
5. Use appropriate tools strategically
7. Look for and make use of structure

And the following **Constructivist 5-E's Processes**:

- Engagement
- Explorations
- Explanation
- Elaboration

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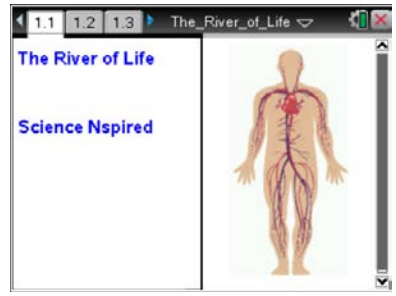
The River of Life

Student Activity

Name ________________

Class ________________

Blood is a body part that often gets overlooked because it is made, in large part, of liquid. This liquid portion of the blood is called the plasma, while the "solid" portion is made up of the blood cells. Later, you will have an opportunity to research what the different components of the blood do for you. For now, however, you will examine the relationship between the body weight and blood volume of a human. Look at the data table below and discuss with a partner what you observe about the relationship between body weight and blood volume.



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

Create a new TI-Nspire™ document.

1. Add a *Lists & Spreadsheets* page.
2. Name Column A ***weight***, and Column B ***pints***.
3. In cell A1, enter the number **60**, then continue to enter values in this column—adding 24 to the previous number—until you reach 300.
4. In cell B1, enter the number 5, and increase it by 2 in each succeeding cell until you have reached 25.
   - The weights are in pounds, and the pints are the number of pints of blood in the human body.
   - Double-check to make sure you have the same number of items in each column.

Weight	Pints
60	5
84	7
108	9
132	11
156	13
180	15
204	17
228	19
252	21
276	23
300	25

5. According to the data table, what is the relationship between body weight and blood volume?

6. a. What is the change in weight from data point to data point?

   b. Is the ΔX the same between each two consecutive *x*-values?

7. a. What is the change in blood volume from data point to data point?

   b. Is the ΔY the same between each two consecutive *y*-values?

The River of Life
Student Activity

Name ______________
Class ______________

8. Now, graph the data by inserting a *Data & Statistics* page.
9. Select **weight** as the *x*-value and **pint** as the *y*-value.
10. Use this graph to figure out approximately how much blood YOU have in your body.
    - There is more than one way to do this, so play around until you find a method that works for you.
    - Hint: It might be a good idea to have a "best-fit" line on your graph.
11. Next, insert a *Graphs* page, graph your data again, and figure out a way to determine your blood volume using this page.
    - After you have finished experimenting with weight and blood volume, move on to the questions that accompany this activity.
12. What is the significance of your answers to #10 and #11?

13. What is the formula for determining the volume of blood if you know your weight?

14. a. Using the regression model (best-fit line) you produced, estimate the volume of blood you have in your body.

    b. How did you make your estimation?

15. How much blood would there be in a person who had a mass of 75 kg? Hint: there are about 2.2 pounds in one kilogram.

16. Estimate the weight in pounds of a person who has 11.5 pints of blood in his body.

17. How much blood would a 7-pound newborn baby have?

18. If this weight/blood volume relationship were true for other animals, too, how many gallons of blood would there be in a horse that had a mass of 500 kg?

19. Estimate the weight of a person who has two gallons of blood in his body.

Name ________________
Class ________________

20. If you decided to donate blood at the blood bank, you would donate one pint. Using your own weight, calculate the percentage of your blood you would be donating.

21 a. If 52% of your blood is water, what is the volume of water circulating in your blood vessels right now?

b. Which of the two main blood components contains the water?

22. Sodium is an abundant ion in the bloodstream. Normally, there are about 2400 milligrams of sodium in one liter of blood. If one liter of blood is about the same volume as two pints of blood, approximately how much sodium do you have flowing through your blood vessels right now? Express your answer in both milligrams and grams.

23. One of the most important functions of the blood is to transport oxygen to all of your cells, and the cells that take care of this for you are called erythrocytes, or red blood cells. Red blood cells are by far the most numerous cells in the blood, averaging about 4.5×10^6 cells per microliter (1000 microliter = 1ml; 1000ml = 1L). How many microliters are there in one liter? Using this information, calculate the approximate number of red blood cells you have in your body right now.

24. Leukocytes, or white blood cells, are another type of blood cell in your body. Human blood contains about 7.0×10^3 WBC's per microliter. Calculate the approximate number of leukocytes you have in your body right now.

25. White blood cells function mainly in defending you against infections. Explain why the number of white blood cells in a person's body may tend to fluctuate a lot more than the number of red blood cells does.

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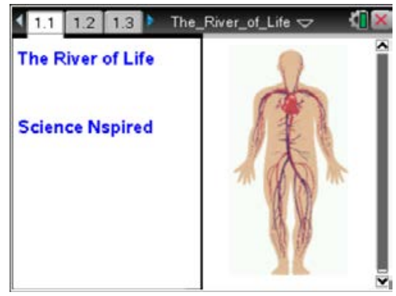
The River of Life
SCIENCE NSPIRED



Science Objectives

- Students will calculate the volume of blood in their own bodies.
- Students will analyze and quantify some of the components of their blood.

Math Objectives

- Students will use tabular data to accurately generate a scatter plot.
- Students will generate a linear regression model, use the function to perform calculations, and interpolate a value on the regression model.

Materials Needed

- TI-Nspire™ or TI-Nspire™ CAS unit for each student

Vocabulary

- plasma
- erythrocytes
- leukocytes
- milligram
- microliter

About the Lesson

- This lesson involves generating a linear regression model for human blood volume vs. body weight.
- As a result, students will:
  - Algebraically calculate their own blood volume.
  - Interpolate on the regression model to determine their blood volume.

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 using multiple applications
- Tracing, interpolating, predicting

Tech Tips:

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

Lesson Materials:

Student Activity

- The_River_of_Life.pdf
- The_River_of_Life.doc

TI-Nspire document

- The_River_of_Life.tns

Discussion Points and Possible Answers

Create a new TI-Nspire™ document.

1. Add a *Lists & Spreadsheets* page.
2. Name Column A ***weight***, and Column B ***pints***.
3. In cell A1, enter the number **60**, then continue to enter values in this column—adding 24 to the previous number—until you reach 300.
4. In cell B1, enter the number 5, and increase it by 2 in each succeeding cell until you have reached 25.
   - The weights are in pounds, and the pints are the number of pints of blood in the human body.
   - Double-check to make sure you have the same number of items in each column.
5. According to the data table, what is the relationship between body weight and blood volume?

   Answer: As body weight increases, blood volume increases.

6. a. What is the change in weight from data point to data point?

   Answer: 24 pounds

   b. Is the ΔX the same between each two consecutive *x*-values?

   Answer: Yes

7. a. What is the change in blood volume from data point to data point?

   Answer: 2 pints

   b. Is the ΔY the same between each two consecutive *y*-values?

   Answer: Yes

8. Now, graph the data by inserting a *Data & Statistics* page.
9. Select **weight** as the *x*-value and **pint** as the *y*-value.
10. Use this graph to figure out approximately how much blood YOU have in your body.
    - There is more than one way to do this, so play around until you find a method that works for you.
    - Hint: It might be a good idea to have a "best-fit" line on your graph.
11. Next, insert a *Graphs* page, graph your data again, and figure out a way to determine your blood volume using this page.

After you have finished experimenting with weight and blood volume, move on to the questions that accompany this activity.

12. What is the significance of your answers to #10 and #11?

    Answer: It means the graph will be linear.

13. What is the formula for determining the volume of blood if you know your weight?

    Answer*:* Pints = 0.083*weight (y=0.083x)

14. a. Using the regression model (best-fit line) you produced, estimate the volume of blood you have in your body.

    Answer: Answers will vary.

    b. How did you make your estimation?

    Answer: Several methods: putting their weight into the equation and solving for pints; tracing along the regression line; etc.

15. How much blood would there be in a person who had a mass of 75 kg? Hint: there are about 2.2 pounds in one kilogram.

    Answer: 15.6 pints

16. Estimate the weight in pounds of a person who has 11.5 pints of blood in his body.

    Answer: 139 pounds

17. How much blood would a 7-pound newborn baby have?

    Answer: 0.6 pints

18. If this weight/blood volume relationship were true for other animals, too, how many gallons of blood would there be in a horse that had a mass of 500 kg?

    Answer: 11.4 gallons

19. Estimate the weight of a person who has two gallons of blood in his body.

    Answer: 193 pounds

20. If you decided to donate blood at the blood bank, you would donate one pint. Using your own weight, calculate the percentage of your blood you would be donating.

    Answer: Answers will vary. Lower percentage for heavier people.

21 a. If 52% of your blood is water, what is the volume of water circulating in your blood vessels right now?

Answer: Answers will vary.

b. Which of the two main blood components contains the water?

Answer: Plasma

22. Sodium is an abundant ion in the bloodstream. Normally, there are about 2400 milligrams of sodium in one liter of blood. If one liter of blood is about the same volume as two pints of blood, approximately how much sodium do you have flowing through your blood vessels right now? Express your answer in both milligrams and grams.

    Sample Answers: Answers will vary.

23. One of the most important functions of the blood is to transport oxygen to all of your cells, and the cells that take care of this for you are called erythrocytes, or red blood cells. Red blood cells are by far the most numerous cells in the blood, averaging about 4.5×10^6 cells per microliter (1000 microliter = 1ml; 1000ml = 1L). How many microliters are there in one liter? Using this information, calculate the approximate number of red blood cells you have in your body right now.

    Sample Answers: Answers will vary

24. Leukocytes, or white blood cells, are another type of blood cell in your body. Human blood contains about 7.0×10^3 WBC's per microliter. Calculate the approximate number of leukocytes you have in your body right now.

    Sample Answers: Answers will vary.

25. White blood cells function mainly in defending you against infections. Explain why the number of white blood cells in a person's body may tend to fluctuate a lot more than the number of red blood cells does.

    Answer*:* WBC numbers tend to increase when a person is sick or injured***.***

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

Wrap Up

Assessment

Formative assessment will consist of questions embedded in the TI-Nspire document. The questions will be graded when the document is 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 student progress.

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DataQuest
28

Titration Curves: An Application of the Logistic Function

Think about how cold germs spread through a school. One person comes to class with a cold and infects other students. At first, the disease spreads slowly, but as more students catch cold and spread it to other classmates, the disease spreads more rapidly. The rate of infection slows down again when most students are infected and there is no one left at school to infect. The maximum number of students in the school who can contract the disease is the number of students in the school.

A logistic function is often used to model this type of situation. The logistic function is an exponential function, but it contains a ratio and offset which make its behavior interesting. The formula for a logistic function is:

$$y = \frac{A}{1 + B^{x-C}} + D$$

You can use this logistic function to model an acid-base titration activity. Chemists combine acid and base solutions while monitoring the pH of the mixture to determine the concentrations of one of the reactants in a process called *titration*. Concentrations are usually made in very small numbers such as 0.000001 or 1×10^{-6}. Instead of working with these small numbers, chemists use a logarithmic scale. pH is the –log[H+] where [H+] is the positive hydrogen ion concentration of a solution. For example, the pH of a solution with a hydrogen ion concentration of 1×10^{-6} is 6. The pH scale runs from 0 to 14. Solutions with a pH of less than 7 are called acids, and solutions with a pH greater than 7 are called bases. Solutions with a pH of 7 are considered neutral.

The change of pH during the titration of an acid with a base produces a titration curve. This curve is not quite a true logistic, but it does have some of the same features as a logistic function. During the first part of the titration, the pH does not change very much because there is enough acid to react with the added base. At the equivalence point, the acid has completely reacted with the base solution. As more base solution is added to the mixture, the pH increases rapidly. Once the solution becomes basic, the pH levels off and approaches the pH of the base being added.

The point at which the most rapid change occurs is called the *equivalence point*. At this point, knowing the volume and concentration of the acid and the volume of the base added allows the chemist to calculate the concentration of the base using a simple proportion.

In this activity, you will add base to an acid and use a logistic function to model the data and locate the equivalence point.

OBJECTIVES

- Record pH versus base volume data for an acid-base titration.
- Manually model the titration curve using a logistic function.
- Describe the role of each parameter in the logistic function.

MATERIALS

TI-Nspire handheld **or**
computer and TI-Nspire software
data-collection interface
pH Sensor
safety goggles
distilled water in wash bottle
25 mL household vinegar
50 mL household ammonia
50 mL or 100 mL graduated cylinder, cup, or beaker

PROCEDURE

1. Obtain and wear goggles.
2. Set up DataQuest for data collection.
   a. Choose New Experiment from the Experiment menu.
   b. Choose Collection Mode ► Events with Entry from the Experiment menu.
   c. Enter **Volume** as the Name and **mL** as the Units. Select OK.
3. Prepare the pH Sensor for data collection.
   a. Connect the pH Sensor to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer.
   b. Loosen the top of the pH storage bottle, and carefully remove the bottle. Slide the top of the bottle up the shaft of the sensor so that the bottle top is out of the way. Do not remove the top from the sensor shaft.
   c. Rinse the tip of the pH sensor with distilled water.
   d. Place the pH sensor in a clean beaker or cup, and support it so that the beaker or cup does not fall.
   e. Add 25 mL of vinegar to the beaker or cup. The vinegar should cover the tip of the sensor.
4. You are now ready to collect data. The data you will collect are the pH of the mixture and the volume of base added to the mixture. In this experiment, the acid used is vinegar and the base is ammonia. It is best if one person adds ammonia while a second person operates DataQuest.
   a. Click the Start button ( ) to prepare to collect data.
   b. Click the Keep button ( ) to record the pH of the vinegar before any ammonia is added.
   c. Since you have added no ammonia, enter **0** and select OK.
   d. Add 5 mL ammonia to the beaker or cup, and gently stir.
   e. Click the Keep button ( ) to record the new pH.
   f. Enter **5** for the total amount of ammonia you have added and select OK.
   g. Repeat this process until you have added a total of 40 mL of ammonia. Remember that the volume of ammonia in the mixture is cumulative, so the volume data point entered increases each time you record the pH and volume. For example, the second ammonia volume data point is 10, the third is 15, and so forth until you reach 40 mL.
   h. Stop data collection ( ) when you are done.
   i. The graph of pH versus volume of ammonia added will be displayed.
5. Click any data point on the graph and use ► and ◄ to examine the data. If you want to collect more data using a fresh sample of vinegar, repeat Steps 3c–e and Step 4.
6. When data collection is completed, use additional distilled water to rinse the pH sensor. Replace the storage bottle on the pH sensor.

DATA TABLE

A	B	C	D

ANALYSIS

1. Click any data point on your graph and use ► and ◄ to read the data point values.
2. Let's investigate the behavior of the logistic equation so you can choose initial values for the parameters.

$$y = \frac{A}{1 + B^{x-C}} + D$$

   The parameter *B* is between zero and one, and the other parameters typically have values between 4 and 10 for this application. If *x* is very small so that the exponential B^{x-C} is then large (remember that *B* is less than one), then the first term is very small. The value of *y* is then approximately equal to *D*. Therefore, trace to the extreme left side of your pH *vs*. volume graph, and find the pH at the smallest *x* and record this value in your data table as *D*. Record this and all values to two significant figures.
3. For large *x*, or more added ammonia, then the exponential B^{x-C} becomes small, and the first term is approximately *A*. Then *y* is approximately *A* + *D*. Trace over to the extreme right side of the graph, and note the pH there, which is the sum *A* + *D*. Use the traced pH value to calculate the value for *A*, and record it in your data table.
4. For the special position of *x* = *C*, then we have $B^0 = 1$, so that the first term is ½ *A*. You can use that to determine a value for *C* by finding the *x*, or the volume of added ammonia, that gives a pH with an approximate value of *D* + ½ *A*. Trace across your graph to determine this value, and record the volume as *C* in your data table.
5. Enter the logistic equation for plotting against your data.
   a. Choose Model from the Analyze menu.
   b. Enter **A/(1+B^(x–C))+D** as the equation for your model. Select OK.
   c. Enter your values for the parameters A, C, and D, which you recorded in your data table. Enter 0.5 as the value for B. You will adjust this value in the next step to obtain a good fit. Select OK.
6. Experiment until you find a value for B that provides a good fit for the data. You can adjust the values of the parameter using the up and down arrows in the details box to the left of the graph. You can also click the parameter value and enter a specific value of your choice. Record the best value for B in your data table and answer Analysis Question 1.

ANALYSIS QUESTION

1. Is the logistic equation a good model for the titration data?

EXTENSION

The TI-Nspire program can perform an automatic logistic regression, although the form of the TI-Nspire logistic expression is slightly different from the one used in the model earlier. TI-Nspire uses the form:

$$y = \frac{c}{1 + ae^{-bx}} + d$$

The key difference between this and the form used earlier is that the exponential function is based on *e*, rather than a direct exponential on a parameter.

Have the TI-Nspire program fit a logistic equation to the data.

a. Remove the model by selecting Remove Model from the Analyze menu.
b. Choose Curve Fit ► Logistic (d≠0) from the Analyze menu.
c. Write the values for the parameters a, b, c , and d in the second column of the Extension Data Table.
   Answer Extension Question 1.
d. Press OK to display a graph of the logistic model with your data.
   Answer Extension Questions 2–4.

EXTENSION DATA TABLE

	Algebraic expression	Parameters from TI-Nspire	Parameters as calculated from model
a (in terms of *B* and *C*)			
b (in terms of *B*)			
c (in terms of *A*)			
d (in terms of D)			

EXTENSION QUESTIONS

1. Use the three parameters a, b and c to write down the TI-Nspire fit equation.
2. From the graph appearance, how does the TI-Nspire fit compare to yours?
3. How do the TI-Nspire parameters compare to those you determined?

   To answer this question you will need to determine the correlation of *A*, *B*, and *C* to a, b, and c. By comparing corresponding locations in the expressions, fill in the Extension Data Table. You will need to use properties of exponential expressions to find the correspondences. After you find these expressions, insert the values of *A*, *B* and *C* from the model to calculate comparison values to those of the calculator.
4. How do the model parameters, when expressed in terms of the TI-Nspire parameters, compare? Should they be similar?

Activity
28

TEACHER INFORMATION

Titration Curves: An Application of the Logistic Function

1. The student pages with complete instructions for data collection using DataQuest (TI-Nspire Technology), EasyData (TI-83/84 Plus calculators), DataMate (other TI calculators), or Logger *Pro* software can be found on the CD that accompanies this book. See *Appendix A* for more information.

2. Before using the pH sensor, rinse the sensor tip in distilled water.

3. At the completion of the activity, use distilled water to rinse the pH electrode. Tightly secure the storage solution bottle on the electrode tip. Refer to the sensor bookelt that came with the pH Sensor for detailed storage information.

4. Students should wear safety goggles while handling chemicals.

5. Use real ammonia, and not a cleaning solution that includes ammonia, in the activity.

6. Rinse all containers well at the end of the activity, flushing the waste with lots of water.

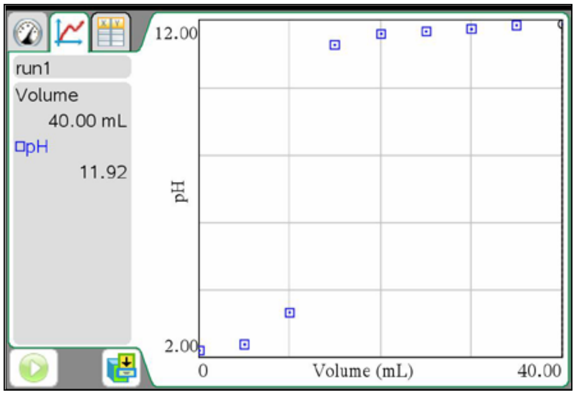
7. The *B* parameter is not well determined by the activity, so that a 10 or 15% change in *B* will produce a barely visible change in the graph. Do not expect consistent values for this parameter, even if students are working with the same data set. For the same reason, the parameter related to *B* will likely be quite different in the calculator curve fit, perhaps even by a factor of five.

8. The logistic function is not an optimum model for a titration curve; chemists use a much more complex model for titration. However, the pH data roughly follow the logistic function, so we use the logistic function as a simplified model.

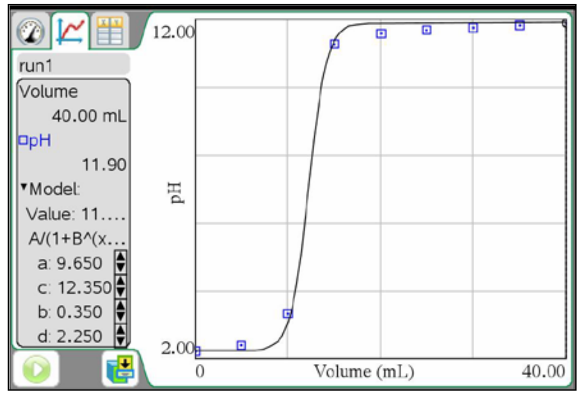
9. You may want to adjust the volume of vinegar used from the suggested volume. Depending on the concentration of the household grade vinegar and ammonia, the optimum volumes will vary. Increasing vinegar volume will shift the titration curve to the right.

10. The Extension of this Activity can be performed with DataQuest (TI-Nspire Technology), EasyData (TI-83/84 Plus calculators), and DataMate (other TI calculators). It cannot be performed with Logger *Pro*.

SAMPLE RESULTS



Sample data



Logistic model on data

DATA TABLE

A	B	C	D
9.65	0.35	12.35	2.25

ANSWERS TO ANALYSIS QUESTION

1. The logistic model fits the titration data very well.

EXTENSION DATA TABLE

DataQuest, EasyData, and DataMate

	algebraic expression	parameters from calculator	parameters as calculated from model
a (in terms of B and C)	$a = B^{-C}$	193084.8	427326.3
b (in terms of B)	$b = -\ln B$	1.01	1.05
c (in terms of A)	$c = A$	9.43	9.65

ANSWERS TO EXTENSION QUESTIONS

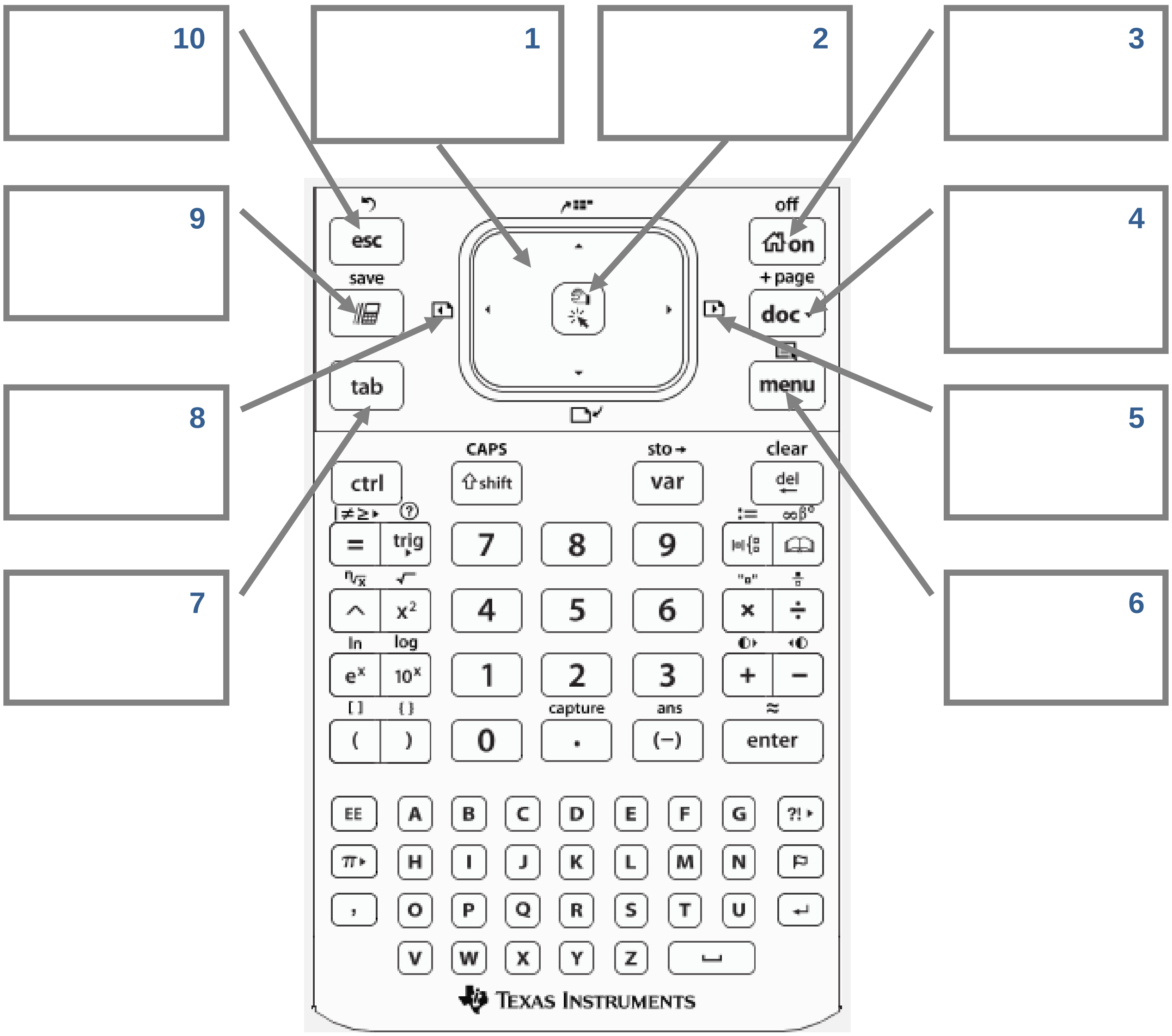
1. Answers will vary.
2. The calculator fit looks to be about the same as my model.
3. The data table is completed as shown above.
4. The parameters from the calculator and the model are similar but not exactly the same. From my experience in adjusting the *B* parameter in the original model, noting that a significant change in *B* made for a small change in the observed fit, I'm not surprised to see that the term depending on both *B* and *C* (which is *B* raised to a large power) is not very close to the calculator fit.

TI-Nspire™ CX Family Overview

TI Professional Development

Activity Overview

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



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Checking and Updating the Operating System

TI PROFESSIONAL DEVELOPMENT

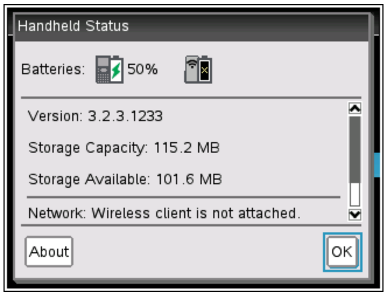
Activity Overview

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

Materials

- TI-Nspire™ Teacher Software and USB connection cable

Viewing Handheld Status



The Handheld Status screen displays the battery status, (OS) version, available space, the network (if any), and your student login name and whether you are logged in.

To view the Handheld Status, press [on] and select **Settings** > **Status**. The Handheld Status dialog box opens.

Note: The About screen displays the handheld type and product ID. To view the About screen from the Handheld Status screen, click **About**. To return to the home screen, press [enter].

Updating the Handheld OS

You can update the OS on your TI-Nspire™ handheld using the TI-Nspire™ Teacher Software or by transferring the OS from one handheld to another. OS upgrades do not delete user documents. If there is not enough room on the receiving handheld for the upgrade, the sending handheld is notified. The only time documents can be affected by an OS installation is if the receiving handheld has a corrupted OS. It is a good practice to back up important documents and folders before installing an updated OS.

Important OS Download Information

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

- The OS for the TI-Nspire™ CX handheld has the file extension *.tco*.
- The OS for the TI-Nspire™ CX CAS has the file extension *.tcc*.
- The OS for the TI-Nspire™ with Touchpad or Clickpad has the file extension *.tno*.
- The OS for the TI-Nspire™ CAS with Touchpad or Clickpad has the file extension *.tnc*.

Always install new batteries before beginning an OS download. When in OS download mode, the APD™ (Automatic Power Down) feature does not function. If you leave your handheld in download mode for an extended time before you begin the downloading process, your batteries may become depleted. You will then need to install new batteries before downloading the OS.

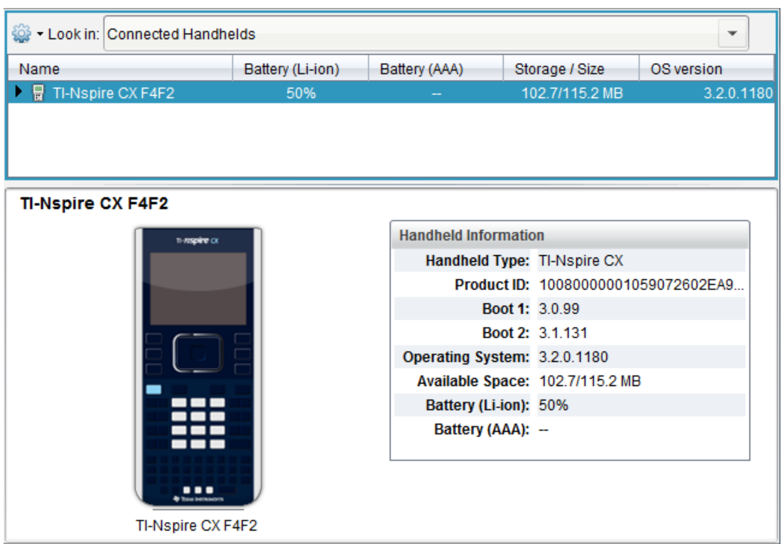
Finding Operating System Upgrades

Your TI-Nspire™ Teacher Software has convenient links to a number of useful Texas Instruments web sites, including those with handheld OS updates. You will need an Internet connection and the appropriate USB cable to download and install the updates.

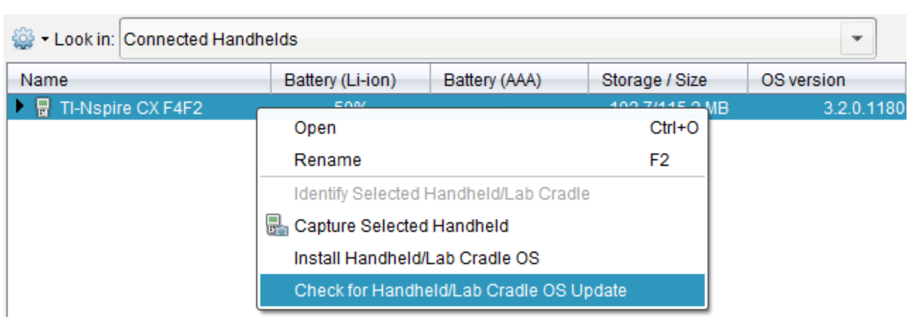
Using TI-Nspire Teacher Software to Update the Handheld OS

Open the TI-Nspire Teacher Software and connect a TI-Nspire handheld to the computer using the USB connection cable. Go to the Document Workspace, select the Content Explorer tab, and click **Connected Handhelds**. Multiple handhelds can be connected to the computer using multiple USB ports, USB hubs, or the TI-Nspire™ Docking Station. If multiple handhelds are connected to the computer, then multiple handhelds appear in the list of Connected Handhelds.

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



To see if a new OS is available, right-click the handheld and select **Check for Handheld OS Update**. To update the OS, right-click the handheld and select **Install Handheld OS**. A window appears that asks you to select the handheld OS file. Select the OS file and click **Install OS**. A window appears informing you that any unsaved data will be lost, and it asks if you want to continue. Select **Yes**.



The Press-to-Test Feature

TI PROFESSIONAL DEVELOPMENT

Activity Overview

The Press-to-Test feature enables you to quickly prepare student handhelds for exams by temporarily disabling folders, documents, and select features and commands. This activity enables Press-to-Test. To disable Press-to-Test, you will need to follow Steps 8-9 using either an additional TI-Nspire handheld or a computer with the TI-Nspire Teacher Software.

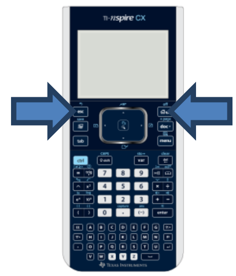
Materials

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

Step 1:

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

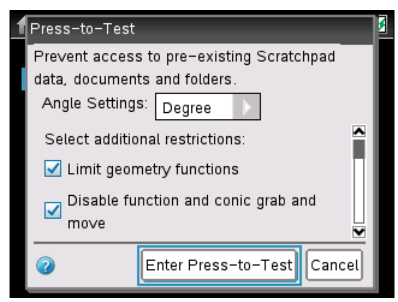
Note: To enable Press-to-Test on TI-Nspire™ with Clickpad, press and hold esc, on, and off/on.



Step 2:

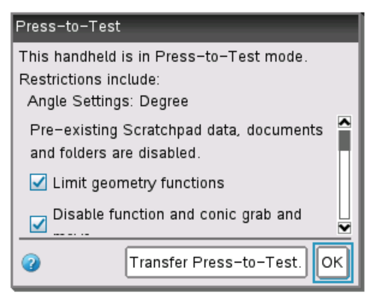
By default, Press-to-Test disables 3D graphing and pre-existing Scratchpad data, documents, and folders. The angle settings can be changed by pressing ▸, selecting the appropriate setting, and pressing ▸ or enter.

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



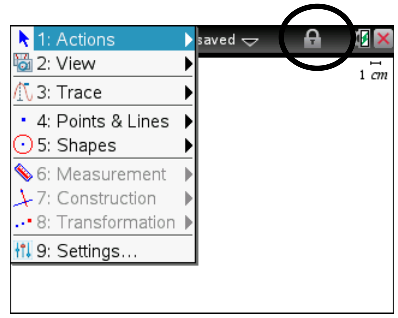
Step 4:

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.

Step 5:

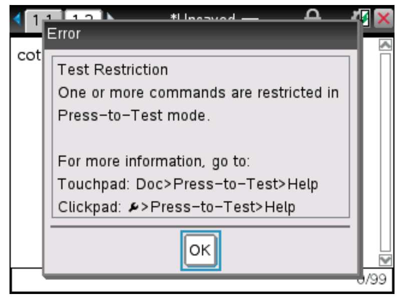
Create a new document, add a Geometry page, and press menu. Since geometry functions are limited, observe that the **Measurement**, **Construction**, and **Transformation** menus are not accessible.

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



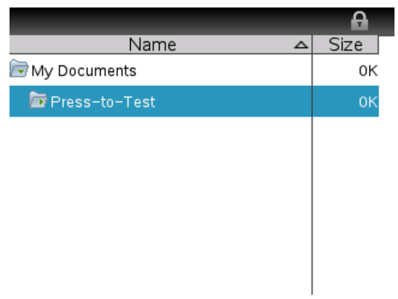
Step 6:

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 on OK.



Step 7:

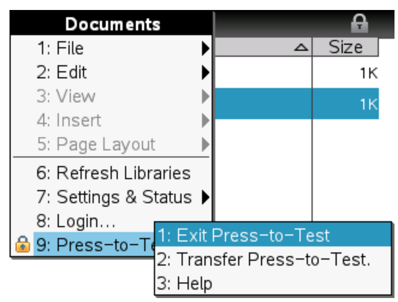
Select on > **My Documents.** While in Press-to-Test mode, a Press-to-Test folder appears in My Documents. All other folders and documents present on the handheld before Press-to-Test mode was entered are inaccessible.



Step 8:

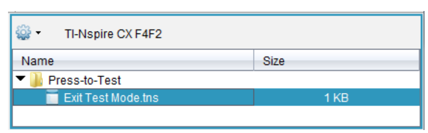
To exit Press-to-Test mode, connect two handhelds using the handheld-to-handheld USB connection cable. Then select doc **> Press-to-Test > Exit Press-to-Test**. The Exit Press-to-Test option appears regardless of whether the other handheld is in Press-to-Test mode.

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



Step 9:

Press-to-Test can also be exited with TI-Nspire Teacher Software or TI-Nspire Navigator Teacher Software by creating a document named ***Exit Test Mode.tns*** and transferring it to connected handhelds.



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

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

Transferring Documents Between Handhelds

TI PROFESSIONAL DEVELOPMENT

Activity Overview

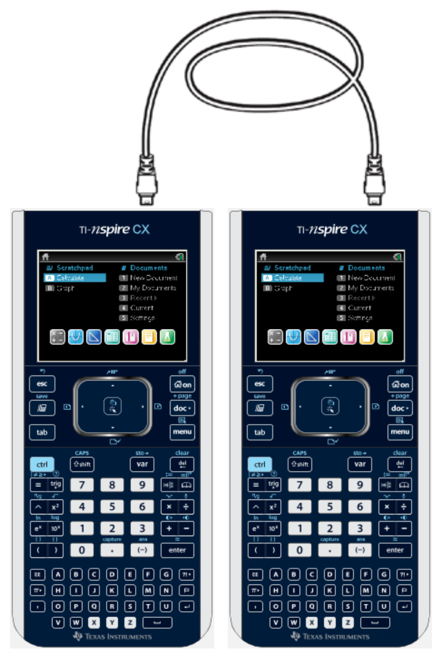
In this activity, you will learn how to transfer a document from one TI-Nspire™ CX handheld to another.

Materials

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

Transferring a document or a folder

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



Step 1:

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

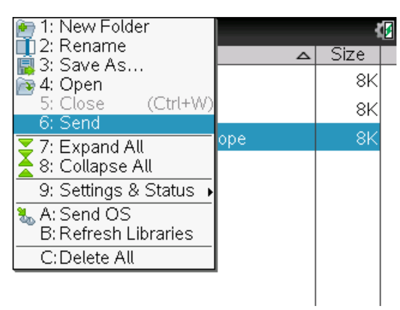
Step 2:

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

Step 3:

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

Step 4:



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

Note: When sending a folder from one handheld to another, the file structure in the sending folder is retained. If the folder does not exist on the receiving handheld, it will be created. If the folder does exist, files will be copied into it, with appended names added to any duplicate files.

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

Guidelines for transferring documents or folders

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

- If you send a document with the same name as an existing document on the receiving TI-Nspire CX handheld, the system renames the sent document by appending a number to the name. For example, if you send a document named *Mydata* to another TI-Nspire handheld that already contains a document named *Mydata*, the document you send will be renamed *Mydata(2)*. Both the sending and receiving units display a message that shows the new name.
- There is a 255-character maximum length for a document name, including the entire path. If a transmitted document has the same name as an existing document on the receiving handheld and the document names contain 255 characters, then the name of the transmitted document will be truncated to allow the software to follow the renaming scheme described in the previous bullet.
- All variables associated with the document being transmitted are transferred with the document.
- Transmissions will time out after 30 seconds.

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

TI PROFESSIONAL DEVELOPMENT

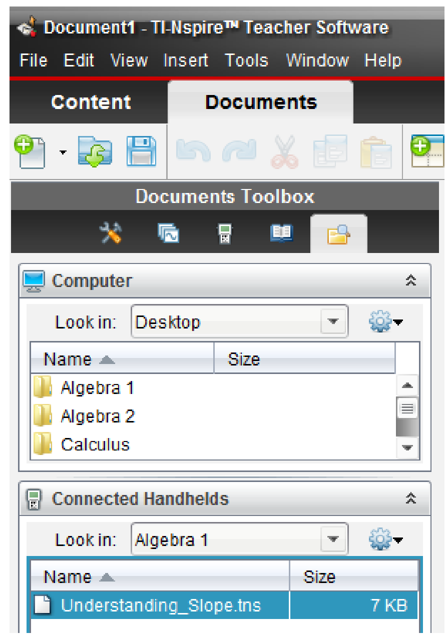
Activity Overview

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

Materials

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

Transferring Documents in the Documents Workspace



Step 1:

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

Step 2:

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

Step 3:

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

Step 4:

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

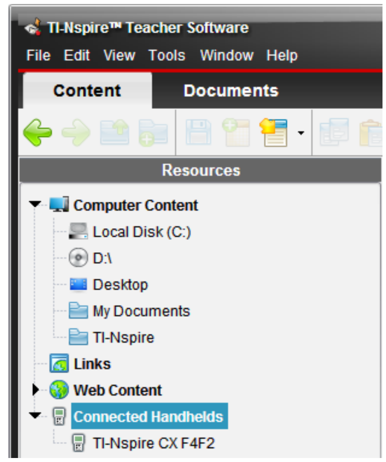
Step 5:

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

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

TI PROFESSIONAL DEVELOPMENT

Transferring Documents in the Content Workspace

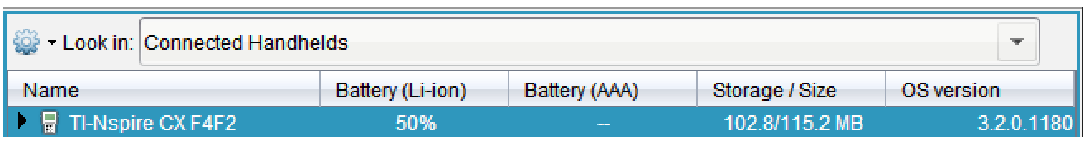


Step 6:

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

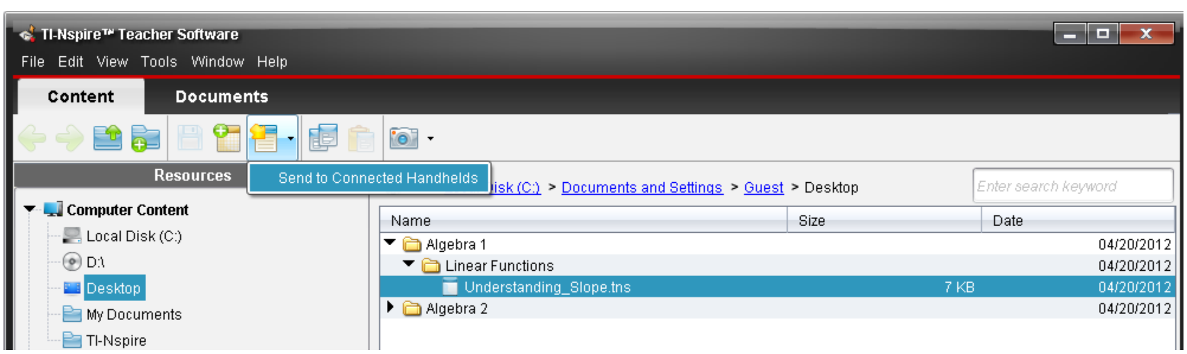
Step 7:

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



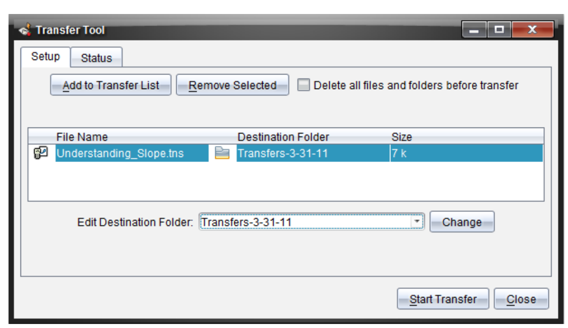
Step 8:

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



Step 9:

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



Inserting an Image into a TI-Nspire™ Document

TI PROFESSIONAL DEVELOPMENT

Activity Overview

In this activity, you will learn how to use the TI-Nspire™ family of Teacher Software to insert images into the Graphs and Geometry applications. You will also learn how to move, resize, compress, and stretch an image, as well as make it appear more transparent.

Materials

- TI-Nspire™ Teacher Software

Step 1:

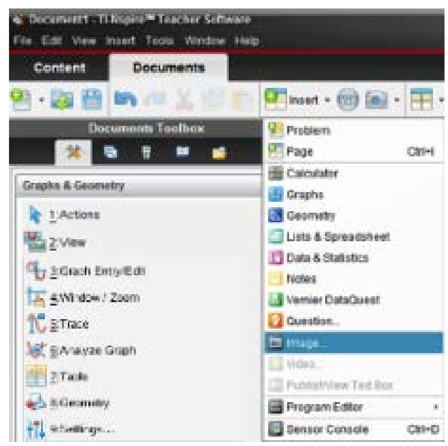
Open the Teacher Software. If the Welcome Screen appears when the software is opened, click to create a new document with a Graphs application as its first page. Otherwise, insert a Graphs application by selecting **Insert >** **Graphs**.

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

Step 2:

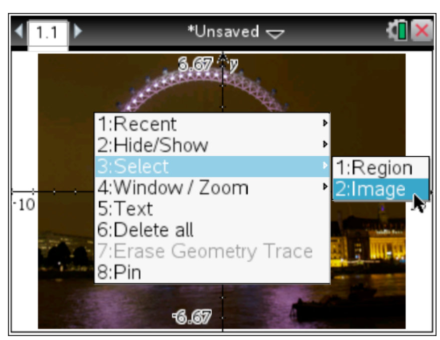
Insert an image into the Graphs application by selecting **Insert >** **Image**. A selection of images is preloaded in the **My Documents >TI-Nspire > Images** folder. Select **Ferris Wheel.jpg** and click Open.

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



Step 3:

Images can be moved, resized, and vertically or horizontally stretched or compressed. To select an image in the Graphs, Geometry, or Question application, right-click on the image and choose **Select > Image**. To select an image in the Notes application, click the image. To move the image, grab and move the image. To resize the image, grab and move a corner. To vertically stretch or compress the image, grab and move the top or bottom edge. To horizontally stretch or compress the image, grab and move the left or right edge.



Inserting an Image into a TI-Nspire™ Document

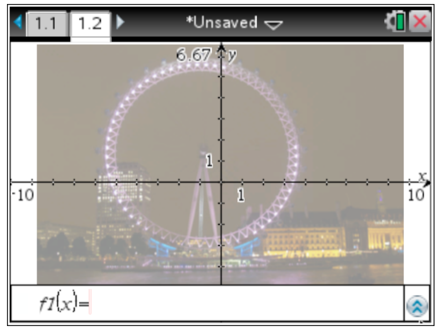
TI PROFESSIONAL DEVELOPMENT

Note: To right-click an object on a handheld, press ctrl menu. To grab an object, press ctrl [grab]. 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**.



Creating a Question Document

TI PROFESSIONAL DEVELOPMENT

Activity Overview

In this activity, you will create a question document using the Question application of the TI-Nspire™ family of Teacher Software. As the document is created, properties of the six question types – Multiple Choice, Open Response, Equations and Expressions, Coordinate Points & Lists, Image, and Chemistry – will be explored.

Materials

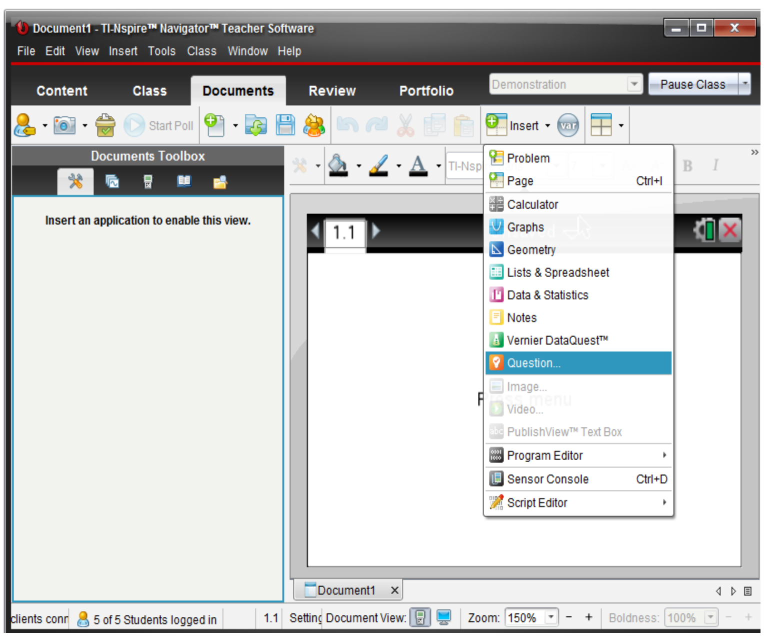
- TI-Nspire™ Teacher Software

Step 1:

Open the Teacher Software. If the Welcome Screen appears, click to create a new document with the Question application as the first page.

Otherwise, go to the Documents Workspace and create a new document by clicking the New Document icon, .

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

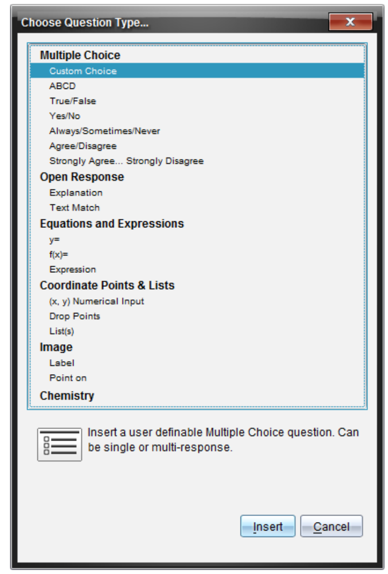


Note: TI-Nspire™ document pages with the Question application can only be created with Teacher Software. The Question application is not available in the TI-Nspire™ Student Software.

Step 2:

The Choose Question Type dialog box appears. Select **Custom Choice** and click **Insert**.

Note: A brief description of the highlighted Question Type appears at the bottom of the window.



Step 3:

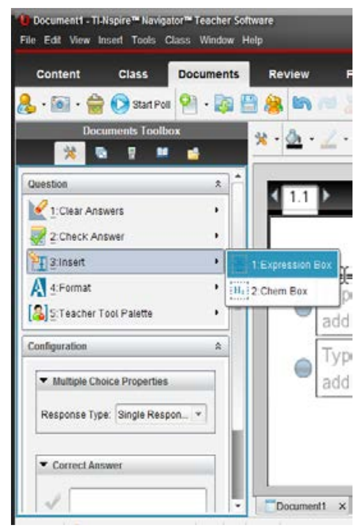
Enter the following problem by typing "Solve for *x*:" and inserting an Expression Box.

Solve for *x*: $\frac{9}{5}x + 32 = 212$

To type the equation into an Expression Box, click on the **Document Tools** pane in the Documents Toolbox. Select **Insert > Expression Box**. Enter the equation. Then, to close an Expression Box, press Enter.

Note: An Expression Box can also be inserted by pressing **Ctrl+M**.

Note: A variety of math templates can be accessed by selecting the Utilities pane in the Documents Toolbox.

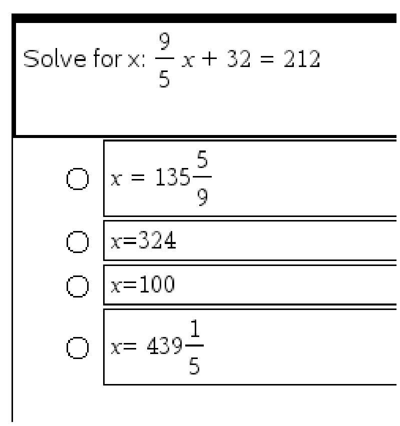


Step 4:

Click in the first answer field. Insert an Expression Box. Type the first answer choice. Press Enter to close the Expression Box. To move to the next answer field, click in the next field or press Enter. Continue to type the following answer choices.

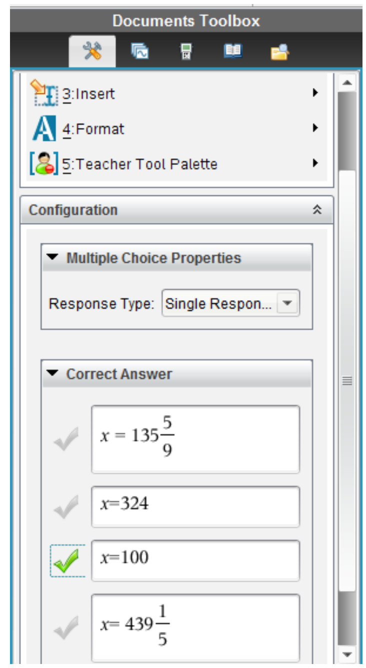
$x = 135\frac{5}{9}$, $x = 324$, $x = 100$, $x = 439\frac{1}{5}$

Note: To remove an empty answer field, click in that field and press the Backspace key.



Step 5:

As you type answer choices, they automatically appear in the Correct Answer fields in the Configuration panel of the Document Tools. Select the correct answer by clicking on the check mark in front of the answer choice.



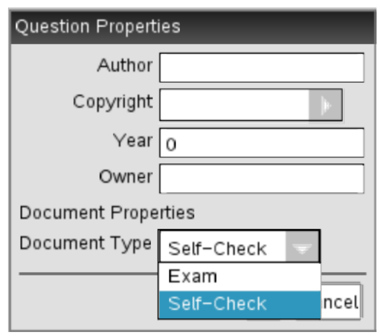
Note: In the Configuration panel, the Multiple Choice Properties can be changed to allow a different Response Type. Single Response allows one correct answer, while Multiple Response allows multiple correct answers. The Multiple Choice Properties and Correct Answer fields can be collapsed by clicking ▾ and expanded by clicking ▸.

Step 6:

There are two types of question documents: Exam and Self-Check. Exam documents can be scored using the TI-Nspire™ Navigator™ System or TI-Nspire™ Navigator™ NC System.

A Self-Check document allows students to check their answers after they select or enter a response. The default setting for the Document Type is Exam.

a Self-Check Question document, select **Teacher Tool Palette > Question Properties**. Change the Document Type to **Self-Check** and click OK.



Note: The document type selected applies to all questions in the current document.

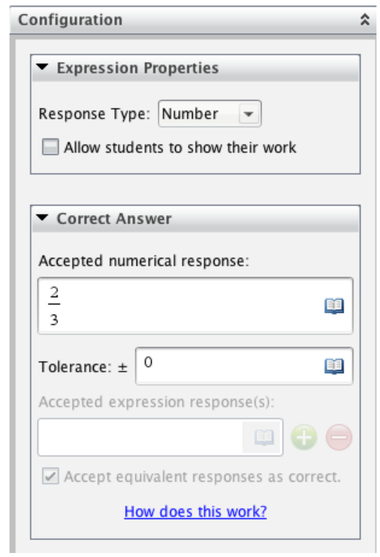
Note: After students answer a question in a Self-Check document, they can check their answers by selecting **Check Answer** from the Menu. A message ("Your current answer is correct." or "Your current answer is incorrect.") is displayed. If the answer is incorrect, two options appear: Show Correct Answer and Try Again.

Note: In Self-Check documents, the Explanation response type (not scored) question does not display the correct or incorrect answer message when students select **Check Answer**. However, any suggested response entered by the teacher will be displayed. The Text Match response type (scored) requires students to exactly match the correct answer, including templates, if applicable. When students select **Check Answer**, the correct or incorrect answer message will be displayed.

Step 7:

Insert a new question by clicking **Insert** and selecting **Question > Equations and Expressions > Expression**. Type the following problem into the question field, inserting an Expression Box for the equation:

What is the slope of the line $2x - 3y = 12$?



Step 8:

In the Configuration panel, under Expression Properties, change Response Type to **Number**. Type $\frac{2}{3}$ in the Correct Answer field.

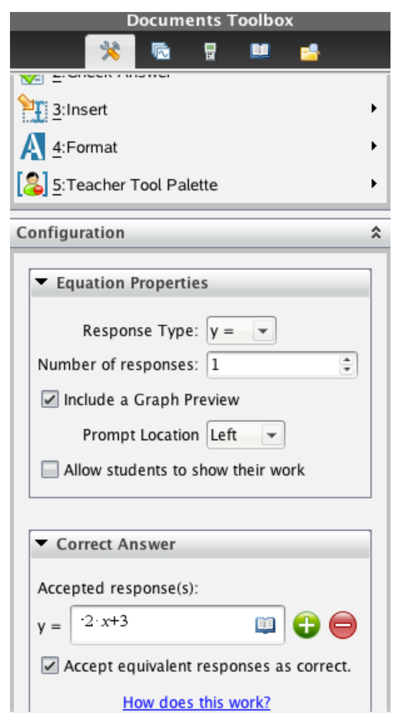
If desired, change the Tolerance from ±0 to ±0.001.

Note: Math templates and symbols can also be accessed by clicking the Utilities icon in the Correct Answer field.

Step 9:

Insert a new question by clicking **Insert** and selecting **Question > Equations and Expressions > *y* =**. Type the following problem into the question field.

Write the equation of a line whose slope is –2 and whose *y*-intercept is 3.



Step 10:

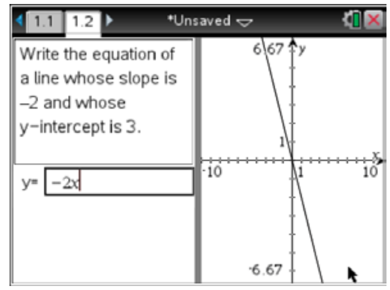
In the Configuration panel, under Equation Properties, check the box for **Include a Graph Preview**. In the Correct Answer field, type $-2x + 3$ as an accepted response. Check the box for **Accept equivalent responses as correct**.

Note: In the Configuration panel, under Equation Properties, the Response Type options include *y* = and *f*(*x*) = notation. The number of responses and prompt location can be changed, and students can be allowed to show their work in a series of blank fields.

Note: When might you choose not to check the box for **Accept equivalent responses as correct**?

Creating a Question Document
TI PROFESSIONAL DEVELOPMENT

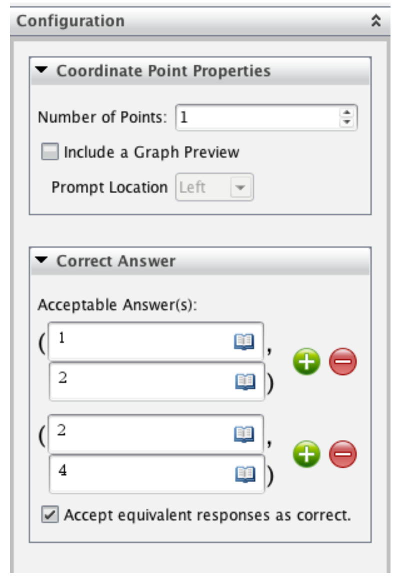
Note: By changing the Equation Properties to **Include a Graph Preview**, the page layout of the question is automatically changed and a Graphs application is inserted on the right side of the screen. When an expression is typed into the *y* = field, the function is automatically graphed. If Enter is pressed, another *y* = field appears.



Step 11:

Insert a new question by clicking **Insert** and selecting **Question > Coordinate Points & Lists > Drop Points**. Type the following problem into the question field.

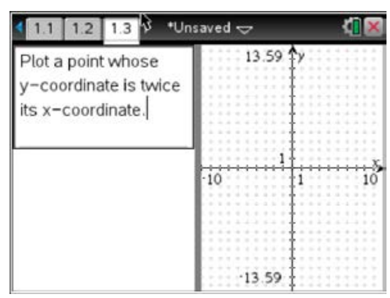
Plot a point whose *y*-coordinate is twice its *x*-coordinate.



Step 12:

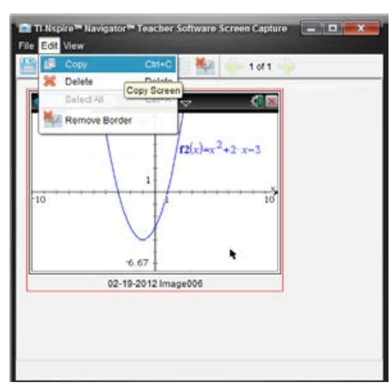
In the Correct Answer field, enter (1, 2) as an acceptable answer. Add an additional acceptable answer field by clicking the green addition icon. Enter (2, 4) as an acceptable answer. Check the box for **Accept equivalent responses as correct**.

Note: The **Drop Points** question type automatically includes a Graphs application with a grid.



Step 13:

Insert a Graphs page by clicking **Insert** and selecting **Graphs**. Graph the function $f1(x) = x^2 + 2x - 3$. Press **CTRL+J** to capture the graph. The image is automatically copied to the clipboard.

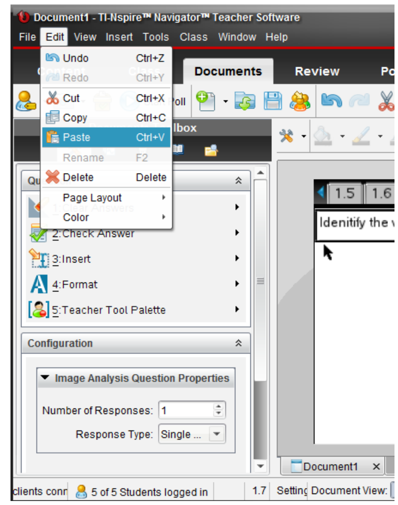


Step 14:

Insert a new question by clicking **Insert** and selecting **Question > Image > Point on**. Type the following problem into the question field.

Identify the zeros of the quadratic graphed below.

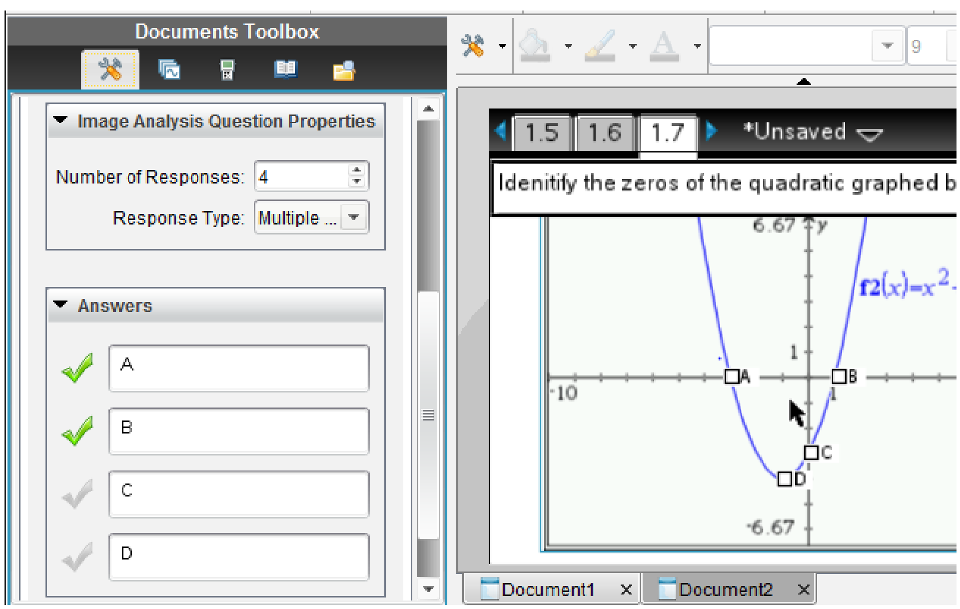
Click on the bottom half of the screen and choose **Edit > Paste** from the drop-down menu at the top of the screen.



Step 15:

In the Configuration menu change the number of responses to four. This will place four points on the image. Move the points so that two of the points are on the two *x*-intercepts, one is on the *y*-intercept, and the final point is on the vertex.

In the **Answers** menu, click the check boxes to identify the correct answer(s).



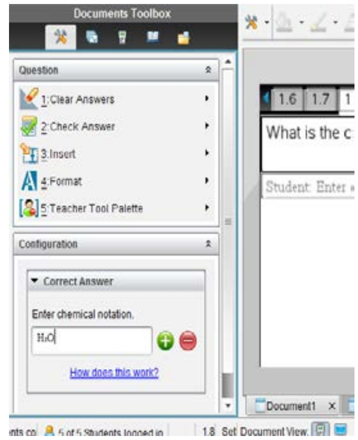
Note: Delete the extra Graphs page by changing to the Page Sorter View in the Documents Toolbox, right-clicking on the extra page, and selecting **Delete**.

Step 16:

Insert a new question by clicking **Insert** and selecting **Question > Chemistry**. Type the following problem into the question field:

What is the chemical formula for water?

In the Correct Answer field type H20. The Chem Box will automatically convert the "2" to a subscript. Chem Boxes can be used on Question and Notes pages to support chemical formulas.

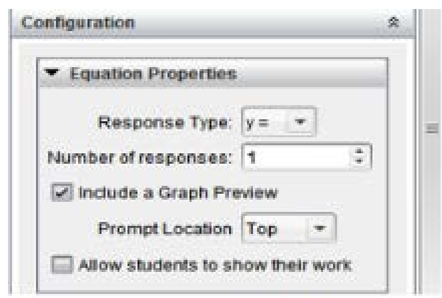


Note: Chemical symbols are automatically recognized. Subscripts are created automatically when numbers are typed after chemical symbols. Exponents are created by using $\boxed{\wedge}$. The equivalence arrow is created by pressing $\boxed{=}$.

Step 17:

Insert a Question application by clicking **Insert > Question.** In the **Equations and Expressions** question type**,** select ***y* =**.

To change the question properties in the Document Tools pane, go to the Configuration panel in the Equation Properties panel. Select **Include a Graph Preview** and change the **Prompt Location** to **Top**.

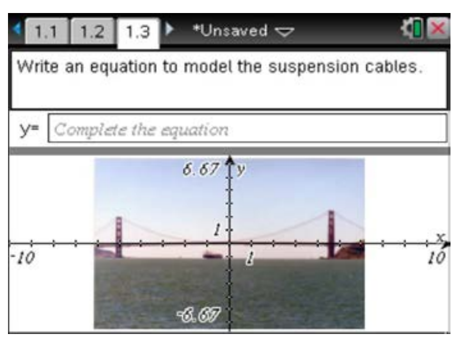


Note: To maximize the area of the Graph Preview, grab and move the gray bar separating the question and answer fields from the Graph Preview.

Step 18:

Insert an image into the Graph Preview by clicking the graph and then selecting **Insert > Image**. Choose **Bridge1.jpg** and click **Open**. Type the following problem into the question field.

Write an equation to model the suspension cables.



Save the document.

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

Data Collection – Getting Started

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

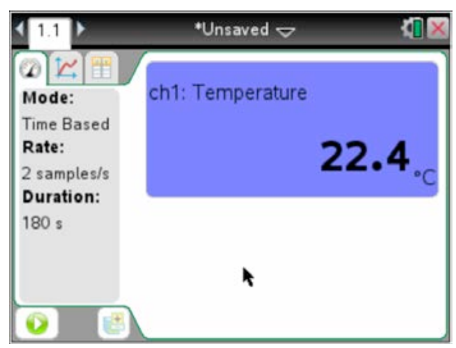
EasyTemp

EasyLink

TI-Lab Cradle

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

Data Collection – How Do I Collect Data?



There are three main methods of data collection:

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

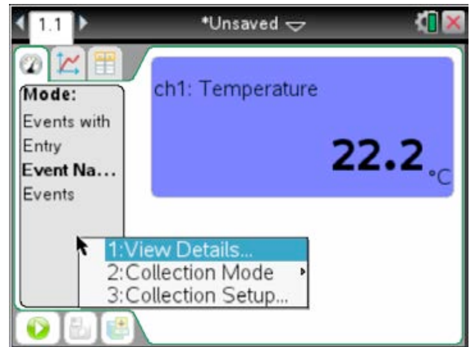
Using the Meter Window

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

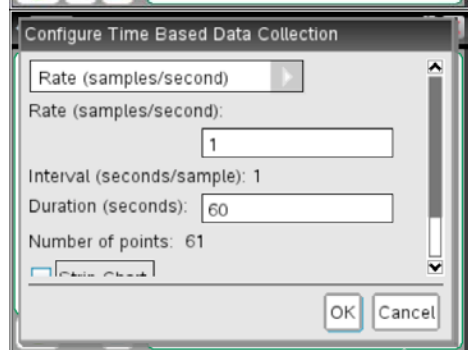
Performing a “Time-Based” Experiment

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

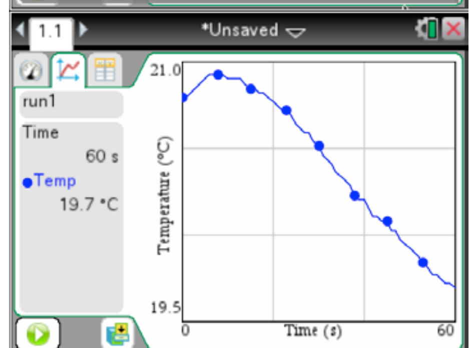
1. Be sure that the mode is set to "Time Based." (The fastest way to change the experiment mode is to "right click" on the **View Details** area on the left side of the screen. Perform a "right click" by pressing the **ctrl** button followed by the menu button.) Select **2:Collection Mode > 1:Time Based**.



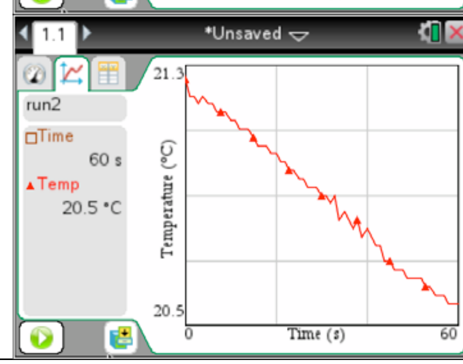
2. Now set up the parameters of how you will collect data in your experiment. For example, in the effervescent tablet experiment, we might want to view the temperature changes over a 60 second period. The rate could be set to 1 sample/second and the duration set to 60 seconds. Click OK when you are finished.



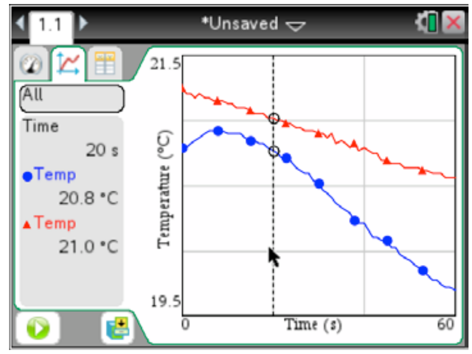
3. Click the **Play** button to begin collecting data. Once data collection begins the Meter view switches to the Graph view and then the graph will autoscale when data collection is complete. *(The graph at the right shows how the temperature changes as a tablet is added to 50 mL of room temperature water.)*



4. If you are finished with the experiment, press the **Stop** button. If not, store the first run of data by clicking the **Store** button. Press **Play** to collect a second run of data. *(The graph at the right shows how the temperature changes as a new tablet is added to a new sample of 100 mL of room temperature water.)*



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.

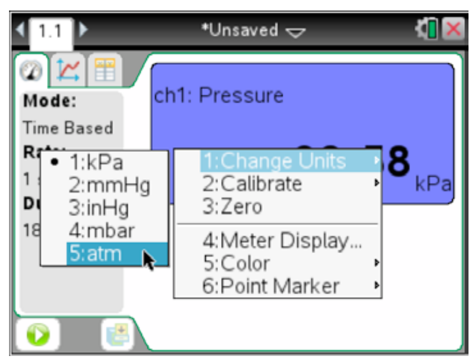


Later in this guide you will see how the Nspire can be used to analyze the data that you have collected in this mode.

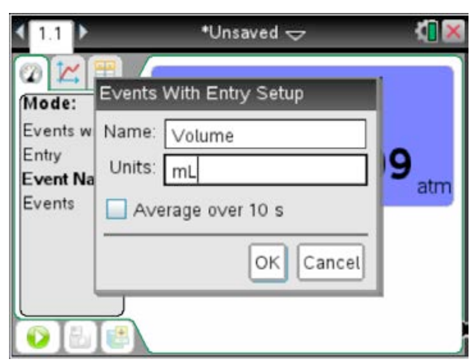
<u>Performing an “Events with Entry” Experiment</u>

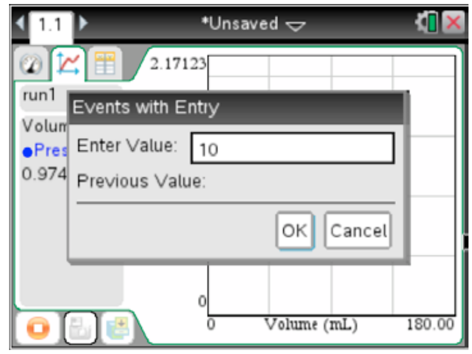
There will be some experiments in which time is NOT an important factor when collecting data. You may wish to collect data at one set of conditions and then under a different set of conditions. For example, what if you were interested in knowing the effect of changing the volume of a specific amount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

1. Before we set up the collection mode, it might be helpful to know that you can “right click” in other areas of the screen as well. For example, in this experiment we may want to change the default units for pressure (kPa) to atmospheres (atm). Simply press **ctrl** menu with the cursor over the **Meter** window, select **1:Change Units** followed by the preferred units.

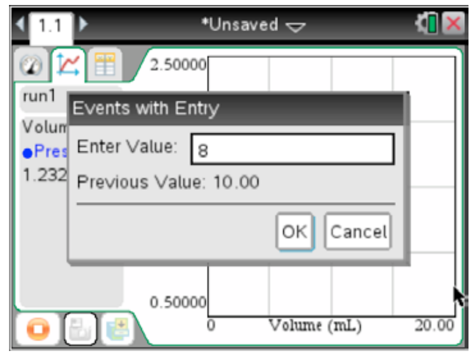


2. Okay, let’s set up the data collection mode. With the cursor in the **View Details** area, press **ctrl** menu and select **2:Collection Mode > 2:Events with Entry**. The “event” is the variable that you are manipulating. Input the appropriate name and units of the event and then click OK. In this case we are changing the volume of 10 mL of air trapped in a plastic syringe. We will be studying the effect of changing this volume on the pressure of the gas.

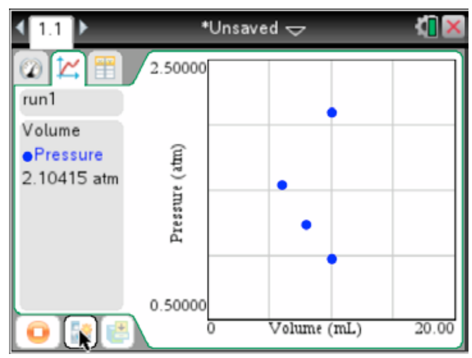




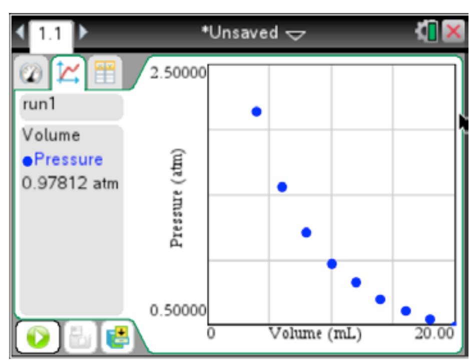
3. Click the **Play** button  to begin. Once data collection begins the Meter view switches to the Graph view. Notice that in this mode a new icon  is visible. This is the **Keep** button and it allows you to take a snapshot of the data when you are ready. *(The graph at the right shows what the screen looks like when the **Keep** button is pressed. The value of 10 mL is entered to represent the 10 mL of air trapped in the syringe.)*



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.)*

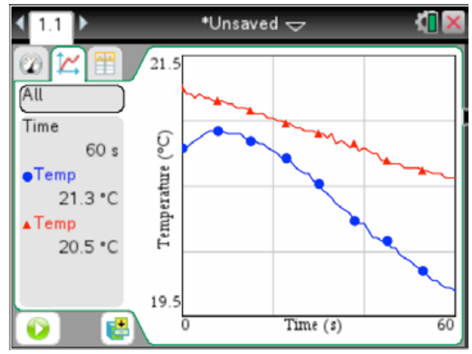


6. You have now finished recording data in Events with Entry mode. Notice that the button in the lower left corner of the screen has returned to the **Play** button. *(The screen at the right shows all of the Pressure and Volume data for a 10 mL sample of air.)*

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

Data Analysis

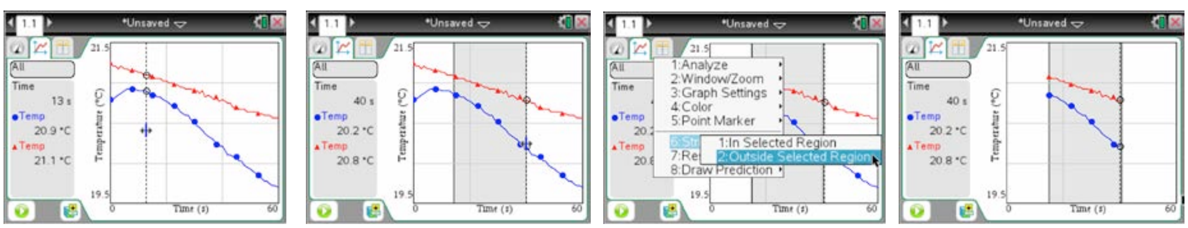
There are a few different tools available in the DataQuest application that make it very easy and quick to analyze the data that you have collected. Two important methods will be presented in this section.

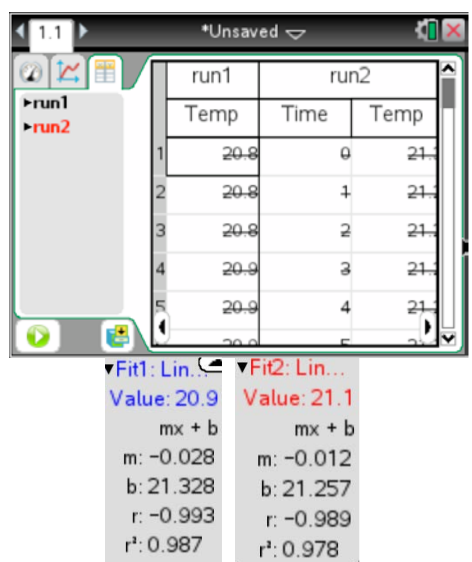


Method 1: Striking Data

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

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

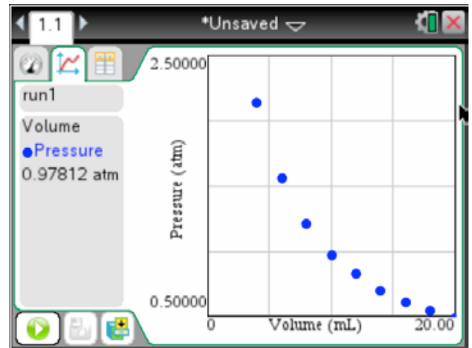




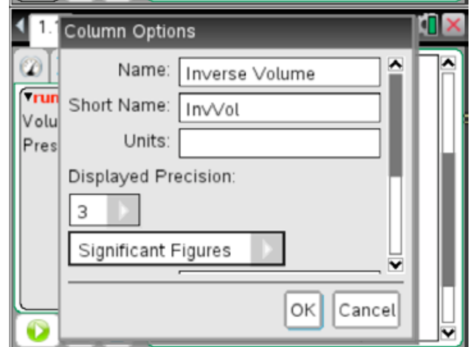
4. Don't worry. Your data is still there (as you can see from the Table view on the right). Striking data allows you to analyze just a portion of the data set without completing removing the information.
5. Now you are able to analyze each linear portion of the temperature graph to determine the different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

Method 2: Adding a Calculated Column in Table View

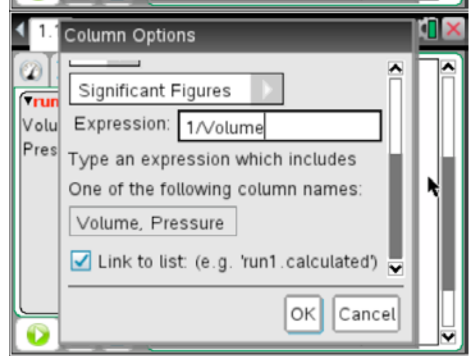
Getting back to the pressure/volume experiment, you'll recall that we created a curve of pressure versus volume values. To determine the equation of a graph, sometimes it is helpful to "linearize" the data. In this section we will explore how a new calculated column of data can be added in Table View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



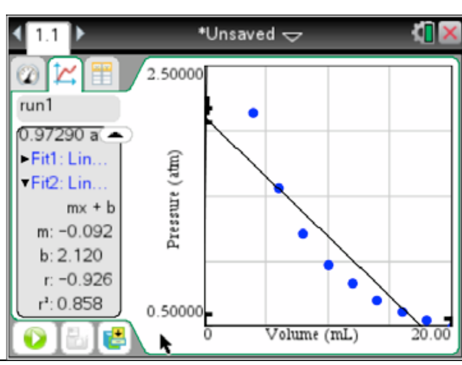
1. Click on the Table view tab . Then "right click" on the **View Details** area followed by **Add Calculated Column**.
2. Type in a name for the new column and any other fields that you find appropriate.

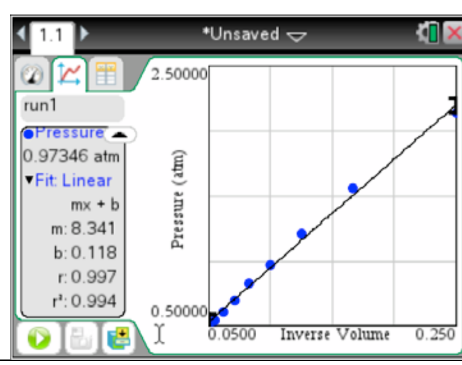


3. In the same window, scroll down until you see the **Expression** field. Enter the mathematical expression for the new column. (In this case, since it is possible to "linearize" the data by graphing Pressure vs. Inverse Volume, the expression entered is 1/Volume.) When finished click OK.



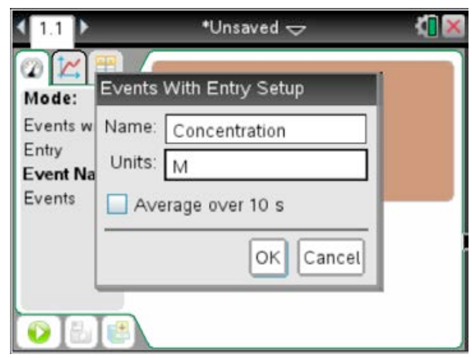
4. Click on the Graph view tab to analyze the data. Press **Menu > Analyze > Curve Fit > Linear**. Obviously the data of pressure vs. volume do not fit the line created as is evidenced by the poor r^2 value of 0.858. (Data points with a good linear fit show an r^2 value of 1.00.)
5. Click on the x-variable at the bottom of the graph (in this case, volume) and select the calculated column variable (inverse volume). Now we have a very linear graph and we can see that Pressure = 8.341 * (1/Volume) + 0.118.



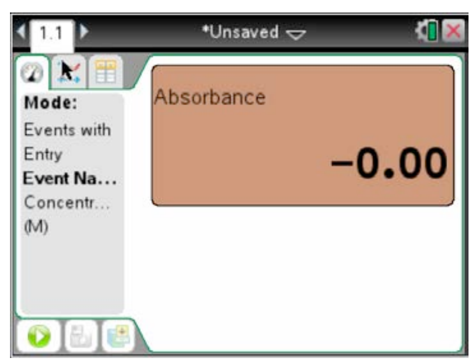


Data Collection and Analysis – Using the Colorimeter

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

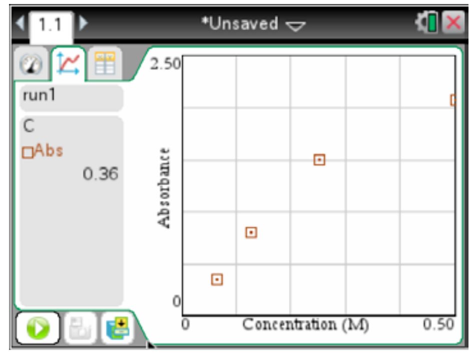


1. Connect the colorimeter to the Nspire using an EasyLink cable or a TI-Lab Cradle.
2. Select an appropriate wavelength of light to be used in the experiment by pressing the left or right arrows on the colorimeter. (You will want to use a different color other than the color of the solution. For example, if we passed green light (565 nm) through a green solution, most of it would be absorbed and we wouldn't see much difference in the data. An ideal color of light to pass through a green solution would be red (635 nm).)
3. With the cursor in the **View Details** area, press **ctrl** menu and select **2:Collection Mode > 2:Events with Entry**. Enter the variable name for the event (usually Concentration) and the appropriate units and click OK.

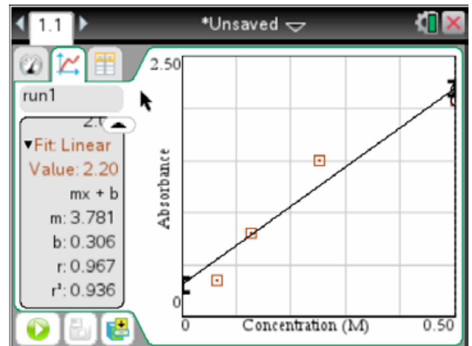


4. Now the device must be calibrated with the solvent being used in the solutions. Fill a plastic cuvette about ¾ with the appropriate solvent (most likely this will be water) and place the cuvette in the holder inside the colorimeter. It is important that one of the smooth sides of the cuvette is pointed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

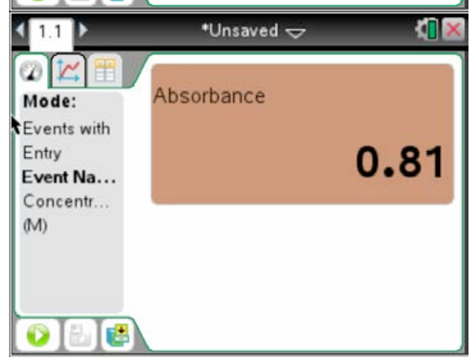
5. When ready to begin collecting data, press **Play** . Replace the water cuvette with the first sample of known concentration being tested. Close the door, wait for the absorbance reading to stabilize, and then press Keep . Input the concentration of the known solution and press OK. Remove the first sample, replace it with the second sample, close the door, and press **Keep**. Repeat this process with the other samples of known concentration. When you are finished with all of the samples of known concentration, press Stop . *(The screen to the right shows absorbance readings for known solutions with concentrations of 0.500M, 0.250M, 0.125M and 0.0625M.)*



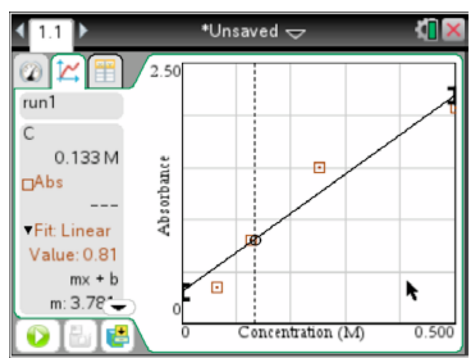
6. Find the best fit line through the data points. To do this press **Menu > Analyze > Curve Fit > Linear**.



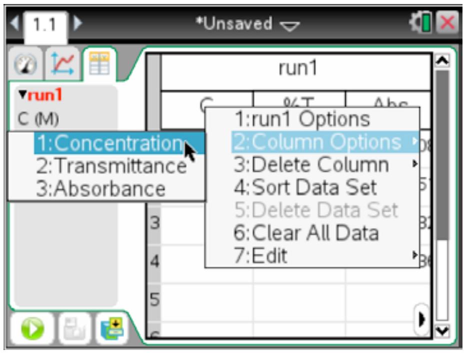
7. Put the sample of unknown concentration in the colorimeter and close the door. Note the absorbance reading once it stabilizes.

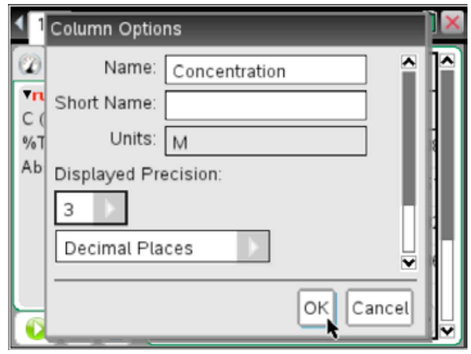


8. To determine the concentration at this absorbance click in the Graph view tab (at the top left of the screen). Then press **Menu > Analyze > Interpolate**. Click somewhere in the graph to see a vertical line. Press the left or right side of the touchpad to move the line around on the graph. When you have moved the cursor to the appropriate place the Fit Linear Value will correspond to the absorbance of the solution. You will then be able to read the concentration value at the top of the **View Details** window. (Note that since the unknown solution showed an absorbance of 0.81 the vertical line was moved into place until the Fit Linear Value was also 0.81. The concentration at this absorbance was 0.133 M.)



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





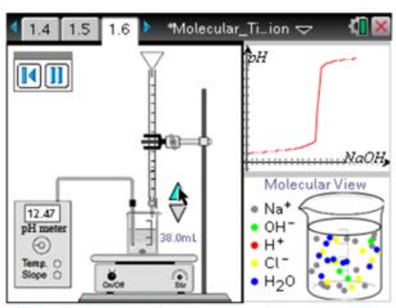
In Conclusion:

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

For further information about other applications within the TI-Nspire handheld, visit:
http://www.atomiclearning.com/k12/en/ti_nspire

For further information about the Vernier sensors that you will use with these experiments, visit:
http://www.vernier.com/products/sensors/

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



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

Example Shown: Molecular Titration Simulator

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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, Science Nspired, and TI-Math. You will search for activities using the Standards Search and Textbook Search, and you will explore additional information regarding professional development.

Materials

- Computer with Internet connection

Step 1:

Go to **education.ti.com > Downloads & 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:

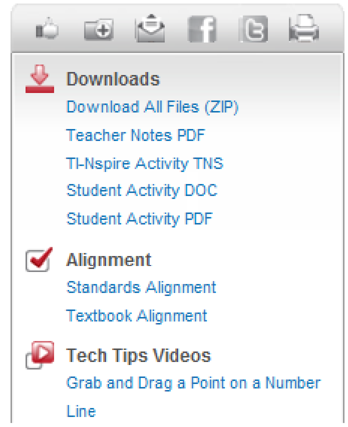
Select a unit from the list. When a unit is selected, a table appears with an image from each activity. The table contains links to download, recommend, and save each activity. It also identifies each activity type:

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.

Online Resources

TI PROFESSIONAL DEVELOPMENT

Step 3:

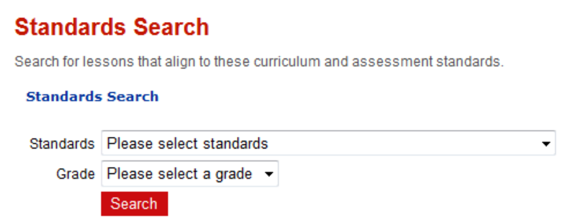


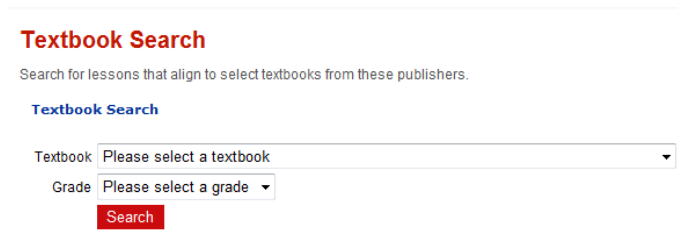
Select an activity from the list. The activity page shows objectives, relevant vocabulary, and additional information. A video offers a preview of the lesson, and related lessons are recommended below.

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

Step 4:

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





Step 6:

Go to **Downloads & Activities > TI Math**, which can also be accessed directly at www.timath.com. Featured TI-Nspire™ and TI-84 Plus activities for various subjects appear in the center of the page. Links to activity archives for each subject appear on the left. Click one of the featured activities.

Step 7:

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

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

The Webinars page contains links to upcoming, free PD webinars. The Archive page contains recordings of past webinars. Associated webinar documents are available for download.

Step 8:

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

TI graphing calculators are permitted on important college entrance exams.

education.ti.com/go/testprep

TEXAS INSTRUMENTS

TI-Nspire™ CX	TI-Nspire™ CX CAS	TI-Nspire™	TI-Nspire™ CAS	TI-84 Plus C Silver Edition	TI-84 Plus Silver Edition	TI-84 Plus	TI-83 Plus	TI-89 Titanium
SAT*	SAT	SAT	SAT	SAT	SAT	SAT	SAT	SAT
AP*	AP	AP	AP	AP	AP	AP	AP	AP
ACT®*		ACT		ACT	ACT	ACT	ACT	
IB®* Exam		IB Exam		IB Exam	IB Exam	IB Exam	IB Exam	
Praxis™*		Praxis		Praxis	Praxis	Praxis	Praxis	

SAT*

MAY 2013	JUN 2013	OCT 2013	NOV 2013
4	1	5**	2**

DEC 2013	JAN 2014	MAR 2014	MAY 2014
7**	25**	8**	3**

For deadlines and registration, visit **collegeboard.com/testing**.

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

ACT®*

JUN 2013	SEP 2013	OCT 2013	DEC 2013
8	21	26	14

FEB 2014	APR 2014	JUN 2014	SEP 2014
8***	12	14	13

For deadlines and registration, visit **act.org**.

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

AP*

MAY 2013	MAY 2013	MAY 2013	MAY 2013
6 Chemistry	8 Calculus AB/BC	10 Statistics	13 Physics B/C

MAY 2014	MAY 2014	MAY 2014	MAY 2014
5 Chemistry	7 Calculus AB/BC	9 Statistics	12 Physics B/C

For deadlines and registration, visit **apcentral.collegeboard.com**.

International Baccalaureate®* (IB) Exam/Praxis™*

For information on the IB test and test dates, visit ibo.org.

For information on the Praxis test and test dates, please visit ets.org/praxis.

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

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T^3 Ticket Outta Here

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What went well today?

What caused you difficulty?

More of ?

Less of ?

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I have learned …

My question is …

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I have learned …

My question is …

My next steps are …

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