



Getting Started with TI-Nspire™ Physics

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The TI-Nspire Classroom

Equivalent Expressions

Which expression is equivalent to $3(8x-2y+7)$?

23%* A. $24x-2y+7$

33% B. $24x-6y+21$

26% C. $8x-6y+21$

18% D. $11x-5y+10$

Michigan 2007, Gr. 8

Albert wants to simplify the expression: $8(3-y) + 5(3-y)$

Which of the following is equivalent to the expression above?

29% A. $39 - y$

40%* B. $13(3 - y)$

7% C. $40(3 - y)$

24% D. $13(6 - 2y)$

(Florida 2006, grade 9)

Exponential growth/decay

Which equation describes the relationship between x and y

16% A. $y = 0.5^x$

15% B. $y = 1/2^x$

18% C. $y = 2^{-x}$

46% D. All of the equations shown

describe the relationship between x and y.

x	y
-4	16
-2	4
0	1
2	0.25

(Maine 2006, 46% correct)

(memorization, rather than understanding)

The Challenge:

For many students ideas may “stick” for the moment but do not stay or transfer to new situations

TI Nspire: A Possible Solution

- Use technology to provide different learning experiences that allow students to interact with the mathematics in new ways.
- Structure lessons that take account of well documented trouble spots.
- Ask questions that reveal student thinking - questions that promote reasoning and sense making.

Research suggests

Students learn if

- they are actively involved in choosing and evaluating strategies, considering assumptions, and receiving feedback.
 - they encounter contrasting cases- notice new features and identify important ones.
 - Struggle with a concept before they are given a lecture
 - Develop both conceptual understandings and procedural skills
- National Research Council, 1999
- NCTM High School Focal Points suggest reasoning and sense making should be the central focus of high school math

Strengthening the practice of formative assessment produces significant learning gains

(Black & William, 1998)

“...when teachers learn to see and hear students’ work during a lesson and to use that information to shape their instruction, instruction becomes clearer more focused and more effective.”

NRC, 2001, p 350

A “TI-Nspired” Teacher

- Asking Questions
- Facilitating Discussion
- Asking Questions
- Assessing Student Understanding
- Asking Questions
- Shaping Instruction Based on What Students are Thinking

A “TI-Nspired” Student

- Engaging in Inquiry
- Making Conjectures
- Building Sense-Making

What is the math/science?

Why does it work?

A “TI-Nspired” Classroom

- Promote classroom discourse.
 - Often, teachers ask a short question, one student gives a short answer, and then the teacher moves on.
- Probe deeper:
 - Ask “Why?”
 - Ask for students to reason things out.
 - Have students comment on other students’ comments.

Pedagogical Foundation:

Students **learn mathematics** by

- taking mathematical actions on mathematical objects,
- observing the mathematical consequences, and
- reflecting on their meanings.

Types of Activities:

- Action/Consequence/Reflection
- Investigative Activities
- Simple “how to” lessons
- Focus on asking questions that generate reasoning and sense making about the mathematics

10 | TI Society Private

Goals of the Workshop:

- Getting started using the TI-Nspire handheld and TI-Nspire Computer Software – Teacher Edition
- Understand the power and potential of TI-Nspire technology’s key content and pedagogical features
- Recognize that TI-Nspire provides opportunities for students to engage in reason and sense making, and making connections
- Recognize the implications of having students create and use their own documents, along with the value of exploration and investigation using pre-made documents



Core Belief for TI-Nspire

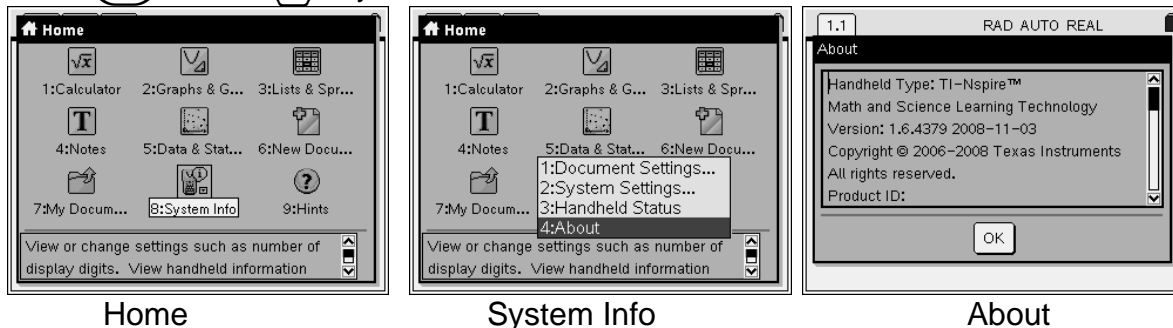
Educators who appropriately and effectively integrate TI-Nspire into their activities and lessons with peers and students will enhance both the teaching and learning of mathematics and science, leading to increased student achievement.

Your active participation in this institute will provide you with content insights, questioning strategies, and technology skills to support your success with TI-Nspire.

Checking and Updating OS on Handheld

Checking TI-Nspire OS

Press  Home  System Info



System Info opens a menu that enables you to view and change document and system settings. You can also view detailed information about your handheld and its battery status.

Viewing handheld details on the About screen

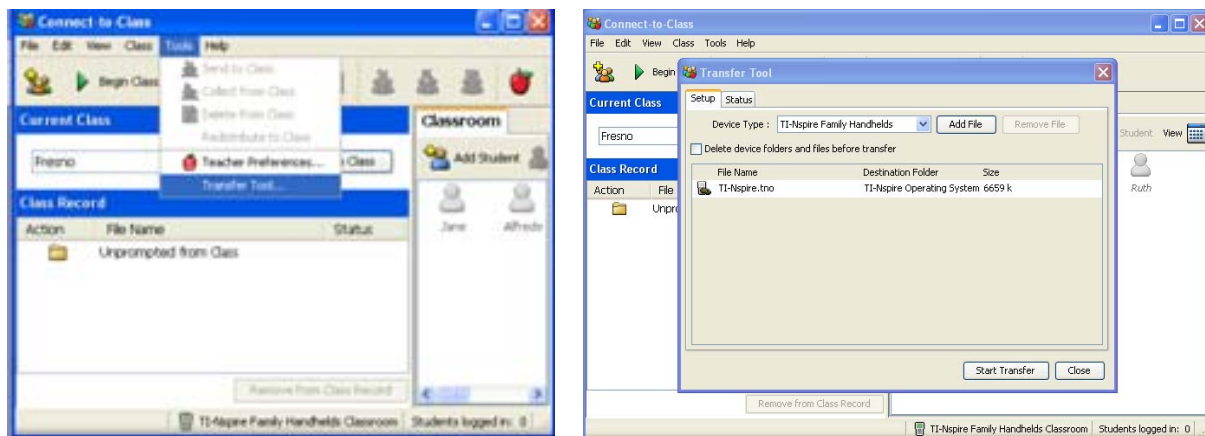
The **About** screen displays information about the TI-Nspire™ handheld type, the operating system (OS) version, and product ID.

For information regarding OS updates, see the chapter *Transferring Files* in the electronic version of the handheld guidebook. This guidebook is available on the Texas Instruments web site: <http://education.ti.com/guides>.

Using Connect-to-Class to Update the Handheld OS

Note: Connect-to-Class can be configured to either manually or automatically check for updates to the software and handhelds. See the Connect-to-Class Reference book or the Help menu.

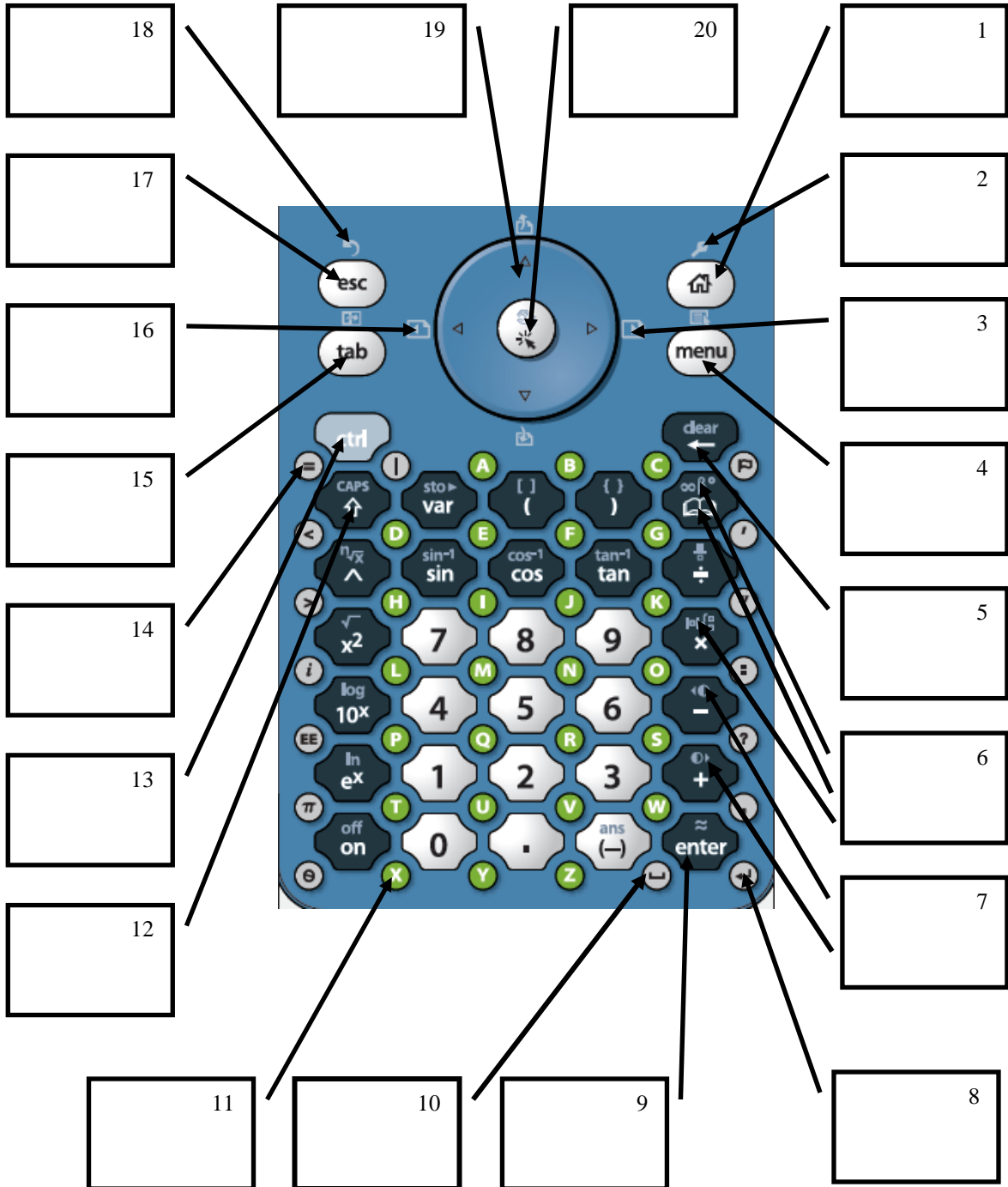
Connect the handheld to the computer via the USB cable. You may connect multiple handhelds at one time using the provided USB hub.



Click on the menu option Tools then Transfer Tool. In the dialog box indicate the type of device and click on Add File. Browse to find the new handheld OS file. Click Start Transfer to begin.

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TI-Nspire™

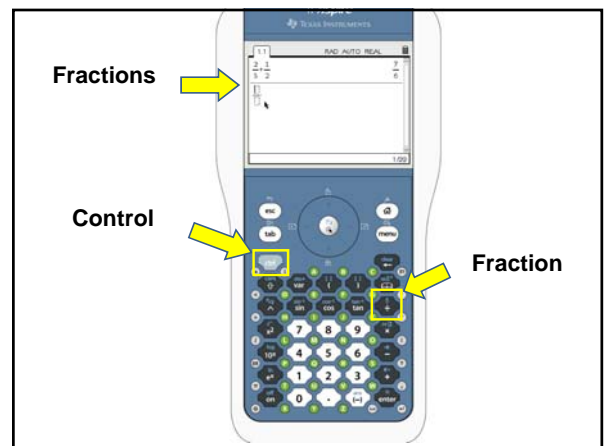
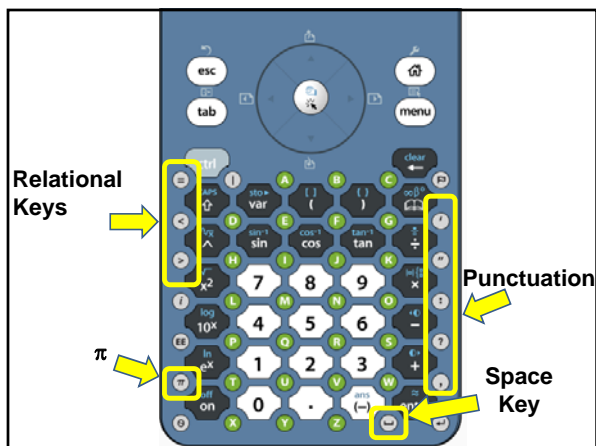
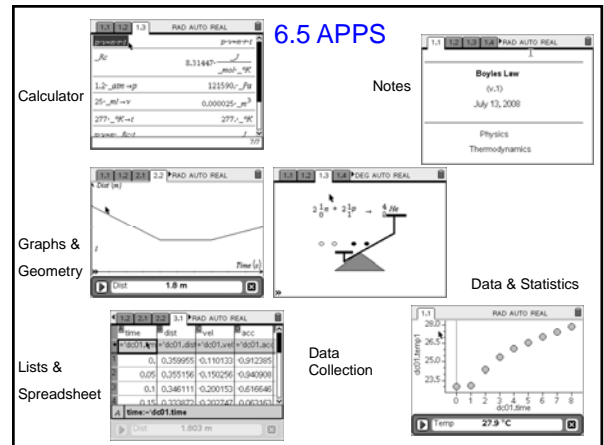
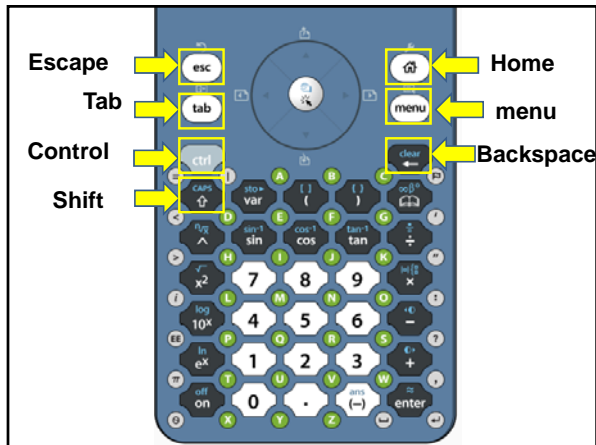
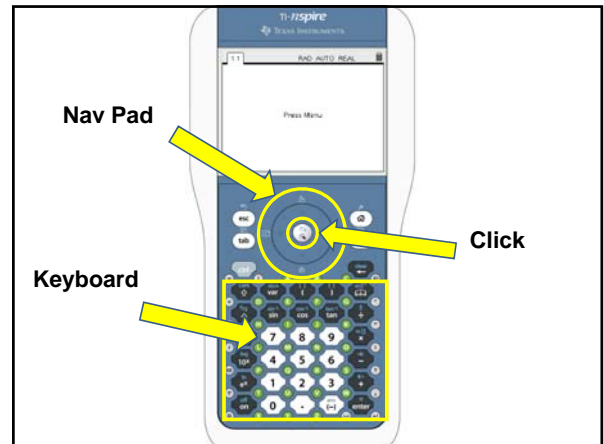


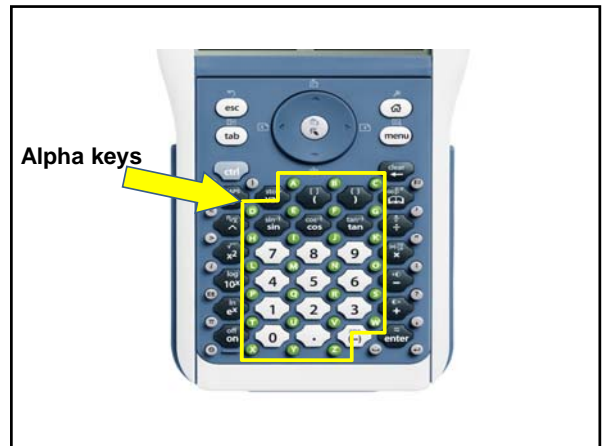
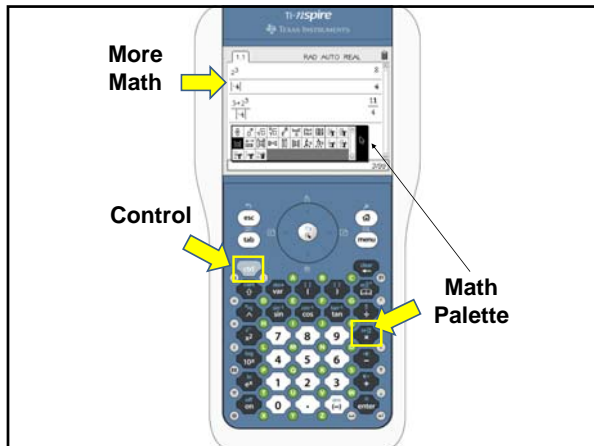
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Introduction to

TI-*n*spire™
math and science learning technology

for The Sciences



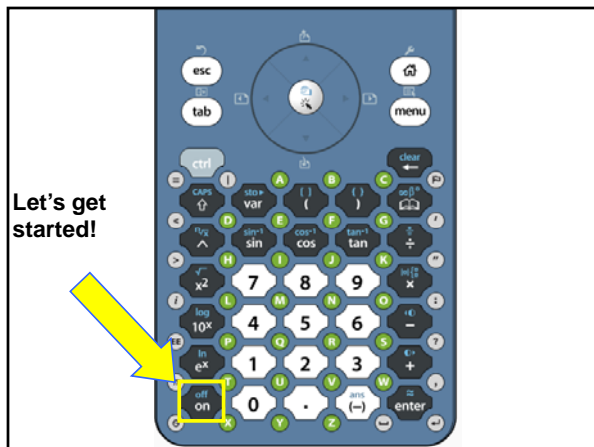


TI-Nspire
math and science learning technology

Important ctrl Keys

- ctrl Z or ctrl esc for Undo
- ctrl Y or ctrl esc for Redo
- Repeat for multiple levels of Undo and Redo
- ctrl C for Copy [once you highlight what you want to copy]
- ctrl X for Cut [once you highlight what you want to cut]
- ctrl V for Paste [once you have copied to the clipboard]
- ctrl S for Save or Save As
- ctrl D to launch the Data Collection APP

Press the ctrl followed by the letter or command.



The Transfer Tool

Connect-to-Class™ software includes a Transfer Tool that you can use to transfer files to TI-Nspire™ handhelds when a class session is not active. The Transfer Tool allows you to transfer document files and operating system (OS) files to a succession of handhelds, without requiring students to log in.

The Transfer Tool streamlines the file transfer process. You can select TI-Nspire™ document and OS files that you have stored on your computer and install them on your students' TI-Nspire™ handhelds. Once the transfer begins, it continues until you stop it. TI-Nspire™ handhelds can be connected in succession and receive queued files. Connect-to-Class™ software keeps track of what handhelds have been connected and the status of file transfers to those handhelds.

If you are sending the same files to your entire class, sending files to devices when students are not present, or if you do not plan on collecting documents using Connect-to-Class™, then you should use the Transfer Tool. Transfer Tool does not require a student's login to send files to the handheld; it simply sends the files to connected devices, allowing you to send files with or without students present. The Transfer Tool also allows you to clear folders and files on the handheld, as well as transfer TI-Nspire™ OS files.

This section covers the information you need to know to use the Transfer tool.

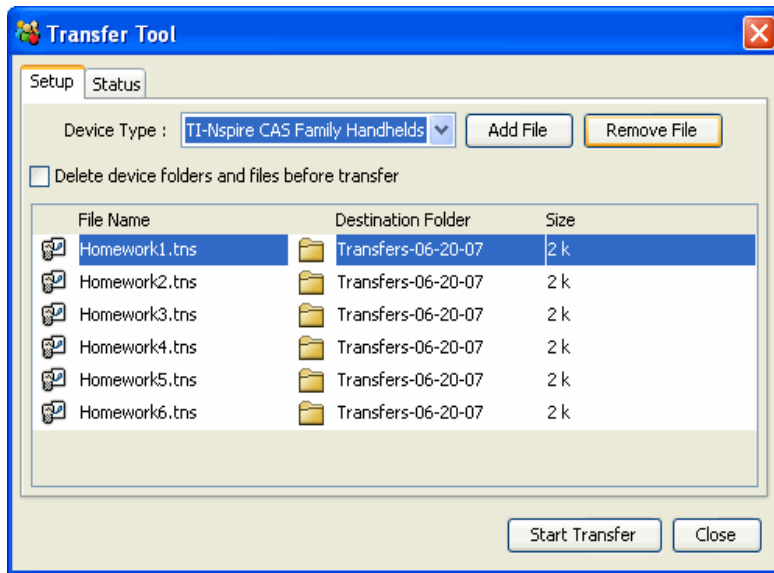
Opening the Transfer Tool

You can open the Transfer Tool from the Connect-to-Class™ software home screen.

To open the Transfer Tool

1. If you have a class session running, end it.
2. Select **Tools > Transfer Tool**.

The Transfer Tool dialog displays.



3. Select the Device type from the drop down menu.

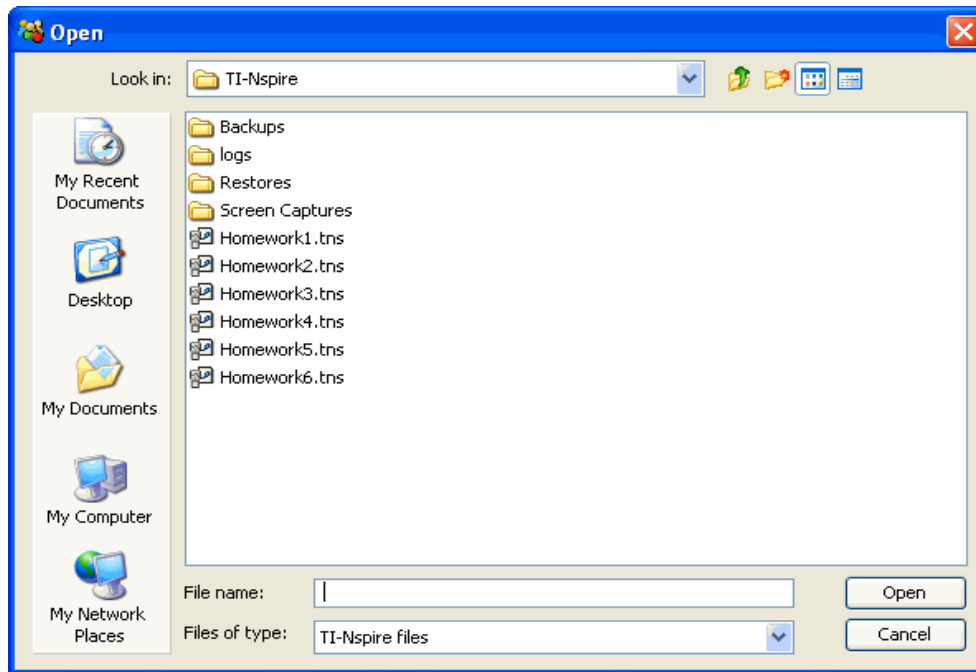
Adding files to the transfer list

You must add TI-Nspire™ document files and operating system files (OS) to the transfer list in order to transfer them.

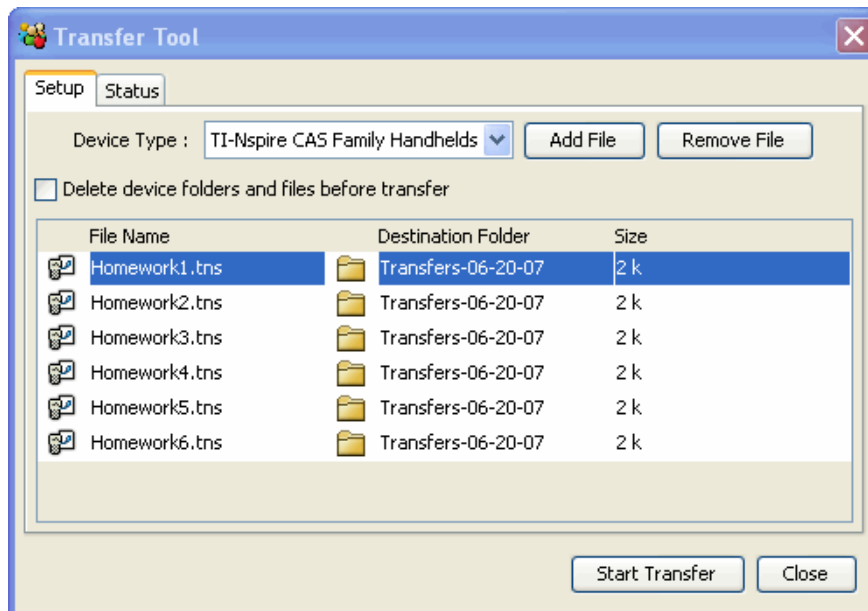
Only one OS per device type may be added to the list. The OS must be a newer version than the one currently on your handheld. You cannot transfer a version of the OS that is already on the handheld, or an older version of the OS.

Adding files to the transfer list

1. If you have not already done so, select the Device type from the drop down menu.
2. Click the **Add File** button.
3. The Open window displays.



4. Navigate to the file you want to add, and click to select it.
Note: To select multiple files, press and hold the **Ctrl** key while clicking each file name.
5. Click **Open**. The file(s) are added to the list on the Transfer Tool screen.

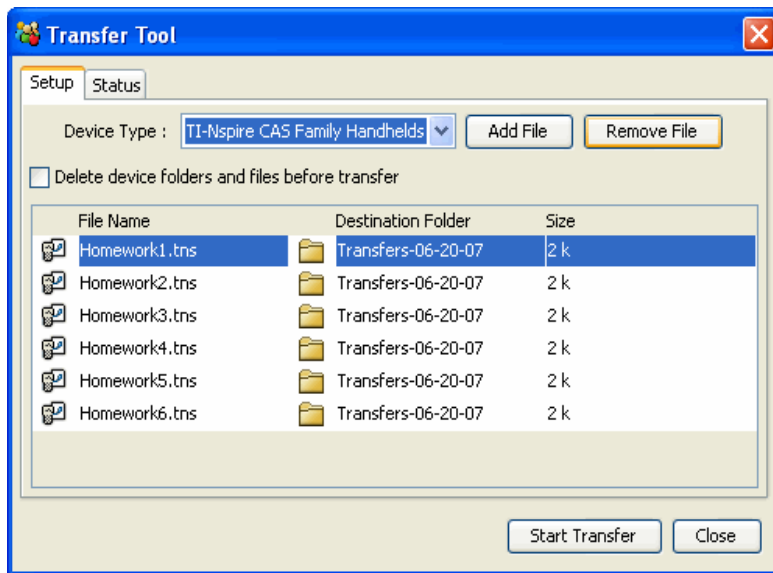


6. Repeat Steps 2 -5 until all files for transfer are added to the list.
7. Click **Start Transfer** to send the files.

Removing files from the transfer list

If there are TI-Nspire™ documents or OS files in the transfer list that you no longer want to have available for transfer, you can remove the files from the transfer list.

1. Click the name of the file you want to remove from the transfer list.



2. Click **Remove File**.

Changing the destination folder

To change the destination folder for the file transfer, double click in the cell and type a new name for the destination folder. Files that you transfer will be stored in this folder on student handhelds.

If the destination folder name you designate does not exist on student handhelds, the software creates it.

Note: Folder names may use alphanumeric characters. Special characters (? / | : * " " < > |) are not allowed.

Viewing transfer status

To view the status of individual file transfer for a selected handheld, click on the + before the file name to expand the display.

In the expanded view, the following information displays for each connected handheld:

- DeviceID (and device icon).
- Name of file
- Progress bar for that file on that handheld.
- Error conditions:
 - Low battery
 - Wrong device type
 - Memory full
 - Lost connectivity

Other transfer status information

- When a new device is connected, the status updates.
- The device progress of a file disappears when it reaches 100%.
- Incomplete device transfers remain in the expanded view of the file status.
- During a transfer session, the transfer tool keeps track of what device IDs have connected and successfully completed one or more transfers.
- If a device unplugs and then replugs into the transfer session, the transfer tool shows the status of completed transfers, and resumes transfer of other files, if necessary.
- During a transfer, if you select the Setup tab, all the controls are disabled (read only).

If you stop a transfer

- Files under the Setup tab remain listed.
- Status information for the transfer no longer displays under the Status tab. The message "No transfers are active. Use the Setup tab to configure and start the transfer" displays.

Deleting device folders and files before transferring files

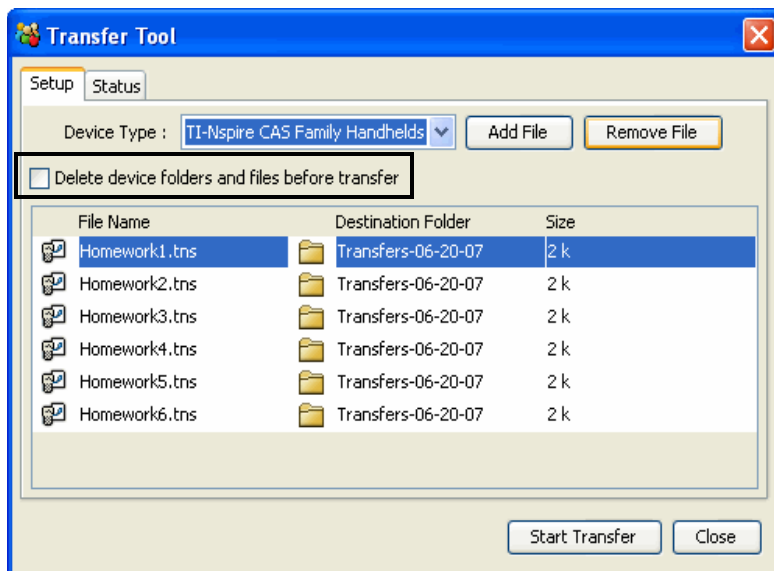
The Transfer Tool provides the option to delete all files and folders on each connected handheld before beginning a new file transfer. This allows you to "baseline" your students' handhelds to make sure that your students' handhelds contain only the files you want them to use. By default, this option is not selected.

You will find this option useful whenever your student's handheld should be blank. Here are some times when you might want to delete folders:

- At the end of a semester, grading period, or conclusion of any Instruction module
- Before administering exams

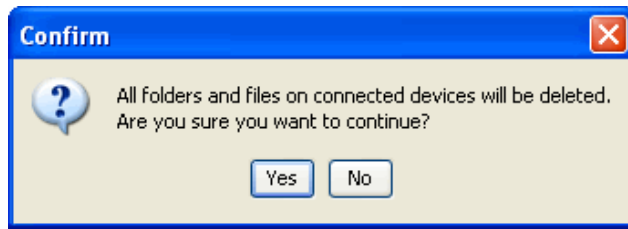
To delete folders and files on connected handhelds

1. Click the check box next to the option.



2. Click the **Start Transfer** button to begin the deletion.

A message displays to confirm that you want to delete the folders and files.



3. Click **Yes** to confirm.

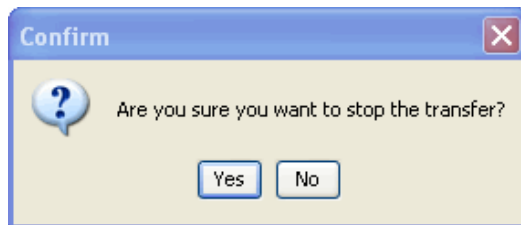
The status tab tracks the progress of the delete actions as they occur, displaying which devices have been plugged in, and when the actions are completed.

Stopping file transfers

You can stop a file transfer at any time.

To stop a file transfer

1. Press the **Stop Transfer** button.
2. A warning dialog displays, asking if you are sure you want to stop the transfer.



3. To confirm that you want to halt transmission, click **Yes**. Transfers are stopped.

Note: If any student devices received the file or files, those files remain on the devices.

Closing the Transfer tool

When you finish transferring files to your students' TI-Nspire™ handhelds, close the Transfer tool. To do this, click **Close**.

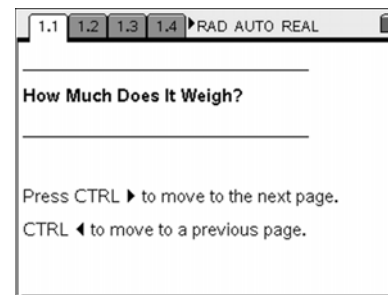


How Much Does It Weigh?

Physics – Teacher Notes

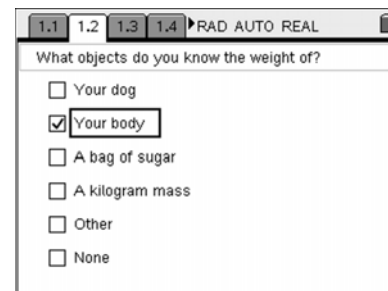
To open the document:

- Press for Home, My Documents.
- Locate the file *How_Much_Does_It_Weigh_Physics* and press to open it. Choose **No** to saving the open document (unless you want to save it).
- Press to move to page 1.2.



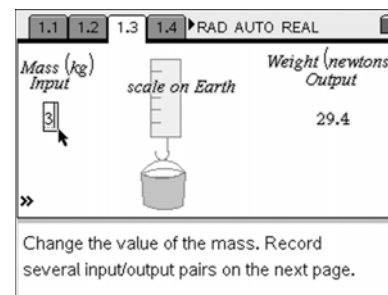
To answer the question:

- Press the down arrow key to move to the desired response.
 - Press to select a response.
- (On questions with multiple responses allowed, to deselect the answer, press a second time. Otherwise, select **MENU > Clear Answers.**)
- After choosing all desired responses, press to move to page 1.3.



To change the input for the mass measured in kilograms:

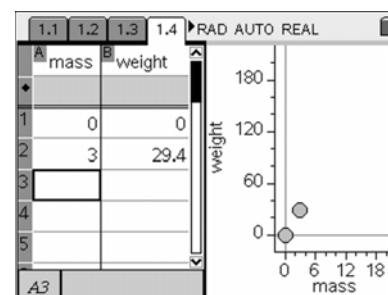
- Move the cursor close to the Mass Input value. An open hand and the word “text” should appear.
 - Press twice to open a text box.
 - Enter a new value by first using arrows to get to the end, pressing to backspace over the previous value, and finally entering the new value.
 - Press to evaluate this value.
- Record the input and output values.
 - Repeat to enter a new input value.
 - Record several input/output pairs.
- Press to move to page 1.4.



A scatter plot of weight versus mass has been set up.

To add input/output pairs in the spreadsheet:

- To enter a value, move to the desired cell.
- Press the number on the keypad and press .



What science concepts can be explored with this activity?

What questions can we ask to highlight the physics concepts?

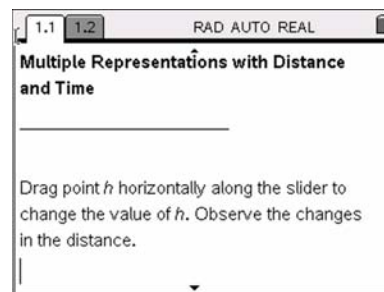
- Press to move to page 1.5 and 1.6 to answer the open-response and multiple-choice questions (multiple responses not allowed).

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Multiple Representations with Distance and Time

STUDENT ACTIVITY

We can use graphs, tables, and formulas to represent algebraic relationships. In this activity you will use all three to investigate how distance travelled is related to time for an object moving with constant speed.



- Open *the TI-Nspire document Multiple Representations Distance Time*.
- Press to move to page 1.2 to begin the lesson.

Problem Situation: Katie is taking a college trip with her family. Katie's mother is a physics teacher who wants her family to be able to compete in the world economy so she changes her car setting from miles to kilometers. They zero the trip odometer before leaving home. The family is a certain distance from her home when they enter the ramp for a highway. Katie now begins checking the distance from home each half hour. They travel 5 hours before stopping for gas. The TI-Nspire document shows three representations of Katie's distance from home.

1. Move h to zero and press once. What do you observe about the three representations? How do the three representations relate to one another and what does it tell you about the hour zero?

2. Move h to three and press once. Move h to another value and press once. Repeat. What do you observe about the three representations?

3. Where do the h and $d(h)$ appear in each representation? What do the h and $d(h)$ represent?

4. Using your answer from question 3, how far did Katie's family travel after 4 hours? Where does this appear in each of the three representations?

Multiple Representations with Distance and Time

STUDENT ACTIVITY

5. a. What was Katie's distance from home when she starting collecting data and how can you identify this in each of the three representations?

- b. How fast was the car moving on the highway and how can you identify this in each of the three representations?

6. Did the family travel at least 200 km in the first two hours? Explain.

7. Why does the slider only move from 0 to 5? How does the slider relate to the original problem?

8. Why doesn't the table or graph show a distance of zero?

9. Suppose Katie's parents increase their speed by 5 km/hour. Describe how this increase in speed would affect each of the representations.

10. Suppose Katie's family was 15 kilometers further from home before entering the highway. Describe how this change would affect each of the representations.



Activity Overview:

- *TI-Nspire™ CAS includes a variety of features useful in physics. This is a brief discovery and exploration activity to see and use some of the CAS features.*

Materials:


- *TI-Nspire™ CAS handheld*
-


Exploring CAS: Applications for Physics




Open a new document with a *Calculator* page by selecting **HOME > New Document > Add Calculator**.


The CAS (Computer Algebra System) built into the TI-Nspire™ CAS system can provide many valuable learning experiences for learners, and useful shortcuts for teachers. There are a variety of templates, menus, and constants available.



Part 1 – Calculator Look

1. Type $83.6 \div 2.7$ and . Note the style of the displayed entry and the answer.



2. Type $1 \div 2 + 5 \div 3$ and . Note the form of the answer.

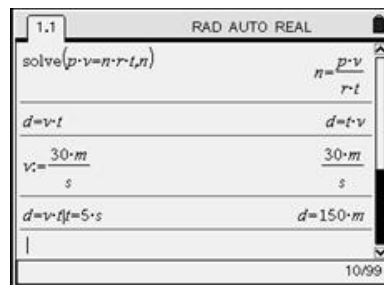
3. Now press the up arrow to highlight the last entry (not the answer), and press . This is a shortcut to re-enter and edit something previously done. Now press  . Note how the form of the answer changed to the decimal approximation.

4. Type **F=m•a** and . Note the format of the result. Also note that you must put the multiplication between *m* and *a*; otherwise it will assume *ma* is a two-character variable string.








5. Press  **A** and . Note the result and how the variables are arranged alphabetically.

Part 2 – Symbolic Manipulation

1. Type **5kg-(1000g/(1kg))** and press . Note how the answer deals with the symbolic units.
2. Type **solve(p-v=n-r-t,n)** and . Note how the equation is rearranged (solved) for the variable after the comma.
3. Try solving other formulas for different variables.



Part 3 – Define and Calculate with Variables

1. Type **d=v·t**.
2. Type **v:=30 m/s**. (The := defines a value for v with units.)
3. Bring **d=v·t** to the active window (as in part 1, step 3) and type **|t=5·s** and . (The vertical bar—below and right of —means “for” or “such that” and evaluates the expression.)
4. Now change t to 1.5 s.
5. Open a new *Calculator* page by selecting **HOME > Calculator**. Type **d=v·t|t=5·s** and .
6. The value of v is still defined. If we opened a new problem, that value would not be transferred to the new problem.
7. There are many constants defined in the system. Type **wt=m·g|m=1_kg** and . Note the underscore (_) found in the symbols template ( ). It references defined variable values or units. Explore these in  under the third tab (°C\°F).





Activity Overview: Exploring CAS

TI-Nspire™ CAS includes a variety of features useful in physics. This is a brief discovery and exploration activity to see and use some of the CAS features.

Teacher Preparation and Notes:

- *Estimated time for activity: 20 min*

Materials:

- *TI-Nspire™ CAS handheld technology*
 - *Exploring_CAS_Student_Physics.doc*
-

Exploring CAS: Applications for Physics

Open a new document with a *Calculator* page by selecting **HOME > New Document > Add Calculator**.

The CAS (Computer Algebra System) built into the TI-Nspire CAS system can provide many valuable learning experiences for learners, and useful shortcuts for teachers. There are a variety of templates, menus, and constants available.

Part 1 – Calculator Look

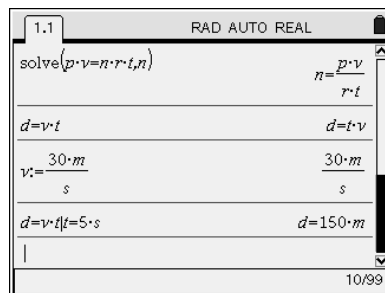
1. Type $83.6/2.7$ and $\left[\frac{\square}{\square} \right]$. Note the style of the displayed entry and the answer.

Teacher Tip: Note the number of digits displayed. This can be changed by pressing **HOME > System Info > Document Settings**. $\left[\text{tab} \right]$ between fields and $\left[\frac{\square}{\square} \right]$ to see options. $\left[\frac{\square}{\square} \right]$ on **OK** or press $\left[\frac{\square}{\square} \right]$ when finished.

2. Type $1/2 + 5/3$ and $\left[\frac{\square}{\square} \right]$. Note the form of the answer.
3. Now press the up arrow to highlight the last entry (not the answer), and press $\left[\frac{\square}{\square} \right]$. This is a shortcut to re-enter and edit something previously done. Now press $\left[\text{ctrl} \right] \left[\frac{\square}{\square} \right]$. Note how the form of the answer changed to the decimal approximation.
4. Type $F=m \cdot a$ and $\left[\frac{\square}{\square} \right]$. Note the format of the result. Also note that you must put the multiplication between m and a ; otherwise it will assume ma is a two-character variable string.
5. Press $\left[\frac{\square}{\square} \right] \left[\text{A} \right]$ and $\left[\frac{\square}{\square} \right]$. Note the result and how the variables are arranged alphabetically.

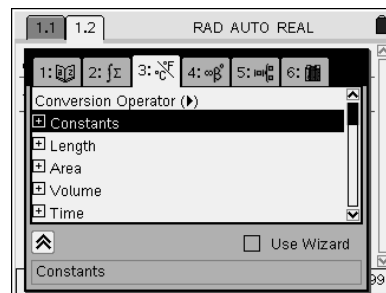
Part 2 – Symbolic Manipulation

1. Type $5\text{kg} \cdot (1000\text{g}/(1\text{kg}))$ and press $\left[\frac{\square}{\square} \right]$. Note how the answer deals with the symbolic units.
2. Type $\text{solve}(p \cdot v = n \cdot r \cdot t, n)$ and $\left[\frac{\square}{\square} \right]$. Note how the equation is rearranged (solved) for the variable after the comma.
3. Try solving other formulas for different variables.



Part 3 – Define and Calculate with Variables

1. Type $d=v \cdot t$.
2. Type $v:=30\text{-m/s}$. (The := defines a value for v with units.)
3. Bring $d=v \cdot t$ to the active window (as in part 1, step 3) and type $|t=5\text{-s}$ and enter . (The vertical bar—below and right of ctrl —means “for” or “such that” and evaluates the expression.)
4. Now change t to 1.5 s.
5. Open a new *Calculator* page by pressing ctrl > **Calculator**. Type $d=v \cdot t|t=5\text{-s}$ and enter .
6. The value of v is still defined. If we opened a new problem, that value would not be transferred to the new problem.
7. There are many constants defined in the system. Type $wt=m \cdot g|m=1\text{-kg}$ and enter . Note the underscore ($_$) found in the symbols template (ctrl enter). It references defined variable values or units. Explore these in enter under the third tab (°C\°F).



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Activity Overview:

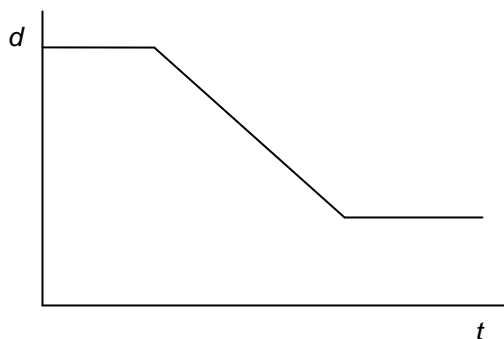
- Given a simple position vs. time graph, you will attempt to reproduce the general shape of this graph by walking in front of the CBR 2™ while collecting data. You will then consider the nature of their motion with respect to the graph. Discuss how speed changed during the activity and describe what the speed vs. time graph should look like before viewing the actual data plot.

Materials:

- TI-Nspire™ CAS handheld
- CBR 2™

Motion Data Collection

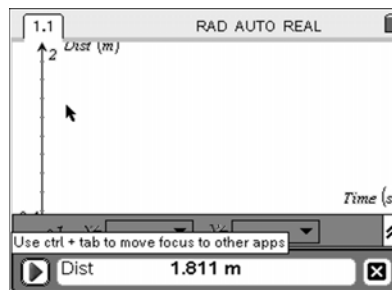
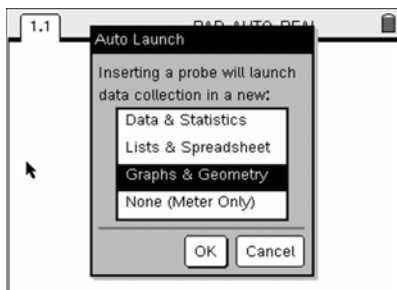
Below is a position vs. time graph:












With a partner, describe this motion and discuss how you could model this by walking.

Step 1. Turn on the TI-Nspire CAS and open a new document by selecting **HOME > New Document**.




Step 2. Connect the CBR 2 to the handheld. An Auto Launch window will appear. Select **Graphs & Geometry** and press . Set the CBR 2 safely near the edge of a table with the sensor head flipped up and pointing to an open area.

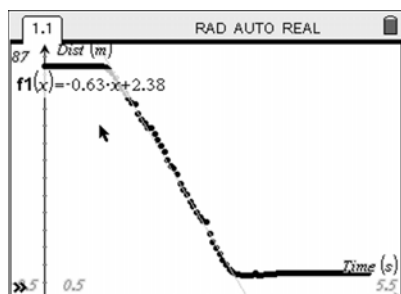


Motion Data Collection

- Step 3.** Choose one of your group to stand in front of the CBR 2 sensor, ready to move. Another of your group starts the data collection when everything is ready by pressing .
- Step 4.** Take turns walking to collect the data simply by pressing . When the Unsaved Data window appears, press  once, and press  to discard the previous run.
- Step 5.** Once a suitable set of data has been collected, close the Data Collection Console (DCC) by pressing  twice and then . Press  to close the entry line;   will bring it back again, if needed.

1. How fast do you think you were moving?

- Step 6.** Select **MENU > Graph Type > Function**. Enter $f1(x) = x$ as the function. Press  to graph the line and  to close the entry line. Move the cursor and grab the line near one end to rotate it about the y -axis, or near the middle to translate it. (Note how the cursor changes.) Move the line to fit with the sloped part of the data plot to the best of your ability. Click  on the line to see its equation.



2. What information can you gain from the equation of the line?
3. What speed does the equation of the line give for your motion?
4. Does the line match the data plot perfectly? What does this mean?
5. What do you think the v vs. t plot for this motion might look like?

Step 7. To view the v vs. t plot, open a new *Graphs & Geometry* application page by selecting **HOME > Graphs & Geometry**. Select **MENU > Graph Type > Scatter Plot**. Press $\left(\frac{\text{2nd}}{\text{F1}}\right)$ to open the x -axis variable menu, select **dc01time**, and $\left(\frac{\text{2nd}}{\text{F2}}\right)$ to confirm this as the x -axis variable. Now $\left(\frac{\text{2nd}}{\text{F3}}\right)$ to the y -axis variable field, $\left(\frac{\text{2nd}}{\text{F4}}\right)$ to open the y -axis variable menu, select **dc01vel1**, and $\left(\frac{\text{2nd}}{\text{F5}}\right)$ to confirm this as the y -axis variable. Press $\left(\frac{\text{2nd}}{\text{F6}}\right)$ to move to the graph window and close the entry line. Select **MENU > Window > Zoom-Data** to resize the window to fit the data better.

6. What information and conclusions can you determine from the v vs. t plot?

Extensions:

What would the acceleration vs. time plot look like for this data?

What should it look like in an ideal case?

Is the ideal case, as shown in the original model graph, possible?

Why not?

What other kinds of motion situations might provide some interesting plots?

What other kinds of plots might represent interesting or important motions?

Does it matter if you walk toward the motion sensor or if someone moves the motion sensor toward you? Explain.

Consider how this device might be related to radar or sonar.

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Motion Data Collection

Physics – Teacher Notes

Activity Overview: Motion Data Collection

Students will be given a simple position vs. time graph. They will attempt to reproduce the general shape of this graph by walking in front of the CBR 2™ while collecting data. They will then discuss the nature of their motion with respect to the graph. They will then consider and describe what the speed vs. time graph should look like before viewing the actual data plot.

Teacher Preparation and Notes:

- *Estimated time for activity: 30–40 minutes*
- *Ensure CBR 2™ units have charged batteries and cables to connect to TI-Nspire™ CAS handhelds.*
- *Students should have some knowledge of motion graphs.*
- *Group students in pairs or triads.*
- *Arrange room so that each group has about 2–3 meters of clear space in front of a table.*

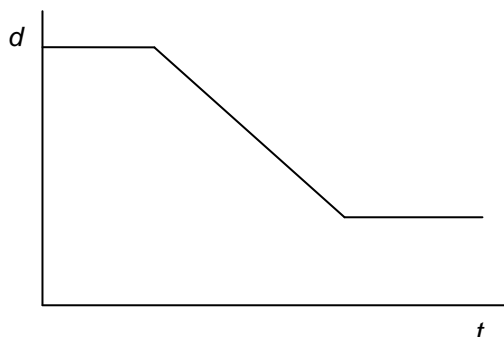
Materials:

- *TI-Nspire™ CAS handheld*
 - *CBR 2™*
-

Motion Data Collection

Motion Data Collection

Show students a position versus time motion graph similar to that shown below:

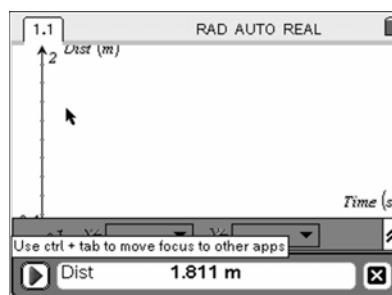
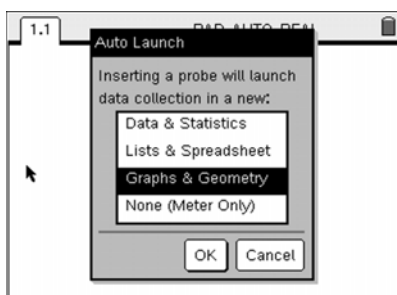


Ask the students to describe this motion and discuss how they could model this by walking.

Step 1. Turn on the TI-Nspire™ CAS and open a new document by selecting **HOME > New Document**.

Teacher Tip: If a document was already open on the handheld, you may direct the students to either save this document with some name or not—thus losing the open document. (tab) to the appropriate button and press (enter).

Step 2. Connect the CBR 2™ to the handheld. An Auto Launch window will appear. Select **Graphs & Geometry** and press (enter). Set the CBR 2 safely near the edge of a table with the sensor head flipped up and pointing to an open area.









Step 3. One student of the group stands in front of the CBR 2 sensor, ready to move. Another student starts the data collection when everything is ready by pressing (enter).

Teacher Tip: The default of the CBR 2 is to collect data for 5 s and to display a distance versus time plot. Also, the direction away from the sensor is defined as positive.

Step 4. Students in a group can take turns walking to collect the data simply by pressing (enter). When the Unsaved Data window appears, press (tab) once, and press (enter) to discard the previous run.




Motion Data Collection

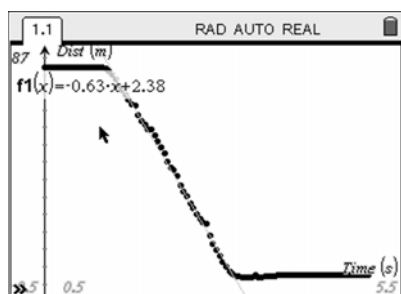
Teacher Tip: Warn students that data collection will begin immediately after the  key is pressed. You can store several runs by choosing the Store button. Multiple runs are stored as *dc01.time*, etc., where “dc01” or “dc02” stands for “data collection run 1” or “data collection run 2.”

Step 5. Once a suitable set of data has been collected, close the Data Collection Console (DCC) by pressing  twice and then . Press  to close the entry line;   will bring it back again, if needed.

1. How fast do you think you were moving?

Answers will vary. Discuss whether a negative should be included in this answer. Discuss how students can estimate this speed from their physical motion and from the data plot on the handheld screen.

Step 6. Select **MENU > Graph Type > Function**. Enter $f1(x) = x$ as the function. Press  to graph the line and  to close the entry line. Move the cursor and grab the line near one end to rotate it about the y -axis, or near the middle to translate it. (Note how the cursor changes.) Move the line to fit with the sloped part of the data plot to the best of your ability. Click () on the line to see its equation.



2. What information can you gain from the equation of the line?

The x coefficient represents the slope of the line. For d vs. t , the slope represents the velocity (with negative sign to represent “backward” speed).

3. What speed does the equation of the line give for your motion?

Students should record the value of the slope of their best-fit line. Units should be m/s.

4. Does the line match the data plot perfectly? What does this mean?

The line will not be a perfect fit. There will be variations in the speed, especially when starting and stopping.

5. What do you think the v vs. t plot for this motion might look like?

Have students sketch what they think the plot should look like. Many may miss the negative direction.

Step 7. To view the v vs. t plot, open a new *Graphs & Geometry* application page by selecting **HOME > Graphs & Geometry**. Select **MENU > Graph Type > Scatter Plot**. Press $\left(\frac{\text{ON}}{\text{OFF}}\right)$ to open the x -axis variable menu, select **dc01time**, and $\left(\frac{\text{ON}}{\text{OFF}}\right)$ to confirm this as the x -axis variable. Now $\left(\text{tab}\right)$ to the y -axis variable field, $\left(\frac{\text{ON}}{\text{OFF}}\right)$ to open the y -axis variable menu, select **dc01vel1**, and $\left(\frac{\text{ON}}{\text{OFF}}\right)$ to confirm this as the y -axis variable. Press $\left(\text{esc}\right)$ to move to the graph window and close the entry line. Select **MENU > Window > Zoom-Data** to resize the window to fit the data better.

6. What information and conclusions can you determine from the v vs. t plot?

The velocity plot will show how inconsistent the motion was. This should tell the students that their speed was not constant over short time intervals. Most of the nonzero points should be negative, indicating that the motion was generally backward, or toward the sensor.

Extensions:

What would the acceleration vs. time plot look like for this data?

The acceleration vs. time plot would be mostly horizontal with a downward spike when motion starts and an upward spike when motion stops. The data are not uniform; therefore, the acceleration vs. time plot would be erratic.

What should it look like in an ideal case?

Is the ideal case as shown in the original model graph possible?

Why not?

In an ideal case, the acceleration vs. time graph would be horizontal at zero acceleration except for a very large positive spike when motion starts and a very large negative spike when motion stops. The original ideal diagram indicates instantaneous speed changes, implying infinite accelerations, which are not possible.

What other kinds of motion situations might provide some interesting plots?

What other kinds of plots might represent interesting or important motions?

There are many different kinds of situations and graphs that would be interesting to study. Sports contexts such as the motion of a baseball from the pitch to a hit provide very rich situations. Encourage students to come up with their own contexts and plots for discussion.

Does it matter if you walk toward the motion sensor or if someone moves the motion sensor toward you? Explain.

The motion sensor ostensibly measures distance away from the sensor face to the target. Relative motion is shown by changes in distance. It does not matter which moves, the target or the sensor, as long as the relative direction is the same—getting closer or getting farther away.

Consider how this device might be related to radar or sonar.

Radar and sonar work in a similar fashion to the motion sensor; each sends out a signal, measures the return time of the signal reflected from a target, and calculates the distance to the target based on the speed of the signal in the medium. Generally, radar emits microwaves through air or empty space, and sonar emits sound through water. The motion sensor emits sound through air. Since the speed of sound in air depends on the temperature, if the motion sensor is used in very cold or very hot conditions, the recorded distances will be slightly farther or closer than the actual distance.

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Using Computer Link

Using the TI-Nspire™ Computer Link Software

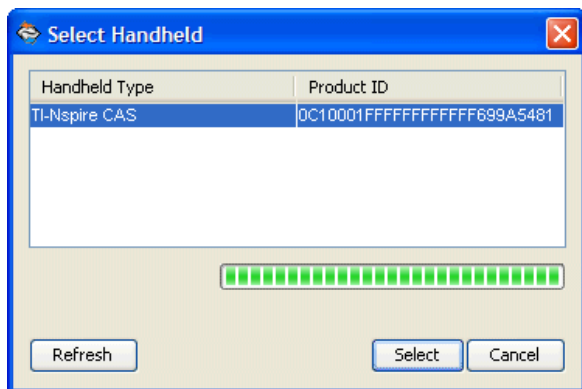
The TI-Nspire™ Computer Link Software lets you:

- Transfer documents between your computer and a TI-Nspire™ handheld.
- Capture images from a TI-Nspire™ handheld screen and use them in computer documents.
- Make a backup of a handheld's documents as a single file on your computer.
- Restore a backup of a handheld's documents.
- Update the operating system (OS) software on a TI-Nspire™ handheld.

Opening the TI-Nspire™ Computer Link Software

1. Make sure you have connected a TI-Nspire™ handheld to your computer.
 2. Double-click the TI-Nspire™ Computer Link Software icon on the desktop.
- The software displays a list of connected handhelds and lets you select one.

Note: You can communicate with only one handheld at a time.

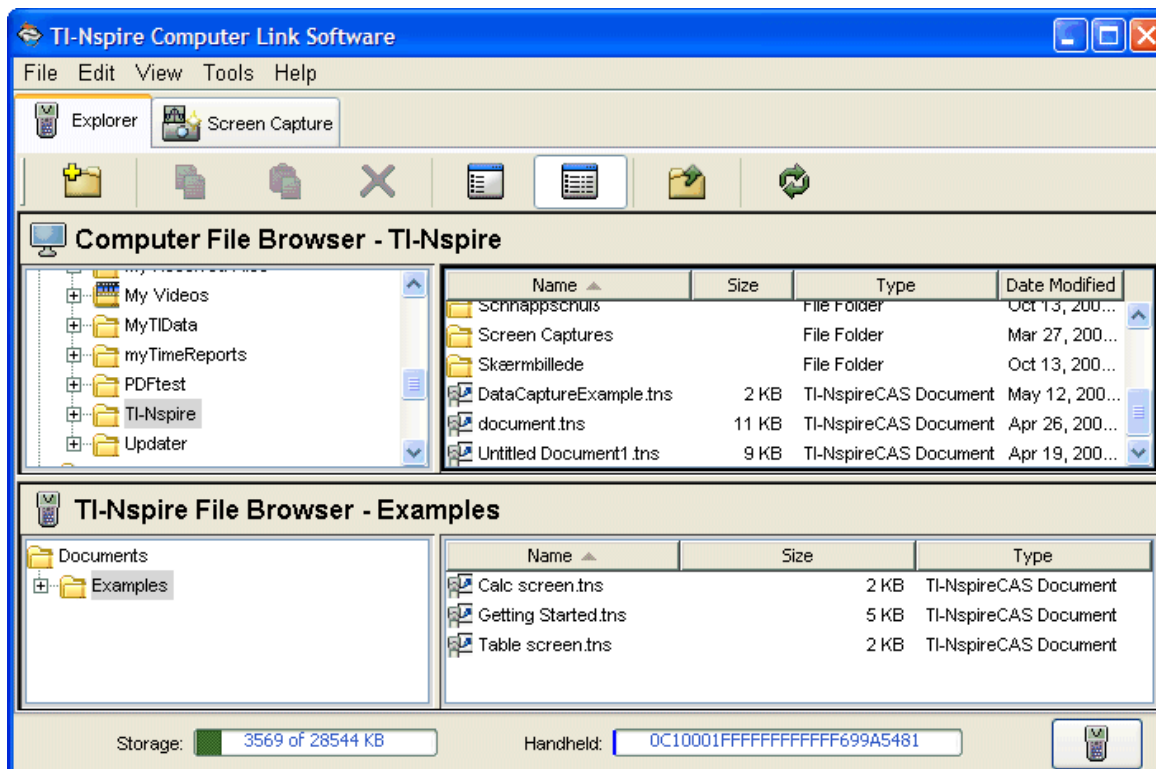


3. If multiple handhelds are connected, click the handheld to which you want to connect.
4. Click **Select**.

Exploring handheld contents

The Explorer tab (see next page) in the TI-Nspire™ Computer Link Software lets you view the contents of a connected handheld and transfer (copy) documents between your computer and the handheld. You can also rename and delete handheld documents.

Using Computer Link



Copying documents/folders by dragging

You can drag the mouse to copy documents/folders between a handheld and the computer or between two folders on the computer.

1. Click the document/folder that you want to copy.

Note: You can select multiple documents/folders by holding down the **Ctrl** key and clicking each document.

2. Drag the selection, and drop it on the desired destination.

The selected items are copied to the destination.

Note: If a document/folder of the same name already exists at the destination, you are asked if you want to replace it.

Copying documents and folders by pasting

You can use the clipboard to copy documents and folders. If you want to move an item instead, copy it and then delete the original.

1. Click the document or folder to be copied.

Note: You can select multiple items by holding down the **Ctrl** key and clicking each item.

2. Click **Edit > Copy** to copy the selected items to the clipboard.

3. Click a folder to select it as the destination.

4. Click **Edit > Paste**.

Explorer copies the items to the destination folder.

Note: If the destination already contains a document with the same name as the one you are copying, you can choose to either replace the existing document or cancel.



Activity Overview:

- *In this activity you will use the TI-Nspire computer software to collect data using a force probe.*

Materials:

- *TI-Nspire™ CAS computer software or Teacher Edition software*
 - *Vernier™ Easy Link*
 - *Mini-to-standard USB adapter*
 - *Vernier Dual Range Force Sensor*
 - *Small cup to hang from the force probe*
 - *16 pennies (dated after 1982) or other like coins*
-

1. On the computer, open the TI-Nspire or TI-Nspire CAS computer software.
2. Connect the Force Sensor to the Easy Link, and use the mini-to-standard USB adapter to connect to the computer.
3. Choose to collect data with the *Data & Statistics* application.
4. Hang a light cup from the force sensor. Select **Sensors** from the menu and then **Zero**. This will zero the probe with the cup attached.
5. From the Experiment in the menu bar, select **Set Up Collection > Events with Entry**.
6. Start the experiment. Add 2 pennies to the cup and click on the file drawer to save the force value. You will be prompted for a value. Enter 2, since you dropped 2 pennies into the cup.
7. Add 2 more pennies and save this value in the same manner. When prompted, enter 4, since that is the total number of pennies in the cup. Continue this process until you have added 16 pennies.
8. Stop data collection. Close the data collection application.
9. From the Data and Statistics menu, select **Analyze > Add Movable Line**. Adjust the slope by grabbing the outer sections of the line. Grab the center section of the line to move it up or down. Fit the line to the data. Record the equation of the line.
10. What does the slope represent in the equation?
11. What is the mass of each penny?
12. How would the equation change had you not zeroed the probe with the cup hanging on it?
13. How would the equation change if you had used quarters instead of pennies?

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Weighing Cents

Physics – Teacher Notes

Activity Overview: Weighing Cents

This activity uses the TI-Nspire computer software to collect force data with entries. Students will add 4 pennies to a cup suspended from a force probe and measure the force. They will then analyze the data.

Teacher Preparation and Notes:

- *Estimated time for activity: 30–40 minutes*
- *Find 16 pennies dated prior to 1982 for each group.*
- *Students should know about what a force is and the relationship between force and mass.*
- *Students should work in groups of 2–4 students.*

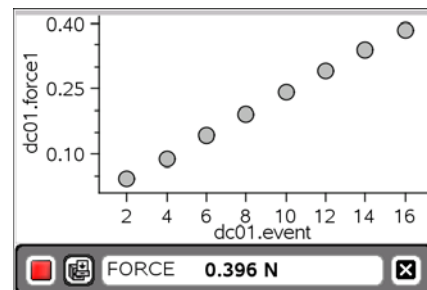
Materials:

- *TI-Nspire™CAS computer software or Teacher Edition software*
 - *Vernier™ Easy Link*
 - *Mini-to-standard USB adapter*
 - *Vernier Dual Range Force Sensor*
 - *Small cup to hang from the force probe*
 - *16 pennies (dated after 1982) or other like coins*
-

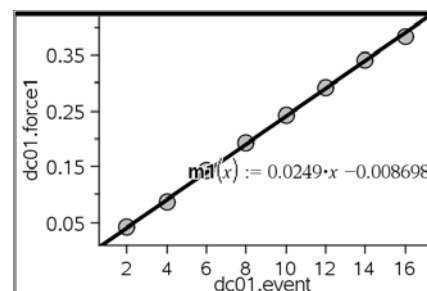
Weighing Cents

1. On the computer, open the TI-Nspire or TI-Nspire CAS computer software.
2. Connect the Force Sensor to the Easy Link and use the mini-to-standard USB adapter to connect to the computer.
3. Choose to collect data with the *Data & Statistics* application.
4. Hang a light cup from the force sensor. Select **Sensors** from the menu and then **Zero**. This will zero the probe with the cup attached.
5. From the Experiment in the menu bar, select **Set Up Collection > Events with Entry**.

6. Start the experiment. Add 2 pennies to the cup and click on the file drawer to save the force value. You will be prompted for a value. Enter 2, since you dropped 2 pennies into the cup.
7. Add 2 more pennies and save this value in the same manner. When prompted, enter 4, since that is the total number of pennies in the cup. Continue this process until you have added 16 pennies.
8. Stop data collection. Close the data collection application.



9. From the Data and Statistics menu, select **Analyze > Add Movable Line**. Adjust the slope by grabbing the outer sections of the line. Grab the center section of the line to move it up or down. Fit the line to the data. Record the equation of the line.



Sample data: $y = 0.0249x - 0.0087$

10. What does the slope represent in the equation?

The slope represents the weight per penny.

11. What is the mass of each penny?

0.0025 kg

12. How would the equation change had you not zeroed the probe with the cup hanging on it?

The equation would have a value for the y-intercept equal to the weight of the cup.

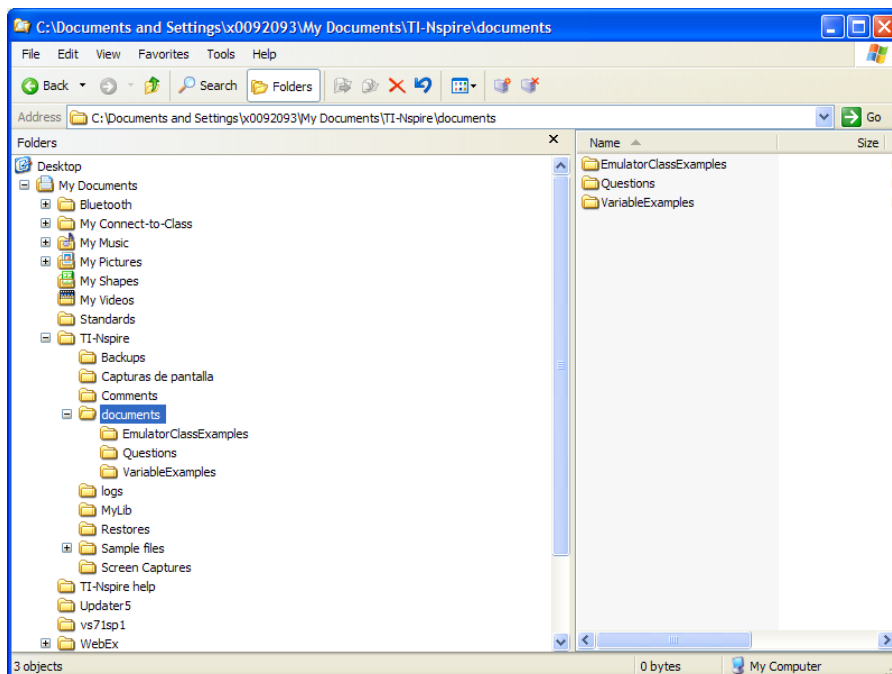
13. How would the equation change if you had used quarters instead of pennies?

The slope would increase, since the weight of a quarter is greater than the weight of a penny.

Using My Documents in the emulator view

Managing new files with My Documents

Files created, edited, or to be used in the Emulator view are saved in the default **documents** folder that is automatically created within the TI-Nspire™ folder.



While in the Emulator view, you can only open a file that is located in **My Documents > TI-Nspire > documents**.

Remember these tips when working with documents in the emulator:

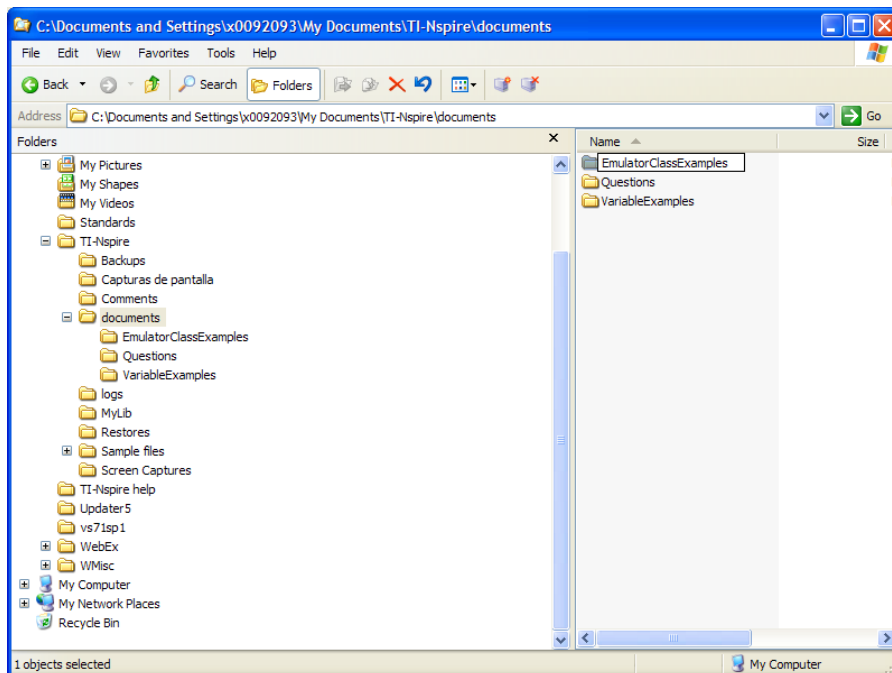
- Before you begin saving files, make a folder in **documents**. Be sure to save files in the folder you have made. You cannot save .tns documents directly in the **documents** folder.
- When you save in the Emulator view, you must save the document as you would on the handheld.
- You cannot use the emulated handheld folder structure to navigate to other locations.
- You cannot use the About, Send OS, or System Setting option on the My Documents menu.
- You cannot view or change System Info (Options) on the home screen.
- To update System or Document settings, you must switch views and then choose **File > Settings**.

Teacher Edition Emulator – My Documents

Opening existing files in My Documents

To open a file you have created:

1. Use Windows® Explorer to create a new folder under **My Documents\TI-Inspire\documents**. This is where you will store the file. In this example, the teacher is creating a new folder named **EmulatorClassExamples**.



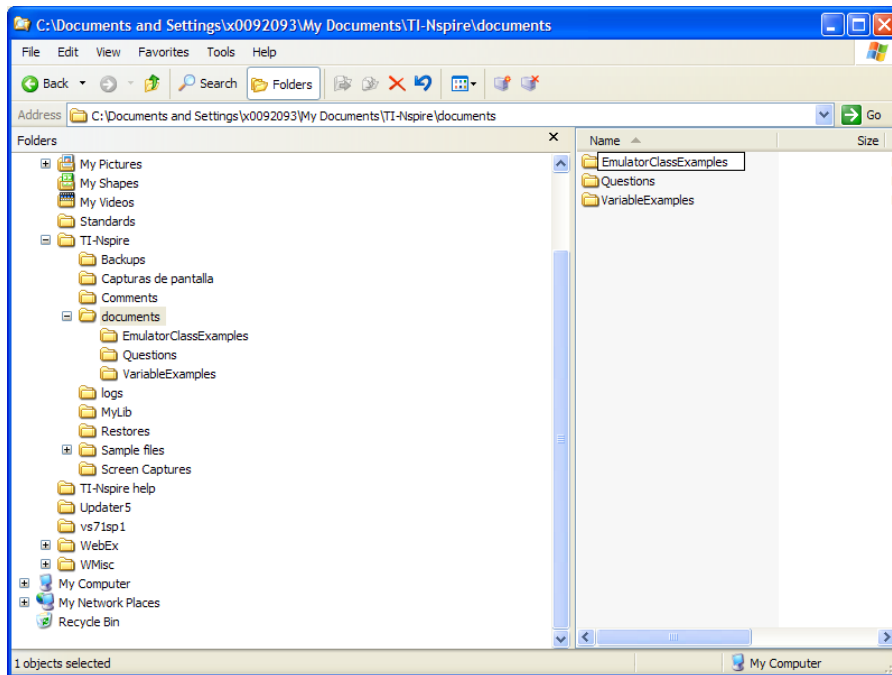
Note: You can also use My Documents on the emulated handheld to create the new folder within the **documents** folder.

2. Using Windows® Explorer, navigate to the location of the file you want to open.
3. Select and copy the file.

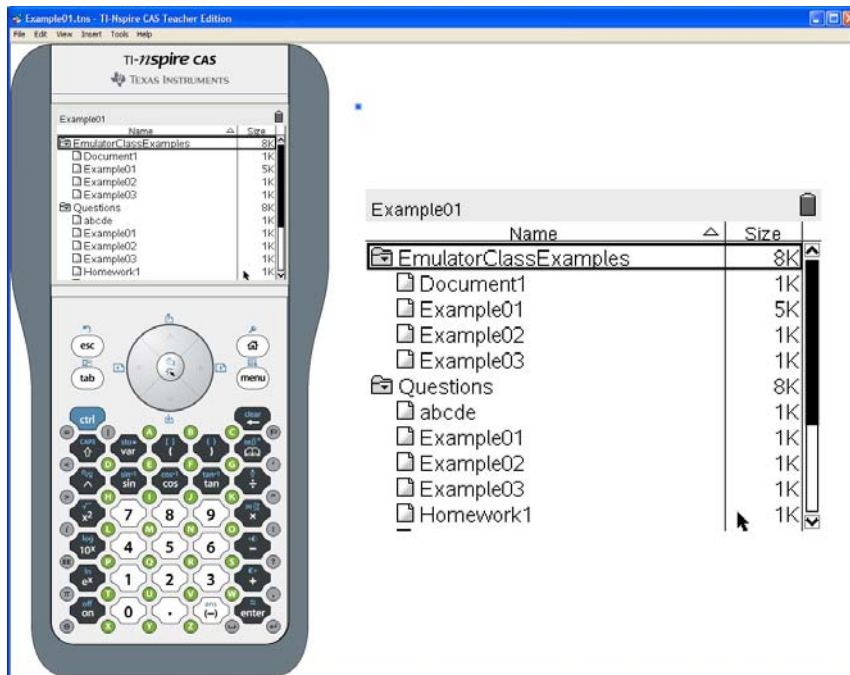
4. Using Windows® Explorer, navigate to **My Documents\TI-Inspire\documents**. You should see the folder you created in Step 1.

Note: You cannot put a .tns file in the documents folder. It must be put in another folder within the documents folder.

Teacher Edition Emulator – My Documents



5. Paste the file into the new folder.
When you open the TI-SmartView™ Emulator, you will be able to open the file from the folder you created. In this illustration, the teacher has added three files to the folder **EmulatorClassExamples**.



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Activity Overview:

In this activity, you will:

- explore the effect of charge and distance on the interaction of three or more charged particles
- solve problems involving finding net forces of the interaction between three or more charged particles

Materials:

- TI-Nspire™ CAS handheld
- Pen or pencil
- Forces_on_Point_Charges.tns

Remember that Coulomb’s law describes the force between two point charges, as follows:

$$F = k \frac{qQ}{r^2}$$

In this equation, k is defined as Coulomb’s constant

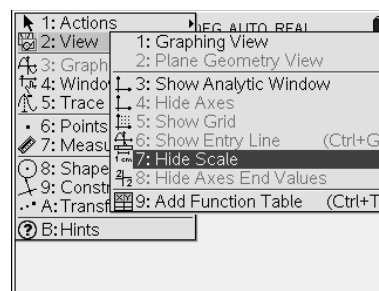
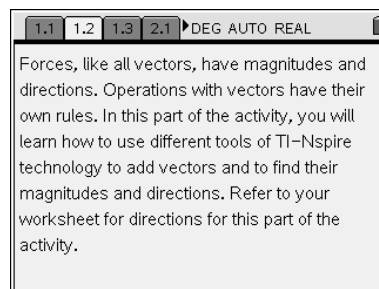
($k = 9 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}$), q and Q are the magnitudes of the charged particles, and r is the distance between the particles.

In a system of three or more charged particles, each pair of particles interacts according to Coulomb’s law. When two or more forces act on a particle, all charges and distances affect the strength and direction of the force of interaction. In order to explore this effect, we need to be able to determine this net force of interaction on a given particle due to all charged particles. Since forces are vectors, you will need to use vector addition rules.

Problem 1 – Graphical Vector Addition

Step 1. Page 1.3 contains a blank *Graphs & Geometry* page. Change the view of this page to Plane Geometry view (**MENU > View > Plane Geometry View**) and hide the scale (**MENU > View > Hide Scale**).

Step 2. Draw two vectors, AB and AC , using the **Vector** tool (**Menu > Points & Lines > Vector**). To draw vector AB , first select the **Vector** tool. Then click once on any point on the page. Press $\text{CAPS} \text{ } \text{A}$ to label the starting point of the vector A . Then drag the cursor to another point, single-click again, and label the ending point of the vector B . To draw vector AC , click again on point A and create another vector that points in another direction. Label the endpoint of this vector C .



Step 3. Next, you will explore the head-to-tail rule of vector addition. According to this rule, you can add two vectors by placing the head of one vector at the tail of the second. The sum of the vectors is then the vector from the tail of the first vector to the head of the second vector. To explore this rule using vectors AB and AC , you must first translate vector AB so that its tail is aligned with the head of vector AC (point C). You can use the **Translation** tool to copy vector AB so that point A is aligned with point C . To do this, choose the Translation tool (Menu > Transformation > Translation). Click on vector AC . Then move your cursor to vector AB and press \cdot . Vector AB will be translated to point C . Draw a point (Menu > Points & Lines > Point) at the end of this new vector and label it D .

Step 4. Use the Vector tool to construct vector AD . Vector AD is the sum of vectors AB and AC . To drag a point, move your cursor over the point until a curved hand appears. Push and hold the \square button until the hand closes. Drag point B around the screen to observe how vector AD changes as the magnitude and direction of vector AB change. Then use the Length and Slope tools (Menu > Measurement > Length and Menu > Measurement > Slope) to measure and label the lengths and slopes of vectors AB , AC , and AD . To use the measurement tools, first select the appropriate tool from the menu. Then click once on the vector you wish to measure. The measurement will appear on the screen. Drag the measurement to where you want it to be, and then click again to place the measurement there. To label a measurement, double-click on the number and then type the label next to the number.

1. How does the length of vector AD compare with the lengths of vectors AB and AC when AB and AC are collinear?
2. How does the direction (slope) of vector AD compare with the slopes of vectors AB and AC ? (Hint: The angle of the vector is equal to the inverse tangent of the slope. You can use the Text and Calculate tools to calculate the angle from the slope measurement you have made.)

Step 5. Next, you will explore the addition of three vectors. To add three vectors, you must first add two of the vectors and then add the third vector to the sum of the other two. Use the Vector tool to construct vector AE pointing in a different direction than vectors AB , AC , and AD . Adding vector AE to vectors AB and AC is equivalent to adding vector AE to vector AD . To add these vectors, open the Translation tool. Click on vector AD and then on vector AE . Vector AE will then be translated to point D . Add a point at the end of this vector and label it F . You can then construct vector AF , the sum of vectors AB , AC , and AD .

Step 6. Move points A , B , C , and E around the screen, and observe how vector AF changes. If you wish, you may hide vectors CD , AD , and DF by choosing Menu > Action > Hide/Show and clicking on each vector in turn. This will make it easier to see how vector AF is related to vectors AB , AC , and AE .

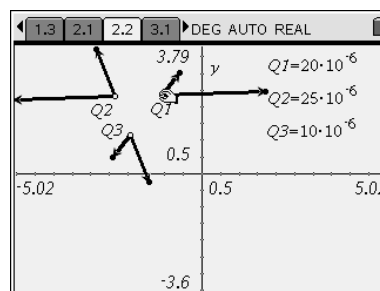
3. Describe the lengths and positions of vectors AB , AC , and AE that are required to make AF become as small as possible.

Problem 2 – Interaction between Three Similarly Charged Particles

Page 2.2 shows three charged particles. Because all three particles are positively charged, the forces between them are all repulsive. The vectors attached to each point show the forces on that particle that are produced by the other two particles. You can drag each point and thus vary the distances between the particles. The numbers on the right-hand side of the screen give the magnitudes of the charges on the particles. You can click on these labels and vary the magnitudes of the charges. The charges are given in units of coulombs (C), and distances are in meters.

Step 1. Find the net force on each particle using head-to-tail vector addition. Then hide the individual forces on each particle (the original vectors present on the page).

Step 2. Vary the locations and magnitudes of the charges. Observe the effects of charge magnitudes and distances between the charges on the magnitude and direction of the net force on each particle.

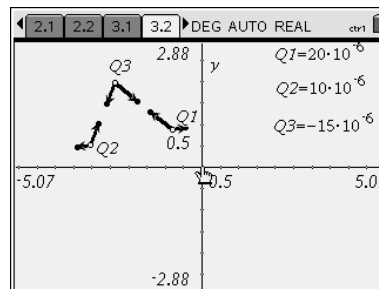


4. Describe the changes you observed in the net force on each particle when you varied the magnitudes and positions of the particles. Did you notice any patterns?
5. What happens to the net force on a particle when its charge is much larger or smaller than the charges on the other two particles?
6. What happens to the net force when one of the particles moves very close to one of the other particles?
7. What happens to the net force on a particle when it is moved far away from the other two particles?
8. What happens to the net force on a particle when it is located exactly between two equally charged particles?
9. Three particles, each with a charge of $+11 \mu\text{C}$, are located at the corners of an equilateral triangle with sides of length 1 m. Calculate the magnitude and direction of the net force on each particle. (Hint: Use the template on page 2.2, adjust the scale if needed, and reproduce the conditions of the problem. Then calculate the magnitude and angle for each net force.)

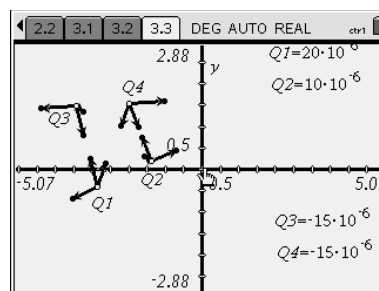
Problem 3 – Interaction between Particles of Opposite Charge

In this problem you will explore how interactions between oppositely charged particles differ from the interactions between particles with the same charge.

Step 1. Move to page 3.2, which shows two positively charged particles and one negatively charged particle. Find the net force on each particle using head-to-tail vector addition. Then hide the individual forces on each particle (the original vectors present on the page). Move the particles around and observe the effects on the resultant forces.



Step 2. Next, move to page 3.3, which shows two positively charged particles and two negatively charged particles. Find the net force on each particle using head-to-tail vector addition. Then hide the individual forces on each particle (the original vectors present on the page). Move the particles around and observe the effects on the resultant forces.



10. What happens to the net forces when oppositely charged particles move very close to one another?
11. What happens to the net force on a negatively charged particle when it is located exactly between two particles of equal positive charge?
12. Explore other symmetrical arrangements of the particles, and describe any patterns that you observe.
13. A particle of charge $+100 \mu\text{C}$ is located at $(-2, 0)$, and a particle of charge $+200 \mu\text{C}$ is located at $(2, 0)$. Where should a negatively charged particle with charge $-50 \mu\text{C}$ be placed so that the net force on this particle has a magnitude of 2 N and is directed at -135° ? (Hint: You can see the coordinates of a point by choosing **Menu > Actions > Coordinates and Equations** and then clicking on the point.)
14. A right isosceles triangle is formed by the charges $Q_1 = +150 \mu\text{C}$, $Q_2 > 0$, and $Q_3 = -120 \mu\text{C}$ located at points $(0, 10)$, $(0, 0)$, and $(-10, 0)$, respectively. The fourth charge, $Q_4 = -145 \mu\text{C}$, is located at the midpoint of the hypotenuse. The net force on charge Q_4 is 10 N in the positive x -direction. What is the charge on Q_2 ?



Forces on Point Charges

Physics – Teacher Notes

Activity Overview:

In this activity, students explore the interaction between charged point particles. They first explore graphical vector addition and then use vector addition rules to explore the net forces on charged particles. The preconstructed templates used in this activity include charged particles, represented by points, and forces of interactions between the particles, represented by vectors. When students change the magnitudes of charges or distances between the particles, the vectors representing the forces of interaction change correspondingly.

Teacher Preparation:

Before carrying out this activity, you should review Coulomb's law with students. Students should also be comfortable with the concept of a vector and the rules of vector addition before beginning this activity.

- *The screenshots on pages 2–9 demonstrate expected student results. Refer to the screenshots on page 10 for a preview of the student TI-Nspire document (.tns file).*
- **To download the student worksheet and TI-Nspire document (.tns file), go to education.ti.com/exchange and enter "9359" in the search box.**

Classroom Management:

- *This activity is designed to be **student centered**, with the teacher acting as a facilitator while students work cooperatively. The student worksheet guides students through the main steps of the activity and includes questions to guide their exploration. Students should record their answers to the questions on notebook paper. If time allows, a whole-class discussion of the activity would be useful for the students.*
- *The ideas contained in the following pages are intended to provide a framework as to how the activity will progress. Suggestions are also provided to help ensure that the objectives for this activity are met.*
- *In some cases, these instructions are specific to those students using TI-Nspire handheld devices, but the activity can easily be done using TI-Nspire computer software.*

Materials:

To complete this activity, each student will require the following:

- *TI-Nspire™ technology*
- *Pen or pencil*
- *Forces_on_Point_Charges_Student_Physics.doc*
- *Forces_on_Point_Charges.tns*

Forces on Point Charges

The following questions will guide student exploration during this activity:

- How do the positions and charges of particles affect the forces acting on the particles?
- How can a preconstructed scenario be used to solve electrostatics problems?

The purpose of this activity is to provide students with an opportunity to explore the interactions between charged particles when three or more particles are present in the system. TI-Nspire technology provides students with a dynamic environment for explorations and tools for graphical and numerical analysis for a variety of situations.

This activity consists of three parts. The preconstructed templates can also be used by the students in and out of class to verify solutions of various problems dealing with point charges and forces between them.

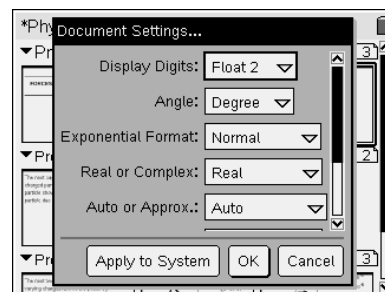
Problem 1 – Graphical Vector Addition

Step 1. In this part of the activity, students use TI-Nspire features to practice graphical methods of vector addition.

First, students should open the file

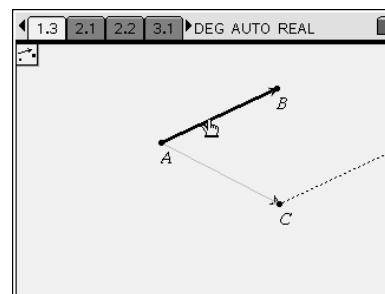
PhysWeek05_PointCharges.tns and read the first two pages. They should then proceed to page 1.3, which contains an empty *Graphs & Geometry* page. Students should change the page to the Plane Geometry view (**Menu > View > Plane Geometry View**) and hide the scale (**Menu > View > Hide**

Scale). It is recommended that students change the document settings for the angle measurements to be in degrees for this activity. To change the document settings, students should press **(ctrl)** **(page sorter)** to enter the page sorter view, press **(menu)** to select the menu, and then select **Document Settings**.



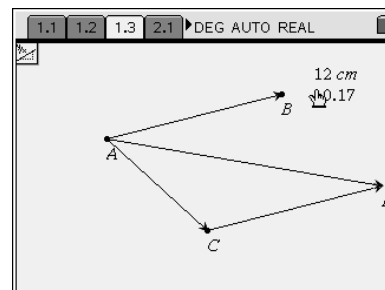
Step 2. Next, students use the **Vector** tool (**Menu > Points & Lines > Vector**) to draw two coterminal vectors, AB and AC , on page 1.3.

Step 3. Next, students should use the **Translation** tool (**Menu > Transformations > Translation**) to translate vector AB to point C . They should label the image of point B as D using the **Text** tool.



Step 4. Next, students construct vector AD , the sum of AB and AC . They then find the magnitude and direction of vector AD using the **Length** and **Slope** measurement tools from the **Measurement** menu. They should then answer questions 1 and 2.

1. How does the length of vector AD compare with the lengths of vectors AB and AC when AB and AC are collinear?

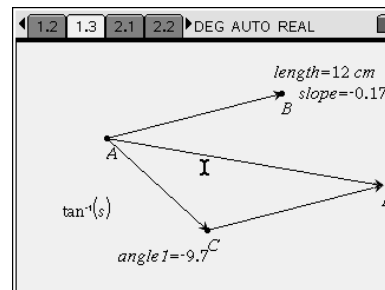
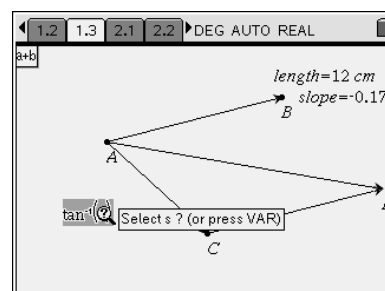


When AB and AC are parallel, AD is equal to the sum of the lengths of AB and AC .

2. How does the direction (slope) of vector AD compare with the slopes of vectors AB and AC ?

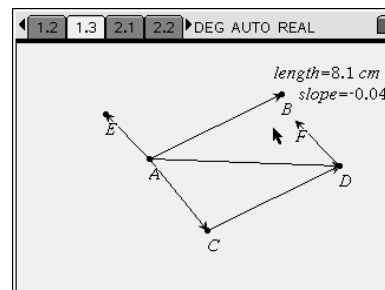
The slope of AD is partway between the slopes of AB and AC . Students can use the **Slope** measurement tool to observe the direction of the resultant vector, or they can find the angle of the vector to the horizontal. Since the slope of the line is equal to the inverse tangent of the angle, students can use the **Text** and **Calculate** tools to find the angle of the resultant vector. The instructions for using this method are given below:

- Choose the **Text** tool (**Menu > Actions > Text**).
- Click on a blank space anywhere on the screen. The text box will open in the edit mode.
- Enter the expression $\tan^{-1}(s)$ and press enter .
- Choose the **Calculate** tool (**Menu > Actions > Calculate**).
- Click on the expression. When **Select s?** appears on the screen, move the cursor and click on the value of the slope. Press enter and the value of the slope should appear. Drag the expression to the desired location and press enter again.



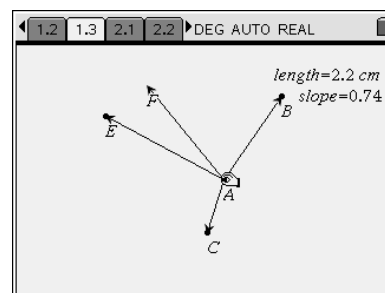
Remind students that when the angle is in the second or third quadrant, they need to add 180° to the angle calculated using the inverse tangent.

Step 5. Next, students explore the addition of three coterminal vectors. They first construct vector AE , which should point in a different direction than vector AB , AC , or AD . Then, they use the **Translation** tool to add vector AE to vector AD . They label the endpoint of this vector F and construct vector AF , which is the sum of vectors AB , AC , and AE .



Step 6. Next, students explore how vector AF changes as they move points A , B , C , and E around the screen. They should then answer question 3 on the student worksheet.

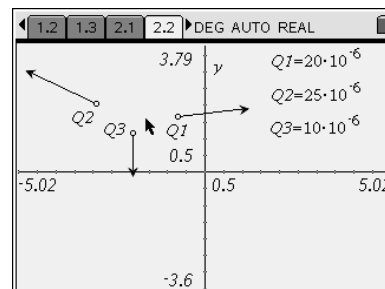
- Describe the lengths and positions of vectors AB , AC , and AE that are required to make AF become as small as possible.



There are several combinations of vectors AB , AC , and AE that will make vector AF extremely small. Encourage students to compare their results with one another and discuss the different solutions.

Problem 2 – Interaction between Three Similarly Charged Particles

Next, students should move to page 2.1 and read the text there. Page 2.2 shows three positively charged particles. The vectors attached to each point show the forces on that particle that are produced by the other two particles. Students can drag each point and thus vary the distances between the particles. The numbers on the right-hand side of the screen give the magnitudes of the charges on the particles. Students can click on these labels and vary the magnitudes of

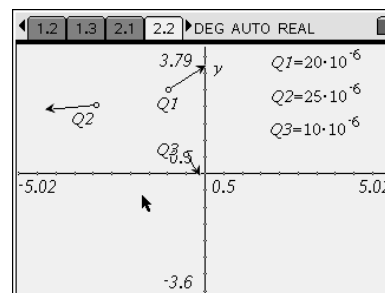


the charges. The charges are given in units of coulombs (C), and distances are in meters.

Step 1. Next, students should find the net force on each particle using head-to-tail vector addition. They should then hide the individual force vectors on the particles, so only the net forces are visible, as shown to the right.

Step 2. Next, students should vary the locations and charges of points $Q1$, $Q2$, and $Q3$ and observe the results. Then, they should answer questions 4–9 on the student worksheet.

- Describe the changes you observed in the net force on each particle when you varied magnitudes and positions of the particles. Did you notice any patterns?



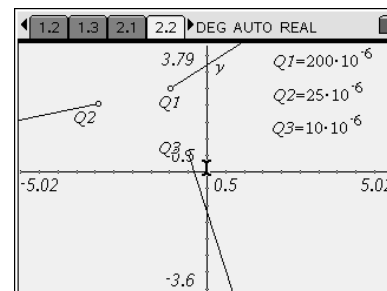
Forces on Point Charges

Due to the open-ended nature of the question, many different responses are possible. However, students should note that the net forces on the particles decreased as the particles got farther apart and increased as they got closer together. Students should also note that the net forces on the particles are directly related to the charges on the particles (i.e., the larger the charges, the larger the net forces).

5. What happens to the net force on a particle when its charge is much larger or smaller than the charges on the other two particles?

When the charge on one particle is much larger than the charges on the other particles, the net forces on all three particles increase significantly. As the charge on one particle approaches zero, the net force on that particle

also approaches zero. Note that students may think that the force on a particle can never go to zero if the other two particles have nonzero charges. Guide them to understand that electric forces affect only charged particles, so a particle with a zero charge will experience no net force.

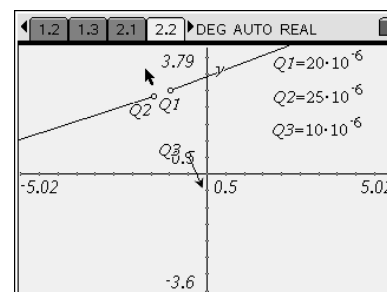


6. What happens to the net force when one of the particles moves very close to one of the other particles?

The forces on the particles become very large.

7. What happens to the net force on a particle when it is moved far away from the other two particles?

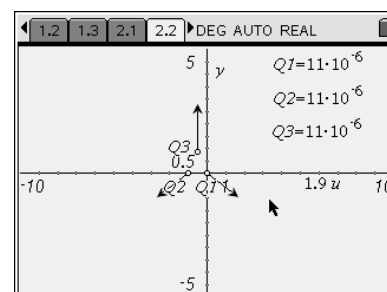
The forces on the particles become very small.



8. What happens to the net force on a particle when it is located exactly between two equally charged particles?

The net force on the central particle is zero because the vectors acting on the central particle have equal magnitudes but opposite directions.

9. Three particles, each with a charge of $+11 \mu\text{C}$, are located at the corners of an equilateral triangle with sides of length 1 m. Calculate the magnitude and direction of the net force on each particle. (Hint: Use the template on page 2.2, adjust the scale if needed, and reproduce the conditions of the problem. Then calculate the magnitude and angle for each net force.)



Forces on Point Charges

Students can use the template on page 2.2 to solve this problem graphically. They can place the three charges, for example, on the points

$(-1, 0)$, $(0, 0)$, and $(-\frac{1}{2}, \frac{\sqrt{3}}{2})$. They can then display the coordinates of points Q1, Q2, and Q3

using the **Coordinates and Equations** tool (**Menu > Actions > Coordinates and Equations**). They can use the **Length** and **Slope** measurement tools to determine the magnitudes and directions of the resulting forces. They should find that the magnitude of the force on each particle is 1.9 N and the directions are as follows:

For $(0, 0)$, $\theta = -30^\circ$; for $(-\frac{1}{2}, \frac{\sqrt{3}}{2})$, $\theta = 90^\circ$; and for $(-1, 0)$, $\theta = 210^\circ$. Students will probably

need to adjust the scale of the graph (**Menu > Window > Window Settings**) to see the net forces clearly. Students should also calculate the magnitudes and directions analytically, using Coulomb's law and vector addition rules. Coulomb's law yields the net force on each particle, as shown on the next page (make sure students convert μC to C):

$$F_c = 2k \frac{q^2}{r^2} \cos(30^\circ)$$

$$F_c = (2)(9 \times 10^9 \frac{\text{N}\cdot\text{m}^2}{\text{C}^2}) \left(\frac{11 \times 10^{-6} \text{C}}{1 \text{m}} \right)^2 (0.866)$$

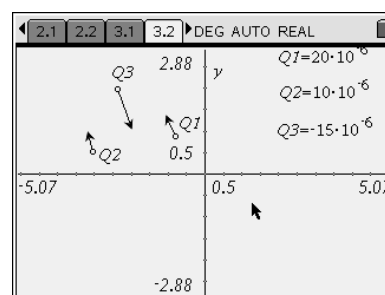
$$F_c = 1.9 \text{ N}$$

Students can use the law of cosines to determine the direction of each vector.

Problem 3 – Interaction between Particles of Opposite Charge

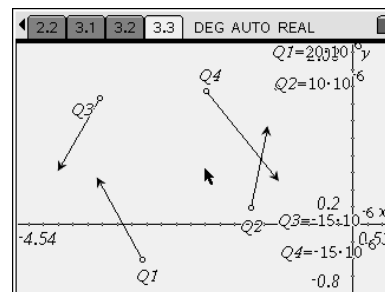
In this part of the activity, students explore the interactions between positively and negatively charged particles. Note that in each template, the sign of the charge cannot be changed. Students should read page 3.1 before moving on to the simulations. (Note: To save time, you may construct the net force vectors for this problem ahead of time in the .tns file, before transferring the file to the students' handhelds or computers.)

Step 1. Students should first move to page 3.2, which shows two positively charged particles and one negatively charged particle. They should use head-to-tail vector addition to find the net force on each particle and then hide the individual force vectors on each particle so only the net forces are visible. They should change the positions and charges of the particles and observe the results.



Forces on Point Charges

Step 2. Next, students should move to page 3.3, which shows two positively charged particles and two negatively charged particles. They should again find the net force on each particle and hide the component forces. After exploring the effects of position and charge on these forces, students should answer questions 10–14 on the student worksheet.

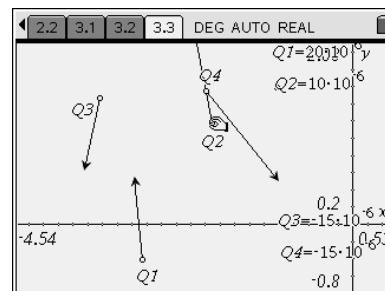


10. What happens to the net forces when oppositely charged particles move very close to one another?

The magnitudes of forces on the oppositely charged particles increase significantly and approach infinity. Their directions become opposite. At the same time, the net force on the third particle approaches zero.

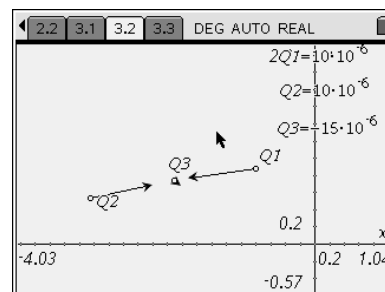
11. What happens to the net force on a negatively charged particle when it is located exactly between two particles of equal positive charge?

When a negatively charged particle is located exactly between two equally positively charged particles, the net force on the negatively charged particle is zero because the two force vectors acting on the central particle have equal magnitudes but opposite directions.

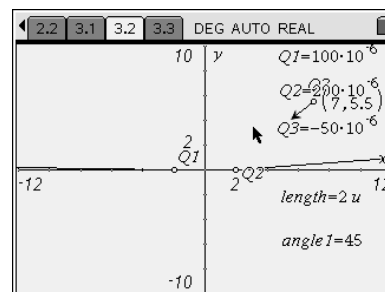


12. Explore other symmetrical arrangements of the particles, and describe any patterns that you observe.

Encourage students to explore different symmetrical arrangements of the particles and discuss their results with the class. Encourage them to predict the net forces resulting from various symmetrical arrangements and then use the templates on pages 3.2 and 3.3 to test their predictions.



13. A particle of charge $+100 \mu\text{C}$ is located at $(-2, 0)$, and a particle of charge $+200 \mu\text{C}$ is located at $(2, 0)$. Where should a negatively charged particle with charge $-50 \mu\text{C}$ be placed so that the net force on this particle has a magnitude of 2 N and is directed at -135° ? (Hint: You can see the coordinates of a point by choosing **Menu > Actions > Coordinates and Equations** and then clicking on the point.)



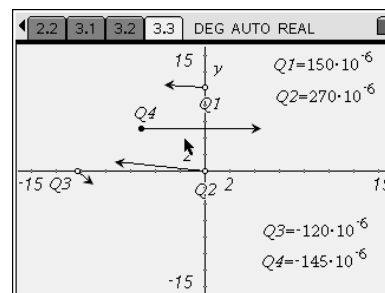
Forces on Point Charges

Two possible coordinates are (7, 5.6) and (-0.385, 0.082). This particular problem is too advanced for analytical solution. It is sufficient if students verify their graphical solution by calculations. In order to do that, they will need to measure the magnitudes and angles of all forces and show that the net force in the system is zero.

Note: If students struggle with this problem, you may first ask them to explore a simpler problem, such as determining the magnitude and direction of the net forces on the particles when they are placed at specific locations.

14. A right isosceles triangle is formed by the charges $Q_1 = +150 \mu\text{C}$, $Q_2 > 0$, and $Q_3 = -120 \mu\text{C}$ located at points (0, 10), (0, 0), and (-10, 0), respectively. The fourth charge, $Q_4 = -145 \mu\text{C}$, is located at the midpoint of the hypotenuse. The net force on charge Q_4 is 10 N in the positive x-direction. What is the charge on Q_2 ?

The charge on particle Q_2 should be approximately **+270 μC** . Once again, students should verify that the net force in the system is zero after they find their solution. If you wish, you may assign additional problems or explorations to student pairs or groups for homework or independent projects.





15. Participants Visit a Web Site – How-To Document

Activity Overview:

Locate an investigation on the Internet, download all the associated files, and send the TNS file to the handheld.

Materials:

- Computer with Internet access, data storage, TI-Nspire Link software with the Standard-A-to-Mini-B USB Connectivity Cable and the CAS TI-Nspire™ handheld

Start at <http://education.ti.com/>.

The screenshot shows the Texas Instruments Education Technology website. The browser window title is "USA and Canada Home by Texas Instruments -US and Canada - Mozilla Firefox". The address bar shows "http://education.ti.com/". The website features a red header with the Texas Instruments logo and the tagline "Your Passion. Our Technology. Student Success.™". The main navigation menu includes "Products", "Downloads", "Getting Started", "Classroom Activities", "Professional Development", and "Funding & Research". The page is divided into several sections: "find products" with links to TI-Nspire™ Technology, Which Calculator is Right for Me?, Products and Accessories, and Buy Now; "product support" with links to FAQs and Knowledge Base, Tutorials, Contact TI, and Production Registration; "downloads" with links to Activities Exchange, Games and Freebies, Apps and Operating Systems, and Latest TI-Nspire OS; "students" with a sub-section for "calculators and accessories" and links to Student Zone, Games & Software, Tutorials, Exam Preparation Tips, and Buy a TI Calculator; and a "What is the key reason for your visit?" poll with options for Product Research, Selection or Purchase, Download Applications and Documents, Training, Events or Professional Development, and Product Support or Registration. The footer includes links for Events, TI in your State, e-newsletter Sign-up, Contact TI, About TI, User Groups, Press, Careers, Student Zone, and Related Sites.



15. Participants Visit a Web Site – How-To Document

Locate the Classroom Activities tab and select Activities for Your Subject.

The screenshot shows a Mozilla Firefox browser window displaying the Texas Instruments Education Technology website. The browser's address bar shows the URL: <http://education.ti.com/educationportal/sites/US/homePage/index.html>. The website header features the Texas Instruments logo and the tagline "Your Passion. Our Technology. Student Success.™". The main navigation menu includes "Products", "Downloads", "Getting Started", "Classroom Activities", "Professional Development", and "Funding & Research". The "Classroom Activities" menu is open, showing options such as "Activities Exchange", "Activities for Your Subject", "Textbook Publisher Connections", "Supplemental Publisher Connections", "Product Tutorials", "Test Prep", "State Practice Exams", "Getting Started Series", and "EXPLORATIONS™ Series Books". The "product support" section includes "FAQs and Knowledge Base", "Tutorials", "Contact TI", and "Production Registration". The "downloads" section includes "Activities Exchange", "Games and Freebies", "Apps and Operating Systems", and "Latest TI-Nspire OS". The "educators" section features a "TI events" calendar and a "How likely are you to recommend our web site to others?" poll with options: "Extremely Likely", "Very Likely", "Very Unlikely", and "Extremely Unlikely". The "ACTIVITIES EXCHANGE" logo is also visible. The browser's address bar at the bottom shows the URL: <http://education.ti.com/educationportal/sites/US/sectionHome/classroomactivities.html>.



15. Participants Visit a Web Site – How-To Document

From the TIMath pull-down window, select TI Physics.

Classroom Activities by Texas Instruments -US and Canada - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://education.ti.com/educationportal/sites/US/sectionHome/classroomactivities.I

David A. Young My eBay PayPal Search Me Mapping Travel Page DAY Local Portfolio T-Bird iWon BlackBoard Las Vegas

dyoung@fayar.net Gmail - Mass_W... Product Tutorial... USA and Canad... Texas Instrume... TI-Nspire™ CAS... Classroom ...

TEXAS INSTRUMENTS
Your Passion. Our Technology. Student Success.™

Education Technology

Enter Keywords Search

Purchase | Support | Sign In

Products | Downloads | Getting Started | **Classroom Activities** | Professional Development | Funding & Research | Site: US and Canada

Classroom Activities
Developed by educators for educators, our activities, tutorials, and textbook information provide ready-to-use ideas for incorporating TI educational technology into your classroom.

Activities Exchange
Discover innovative classroom activities that are aligned to your curriculum and state standards.
[▶ Learn More](#)

Textbook Publisher Connections
Find information, links, and activities for your classroom textbook.
[▶ Learn More](#)

Product Tutorials
Get started using your TI products with interactive tutorials on calculation, scientific notation, graphing

Activities for Your Subject
Sign up to receive weekly email alerts featuring a full spectrum of downloadable, ready-to-use activities.

TIMATH

TI Math
TI Physics
TI Middle Grades

Supplemental Publisher Connections
Publishers of supplemental materials featuring TI technology.
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Test Prep Materials
TI graphing calculators are permitted on many college and advanced placement exams. Students can

TI Classroom Activities CD

Over 350 math and science activities aligned to state, national and provincial standards.
[▶ Send me a free TI Classroom Activities CD!](#)

Done



15. Participants Visit a Web Site – How-To Document

Explore the activities and select one to download.

The screenshot shows a Mozilla Firefox browser window displaying the TI Physics Activities website. The browser's address bar shows the URL <http://www.tiphysics.com/activities/#>. The website header features the Texas Instruments logo and the text "TI Physics" with the tagline "Your Passion. Our Technology. Student Success." Below the header is a navigation menu with links for "Activities", "TI-Nspire CAS Info", "Student Success", "Training", and "Sign Up Now". A prominent banner for "New 2008 Physics Activities" includes an image of a TI-Nspire calculator and a calendar icon indicating "Tuesday 2" for the "2008-09 school year". A text box below the banner explains that new dynamic activities are added weekly and are archived for review. The main content area is titled "TI-Nspire™ Activities:" and includes a link to learn more about TI-Nspire. Below this is a table listing activities with columns for Title, Topic, Subject, Date, and Download.

Title	Topic	Subject	Date	Download
Coulomb's Law	Applications of Electricity and Magnetism	Physics	3/24/2009	Downloaded: 0
Polarization of Light	Waves	Physics	3/17/2009	

Download all the files and note the filename, type, and location.



15. Participants Visit a Web Site – How-To Document

If you cannot locate a worthy or interesting activity, go to the Activity Exchange by selecting the Go to Education.TI.com link at the bottom of the page and search.

Introducing the TI-Nspire CAS learning handheld and computer software TI-Nspire CAS (Computer Algebra System) technology is designed to support your instruction and curriculum. Realize the power of visual learning when it is applied to symbolic mathematics. TI-Nspire CAS technology adds a new interactive dimension, so your students are able to use educational technology to explore symbolic answers and the multiple representations of different problems.

- Perform symbolic algebra and symbolic calculus on a user-friendly interface.
- Experience spreadsheet capabilities similar to using Microsoft Excel® software.
- Show students the cause-and-effect nature of changes in real-time, on one screen.
- Help students input the proper exponents for exploring physics problems.

To request a demonstration contact a TI Educational Technology Consultant, at ti-educators@ti.com or send your comments and questions about this website.

Topic: Coulomb's Law

Activity Overview:
In this activity, students explore the relationship between force, charge, and distance for two charged particles, i.e., Coulomb's law. Students observe how force changes with distance by moving a charged particle. By fitting the data collected for force vs. distance to a power regression equation, students determine that electrical force is inversely proportional to distance squared. After determining the dependence of electrical force on charge, the students are able to write the Coulomb's law equation. Next, students see how force changes with like and unlike charges. The activity ends with an application of Coulomb's law to solve a problem involving two charged particles and a test charge.

[Click to play video.](#) [Click to view activity.](#)

[Order Trial Kit](#) [Go to Education.TI.com](#) [Sign Up for Weekly Email Activity Alerts](#) [Sign Up Now!](#)

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<http://www.education.ti.com/>



15. Participants Visit a Web Site – How-To Document

Select Activity Exchange from the Classroom Activities tab.

The screenshot shows a Mozilla Firefox browser window displaying the Texas Instruments Education Technology website. The address bar shows the URL: <http://education.ti.com/educationportal/sites/US/homePage/index>. The website header includes the Texas Instruments logo and the text "Education Technology". A navigation menu is visible with the following items: Products, Downloads, Getting Started, Classroom Activities, Professional Development, and Funding & Research. The "Classroom Activities" menu is expanded, showing a list of options: Activities Exchange, Activities for Your Subject, Textbook Publisher Connections, Supplemental Publisher Connections, Product Tutorials, Test Prep, State Practice Exams, Getting Started Series, and EXPLORATIONS™ Series Books. The "Activities Exchange" option is highlighted. Below the navigation menu, there is a large image of a person performing a handstand. To the right of the image, there is a "product support" section with links to FAQs and Knowledge Base, Tutorials, Contact TI, and Production Registration. Below that is a "downloads" section with links to Activities Exchange, Games and Freebies, Apps and Operating Systems, and Latest TI-Nspire OS. On the right side of the page, there is a "students" section with a search bar and a "Buy a TI Calculator" button. Below that is a "TI events" section with a calendar icon and a "Find out what events are happening in your area" link. At the bottom right, there is a "How likely recommender others?" section with radio buttons for "Extremely Like", "Very Likely", "Very Unlikely", and "Extremely Unlikely", and a "VOTE" button. The browser's address bar at the bottom shows the URL: http://education.ti.com/educationportal/activityexchange/activity_list.do?cid=us.



15. Participants Visit a Web Site – How-To Document

You may use the Advanced Search option to focus your search to TI-Nspire and the science topic of interest.

Texas Instruments Activities Exchange: Browse by Subject - Mozilla Firefox

File Edit View History Bookmarks Tools Help

http://education.ti.com/educationportal/activityexchange/activity_list.do?cid=us

David A. Young My eBay PayPal Search Me Mapping Travel Page DAY Local Portfolio T-Bird iWon BlackBoard Las Vegas

dyoung@f... Gmail - M... Product T... USA and ... Texas Inst... TI-Nspire... Classroom... Classroom... Texas Inst... Texas...

Browse by Subject

Welcome to this free, collaborative forum where educators can share favorite activities using TI technology. You can begin browsing for activities by selecting a subject area below.

ACTIVITIES EXCHANGE

Browse by Subject Submit Activity Saved Activities Advanced Search quick search

Math

- Algebra I... (1015)
- Algebra II... (390)
- Calculus... (357)
- Elementary Math... (109)
- Geometry... (728)
- Math General... (275)
- Middle Grades Math... (420)
- PreAlgebra... (363)
- Precalculus / Trig... (362)
- Statistics... (382)

Science

- Biology... (89)
- Chemistry... (123)
- Earth Science... (47)
- Elementary Science (1)
- Environmental Science... (28)
- Forensics... (22)
- Life Science... (30)
- Middle Grades Science... (37)
- Physical Science... (98)
- Physics... (172)
- Science General... (132)

Other Subjects

- English/Language Arts... (134)
- Social Studies... (190)
- World Languages... (31)

Standards Search

Search by curriculum standard.

Search

Textbook Search

Search by select textbooks.

Search

TI-Nspire™ Activities

Check out activities for the new TI-Nspire family of products.

TI-Nspire Search

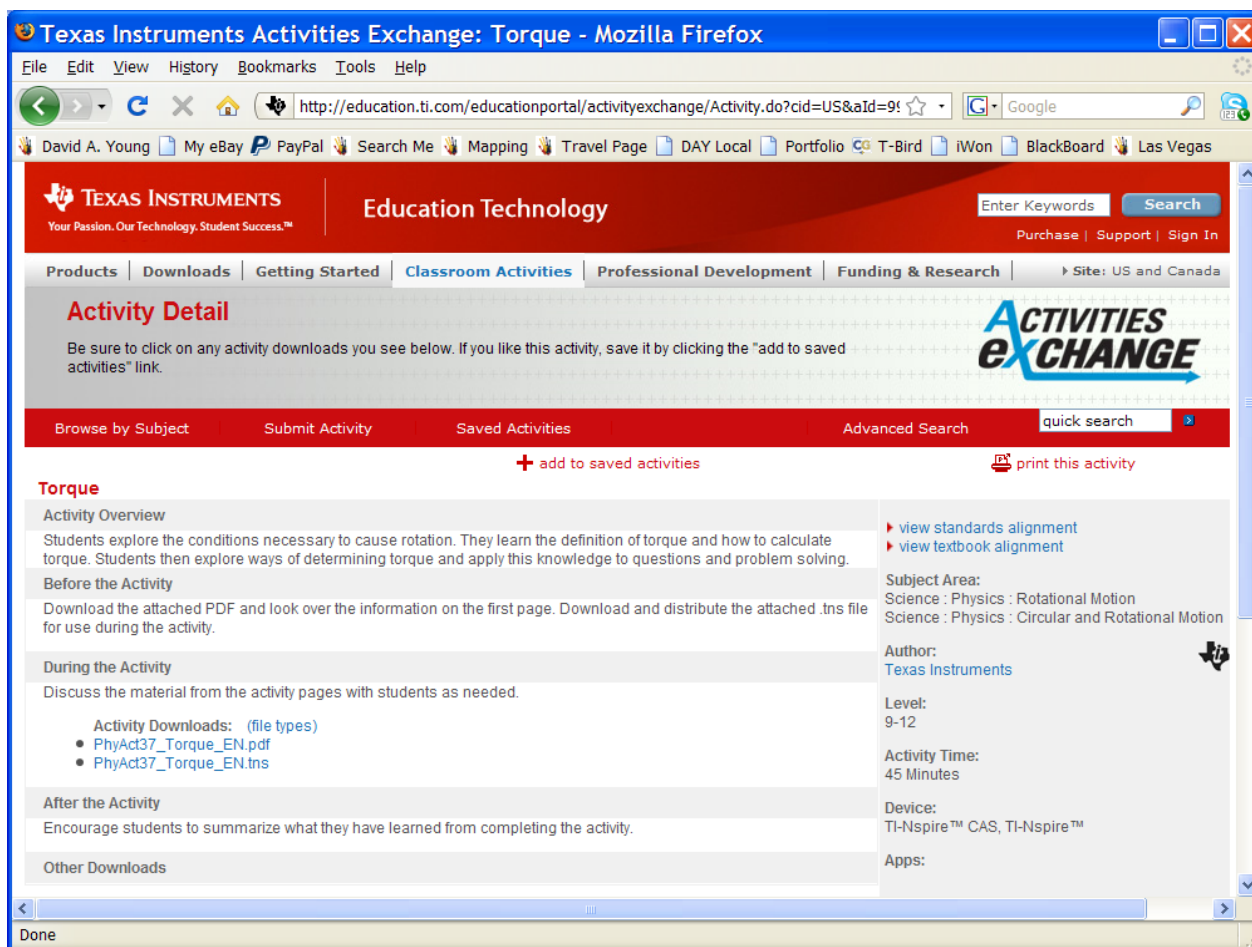
Events | TI in your State | e-newsletter Sign-up | Contact TI | About TI | User Groups | Press | Careers | Student Zone | Related Sites

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javascript:gothere('ActivitySearch.do?cid=US&mode=advanced')

15. Participants Visit a Web Site – How-To Document

When you locate an activity in Activity Exchange, read over the instructions and download the files. Note the filename, type, and location.



The screenshot shows a Mozilla Firefox browser window displaying the Texas Instruments Activities Exchange website. The page title is "Torque". The navigation menu includes "Products", "Downloads", "Getting Started", "Classroom Activities", "Professional Development", and "Funding & Research". The "Activity Detail" section for "Torque" includes an overview, instructions for "Before the Activity", "During the Activity", and "After the Activity". Under "During the Activity", there is a section for "Activity Downloads" with two links: "PhyAct37_Torque_EN.pdf" and "PhyAct37_Torque_EN.tns". On the right side, there is a sidebar with "Subject Area" (Science: Physics: Rotational Motion and Science: Physics: Circular and Rotational Motion), "Author" (Texas Instruments), "Level" (9-12), "Activity Time" (45 Minutes), "Device" (TI-Nspire™ CAS, TI-Nspire™), and "Apps".

Now that you have the activity, you want to send the TNS file to your handheld. Connect your handheld and the computer with the Standard-A-to-Mini-B USB Connectivity Cable.



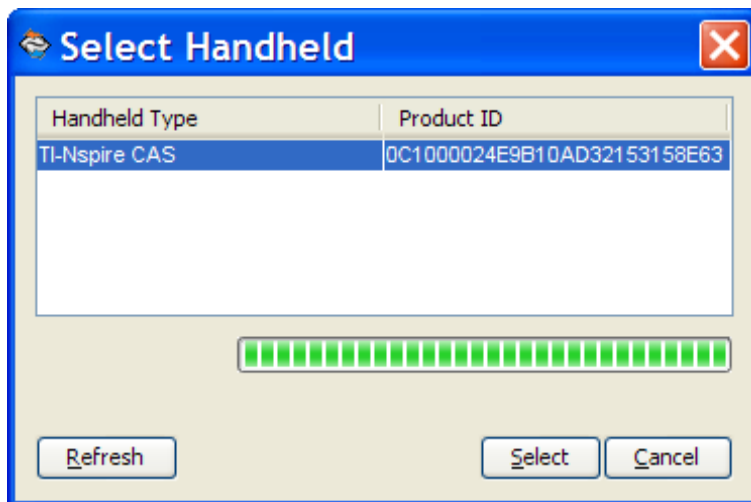


15. Participants Visit a Web Site – How-To Document

Launch the TI-Nspire Link software.

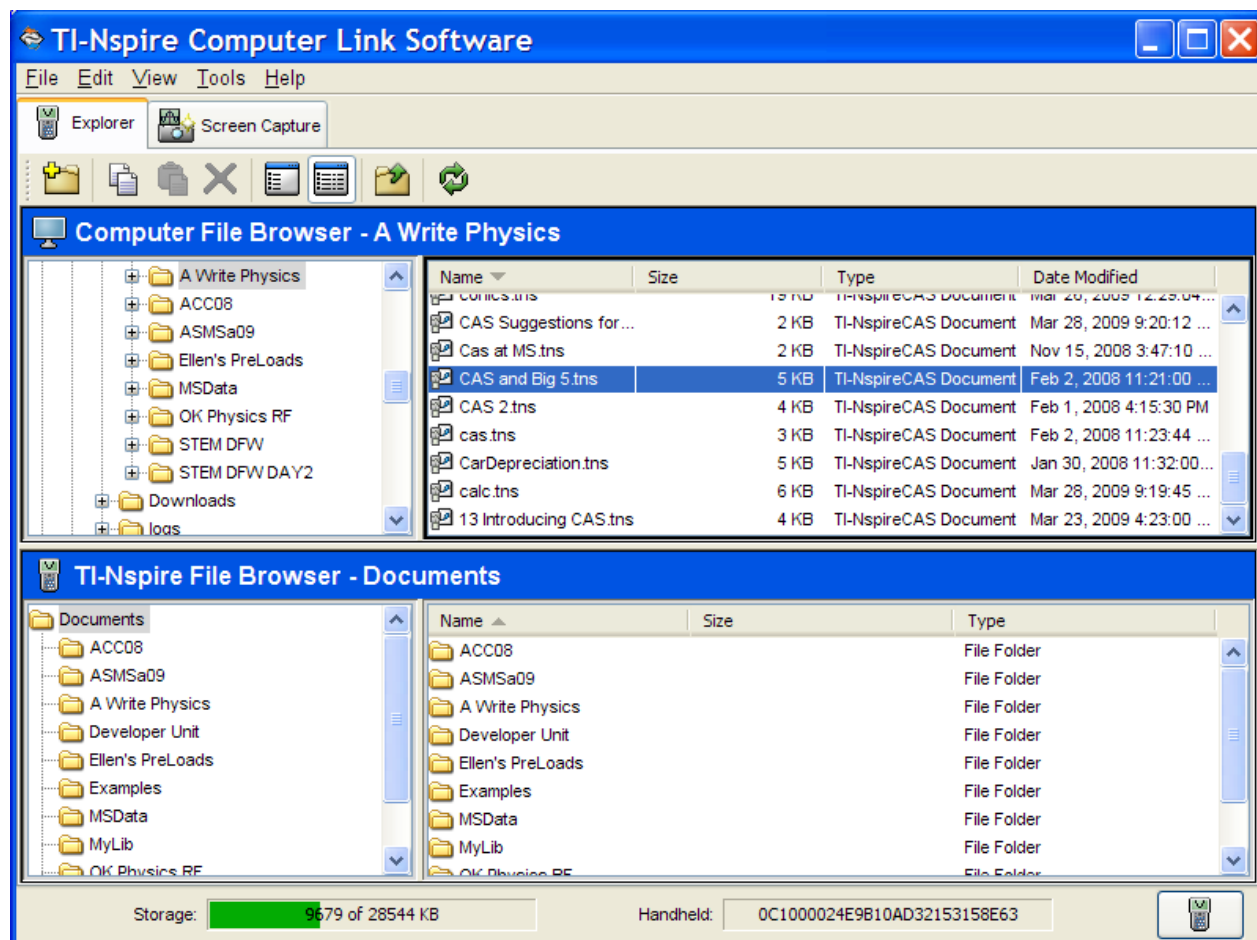


Select your handheld and then locate the TNS file on your computer in the top screen.





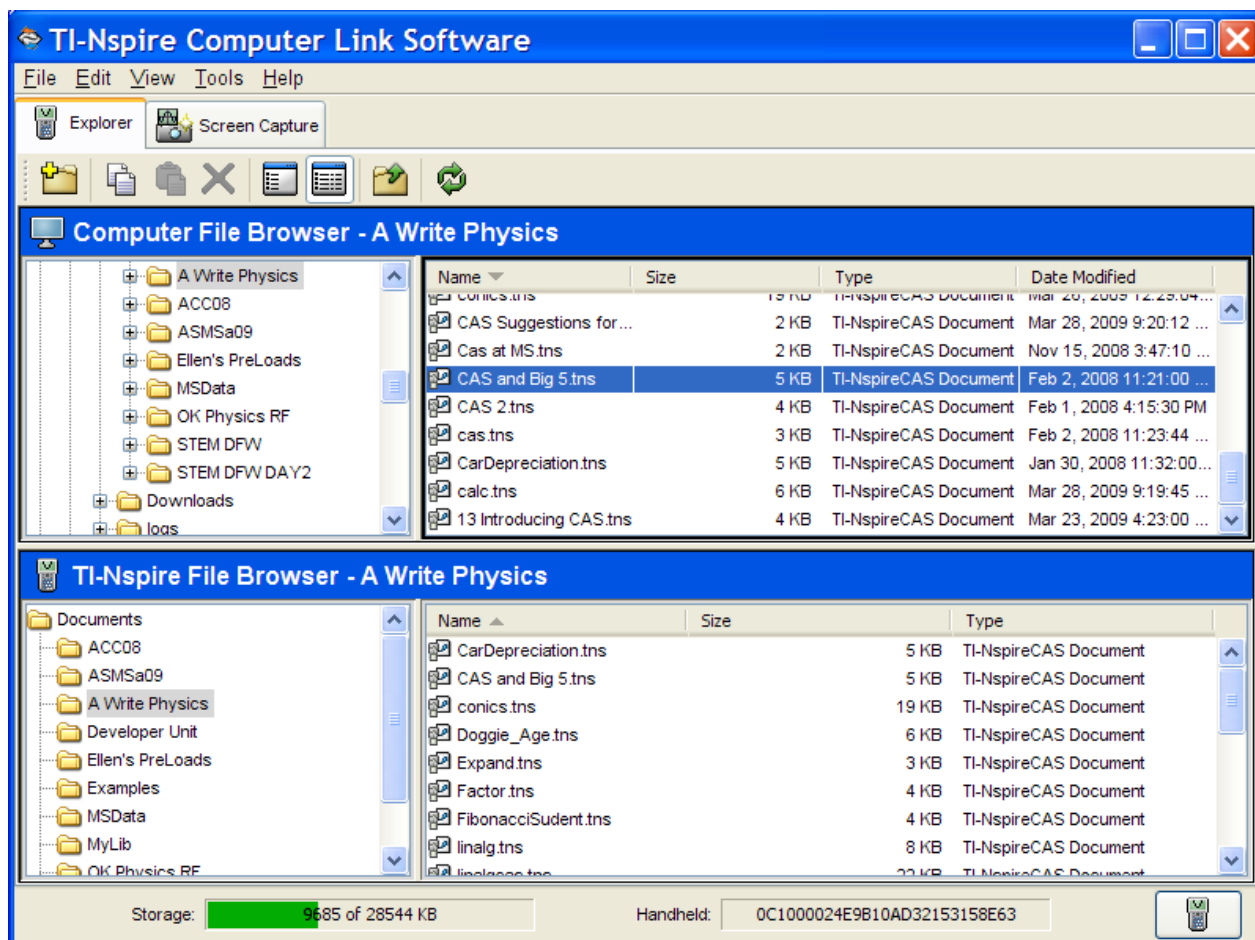
15. Participants Visit a Web Site – How-To Document



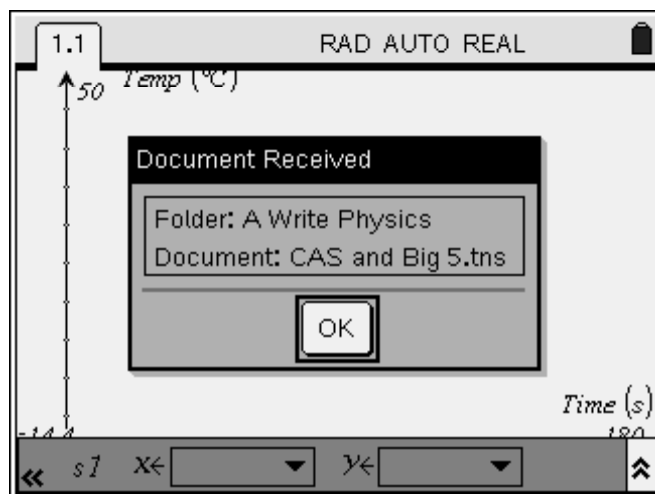
Then drag the file into the folder on your handheld on the bottom part of the screen.



15. Participants Visit a Web Site – How-To Document



You will notice on your handheld a message indicating that the document has been received.

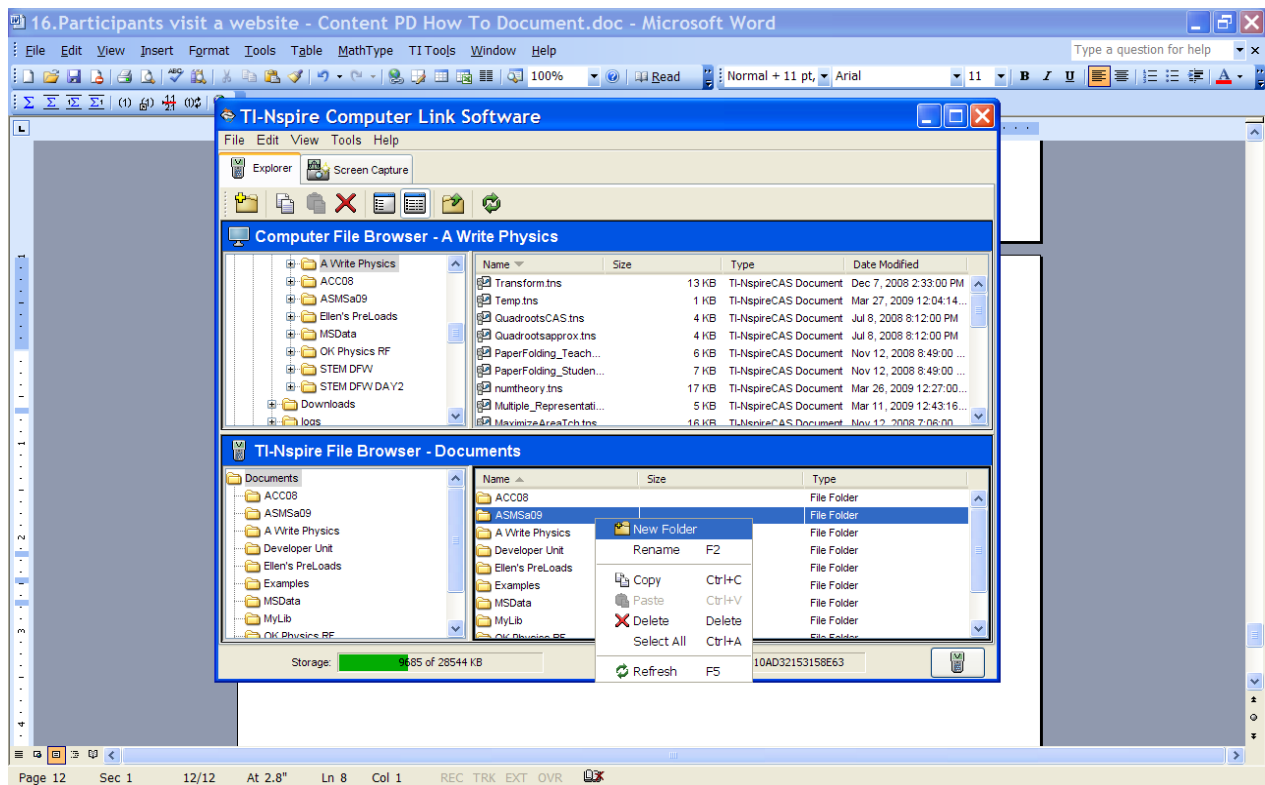




15. Participants Visit a Web Site – How-To Document

Extensions:

- Try to take a file from your handheld and store a copy on the computer.
- Take a screenshot from your handheld.
- File management—Move, copy, and delete files from your handheld.
- Create a new folder. Rename a folder.





Activity Overview:

- You have located an activity that you think is worthy and have downloaded the files. In this experience you will work through the investigation and then share with the group what you learned.

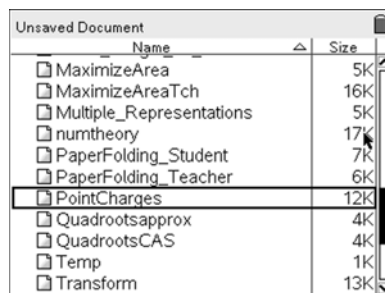
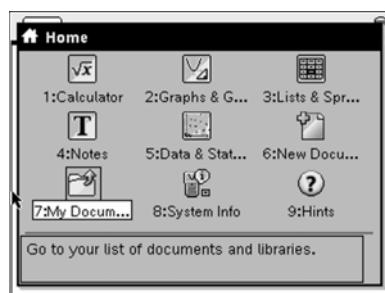
Materials:

- TI-Nspire™ CAS handheld
- Files from “Participants Visit a Web Site” activity
- Unit-to-unit link cable

Part 1 – Doing the Activity

Look over the instructions and follow the indicated steps to realize the activity.

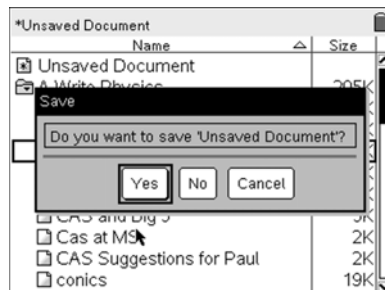
Open the file on your handheld. Press . Recall that you took note of the filename and location when you sent it to your handheld earlier. Once you locate the file and highlight it, press .



You might be challenged to save or discard an open document. Choose the right choice using the and/or keys.

Make note of things that were revealing or problematic as you move through the experience of the activity.

Consider how you might use this activity in your classes and how you might modify it.



Part 2 – Sharing the Activity

Prepare to share the activity. You may be asked to do this in a pair/share environment, in the whole group, or both.

Try to address these issues:



1. Why did you select the chosen activity? Where did you find it?
2. Did it meet your expectations?
3. What was cool about it?
4. What needs work before you would use it with your classes?
5. What tech issues did you have making it go?
6. What advice would you give another teacher who was planning to use this activity?

If you are in a pair/share environment, select the best activities/activity from your group to share with the whole group. Also prepare to include any relevant insights worthy of the group.

Part 3 – Actually Share the Activity TNS Document (Handheld to Handheld)

Send the TNS file from your activity to at least one other in the class.

Using the unit-to-unit link cable, plug your handheld into another.

On your handheld, go to My Documents [ ] and position your cursor/bar on the file.

Press   to select 5:Send.

When the transfer is complete, the other handheld will show the filename and the folder that was used.

