Physics with TI-Nspire™ and TI-Nspire™ Navigator™ – Day 1

I can…	TI-Nspire™ Handheld (HH) Data Collection (DC) TI-Nspire™ Navigator™ (Nav)
Login to class.	HH
Open a transferred TI-Nspire™ document.	HH
Grab and drag an object.	HH
Move from page to page.	HH
Locate specific keys on the TI-Nspire™ keypad.	HH
Open a new document.	HH
Add an application to a new document.	HH
Collect data using a temperature sensor.	HH/DC
Perform basic calculations.	HH
Graph a function.	HH
Use the Scratchpad and return to a document.	HH
Open a simulation and complete the task.	HH
Use a motion detector and match a given graph.	HH/DC

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Student Login
TI PROFESSIONAL DEVELOPMENT

Objective

- Participants will learn how students log in to a TI-Nspire™ CX Navigator™ class.

TI-Nspire™ CX Navigator™ Features

- Logging in to the TI-Nspire™ CX Navigator™ System from a handheld

TI-Nspire™ Technology Skills:

- Logging in as a student

Tech Tips:

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

The TI-Nspire™ CX Navigator™ System uses both your computer and your students' handhelds. Your computer and your students' handhelds communicate through the TI-Nspire™ CX Navigator™ access point.

You do not have to begin a class and have students log into the TI-Nspire™ CX Navigator™ network to communicate with your students' handhelds. Without beginning a class, you can use the Transfer Tool to send or delete documents and/or operating systems on the students' handhelds. However, if you plan to use Quick Poll, Class Capture, Live Presenter, or place documents in the Portfolio during the TI-Nspire™ CX Navigator™ class session, then you must log in student handhelds to the TI-Nspire™ CX Navigator™ network.

1. On the teacher computer, within the TI-Nspire™ CX Navigator™ Teacher Software, press Begin Class.
2. Turn on the handheld that is connected to a wireless network adapter (or locked in the cradle). You will notice the following icons on the handheld in the upper right hand corner.

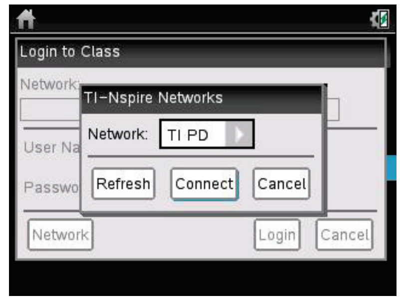
Icon	Status	Meaning
	Blinking	The handheld is searching for an access point.
	Solid with ✓	The handheld has found an access point.
	Solid with a warning sign	The handheld is not communicating with the wireless network adapter. Detach the handheld from the wireless adapter, wait for the icon to disappear, and then reattach the handheld to the adapter.
	Blinking	The handheld is connected to the network and is ready to log in.
	Solid	The handheld is logged in to the network and is fully charged.

Student Login

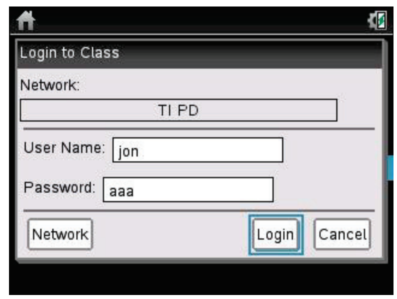
TI PROFESSIONAL DEVELOPMENT

3. When the icon appears in the upper right-hand corner of the handheld, a "Login to Class" dialog box will appear.
   - If the dialog box does not appear, have students press [on] > **Settings > Login….**

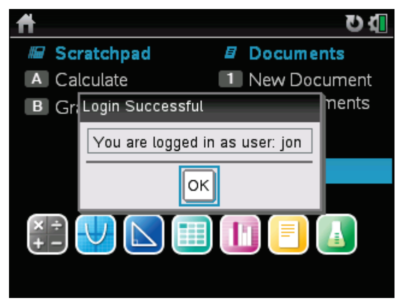
4. When logging in for the first time, a network must be selected. Click the **Network** button, select the appropriate network from the Network drop-down field, and click **Connect**.
   - A network only needs to be selected once, not every time a handheld is logged in.



5. Students will first enter their User Name, press [tab], and then enter their Password.
   - Passwords must be at least 3 characters. The teacher might have chosen the student password when setting up the class.



6. Press [enter], and the "Login Successful" dialog box will appear on the handheld.



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.”

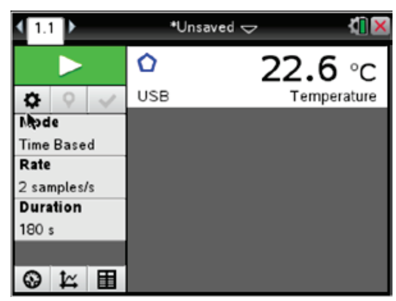
A new document will appear. Though you have the opportunity to add one of the seven built-in TI-Nspire applications, do not select an application at this time.

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 <u>then</u> 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 these icons represent? 

Introduction to Data Collection

TI Professional Development

Step 4:

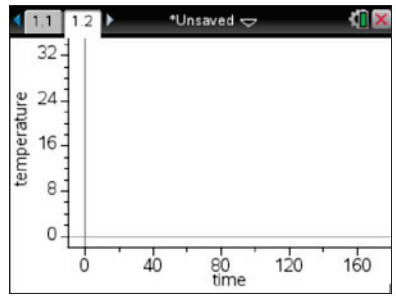
Let the temperature probe reach room temperature. Note your measure of the temperature of the room and compare it with others around you.

- 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.

Prepare to start collecting the data by pressing [tab] until the **Start Collection** button at the top of the screen is highlighted. Start heating the probe. Then press [enter]. Alternately, you can hover the cursor over the Start Collection 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 Start 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 check appears. Clicking this will store the latest data set.

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, use the Touchpad to position the pointer over the TableView 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:

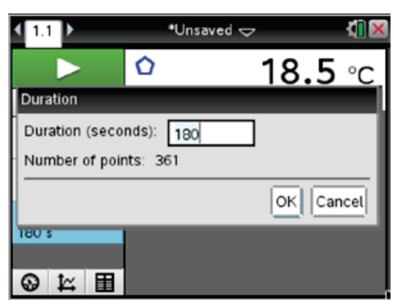
To save the results from the first experiment, use the Touchpad to position the pointer over the Store latest Data icon and press .

- What changes do you notice on the screen?

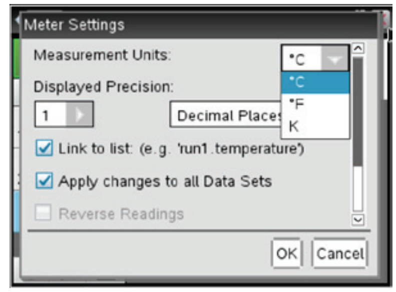
Step 11:

Now design an experiment that will cool the temperature probe.

Consider changing some of the options by clicking an area of interest (Mode, Rate, Duration, Settings). For example, change the default settings of three minutes by clicking on Duration and entering a new value (in seconds).



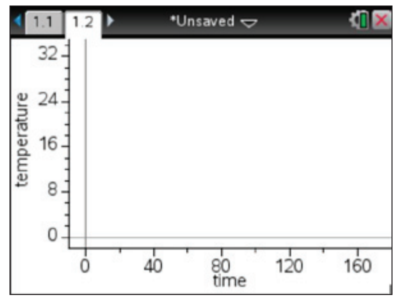
Note that these options are also under the menu. Based on what you learned in the heating experiment, adjust the settings as needed for your cooling experiment.



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 Start button ▶, and press enter to start.

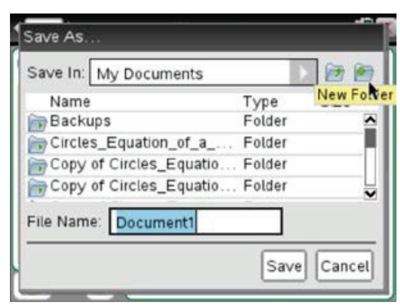
Step 14:

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 as a document, press ctrl S, name the document, and select a folder to place it in. If necessary, create a new folder.



How Does It Stack?

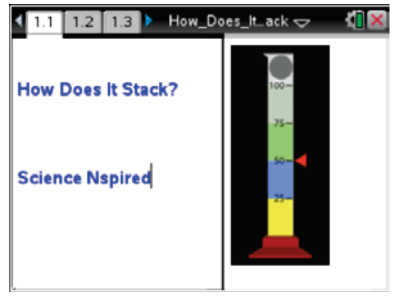
Student Activity

Name ________________

Class ________________

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

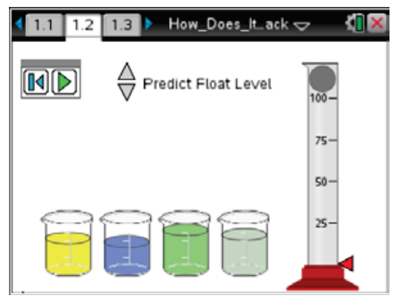
Have you ever wondered why ice floats in water? Do you know why a mixture of oil and vinegar eventually separates? Have you wondered why a rock sinks in water, while polystyrene foam floats? In this activity, you'll use a simulation to explore these questions.



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.

1. Each beaker has a different mass and volume of a solution. You may need to reveal the information, depending on the technology you are using. **IMPORTANT: If you click or tap on the beaker, the liquid will be "poured" into the cylinder, forcing you to reset and start over.**



Tech Tip: To reveal the mass and volume, hover over the beakers. Be careful not to "select" them, as the liquid will be poured into the cylinder. If this happens, you will need to reset, and start over.

Tech Tip: Selecting the button will reset the simulation and ALL the masses and volumes of ALL the liquids in the beakers change. You will need to start over.

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

How Does It Stack?

Student Activity

Name _______________

Class _______________

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

What is the formula for calculating density? ______________________________

> **Tech Tip:** Press [Scratchpad] to use Scratchpad instead of moving between pages 1.2 and 1.3 to perform calculations.

Container 1	Container 2	Container 3	Container 4
Density: __________ Order___	Density: __________ Order___	Density: __________ Order___	Density: __________ Order___

3. Once you have determined the densities, return to page 1.2 and click on the beaker containing the solution that will settle to the very bottom of the cylinder. Then, continue to "pour" the liquid from each beaker into the cylinder in the order in which they will settle. If you are correct, indicate the order of how the liquids settled- 1 being at the top, 4 being at the bottom.
***If you select an incorrect order, you will receive a Goat. Reset [Reset] the page and try again. Use the multiple trials space at end to record new data. Go back to step #1.*

4. Hover the cursor (or it may already be evident) 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 cylinder. **Be careful with this prediction—if you are wrong, you will have to start over!**

7. Click the play button [Play] 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 [Reset] and try again until you receive the Gold Star. You will need to start all over again, and use the space at end for multiple trials. Go back to step #1.*

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

How Does It Stack?

Student Activity

Name ______________

Class ______________

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

If you make a mistake, and receive "The Goat", you will need to start over. Use the following space to record your data for multiple trials. If you need more space, use the back of your paper for more trials.

Try #2:

Container 1	Container 2	Container 3	Container 4
Mass: ____________ Volume: __________ Density: __________ Order___	Mass: ____________ Volume: __________ Density: __________ Order___	Mass: ____________ Volume: __________ Density: __________ Order___	Mass: ____________ Volume: __________ Density: __________ Order___
Solid Ball: Mass: ___________ Volume:___________		Density of the Ball: __________	

Try #3

Container 1	Container 2	Container 3	Container 4
Mass: ____________ Volume: __________ Density: __________ Order___	Mass: ____________ Volume: __________ Density: __________ Order___	Mass: ____________ Volume: __________ Density: __________ Order___	Mass: ____________ Volume: __________ Density: __________ Order___
Solid Ball: Mass: ___________ Volume:___________		Density of the Ball: __________	

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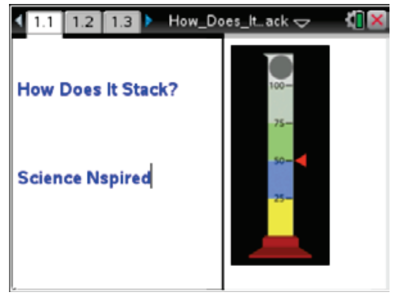
How Does It Stack?

TEACHER NOTES

SCIENCE NSPIRED

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

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.

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

- 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

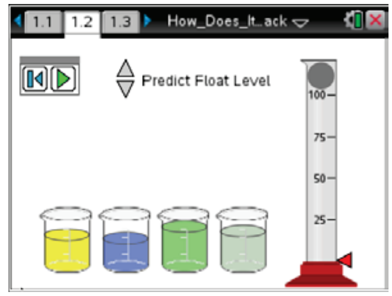
- How_Does_It_Stack_Student.doc
- How_Does_It_Stack_Student.pdf

TI-Nspire document

- How_Does_It_Stack.tns

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/tap 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.

Tech Tip: The directions presented to students are slightly different on this platform. The mass and volume data is also displayed automatically.

Tech Tip: Selecting the button will reset the simulation and ALL the masses and volumes of ALL the liquids in the beakers change. The students will basically have to start over again.

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: $\text{density} = \dfrac{\text{mass}}{\text{volume}}$.
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. They are asked to record the order of the solutions—1 to 4 (most dense/bottom).**
   If the student is not successful, he/she will get a "Goat" and will have to reset the page to start over. Be sure they understand with each mistake, they will have to go back to step #1.
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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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.

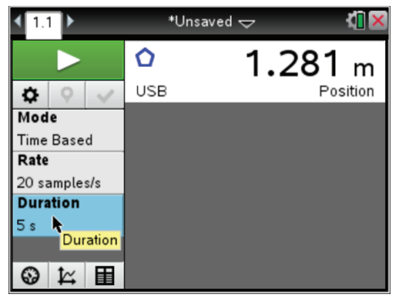
Materials

- 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. The Vernier DataQuest™ app for TI-Nspire will automatically launch.

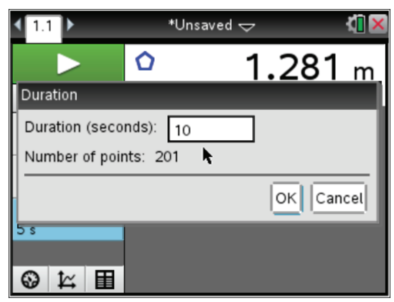


Hold the CBR 2 so that it points toward a smooth surface like a wall or door. Move forward and backward to observe the reading changes on the meter.

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. Move the cursor over the **Duration** area at the left and click (see screen shot). A dialog box will appear. Change the duration to 10 seconds.

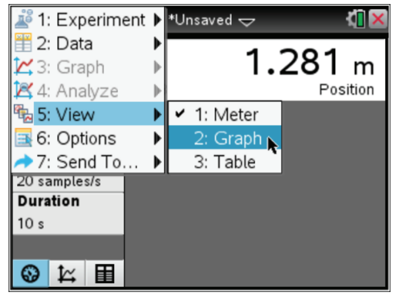


Match Me
Student Activity

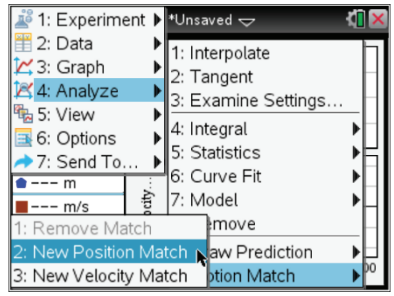
Name ______________

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. (Alternatively, you can click on the Graph View icon at the bottom of the screen.)



Press **Menu > Analyze > Motion Match > New Position Match**. (Or, hover over the graph and press **ctrl > Menu > Motion Match > New Position Match**.)



2. What physical quantity is the dependent variable?

   ____

   A. velocity in meters/second

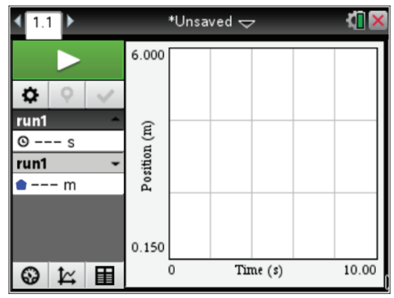
   B. position in meters

   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?

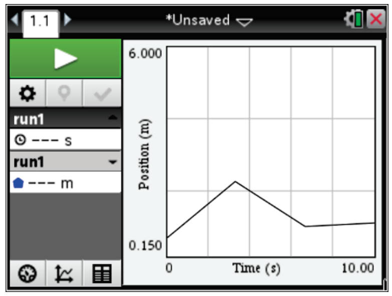
   c. At approximately what distance from the wall should the motion detector be located to match the initial position in the motion graph?

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

7. Click the **Start Collection**  arrow in the upper-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 **Enter** 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.

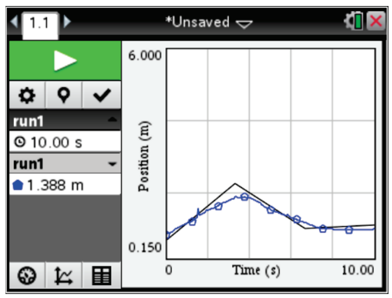
8. Describe the parts of your graph that were difficult to match and how you made adjustments, based on your graph of your walk, to make a better match in your next attempt.

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 clicked. 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 s to 4 s, the person moved too slowly to reach maximum distance – a little over 2 m from the wall.*



Part 2—Extend and Explore

Select **Menu > Analyze > Motion Match > New Position Match**. Click **Start Collection** and walk to match the graph. A trial can be saved by Clicking the **Store latest Data Set**  icon below 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

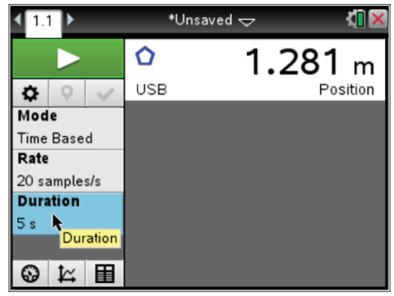
- speed
- velocity
- initial position

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 & Troubleshooting Tips:

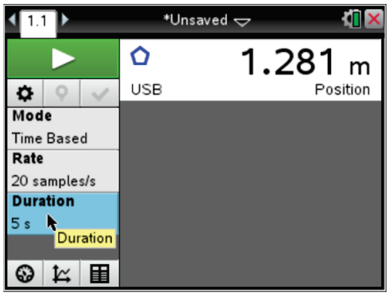
1. Flip the motion detector open. Set the switch to normal.
2. Check that the four AA batteries in the motion detector are good.
3. Unplug and plug the CBR 2™ back in.
4. When using an older CBR or motion detector with the TI-Nspire™ Lab Cradle, you might need to launch the Vernier DataQuest™ app. Then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

Lesson Files:

Student Activity

- Match_Me_Student.pdf

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.

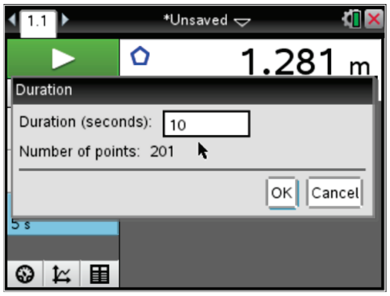
> **Tech Tip:** The Vernier DataQuest app is user-friendly. It should launch when the CBR 2 is connected. To begin the data collection, click the green **Start Collection**  arrow in the upper-left corner of the screen. Or press **Tab** until the start arrow is highlighted, and then press **Enter** when ready.

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 1.281 m from the wall or closest object.

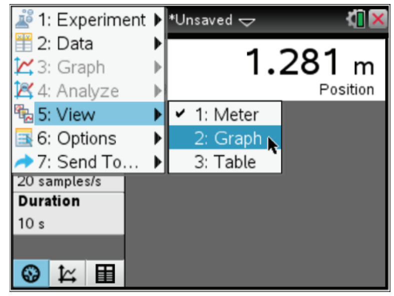
> **Teacher Tip:** When the CBR 2 is first connected, it begins clicking and displays a measurement. Have the students move the CBR 2 by pointing it at different objects. Ask them what the motion detector is doing. It should be measuring the distance from the CBR 2 to the object directly in front of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

You will set up an experiment for 10 seconds. Move the cursor over the **Duration** area at the left and click (see screen shot). A dialog box will appear. Change the duration to 10 seconds.

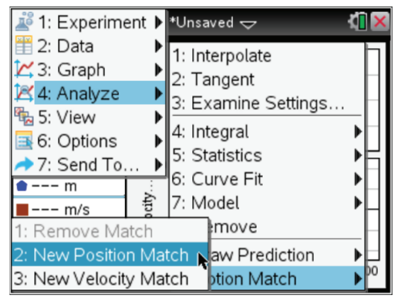


> **Teacher Tip:** Settings can be changed in the DataQuest™ application by clicking on the appropriate position in the window. Many menu options can also be accessed by pressing **ctrl > Menu** while the cursor is on the window position of interest.

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. (Alternatively, you can click on the **Graph View** icon at the bottom of the screen.)



Select **Menu > Analyze > Motion Match > New Position Match**. (Or, hover over the graph and press **ctrl > Menu > Motion Match > New Position Match**.)



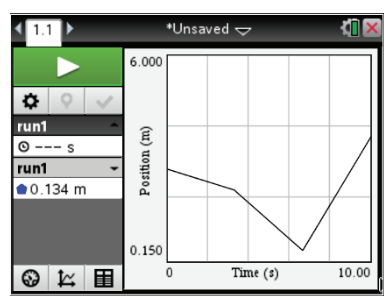
2. What physical quantity is the dependent variable?
   A. velocity in meters/second
   B. position in meters
   C. time in seconds

   Answer: B. position in meters

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

   Sample Answer: The time in seconds, the independent variable, is plotted on the *x*-axis.

Draw your Position Match on the graph to the right.



Answer: Student graphs will vary because the Vernier DataQuest app automatically generates new graphs based on the collected data.

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 6 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 might 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 might 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 the target.

> **Teacher Tip:** It is important for students to make a prediction before simply starting to collect data. Making predictions and testing those predictions supports higher-level thinking.

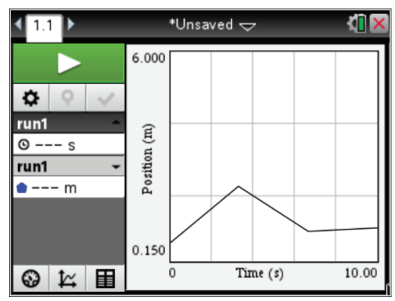
7. Click the **Start Collection**  arrow in the upper-left corner of the screen. Point the CBR 2 at a wall, and move back and forth until your graph matches the Position Match graph as closely as possible. If you are not pleased with your first attempt, press **Enter** to repeat. You might want to review 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.

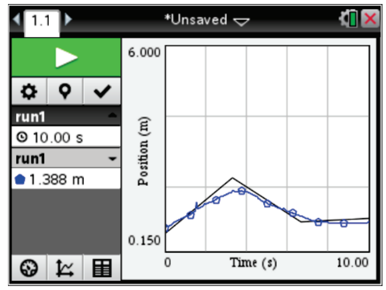
Now, look at the graph shown at the right.



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 about 0.8 m from the wall and moves away from the wall at a constant velocity for about 3.3 s. The walker gets about 2.2 m from the wall and then begins walking toward the wall at about the same rate for another 3 s, arriving back at 1.0 m from the wall. The walker then begins to slowly move away from the wall until a total time of 10 s has elapsed. The slopes of the first two sections appear to indicate the same speed, but the first of these velocities is positive, while the second is negative. The walker moved slowest during the time period from 7 to 10 s.

10. Describe the graph with the round dots at the right that was created when **Start Collection** was clicked. 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 s to 4 s, the person moved too slowly to reach maximum distance – a little over 2 m from the wall.*



<u>Sample Answer</u>: Answers will vary but might include the following information: The walker began a very little too far from the wall, so the *y*-intercept value is slightly more than it should be. The walker was moving too slowly so did not get far enough away from the wall when it was time to turn back. The walker was moving at about the right velocity for the second section of the graph, but stopped for the final position instead of slowly backing away again.

> **Teacher Tip:** If time permits, you should have each student match a graph without coaching. You might 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

Select **Menu > Analyze > Motion Match > New Position Match**. Click **Start Collection**, and walk to match the graph. A trial can be saved by clicking the **Store Latest Data Set** ✓ icon below Start.

11. Discuss your new match with a classmate.

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

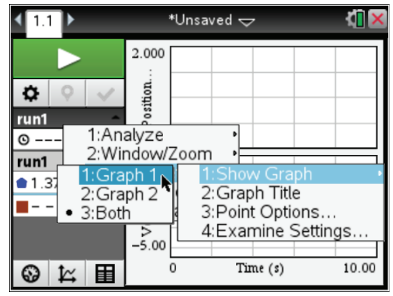
Teacher Extension

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.

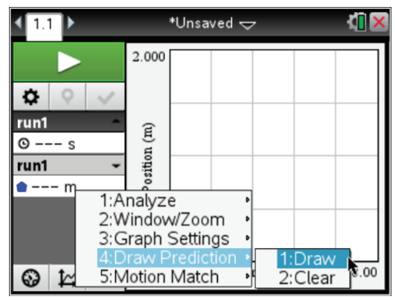
1. Open a new TI-Nspire document and then connect the CBR 2 data collection device.

2. You will set up an experiment for 10 seconds. Click on the Duration window. Change the duration to 10 seconds.

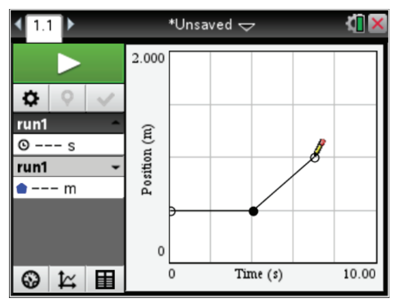
3. Now, set up the graph. Click on the Graph View icon at the bottom. Then, move the cursor over the graph space and select **ctrl > Menu > Graph Settings > Show Graph > Graph 1**.



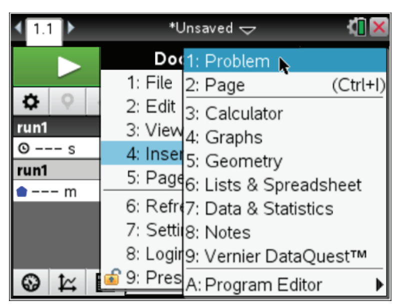
4. To draw your own graph to be matched, move the cursor over the graph space, and select **ctrl > Menu > Draw Prediction > Draw**.



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** (move the cursor over the graph space and select **ctrl > Menu > Graph Settings > Show Graph > Graph 2**).



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