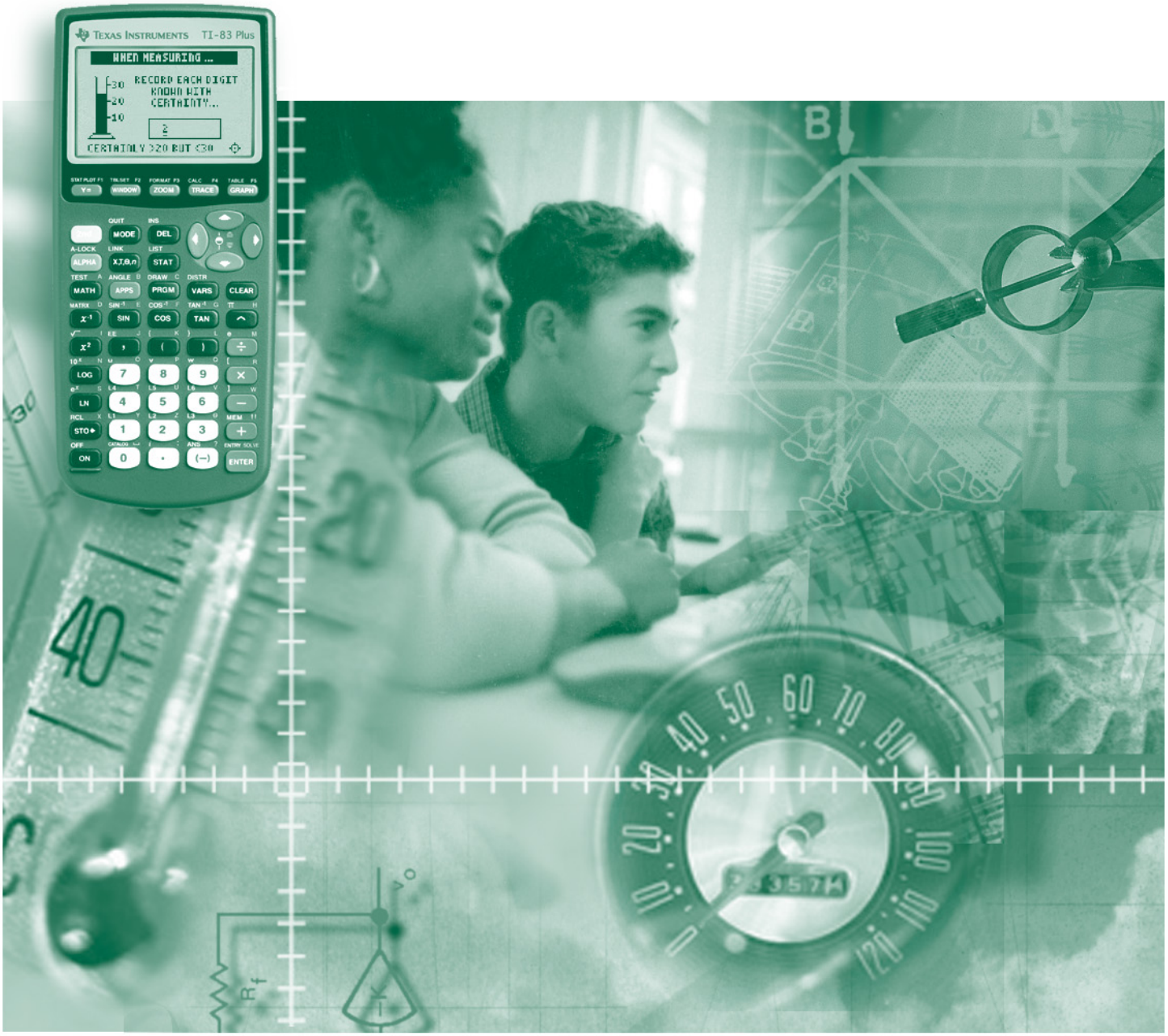
Texas Instruments

Fundamental Topics in **Science**



Version 1.0

Texas Instruments

Fundamental Topics in Science

Software Application for the TI-83 Plus

Student and Teacher Classroom Materials

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Manufacturer is Texas Instruments Incorporated, 7800 Banner Drive, M/S 3962, Dallas, Texas 75251.

Fundamental Topics in Science

Introduction to Fundamental Topics in Science

Note to Teachers

Welcome to the Fundamental Topics in Science software application for the TI-83 Plus. The application and Classroom Materials were designed to help students review and reinforce selected concepts taught in Science. Fundamental Topics in Science is easy to use, even for inexperienced calculator users, and it encourages students to explore concepts on their own.

Navigating Fundamental Topics in Science (pages viii–x) explains how to move around the application. You may wish to copy these pages for your students.

National Science Education Standards

The Teacher Notes for each topic include extracts of some of the relevant standards from Chapter 6: Science Content Standards in National Research Council, *National Science Education Standards* (Washington: National Academy Press, 1994). A readily accessible version of the entire standards may be found at:

http://stills.nap.edu/html/nses/html/

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Organization of Fundamental Topics in Science

Fundamental Topics in Science is organized in table-of-contents form. There are six topics.

1:SCIENTIFIC METHOD	Helps students understand that science is a process, not just dry facts, and involves them in following such a process as they study human heart rate.
2:PRECISION & ACCURACY	Helps students learn the difference between the two terms. It then introduces them to significant figures (significant digits) and provides hands-on practice.
3:SCIENTIFIC NOTATION	Introduces scientific notation and provides hands-on practice in using scientific notation, including practice with conversions to and from decimal notation and basic arithmetic operations.
4:UNITS & CONVERSIONS	Demonstrates the need for units and introduces students to SI units. It also covers conversions and dimensional analysis.
5:DATA & GRAPHS	Shows that presenting some data as tables and graphs can help significantly in understanding the data. The chapter introduces students to curve fitting.
6:VECTORS	Defines vectors and explains vector arithmetic and vector resolution, while providing students with practice in both.

Each topic is presented in three subsections.

1:INTRODUCTION	Presents a brief overview, often showing the real-world usefulness of the topic.
2:CONCEPTS	Presents definitions, concepts, and examples.
3:ACTIVITIES	Includes interactive activities that reinforce the concepts presented in the **INTRODUCTION** and **CONCEPTS** sections and that help students practice skills related to the topic.

Fundamental Topics in Science Classroom Materials include **Teacher Notes** and **Try-It!™ on Your TI-83 Plus** reproducible student activity sheets for every topic.

Several topics contain **WRITE IT DOWN** screens. These questions are usually of a discussion nature, as are questions on the **Try-It!** activity sheets. If your students are keeping journals, Fundamental Topics in Science is appropriate journal material, so you may prefer that students record their responses in their journals.

Try-It!™ on Your TI-83 Plus

These activities help students learn features of the TI-83 Plus and of the free **SCIENCE TOOLS** application, which is accessible from the **SCIENCE CHAPTERS** menu when it is installed.

The TI-83 Plus features are described more fully in the *TI-83 Plus* guidebook. The **SCIENCE TOOLS** application is described more fully in the *TI-83 Plus Science Tools* user guide.

Note: The international version of **SCIENCE TOOLS** is not accessible from the **SCIENCE CHAPTERS** menu; use the APPS menu.

Installing this Application

When students install **FUNDAMENTAL TOPICS**, they probably should install the free application **SCIENCE TOOLS** at the same time. These tools are used in the **Try-It!™ on Your TI-83 Plus** student activity sheets. When the **SCIENCE TOOLS** application is installed, it is accessible from the **SCIENCE CHAPTERS** table of contents (it is also available directly from the APPS menu).

Note: The international version of **SCIENCE TOOLS** is not accessible from the **SCIENCE CHAPTERS** menu; use the APPS menu.

Installing this application requires TI-GRAPH LINK™ software and link cable. A link cable can be purchased from TI's online store:

http://epsstore.ti.com

If you receive an **Archive Full** error message while installing the **FUNDAMENTAL TOPICS** or **SCIENCE TOOLS** applications, the calculator does not have sufficient memory for the application. You must delete applications and/or archived variables (see below).

Deleting an Application

Deleting an application completely removes the application from the TI-83 Plus . The space then becomes available for a different application. The deleted application may be reloaded at a later date. Before deleting an application from the TI-83 Plus , it can be backed up to a PC using the **Link > Receive Flash Application** menu in the TI-GRAPH LINK software for the TI-83 Plus. You can reload it to the TI-83 Plus later using the **Link > Send Flash Software** menu in the TI-GRAPH LINK software.

To delete an application or archived variable:

1. Press 2nd [MEM] to display the MEMORY menu.
2. Select **2:Mem Mgmt/Del**.
3. Select **A:Apps** or **B:AppVars**.
4. Press ▼ until the ▶ indicator is next to the item you wish to delete.
5. Press DEL.
6. Select **2:Yes** when asked **Are You Sure?**
7. Press 2nd [QUIT] to return to the home screen.

Navigating Fundamental Topics in Science

Starting the Application

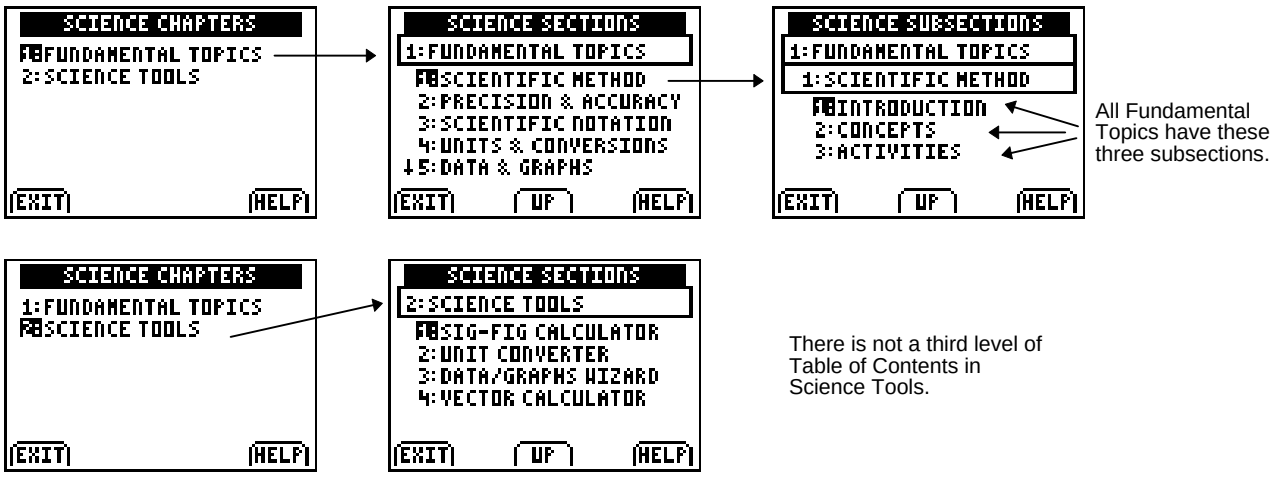
1. Press [APPS] to display the APPLICATIONS menu.
2. Select **FunSci**. The **FUNDAMENTAL TOPICS IN SCIENCE** title page is displayed.

3. Press any key to start the application.

A Table of Contents screen is displayed. It is the Table of Contents from which you last exited **FUNDAMENTAL TOPICS** or **SCIENCE TOOLS**. You may select one of the items on the menu or press ⟨**UP**⟩ as often as necessary to go to the Table of Contents screen that you need.

Table of Contents Screens

There are three levels of Table of Contents screens.



Note: When you exit and re-enter the application, you return to the Table of Contents from which you exited.

Returning to the Table of Contents

From most **INTRODUCTION**, **CONCEPTS**, **ACTIVITIES**, or **SCIENCE TOOLS** screens, you can press [2nd] [QUIT] as many times as needed to return to the Table of Contents. You may then select one of the items on the menu or press ⟨**UP**⟩ to go to higher levels of the Table of Contents.

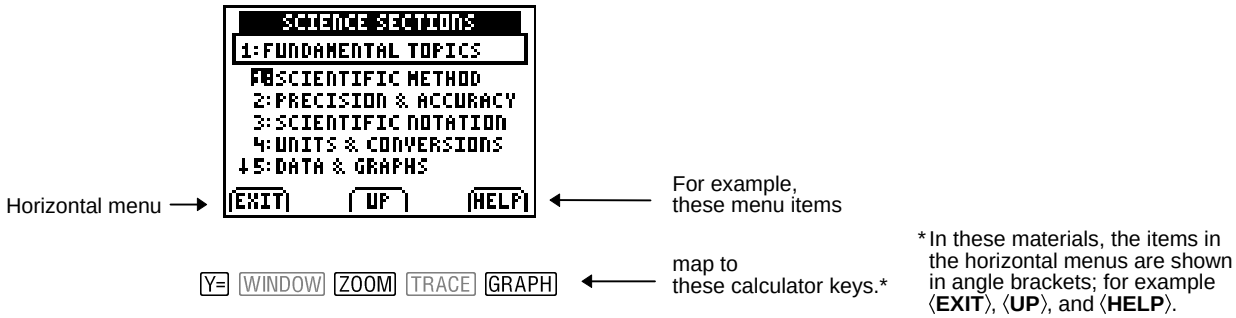
Leaving the Application

To leave either application, press [2nd] [QUIT] as many times as needed to return to a Table of Contents screen, and then press ⟨**EXIT**⟩. When you re-enter the application, you return to this same Table of Contents screen.

Horizontal Menus

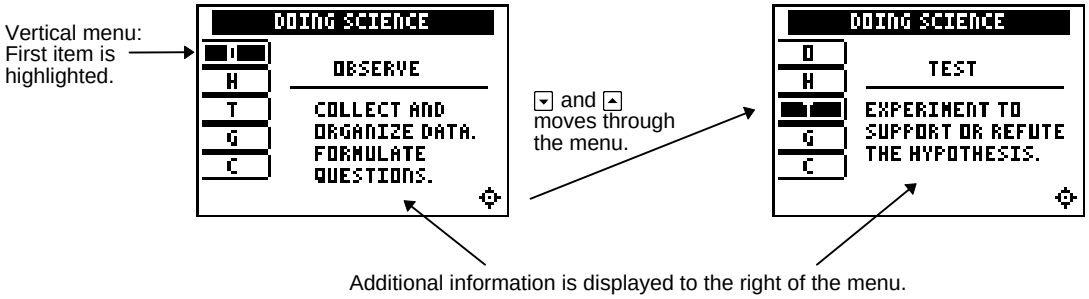
A horizontal menu may be displayed at the bottom of the screen. The menu items help you move between screens in the application. The menu items change from one screen to another.

To select a menu item, press the calculator key that corresponds to the menu item on the screen.

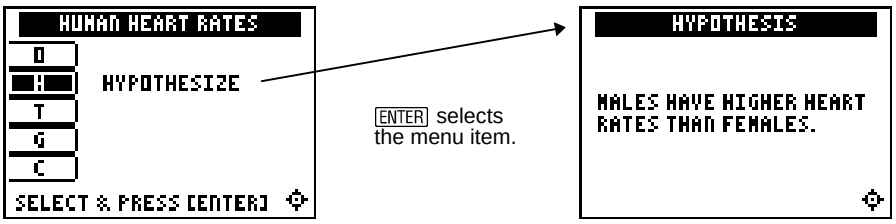


Vertical Menus

When the up and down arrows of the navigation star (✥) are flashing, press ▼ and ▲ to highlight an item in a vertical menu.



Some vertical menus only provide information. Other vertical menus are used for navigation. If **SELECT & PRESS [ENTER]** is displayed, pressing [ENTER] displays the first in a sequence of screens for this selection.

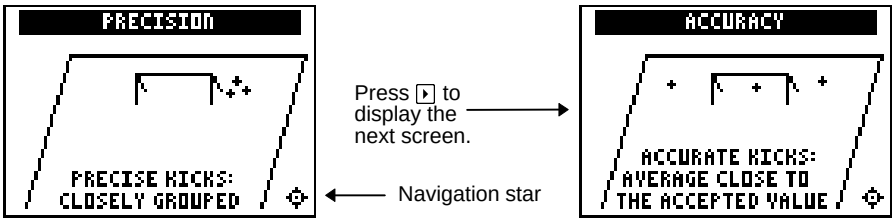


If ⟨**MENU**⟩ is displayed, pressing it returns you to the vertical menu.

Navigation Star

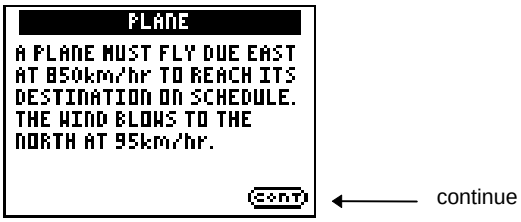
The navigation star is located on the bottom right of many screens.

When the right and left arrows of the navigation star are flashing, press ◀ and ▶ on the calculator to page back and forward between screens. ▲ and ▼ are used to navigate vertical menus (see below).



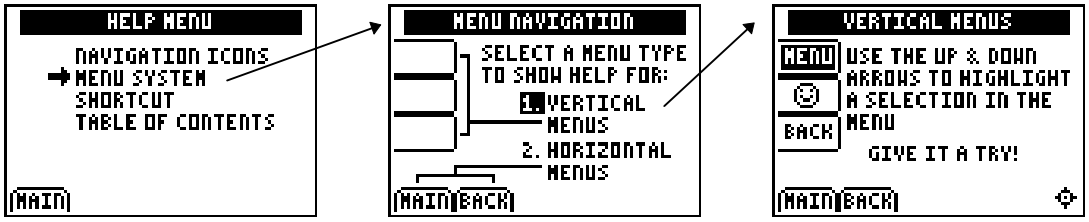
⟨CONT⟩

When you see ⟨**CONT**⟩ (continue), you can press any key to go to the next screen.



HELP

From a Table of Contents screen, press ⟨**HELP**⟩ to view information about features of the application. To select an item, press ▼ to highlight it, and then press ENTER. To exit the help screens, press ⟨**MAIN**⟩ or press 2nd [QUIT].

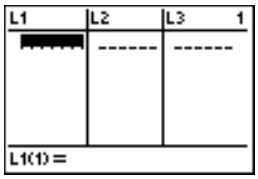
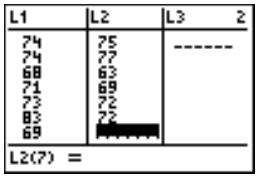


Name _____
Date _____

1: Scientific Method — Try-It!™ on Your TI-83 Plus

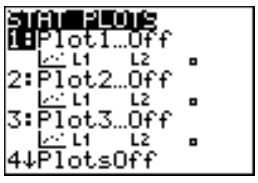
Enter the data

Record the heart rates of all students in the class. Then enter the rates in the list editor (the two lists do not have to have the same number of elements).

To Do This	Press	Display
1. Exit Fundamental Topics in Science. Clear the home screen.	2nd [QUIT] ⟨**EXIT**⟩ CLEAR CLEAR	
2. Display the list editor. 3. Clear each list as necessary. 4. Scroll to **L1**.	STAT **1:Edit...** ▲ to go to the list name CLEAR ENTER ◄ or ► to go to the next list ◄ or ►, as necessary	
5. Enter the rates for the boys in list **L1**. 6. Enter the rates for the girls in list **L2**. **Note:** Your numbers will be different than those shown.	Type each number, then ENTER ► to go to **L2** Type each number, then ENTER	

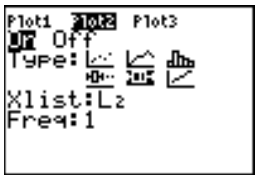
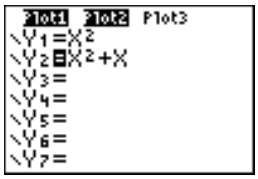
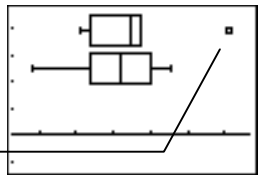
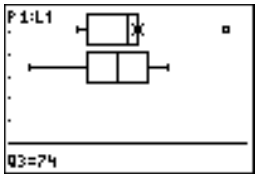
Define the statistical plots as box plots

Once you have entered the lists, you can examine the data using several different types of statistical plots. First, look at the two forms of box plots.

To Do This	Press	Display
1. Go to the **STAT PLOTS** screen. **Note:** The TI-83 Plus lets you define up to three different stat plots.	2nd [STAT PLOT]	
2. Turn on **Plot1** and define it as a **ModBoxplot** (⊡▪▪) of the male heart rates. **Note: ModBoxplot** graphs the outliers (data more than 1.5 times the difference between the third quartile [Q3] and the first quartile [Q1]) as points rather than as part of the box.	**1:Plot1** ENTER to turn on **Plot1** ▼ ► ► ► ENTER (⊡▪▪) ▼ 2nd [L1] ▼ ALPHA **1** ▼ ENTER (□)	

Name _____
Date _____

Define the statistical plots as box plots (cont.)

To Do This	Press	Display
3. Turn on **Plot2** and define it as a **Boxplot** (⊡) of the female heart rates. **Note: Boxplot** doesn't graph anything as a point, so **Mark** is not defined. **Note:** If **Plot3** was **On** in step 1, you will need to turn it off, following the procedure in step 2.	▲ ▲ ▲ ▲ ▲ to go to the list of plots ▶ ENTER to go to **Plot2** ENTER to turn on **Plot2** ▼ ▶ ▶ ▶ ▶ ENTER (⊡) ▼ 2nd [L2] ▼ ALPHA **1** ENTER	
4. On the Y= screen, if any of the equations are selected (highlighted), turn them off. **Note:** On the TI-83 Plus, the graph screen displays both graphs and stat plots, which is why you should turn off any graphing equations.	Y= **Note:** The keystrokes below would turn off **Y2** in the screen at right. ◀ ▼ ENTER	**Note:** On this screen, **Y2** is selected, **Y1** is not. 
5. Display the plots in an appropriate viewing window. **Note:** The **ZoomStat** command automatically calculates a good viewing window.	ZOOM **9:ZoomStat**	
When you select **ZoomStat**, the plots are displayed immediately.		
6. Explore the median and range of the plots using the trace feature.	TRACE ◀ or ▶ to move on a plot ▼ or ▲ to move between plots	

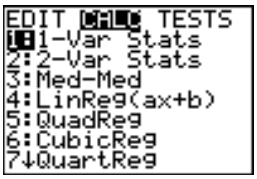
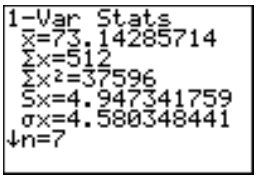
What is the median value for the boys? For the girls? Write a description of the heart-rate samples based on the box plots.

Name _____
Date _____

Calculate statistical variables

In addition to examining data graphically, the TI-83 Plus lets you examine data numerically. There are individual commands on the LIST STAT menu to calculate individual statistics such as the mean, median, standard deviation, and minimum of a list. The **1-Var Stats** command on the STAT CALC menu calculates and displays all the statistics at once.

Calculate the statistics for the boys.

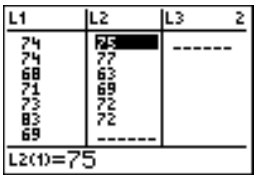
To Do This	Press	Display
1. Return to the home screen.	2nd [QUIT]	
2. Copy the **1-Var Stats** function from the STAT CALC menu to the home screen.	STAT ▶ **1:1-Var Stats**	
3. Specify the list.	2nd [L1]	
4. Calculate the values.	ENTER ▼ or ▲ to see additional values	

What is the median value for the boys (**L1**)? Describe what you learn from the other statistical variables.

Name _____
Date _____

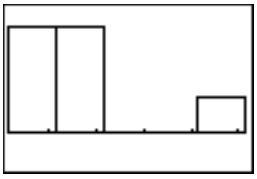
Examine data with the Data/Graphs Wizard

You can use the **DATA/GRAPHS WIZARD** in **SCIENCE TOOLS** to access the list editor and stat plot features of the TI-83 Plus.

To Do This	Press	Display
1. Display the **SCIENCE TOOLS** menu. **Note:** You also can access the **SCIENCE TOOLS** menu from the **SCIENCE CHAPTERS** menu.	[APPS] Select **SciTools** [ENTER] to leave the title page	
2. Display the **DATA/GRAPHS WIZARD** screen.	**3:DATA/GRAPHS WIZARD**	
3. Enter or edit data. **Note:** The **DATA/GRAPHS WIZARD** uses the list feature of the TI-83 Plus that you used above. If you had not already entered the data into lists, you could do so now.	⟨**DATA**⟩	

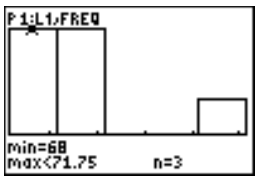
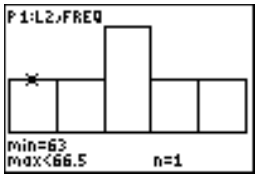
Define the statistical plots as histograms with the Data/Graphs Wizard

Plot the heart rates as histograms.

To Do This	Press	Display
1. Display the **DATA/GRAPHS WIZARD** screen and select **PLOT DATA**. A menu of four types of plots is shown. **Note: Boxplot** and **NormProbPlot** are not available in the wizard.	[2nd] [QUIT] ⟨ ⟩	
2. Select **Histogram** ( ).	⟨ ⟩	
3. Select the list for the boys. The wizard lets you plot only one list at a time as a histogram. The data is plotted immediately. The wizard automatically turns off any selected Y= equations and plots in the **ZoomStat** viewing window.	**1:L1**	

Name _____
Date _____

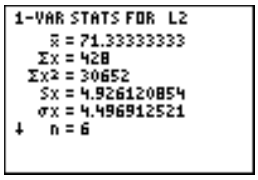
Define the statistical plots as histograms with the Data/Graphs Wizard (cont.)

To Do This	Press	Display
4. Trace the values to analyze the data.	[TRACE]	
5. Plot and trace a histogram for the girls.	[2nd] [QUIT] ⟨ ⟩ ⟨ ⟩ **2:L2** [TRACE]	

What do you learn about heart-rate samples based on the histogram for the boys? For the girls?

Calculate the statistical variables with the Data/Graphs Wizard

Calculate the statistics for the girls.

To Do This	Press	Display
1. Display the **DATA/GRAPHS WIZARD** screen and select **ANALYZE DATA**. Select the girls' list.	[2nd] [QUIT] ⟨**STAT**⟩ **2:L2** ▼ to see additional values	

What is the median value for the girls (**L2**)? How would you compare the statistics for the boys (obtained earlier in this Try-It! activity) to those of the girls?

Objectives

Upon completion of this section, students should be able to:

- Give a reasonable definition of science.
- Describe a process (a "scientific method") for conducting scientific investigation that includes: observing a phenomenon, creating a testable statement (hypothesis) regarding the phenomenon, designing a test of the hypothesis, generalizing the test findings, and communicating the test results.

Relevant National Science Education Standards

From Science as Inquiry—Content Standard A

Identify Questions and Concepts that Guide Scientific Investigations. *Students should formulate a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding a hypothesis and the design of an experiment.*

Design and Conduct Scientific Investigations. *The investigation may also require student clarification of the question, method, controls, and variables; student organization and display of data; student revision of methods and explanations; and a public presentation of the results with a critical response from peers.*

Use Technology and Mathematics to Improve Investigations and Communications. *A variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. Mathematics plays an essential role in all aspects of an inquiry.*

Formulate and Revise Scientific Explanations and Models Using Logic and Evidence. *Student inquiries should culminate in formulating an explanation or model. Models should be physical, conceptual, and mathematical.*

Recognize and Analyze Alternative Explanations and Models. *Students should be able to use scientific criteria to find the preferred explanations.*

Communicate and Defend a Scientific Argument. *Students in school science programs should develop the abilities associated with accurate and effective communication. These include . . . summarizing data, . . . developing diagrams and charts, explaining statistical analysis, . . . constructing a reasoned argument, and responding appropriately to critical comments.*

Common Student Errors

Students often think that outcomes of science (such as facts, models, and theories) or modes of conducting science (such as lab experiments) are science itself. Emphasize that science is a dynamic process for explaining observations and predicting the results of related phenomena. Scientific conclusions are always subject to revision as a result of further experimentation. You may also use the following in describing science.

- Science is a mode of inquiry rather than a set of known facts.
- Science is based on controlled, repeatable experiments; similar results can be expected when an experiment is repeated under similar conditions.

Using the Fundamental Topics in Science Application

To begin the application, press [APPS], select **FunSci**, and press any key. The displayed Table of Contents page shows the last place the student was in **FUNDAMENTAL TOPICS** or **SCIENCE TOOLS**. The student may need to press ⟨**UP**⟩ one or more times to go to the Science Chapters Table of Contents and then select **1:FUNDAMENTAL TOPICS**, **1:SCIENTIFIC METHOD**, **1:INTRODUCTION** to begin. You may need to tell students how to navigate the application, if they are not yet familiar with it, or print Navigating Fundamental Topics in Science on pages viii–x of the Introduction.

Introduction

This section explores the question "What is Science?" On a **WRITE IT DOWN** screen, students are asked to describe what they think science is. The question is explored more fully, and one definition is presented. If your students are keeping journals, Fundamental Topics in Science is good journal material. If they are not keeping journals, have them write their responses on a blank sheet of paper.

Concepts

This section explores what it means to "Do Science."

A common process for scientific investigations is presented.

- Observe — Collect and organize data. Formulate questions.
- Hypothesize — Form a tentative, testable explanation. Design a test.
- Test — Experiment to support or refute the hypothesis.
- Generalize — Develop a model or theory that explains the data.
- Communicate — Share findings so others can investigate further.

You may wish to avoid calling this process "the" scientific method, since students might assume this is the only method used by scientists. Point out that a scientific method can be any one of several processes that:

- Leads to sound conclusions.
- Is repeatable.
- Encourages further investigation.

Activity—Variations in Human Heart Rate

In this section, students write a statement corresponding to each of the five steps in the scientific investigation process outlined in **CONCEPTS**. Accurate and effective communication in written form is an integral part of scientific investigation. It is important that students learn that proper scientific investigations require discipline in the descriptions and testing. In other words, it is not appropriate to "wing it," "make it up as you go along," or "change horses in midstream," to borrow a few clichés. This activity reinforces these ideas.

At any time students can select ⟨**MENU**⟩ to return to the **ACTIVITIES** menu.

Observe. Students are already aware that heart rates vary from one person to another. In the activity, they learn about scientific method by investigating this phenomenon. In a **WRITE IT DOWN** screen, students are asked to list factors they think might affect heart rate.

Hypothesize. Students begin by investigating a single factor: gender. One of many possible hypotheses is shown in the application. You may wish to suggest that students try formulating their own hypotheses in writing. Point out that it is more important that they form a simple, testable hypothesis than that their hypothesis be correct (i.e., it isn't improper to formulate and test a hypothesis that you hope to prove false). Three such hypotheses are:

- Boys have higher (faster) heart rates than girls.
- Girls have higher (faster) heart rates than boys.
- There is no significant difference in heart rate due to gender.

In a **WRITE IT DOWN** screen, students are asked how they could test the hypothesis "males have higher heart rates than females."

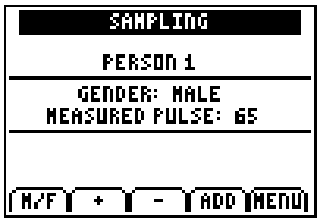
Test. As with any open-ended scientific investigation, responses will vary. At this stage, it is not important that students resolve the question about variation of heart rate among humans. It is more important that the students explore the steps in the scientific process. Emphasize that a study of this particular example, like that of other phenomena, can elicit an almost limitless number of different hypotheses. Each could be investigated using a scientific process.

Tell the students that pulse rate is indicative of heart rate. Show them various ways they might measure pulse rates. One common method is to place an index finger on a prominent artery, such as the one found on the underside of the wrist or in the neck just behind the jaw bone.

Tell them it is common to count the number of pulses in a brief period then multiply by a factor. For example, count the pulses for 10 seconds and then multiply by 6 to estimate the pulse rate as typically expressed in beats per minute. While convenient, this method introduces error—which is a great topic for further discussion.

Before beginning the test step, discuss with students what they think might be a reasonable sample size for testing their hypothesis. The activity suggests they should measure the pulse rates of at least six classmates.

As students take each other's heart rates, they enter them on the activity screen, using ⟨**M/F**⟩ to toggle gender and ⟨**+**⟩ or ⟨**–**⟩ to change the measured pulse, and then ⟨**ADD**⟩. After a person is added, students can select ⟨**MORE**⟩ to record another sample or ⟨**MENU**⟩ if they are finished. The cumulative results are displayed until a key is pressed. Instruct the students if you want them to record the readings and cumulative result.



Activity—Variations in Human Heart Rate (cont.)

Generalize. After entering the pulse rates and viewing the results, students are asked to state the test conclusions, and then generalize about the effect of gender on heart rate. In a **WRITE IT DOWN** screen, each student is asked to:

- State the conclusions he or she can draw from the findings. Students might indicate that their findings proved, disproved, or were inconclusive about whether the hypothesis was true or false.
- Discuss limitations. Students might mention such things as: inaccurate measurement of pulse rate, small sample size, the variation of too many factors (activity level, etc.).
- Discuss how well the results of the sample indicated rates in the class, the school, the community, the world.
- Discuss if the test indicated whether gender was the sole factor affecting heart rate.
- Design a test for another factor.

Communicate. Students share their findings and generalizations with the class. They should describe in writing how their findings compared with those of other students.

Extension. Encourage students to design (and perform, if time permits) investigations of other factors affecting heart rate such as age, weight, physical condition, activity level, and heredity.

Remind them that, in general, results are easier to interpret if only one factor is varied at a time; for instance:

- Test 2: Measure one person's pulse at varying levels of physical activity (sleeping, standing, after running several minutes, etc.).
- Test 3: Measure the at-rest pulse rates of several similarly-aged boys of varying weights.

To help students isolate factors, you might have them develop a chart such as the sample one below. You can also discuss with students that not all factors are independent of each other, such as weight and physical condition.

	tested factor	**common factors**	**variable factors**
activity	gender	age activity level	weight heredity physical condition
test 2	activity level	age weight heredity physical condition	none (all tests on one person)
test 3	weight	gender age activity level	heredity physical condition

Try-It!™ on Your TI-83 Plus

This Try-It! activity requires the use of the Science Tools application. This free application came with the Fundamental Topics in Science application and is accessible from the **SCIENCE CHAPTERS** menu, but it must be loaded separately.

Students continue exploring the heart-rate question through two TI-83 Plus functional areas:

- The list editor, stat plot, and statistical calculation features of the calculator.
- The data, plot, and stat features of the **DATA/GRAPHS WIZARD** in **SCIENCE TOOLS**.

The **DATA/GRAPHS WIZARD** accesses the calculator features in a simple, focused user interface, so many students will find the wizard easier to use for most problems.

You might direct the students to use the Try-It! activity for one of the tests suggested in the extension above.

Space is provided for written answers on the Try-It! sheets, but if the students are keeping journals, you may wish to direct them to record their responses in their journals instead.

Note: The calculator features are described more fully in the *TI-83 Plus* guidebook. The **SCIENCE TOOLS** application is described more fully in the *TI-83 Plus Science Tools* user guide.

Name _____
Date _____

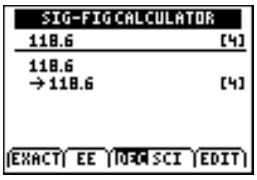
2: Precision & Accuracy — Try-It!™ on Your TI-83 Plus

Determining significant figures

For 125.0 milliliters of water, students reported the following measurements of mass.

118.6	g	127.308	g	130	g	121.0	g	123.084	g
120	g	122.4	g	124.2	g	126.5	g	125	g

Use the **SIG-FIG CALCULATOR** in **SCIENCE TOOLS** first to determine the number of significant figures in each measurement, then to convert each measurement to ***four significant figures***.

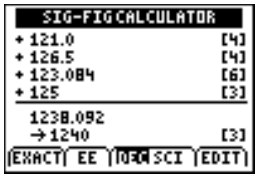
To Do This	Press	Display
1. Display the **SCIENCE TOOLS** menu. **Note:** You also can access the **SCIENCE TOOLS** menu from the **SCIENCE CHAPTERS** menu.	If necessary, exit **FunSci** APPS Select **SciTools** ENTER to leave the title page	
2. Display the **SIG-FIG CALCULATOR**. 3. Enter the first value from the data. The number of significant figures is shown on the right. 4. Repeat for all measurements and complete the table below.	**1:SIG-FIG CALCULATOR** **118.6** If **SCI** appears in reverse video, press ⟨**DEC SCI**⟩ ENTER	

Original data	Number of significant figures	Data with four significant figures
118.6	**4**	**118.6**
120		
127.308		
122.4		
130		
124.2		
121.0		
126.5		
123.084		
125		

Name _____
Date _____

Calculate the sum of the original data

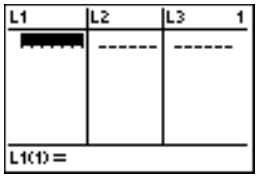
The calculator performs calculations indiscriminately, using all of the digits that you enter. The **SIG-FIG CALCULATOR**, however, uses rules based on significant figures to determine the result. These rules are explained in the *TI–83 Plus Science Tools* user guide. For addition, the **SIG-FIG CALCULATOR** adds the numbers as the calculator would, but then rounds the answer to the number of places in the least precise of the measurements.

To Do This	Press	Display
1. Enter each value using all of the digits in the measurement. 2. Repeat using four significant figures.	**118.6** [+] **120** [+] . . . **125** [ENTER]	

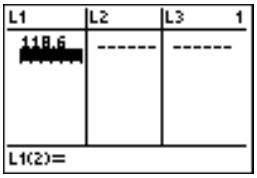
What were the results? Which measurement(s) were the least precise? What is the average measurement?

Enter the data

You can use the list and statistical features of your TI-83 Plus to help you determine how precise and how accurate this set of measurements is. In the list editor, enter measurements in list **L1** to ***four significant figures***.

To Do This	Press	Display
1. Exit **SCIENCE TOOLS**. Clear the home screen.	[2nd] [QUIT] ⟨**EXIT**⟩ [CLEAR] [CLEAR]	
2. Display the list editor. 3. Clear each list as necessary. 4. Scroll to **L1**.	[STAT] **1:Edit** [▲] to go to the list name [CLEAR] [ENTER] [◄] or [►] to go to the next list [◄] or [►], as necessary	

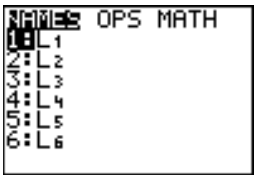
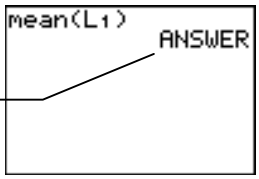
Name _____
Date _____

5. Enter the first data point. 6. Repeat for the other points. Remember to enter four significant figures. Notice that even if you correctly enter **120.0**, the calculator drops the decimal and the following zero.	**118.6** ENTER . . .	

Name _____
Date _____

Calculate the average

Determine the average (mean) of these measurements.

To Do This	Press	Display
1. Return to the home screen.	2nd [QUIT]	
2. Copy the **mean(** function from the LIST MATH menu to the home screen.	2nd [LIST] ▶ ▶ **3:mean(**	
3. You can reference all of the values in a list with the list name. Copy the name of the list (**L1**) from the LIST NAMES menu to the home screen.	2nd [LIST] **1:L1**	
4. Complete the expression and evaluate.	) ENTER Answer displays here.	

What did you calculate for the average (mean)?

Name _____
Date _____

Calculate percent error

If the accepted value for the mass of 125.0 milliliter of water is 125.0 g, how ***accurate*** would you consider this set of measurements? You can express the accuracy in terms of ***percent error***.

$$\text{percent error} = \frac{(\text{accepted value} - \text{experimentally determined value})}{(\text{accepted value})} * 100$$

Use your TI–83 Plus to calculate the percent error.

To Do This	Press	Display
1. Calculate the percent error. Parentheses are very important for correctly grouping numbers in calculators. Remember to retain only four significant figures in the mean. **Tip:** Instead of retyping the answer from a previous calculation, you can press 2nd [ANS].	((**125.0** − *nnn.n* (enter the mean calculated above)) ÷ **125.0**) × **100** ENTER	mean(L1) ANSWER ((125.0-???.?)/125.0)*100 ANSWER

What was the percent error? Do you think this is a large error or a small error?

Name _____
Date _____

Calculate standard deviation

Standard deviation is an excellent indicator of the ***precision*** of measurements. Range (the difference between the maximum and minimum measurements) also shows precision. Use your TI–83 Plus to calculate the standard deviation and range of this set of measurements.

To Do This	Press	Display
1. Copy the **stdDev(** function from the LIST MATH menu to the home screen.	2nd [LIST] ▶ ▶ **7:stdDev(**	NAMES OPS MATH 1:min(2:max(3:mean(4:median(5:sum(6:prod(7:stdDev(
2. Enter the list name, complete the expression, and evaluate. **Tip:** This is an alternate way to enter a list name.	2nd [L1]) ENTER	mean(L1) ANSWER ((125.0-???.?)/125.0)*100 ANSWER stdDev(L1) ANSWER
3. Calculate the range (maximum value minus minimum value).	2nd [LIST] ▶ ▶ **2:max(** 2nd [L1]) − 2nd [LIST] ▶ ▶ **1:min(** 2nd [L1]) ENTER	((125.0-???.?)/125.0)*100 ANSWER stdDev(L1) ANSWER max(L1)-min(L1) ANSWER

What value did you calculate for the standard deviation? For the range? Given these calculations, describe how ***accurate*** these measurements were; how ***precise*** they were.

Objectives

Upon completion of this section, students should be able to:

- Define ***precision*** and ***accuracy***, and distinguish between the two terms in practice.
- Define ***significant figures***.
- Recognize precision and accuracy limitations of measuring instruments.
- Report measurements using the appropriate number of significant figures.
- Apply rules to determine the significant figures in arbitrary values and in the results of calculations.

Relevant National Science Education Standards

From Science as Inquiry—Content Standard A:

Use Technology and Mathematics to Improve Investigations and Communications. *Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results.*

Understanding about Scientific Inquiry. *Scientists rely on technology to enhance the gathering and manipulation of data. . . The accuracy and precision of the data, and therefore the quality of the exploration, depends on the technology used.*

Common Student Errors

Students do not understand, nor correctly apply, the terms ***precision*** and ***accuracy***.

Students assume values are of unlimited accuracy and precision, regardless of source (measurement, textbook problems, computer or calculator displayed results). Emphasize that all measurements introduce error, but quality instruments and good operator practices can minimize such error.

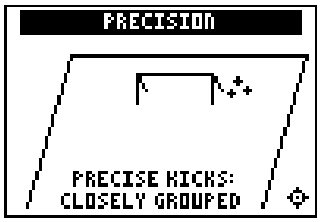
Using the Fundamental Topics in Science Application

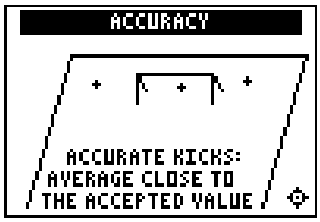
To begin the application, press [APPS], select **FunSci**, and press any key. The displayed Table of Contents page shows the last place the student was in **FUNDAMENTAL TOPICS** or **SCIENCE TOOLS**. The student may need to press ⟨**UP**⟩ one or more times to go to the Science Chapters Table of Contents and then select **1:FUNDAMENTAL TOPICS**, **2:PRECISION & ACCURACY**, **1:INTRODUCTION** to begin. You may need to tell students how to navigate the application, if they are not yet familiar with it, or print Navigating Fundamental Topics in Science on pages viii–x of the Introduction.

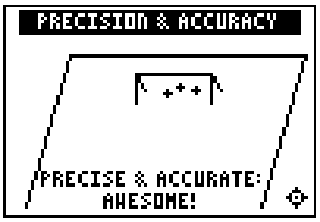
Introduction

This section explores the meanings of the terms ***precise*** and ***accurate***. Notice the analogy of precision and accuracy of measurements to that of three sets of soccer kicks. Point out that:

- High precision results in closely grouped, repeatable values (but not necessarily near the accepted standard).
- High accuracy results in values whose average is near the accepted standard (although individual values may differ widely).
- Obviously, both high precision and high accuracy are desirable. Precision is often preferable in measuring instruments. Since precise results are highly predictable, a correction can be applied using a process known as calibration so that the net result is made accurate.







Extension

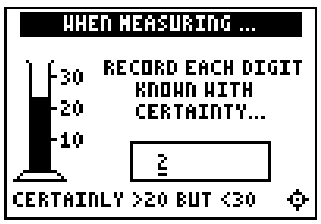
Point out to students that while both high precision and high accuracy are desirable, this is not always possible. These are possible work-group discussion topics.

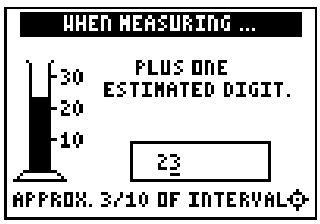
- Ask, "If your team could kick precisely or accurately, but not both, which would you prefer, and why?" Tell them to explain their reason in writing. Some students might say, "Accurately, because we'd stand the best chance of getting at least one score." But others might say, "Precisely, because the goal is to win the game. If both teams were equally accurate, it might be a tie. Only with high precision would you stand the chance of a big win." They would certainly have a case!
- Ask students to describe what might be the effects of high accuracy, but low precision, for situations such as a political election, determining the age of artifacts from an archaeological dig, or taking a population census. Then ask them to describe what might be the effects of high precision, but low accuracy, for the same situations.

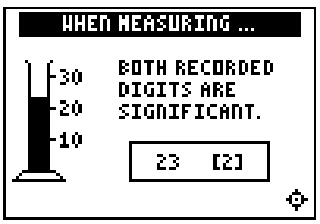
Concepts

This section explores proper recording practices and significant figures.

Remind students that, when reading a measuring instrument, it is standard laboratory practice to report all the certain digits (limited by the instrument's finest divisions) ***plus*** the first estimated digit.







Activity—The Big Sig-Fig Dig

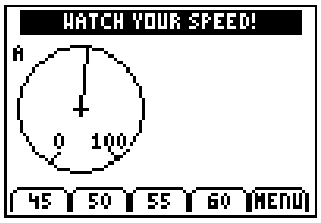
This activity gives students practice in identifying which digits in a value are significant.

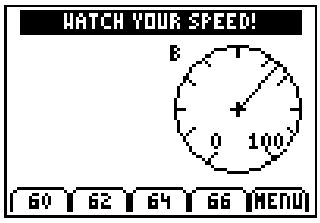
For each underlined digit, students select ⟨**SIG**⟩ if the digit is significant or ⟨**NOT**⟩ if the digit is not significant. They earn 10 points for each correct answer, up to a maximum of 410. Tell students if you wish them to record their scores and if they can repeat the activity to improve their scores.

At any time students can select ⟨**MENU**⟩ to return to the **ACTIVITIES** menu. If a student is having trouble, you can suggest that he or she select ⟨**MENU**⟩ and begin the activity again. The cumulative score is displayed during the entire activity. The reward level (bronze, silver, or gold) displays after the activity is over; the student can press any key to return to the **ACTIVITIES** menu.

Activity—Watch Your Speed

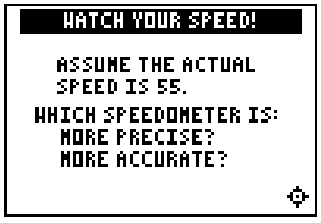
This activity reinforces the concepts of precision and accuracy that were introduced in the **INTRODUCTION** and **CONCEPTS**. Students are shown two speedometers and asked to select the most appropriate instrument reading for each.

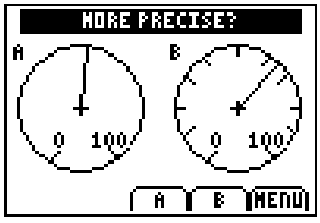


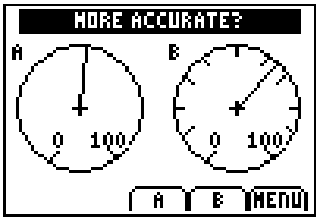


Many students may incorrectly respond ⟨**55**⟩ on the first speedometer. Remind them that when making a measurement it is standard laboratory practice to report all the certain digits (limited by the instrument's finest divisions), and then the first estimated digit.

Students are again shown the two speedometers and, given an actual speed of 55, are asked to state which is more precise and which is more accurate.







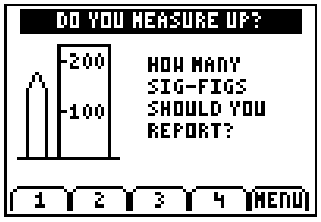
You may need to remind students to:

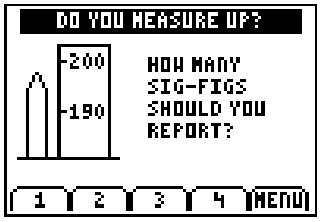
- Use the number of significant figures read from each speedometer to determine which is more precise.
- Compare the indicated value of each speedometer to the actual speed to determine which is more accurate.

Students can select ⟨**MENU**⟩ to return to the **ACTIVITIES** menu. If a student is having trouble, you can suggest that he or she select ⟨**MENU**⟩ and begin the activity again.

Activity—How Do You Measure Up?

In this activity, which reviews significant figures as well as precision and accuracy, students measure the height of the Washington Monument using two different rulers.





Each student also asks three other students what their measurements were and enters them in the calculator.

Students can select ⟨**MENU**⟩ to return to the **ACTIVITIES** menu. If a student is having trouble, you can suggest that he or she select ⟨**MENU**⟩ and begin the activity again.

Try-It!™ on Your TI-83 Plus

Point out the difficulty caused by the measurements that were not recorded to the specified four significant figures. As a result, rounding and assumptions must be made. Discuss with students which measurements had too many significant figures and which had too few.

Students use the **SIG-FIG CALCULATOR** in **SCIENCE TOOLS** to complete the second and third column in the chart below.

Original data	Number of significant figures	Data with four significant figures
118.6	4	118.6
120	2	120.0
127.308	6	127.3
122.4	4	122.4
130	2	130.0
124.2	4	124.2
121.0	4	121.0
126.5	4	126.5
123.084	6	123.1
125	3	125.0

Try-It!™ on Your TI-83 Plus (cont.)

Students then use the list editor and statistical calculation features of the calculator.

Some indicators of ***accuracy*** include:

Average = **mean(L1)** = 123.81 g

$$\text{percent error} = \frac{(\text{accepted value} - \text{experimentally determined value})}{(\text{accepted value})} * 100$$

$$\text{percent error} = \frac{(125.0 - 123.8)}{(125.0)} * 100 = 0.96\%$$

Students are asked if this is a large error or a small error. You may need to remind students that this isn't a 96% error, which is a large error; instead it is close to a 1% error, which is a small error.

This portion of Try-It! activity requires the use of the Science Tools application. This free application came with the Fundamental Topics in Science application and is accessible from the **SCIENCE CHAPTERS** menu, but it must be loaded separately.

Standard deviation is an excellent indicator of the ***precision*** of measurements. Range is another way of evaluating how precise a measurement is. Students use the TI-83 Plus to make these calculations.

Standard deviation = **stdDev(L1)** = 3.517 g

Range = [**max(L1)** − **min(L1)**] = 130.0 g − 118.6g = 11.4 g

Students are asked to describe in writing how accurate and how precise the measurements are.

You may recommend that students routinely use the **1-VAR STATS** function rather than performing individual calculations or calculator operations. See the Try-It! activity in **SCIENTIFIC METHOD** for an example.

Space is provided for written answers on the Try-It! sheets, but if the students are keeping journals, you may wish to direct them to record their responses in their journals instead.

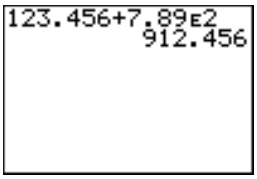
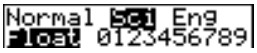
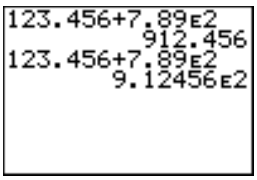
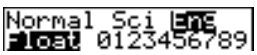
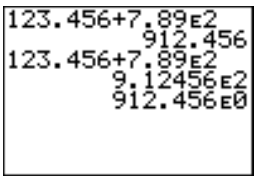
Note: The calculator features are described more fully in the *TI-83 Plus* guidebook. The **SCIENCE TOOLS** application is described more fully in the *TI-83 Plus Science Tools* user guide.

Name _____
Date _____

3: Scientific Notation — Try-It!™ on Your TI-83 Plus

Notation formats on the home screen

Enter the mixed-format problem **123.456+7.89E2** on the home screen and display the result in all three formats: Decimal (**Normal**), Scientific Notation (**Sci**), and Engineering (**Eng**).

To Do This	Press	Display
1. Exit Fundamental Topics in Science. Clear the home screen.	2nd [QUIT] ⟨**EXIT**⟩ CLEAR CLEAR	
2. Set the notation mode to **Normal**, with floating digits.	MODE ENTER to select **Normal** ▼ ENTER to select **Float**	
3. Return to the home screen. Enter and evaluate the expression **123.456+7.89E2**. The format of the entry line is not changed. The result appears in **Normal** (decimal) format.	2nd [QUIT] **123.456** + **7.89** 2nd [EE] **2** ENTER	
4. Set the notation mode to **Sci**.	MODE ▶ ENTER to select **Sci**	
5. Return to the home screen and re-evaluate the expression. **Note:** There are two ways to re-evaluate an expression. ENTER alone automatically executes the previous home screen entry. 2nd [ENTRY] pastes the previous entry onto a new line. ENTER executes it. The format of the entry line is not changed. The result appears in **Sci** (scientific notation) format.	2nd [QUIT] 2nd [ENTRY] ENTER	
6. Set the notation mode to **Eng**.	MODE ▶ ▶ ENTER to select **Eng**	
7. Return to the home screen and re-evaluate the expression. The result appears in **Eng** (engineering) format.	2nd [QUIT] ENTER	

Name _____
Date _____

Change the decimal notation

Look at the effect of changing the mode that determines the number of decimal places displayed.

To Do This	Press	Display
1. Return the display format setting to **Normal**, change the number of decimal places to 1, recall the expression, and re-evaluate it. The result displays with one decimal.	MODE ENTER ▼ ▶ ▶ ENTER 2nd [QUIT] 2nd [ENTRY] ENTER	123.456+7.89E2 912.456 123.456+7.89E2 9.12456E2 912.456E0 123.456+7.89E2 912.5
2. Return the decimal setting to **Float**, recall the last answer, and re-evaluate it. Notice that the notation and decimal display modes affect only how an answer is displayed. They do not affect how values are entered or interpreted, nor do they affect the value of the result in the calculator memory.	MODE ▼ ENTER 2nd [ANS] ENTER	123.456+7.89E2 9.12456E2 912.456E0 123.456+7.89E2 912.5 Ans 912.456

Notation formats in the SIG-FIG calculator

Enter the mixed-format problem **123.456+7.89E2** in the **SIG-FIG CALCULATOR** and display the result in all decimal and scientific notation formats.

To Do This	Press	Display
1. Display the **SCIENCE TOOLS** menu. **Note:** You also can access the **SCIENCE TOOLS** menu from the **SCIENCE CHAPTERS** menu.	APPS Select **SciTools** ENTER to leave the title page ⟨**UP**⟩ as necessary	SELECT A TOOL 1:SIG-FIG CALCULATOR 2:UNIT CONVERTER 3:DATA/GRAPHS WIZARD 4:VECTOR CALCULATOR EXIT
2. Display the **SIG-FIG CALCULATOR** screen.	**1:SIG-FIG CALCULATOR**	

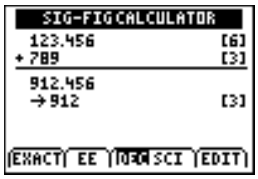
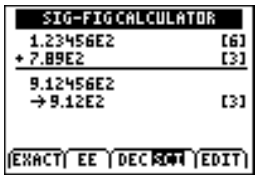
Determine if the **SIG-FIG CALCULATOR** is in decimal or scientific notation mode:

The current mode is decimal.

The current mode is scientific notation.

Name _____
Date _____

Notation formats in the SIG-FIG CALCULATOR (cont.)

To Do This	Press	Display
3. If necessary, change the result mode to decimal.	If necessary, ⟨**DEC SCI**⟩	
4. Enter the expression **123.456+7.89E2**.	**123.456** ⊞ **7.89** ⟨**EE**⟩ **2**	
5. Evaluate the expression. The format of the entry lines are changed to decimal notation. The result is displayed in decimal notation and converted to the correct number of significant figures.	ENTER	
6. Change the result mode to scientific notation.	⟨**DEC SCI**⟩	
7. Re-enter the expression **123.456+7.89E2** and evaluate. The entry area is cleared automatically as you begin to type. The format of the entry lines are changed to scientific notation when you press ENTER. The result is displayed in scientific notation and converted to the correct number of significant figures.	**123.456** ⊞ **7.89** ⟨**EE**⟩ **2** ENTER	

3: Scientific Notation — Teacher Notes

Objectives

Upon completion of this section, students should be able to:

- Given a number in scientific notation, express it in standard decimal form.
- Given a number in standard decimal form, express it in scientific notation.
- Perform addition and subtraction with numbers expressed in scientific notation.
- Perform multiplication and division with numbers expressed in scientific notation.

Relevant National Science Education Standards

From Science as Inquiry—Content Standard A:

Use Technology and Mathematics to Improve Investigations and Communications. *Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results.*

Common Student Errors

Students often are unclear about the effect on the exponent when the decimal point is "moved" right or left. The value of the exponent increases by 1 for each place the decimal point is shifted left; the value of the exponent decreases by 1 for each place the decimal point is shifted right.

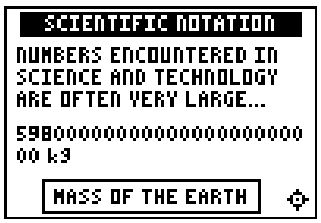
When multiplying numbers in scientific notation, students sometimes multiply the exponents rather than adding them. They have a similar problem when dividing numbers in scientific notation.

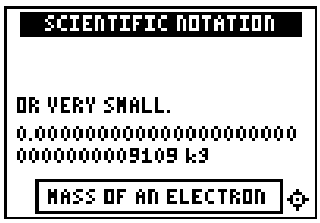
Using the Fundamental Topics in Science Application

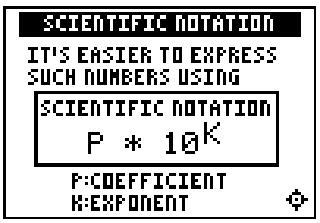
To begin the application, press APPS, select **FunSci**, and press any key. The displayed Table of Contents page shows the last place the student was in **FUNDAMENTAL TOPICS** or **SCIENCE TOOLS**. The student may need to press ⟨**UP**⟩ one or more times to go to the Science Chapters Table of Contents and then select **1:FUNDAMENTAL TOPICS**, **3:SCIENTIFIC NOTATION**, **1:INTRODUCTION** to begin. You may need to tell students how to navigate the application, if they are not yet familiar with it, or print Navigating Fundamental Topics in Science on pages viii–x of the Introduction.

Introduction

This section explores—through examples—the need for scientific notation.

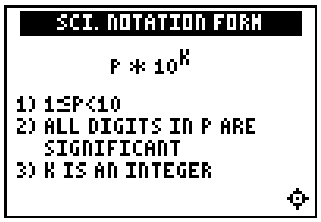


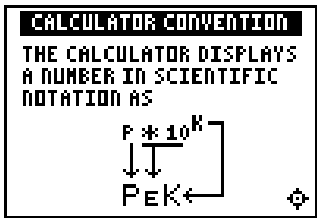




Concepts

This section explores the format, rules, and process for expressing numbers in scientific notation. The standard form for scientific notation is given. Then, the process of conversion from standard decimal notation to scientific notation is modeled, with an example, to demonstrate the process. The calculator representation of scientific notation is shown.



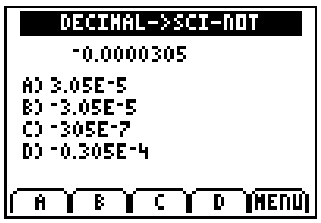


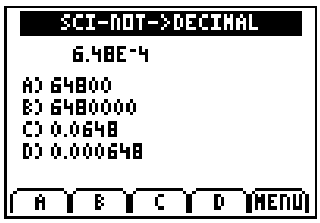
Finally, the four basic arithmetic operations for numbers expressed in scientific notation are shown, step by step.

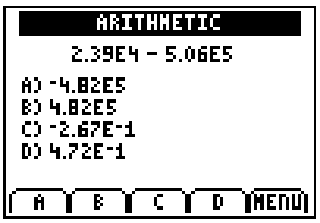
This topic assumes that students understand the concept of significant digits covered in the previous section (Precision & Accuracy).

Activities—Decimal→Sci-Not, Sci-Not→Decimal, Arithmetic

These activities provide students with practice in scientific notation. For each of three activities, ten conversion problems are presented (the order varies each time).







Students press ⟨**A**⟩, ⟨**B**⟩, ⟨**C**⟩, or ⟨**D**⟩ to select the correct answer. They earn 20 points for the correct answer on the first try, 10 points on the second try, up to a maximum of 200 points. Tell students if you wish them to record their scores and if they can repeat the activity to improve their scores.

After each problem, students can select ⟨**MORE**⟩ to try another problem. At any time they can select ⟨**MENU**⟩ to return to the **ACTIVITIES** menu. If a student is having trouble, you can suggest that he or she select ⟨ **MENU** ⟩ and begin the activity again. The cumulative score is displayed during the entire activity. The score displays after the activity is over; the student can press any key to return to the **ACTIVITIES** menu.

Try-It!™ on Your TI-83 Plus

This Try-It! activity requires the use of the Science Tools application. This free application came with the Fundamental Topics in Science application and is accessible from the **SCIENCE CHAPTERS** menu, but it must be loaded separately.

Students enter a mixed calculation (values in both decimal and scientific format) and then display the results in varying formats. The same activity is used on the home screen and in the **SIG-FIG CALCULATOR** so that students can observe the differences between them.

If students are not already familiar with the calculator, explain that on the TI-83 Plus they can enter values in either decimal format or scientific notation format anywhere they need to enter a value (on the home screen, in the list editor, as a WINDOW setting, and so on). However, they specify on the MODE screen how they want results to ***display*** on the home screen and in the list editor.

There are three display notation formats on the TI-83 Plus.

- Decimal (**Normal**)
- Scientific Notation (**Sci**)
- Engineering (**Eng**)

You may need to explain that Engineering Notation is similar to Scientific Notation, except that instead of the value always having one place to the left of the decimal, the exponent is always a multiple of three (hence there may be one, two, or three digits to the left of the decimal).

Space is provided for written answers on the Try-It! sheets, but if the students are keeping journals, you may wish to direct them to record their responses in their journals instead.

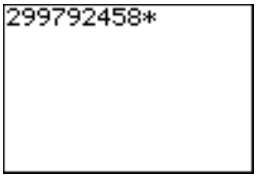
Note: The calculator features are described more fully in the *TI-83 Plus* guidebook. The **SCIENCE TOOLS** application is described more fully in the *TI-83 Plus Science Tools* user guide.

Name _____
Date _____

4: Units & Conversions — Try-It!™ on Your TI-83 Plus

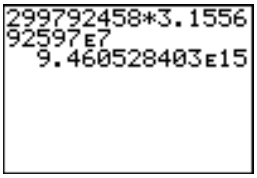
Calculate the distance light travels in one year

Express the distance that light travels in one year (known as 1 light-year) in m. The speed of light is 2.99792458×10^8 m/s. Distance = speed × time.

To Do This	Press	Display
1. Exit Fundamental Topics in Science. Clear the home screen.	2nd [QUIT] ⟨**EXIT**⟩ CLEAR CLEAR	
2. Display the **SCIENCE TOOLS** menu. **Note:** You also can access the **SCIENCE TOOLS** menu from the **SCIENCE CHAPTERS** menu.	APPS Select **SciTools** ENTER to leave the title page	
3. Display the **UNIT CONVERTER** screen.	**2:UNIT CONVERTER**	
4. Display the list of constants. Highlight **c** (speed of light).	⟨**CONSTANT**⟩ ▶ ▶ ▶ ▼ ▼	
5. Export the value of **c** to the home screen. 6. Return to the home screen and enter a multiplication sign.	⟨**EXPT**⟩ 2nd [QUIT] 2nd [QUIT] ⟨**EXIT**⟩ ×	
7. Return to Science Tools and display the **UNIT CONVERTER** screen. 8. To determine the number of seconds in a year, display the **TIME** conversion screen.	APPS Select **SciTools** ENTER to leave the title page **2:UNIT CONVERTER** **4:TIME**	

Name _____
Date _____

Calculate the distance light travels in one year (cont.)

To Do This	Press	Display
9. Convert 1 year to seconds. **Note:** Values are automatically displayed in scientific notation when you press ENTER.	**1** ▶ ▶ ▶ ▼ ENTER ▲ ENTER	
10. Export the number of seconds in a year to the home screen. 11. Return to the home screen and evaluate the expression to determine the number of meters that light travels in a light-year. **Note:** The TI-83 Plus displays very large and very small numbers in scientific notation, even if the display setting is **Normal**.	⟨**EXPT**⟩ 2nd [QUIT] 2nd [QUIT] ⟨**EXIT**⟩ ENTER	

Objectives

Upon completion of this section, students should be able to:

- Recognize the seven ***SI base units*** and several common ***derived units***.
- Perform conversions using various ***SI prefixes***.
- Perform conversions other than SI.
- Use ***dimensional analysis*** to help understand relationships among physical quantities and their units.

Relevant National Science Education Standards

From Science as Inquiry—Content Standard A:

Use Technology and Mathematics to Improve Investigations and Communications. *Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results.*

Common Student Errors

Students do not consistently include the proper units when expressing physical quantities. Even though the examples are silly, the **INTRODUCTION** section will help them understand the importance.

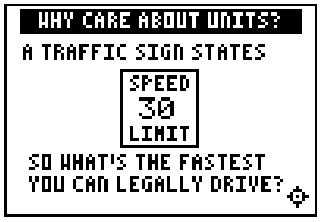
Students do not recognize how dimensional analysis can be used as a "sanity check" for calculated results, or how to use dimensional analysis to help them recall mathematical relationships among physical quantities. Several examples in the **CONCEPTS** section and the **DIMENSIONAL DEMENTIA** activity will assist them.

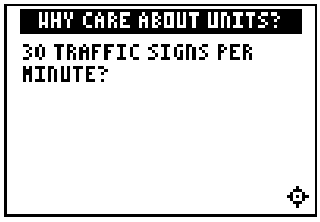
Using the Fundamental Topics in Science Application

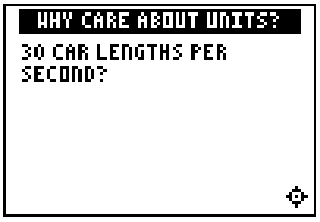
To begin the application, press APPS, select **FunSci**, and press any key. The displayed Table of Contents page shows the last place the student was in **FUNDAMENTAL TOPICS** or **SCIENCE TOOLS**. The student may need to press ⟨**UP**⟩ one or more times to go to the Science Chapters Table of Contents and then select **1:FUNDAMENTAL TOPICS**, **4:UNITS & CONVERSIONS**, **1:INTRODUCTION** to begin. You may need to tell students how to navigate the application, if they are not yet familiar with it, or print Navigating Fundamental Topics in Science on pages viii–x of the Introduction.

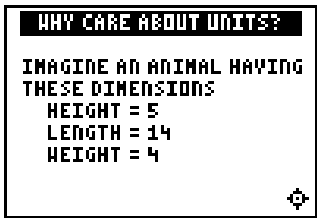
Introduction

This section begins by exploring the idea that it is meaningless to describe a physical quantity without including its associated unit of measurement. Two examples are given.



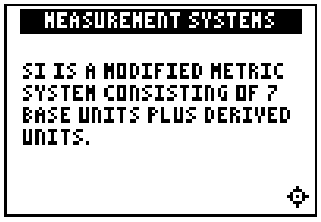


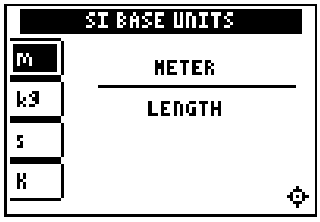


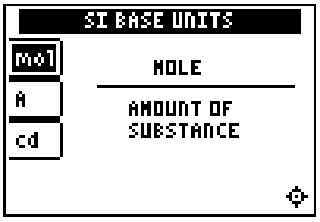


Concepts

This section addresses the idea of standard measuring systems and introduces the SI measurement system. Students probably are comfortable with measurements of length, mass, time, and temperature, but less familiar with amount of substance, electric current, and luminous intensity. You may want to discuss the types of measurements where those units would be used. Even though these units may not be studied in detail in your course, we include them because these seven units are the basis from which all other SI units are derived.







Students may be interested to know that SI is an acronym for "Le Systeme International d'Unites" (the International System of Units).

Extension

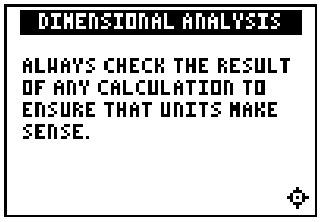
The acceptance of SI as a worldwide standard offers tremendous advantages in science and technology as well as in commerce. Ask students if they have encountered problems trying to use two different measuring systems together. Examples they might come up with include trying to remove an "English" nut (one specified to SAE standards) with a metric socket set (or vice versa), trying to pour a liter bottle of juice into a quart container, or inheriting a recipe with European measurements.

SI prefixes are used when describing very large or very small quantities. The prefixes are not limited, however, to SI. Students are probably familiar with some of the prefixes such as giga, mega, kilo, and nano in the context of personal computers.

Concepts (cont.)

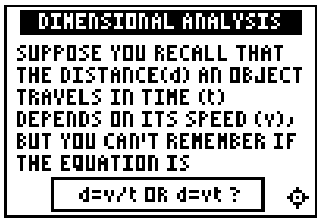
An example is presented showing how to convert numbers from one unit to another. The same process (the factor-label method) applies to any conversion, whether or not SI prefixes are involved.

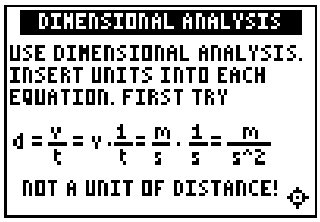
The concept of dimensional analysis is presented, with several examples.

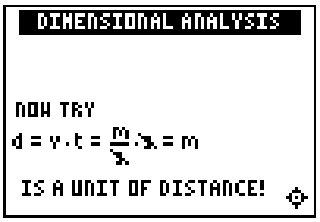


In addition to the examples given, you may wish to use several others to illustrate the use of dimensional analysis in predicting or verifying relationships. For example: fuel efficiency (miles/gallon); earnings rate (dollars/hour); stream flow rate (gallons per minute, cubic feet per second, etc.).

Dimensional analysis can also be used ensure that equations are correctly formulated. You should caution students about the limitations of dimensional analysis. For instance, certain factors, such as proportionality constants, cannot be predicted.





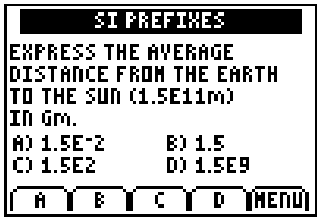


Activity—SI Prefixes

This activity provides students with practice in converting using SI prefixes. Five conversion problems are presented (the order varies each time).

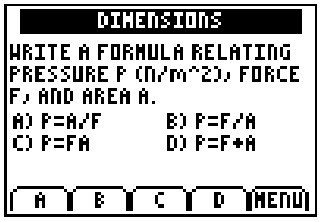
Students press ⟨**A**⟩, ⟨**B**⟩, ⟨**C**⟩, or ⟨**D**⟩ to select the correct answer. They earn 20 points for the correct answer on the first try, 10 points on the second try, up to a maximum of 140 points. Tell students if you wish them to record their scores and if they can repeat the activity to improve their scores.

After each problem, students can select ⟨**MORE**⟩ to try another problem. At any time they can select ⟨**MENU**⟩ to return to the **ACTIVITIES** menu. If a student is having trouble, you can suggest that he or she select ⟨**MENU**⟩ and begin the activity again. The cumulative score is displayed during the entire activity. The score displays after the activity is over; the student can press any key to return to the **ACTIVITIES** menu.



Activity—Dimensions

This activity provides students with practice in dimensional analysis. Seven problems are presented (the order varies each time).



Students press ⟨**A**⟩, ⟨**B**⟩, ⟨**C**⟩, or ⟨**D**⟩ to select the correct answer. They earn 20 points for the correct answer on the first try, 10 points on the second try, up to a maximum of 140 points. Tell students if you wish them to record their scores and if they can repeat the activity to improve their scores.

After each problem, students can select ⟨**MORE**⟩ to try another problem. At any time they can select ⟨**MENU**⟩ to return to the **ACTIVITIES** menu. If a student is having trouble, you can suggest that he or she select ⟨**MENU**⟩ and begin the activity again. The cumulative score is displayed during the entire activity. The score displays after the activity is over; the student can press any key to return to the **ACTIVITIES** menu.

Extension

Point out that certain commonly used unit combinations are given special names.

- force Newton $kg \cdot m/s^2$
- work or energy Joule $N \cdot m$
- pressure Pascal N/m^2

Units other than standard SI units are sometimes used for convenience (such as when the SI unit is very large or very small in the typical environment).

- volume liter $10^{-3}m^3$
- force dyne $g \cdot cm/s^2$

Try-It!™ on Your TI-83 Plus

This Try-It! activity requires the use of the Science Tools application. This free application came with the Fundamental Topics in Science application and is accessible from the **SCIENCE CHAPTERS** menu, but it must be loaded separately.

You may direct the students to perform the given unit conversions manually and turn in their work sheets (using the **UNIT CONVERTER** tool only to check their work) or have them use the **UNIT CONVERTER** for all applicable portions.

$$\text{distance} = \text{rate} \bullet \text{time} = \frac{3.00\times10^{8}\ \text{m}}{\text{s}} \bullet \frac{1\ \text{y}}{} \bullet \frac{365\ \text{days}}{\text{y}} \bullet \frac{24\ \text{h}}{\text{day}} \bullet \frac{60\ \text{min}}{\text{h}} \bullet \frac{60\ \text{s}}{\text{min}} = 9.46\times10^{15}\ \text{m}$$

Space is provided for written answers on the Try-It! sheets, but if the students are keeping journals, you may wish to direct them to record their responses in their journals instead.

Note: The **SCIENCE TOOLS** application is described more fully in the *TI-83 Plus Science Tools* user guide.

Extension

Have the students express the average distance from the earth to the sun (1.50×10^{11} m) in light-years.

$$1.50\times10^{11}\ \text{m} \bullet \frac{\text{light-year}}{9.46\times10^{15}\ \text{m}} = 1.59\times10^{-5}\ \text{light-year}$$

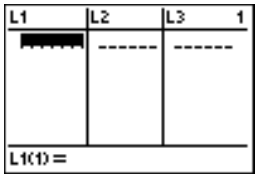
Name _____
Date _____

5: Data & Graphs — Try-It!™ on Your TI-83 Plus

Enter population information into lists with the Data/Graphs Wizard

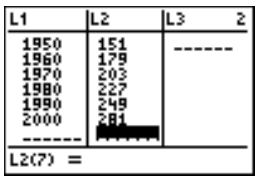
The United States began the decennial population census in 1790 for purposes of apportioning congressional seats. In recent decades, the figures also have been used for projecting growth.

Year	Resident Population	Year	Resident Population
1790	3.93	1900	76.2
1800	5.31	1910	92.2
1810	7.24	1920	106
1820	9.64	1930	123
1830	12.9	1940	132
1840	17.1	1950	151
1850	23.2	1960	179
1860	31.4	1970	203
1870	38.6	1980	227
1880	50.2	1990	249
1890	63.0	2000	281

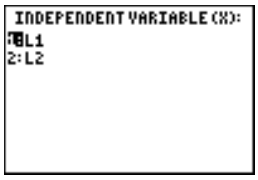
To Do This	Press	Display
1. Display the **SCIENCE TOOLS** menu. **Note:** You also can access the **SCIENCE TOOLS** menu from the **SCIENCE CHAPTERS** menu.	If necessary, exit **FunSci** APPS Select **SciTools** ENTER to leave the title page	
2. Display the **DATA/GRAPHS WIZARD** screen.	**3:DATA/GRAPHS WIZARD**	
4. Select the option for **NEW/EDIT DATA**. **Note:** The **DATA/GRAPHS WIZARD** uses the list feature of the TI-83 Plus. If the calculator has named lists in the editor, you may have to press ▶ to scroll to **L1**. 5. Clear each list as necessary. 6. Scroll to **L1**.	⟨**DATA**⟩ ▲ to go to the list name CLEAR ENTER ◀ or ▶ to go to the next list ◀ or ▶, as necessary	

Name _____
Date _____

Enter population information into lists with the Data/Graphs Wizard (cont.)

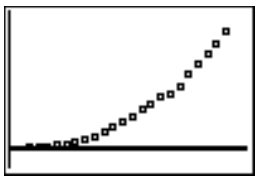
To Do This	Press	Display
7. Enter the years into **L1**. 8. Enter the population into **L2**.	Type each number, then ENTER ▶ to go to **L2** Type each number, then ENTER	

Plot the data

To Do This	Press	Display
1. Display the **DATA/GRAPHS WIZARD** screen.	2nd [QUIT]	
2. Select **PLOT DATA**. The **DATA/GRAPHS WIZARD** offers four types of plots. The **SCATTERPLOT** and **XY LINE** are appropriate for paired data.	⟨ ⟩	
3. Choose a scatter plot. For your convenience, the **DATA/GRAPHS WIZARD** shows only the names of lists that have data in them.	⟨ ⟩	

Name _____
Date _____

Enter population information into lists with the Data/Graphs Wizard (cont.)

To Do This	Press	Display
4. The independent variable list (years) is in **L1**. The dependent variable list (population) is in **L2**. **Note:** For your convenience, for the dependent variable the **DATA/GRAPHS WIZARD** shows only lists with the same number of elements as the independent list (including the independent list). Trying to plot empty lists or lists of unequal length would cause a calculator error. When you select the dependent list, the plot displays immediately in an appropriate graphing window.	**1:L1** **2:L2**	

Describe in words the shape of the curve created by the points. Where do you think the curve is flattest? Where is it steepest? Use that information to write a sentence about US population growth.

Find a curve to fit the data

Words can describe data in general, but mathematical functions can model the data more specifically. In the real world, data rarely sits perfectly on a curve.

A "perfect fit" can be guaranteed only by a function of degree **n–1** for **n** data points. Thus, you can always find a linear function (ax+b) that is a perfect fit for two points or a quadratic function (ax^2+bx+c) that is a perfect fit for three points, and so on. However, often a perfect fit can be found with a function of a lesser degree. For example, the linear function y=2x+1 is a perfect fit for the three points (1,3), (2,5), and (5,11).

What would the form of a guaranteed "perfect fit" equation look like for the population data? (You may stop writing when you get to the end of the line.)

Name _____
Date _____

Find a curve to fit the data (cont.)

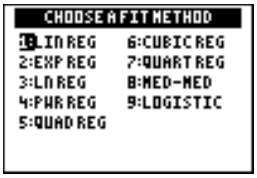
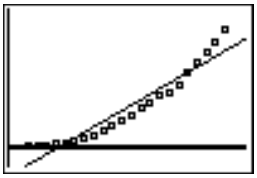
Obviously, "perfect fit" equations aren't very practical and often don't do a good job of predicting (extrapolating) other data. Therefore, a best-fit curve is often used. Choosing a best-fit curve with the TI-83 Plus requires these basic steps.

- You choose a function with a shape that looks similar to the data (beginning with the simpler curves).
- The TI-83 Plus uses algorithms to determine the coefficients (a, b, c, and so on) required to best fit that function to the data.
- You examine the points and curve visually and numerically to determine how good the fit is.

These three steps can be repeated until you think you have found the right function.

Note: If you want a refresher on the shapes of these functions, you can return to **DATA & GRAPHS** in **FUNDAMENTAL TOPICS**. When you return to the **DATA/GRAPHS WIZARD**, repeat the steps beginning with Plot the Data above. (The values you entered in the lists are still there.)

Fit a curve to the data and analyze visually

To Do This	Press	Display
1. Display the **DATA/GRAPHS WIZARD** screen.	2nd [QUIT]	
2. Select a function to fit. Begin with the linear function. **Note:** Some types of functions take longer to calculate, and there may be a pause before the graph screen replaces the menu screen. **Note:** If a function is inappropriate for a set of data, the message **FIT ERROR** will display below the menu. Press ENTER and choose a new function.	**1:LIN REG**	

Describe how well the linear function fits the points. What is "wrong" with the fit? How well do you think it would predict population in 200 years?

Name _____
Date _____

Analyze the result quantitatively

There is a statistical variable, r^2 or R^2, called the ***coefficient of determination***, that is often used to describe numerically how good a fit is. The TI-83 Plus automatically calculates it (and other statistical variables) when you fit a curve to data. In general terms, r^2 or R^2 is calculated by analyzing how far away each point is from its predicted value on the curve.

The coefficient of determination is r^2 for **LIN REG**, **EXP REG**, **LN REG**, **PWR REG**, and R^2 for **QUAD REG**, **CUBIC REG**, and **QUART REG**. It is not calculated for **MED-MED**, or **LOGISTIC**. The closer that r^2 or R^2 is to 1, the better.

Note: The Fundamental Topics in Science application resets the statistical variables. In order to complete this exercise, you must run the Science Tools application by selecting it from the APPS menu on the TI-83 Plus instead of selecting it from the **SCIENCE CHAPTERS** menu in **FUNDAMENTAL TOPICS**.

To Do This	Press	Display
1. Exit **SCIENCE TOOLS**. Clear the home screen.	[2nd] [QUIT] [2nd] [QUIT] ⟨**EXIT**⟩ [CLEAR] [CLEAR]	
2. Copy the r^2 variable from the VARS EQ menu to the home screen and evaluate it.	[VARS] **5:Statistics...** [▶] [▶] (to the EQ menu) **8:r^2** [ENTER]	r^2 .9196943682

Fit an exponential curve to the data and analyze the result

.920 is not a particularly good r^2. Look for a better fit. Repeat the steps above for an exponential regression.

Describe how well the exponential function fits the points. What is the r^2? How well do you think the exponential model would predict population in 200 years? Describe the living conditions in the United States if the exponential model were correct.

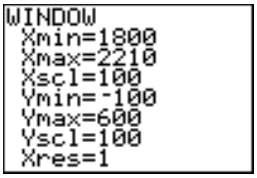
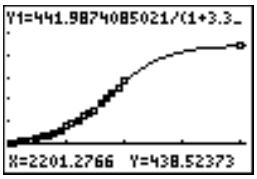
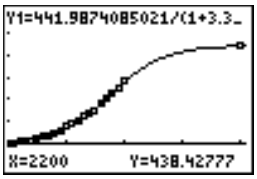
A mathematical model should be interpreted in relationship to the real world. This example is a special class of data modeling known as a growth model. While an exponential function may describe the data fairly well in the data collection period and interpolate well for years in between measurements, it often is too steep near the end of the data. The logistic model usually predicts future growth better than linear and exponential models, since the curve levels off after the "growth spurt." It is reasonable to expect population will approach a limit rather than increasing without bound.

Name _____
Date _____

Fit a logistic curve to the data and analyze visually

Repeat the steps above for the logistic regression. (This regression takes a while to plot; be patient.) Neither **r²** nor **R²** is calculated for the logistic regression, so you will have to rely on visual analysis.

You can change the viewing window and trace the function to determine the predicted value in 200 years (the year 2200).

To Do This	Press	Display
1. When the regression and plot are displayed, change the X range to 2210 to include the year 2210 and the Y range to accommodate a larger population.	WINDOW **1800** ENTER **2210** ENTER **100** ENTER (-) **100** ENTER **600** ENTER **100** ENTER	
2. Trace to a value near the year 2200.	TRACE ▼ (to move to **Y1**) ▶ (to near **X=2200**)	
3. You can display the value of **Y** at exactly 2200.	**2200** ENTER	

How well does the data fit visually? What is the approximate population in the year 2200? (Remember to give your answer to three significant figures.) List several real-world factors that would suggest that a logistic model is more likely to be accurate than an exponential model.

The US Census Bureau uses a complex model to project population. Their model estimates the population in 2050 will be 404 million, and in 2100 will be 571 million. How does this compare with the logistic model's predictions for those years? What does this suggest about the results for 2200?

Objectives

Upon completion of this section, students should be able to:

- Enter one or more related sets of data into tables or lists.
- Plot and interpret sets of data using one or more plot types (scatter plot, xy-line, histogram, modified box plot).
- Recognize common mathematical functions that model patterns in plotted data.
- Perform basic statistical analysis methods to help interpret data sets.

Relevant National Science Education Standards

From Science as Inquiry—Content Standard A:

Design and Conduct Scientific Investigations. *The investigation may also require . . . student organization and display of data. . .*

Use Technology and Mathematics to Improve Investigations and Communications. *A variety of technologies, such as hand tools, measuring instruments, and calculators, should be an integral component of scientific investigations. For example, . . . charts and graphs are used for communicating results.*

Communicate and Defend a Scientific Argument. *Students in school science programs should develop the abilities associated with accurate and effective communication. These include . . . summarizing data, using language appropriately, developing diagrams and charts, explaining statistical analysis . . .*

Common Student Errors

When entering data into tables or lists, students do not maintain one-to-one correspondence among related data. This results in an **ERR:DIM MISMATCH** when the student attempts to display a **Scatter** ( ) plot or an **xyLine** ( ) plot using lists of different dimensions (length, number of elements).

Students need to review basic graphing skills periodically. The activity **ABC'S OF XY-GRAPHS** is especially helpful.

Students have trouble identifying trends in data and correlating such trends to mathematical functions. Several of the most common function types are represented in **CONCEPTS**. The **NAME THAT FUNCTION** activity helps check and reinforce their ability to recognize the common function types.

Using the Fundamental Topics in Science Application

To begin the application, press APPS, select **FunSci**, and press any key. The displayed Table of Contents page shows the last place the student was in **FUNDAMENTAL TOPICS** or **SCIENCE TOOLS**. The student may need to press ⟨**UP**⟩ one or more times to go to the Science Chapters Table of Contents and then select **1:FUNDAMENTAL TOPICS**, **5:DATA & GRAPHS**, **1:INTRODUCTION** to begin. You may need to tell students how to navigate the application, if they are not yet familiar with it, or print Navigating Fundamental Topics in Science on pages viii–x of the Introduction.

Introduction

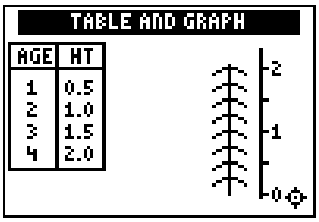
This section introduces the idea that data is everywhere, and that we need to organize data in order to make sense of it. Tables and graphs are powerful tools for representing data in an organized, visual, and concise manner.

Concepts

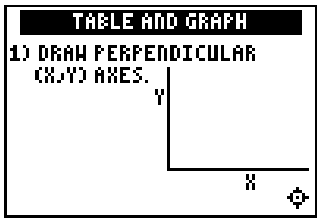
If your students are keeping journals, you may want them to write their responses in their journals. If they are not keeping journals, have them write their responses on a blank sheet of paper.

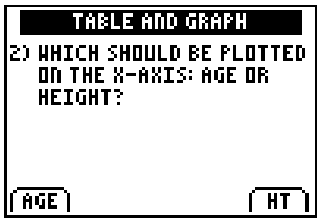
This section explores how tables and graphs are very effective ways to view certain types of data. Measurements taken over time are one such type of data. The growth of a tree is animated over a period of several years. On a **WRITE IT DOWN** screen, students are first asked to write a sentence describing the tree's growth.

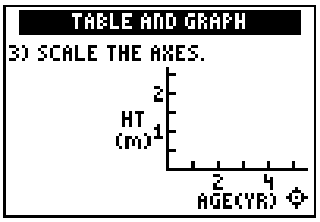
Next, a table and plot of the data representing the tree's growth is developed.

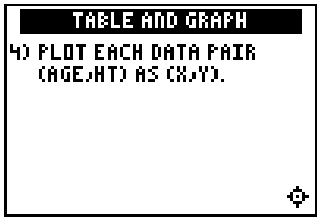


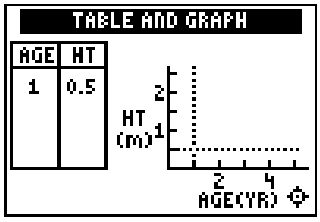
The creation of a graph is developed step by step.

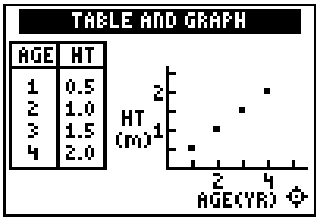












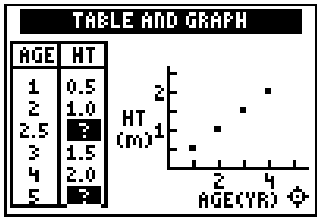
In a second **WRITE IT DOWN** screen, students are asked to discuss ways in which a table and plot are more useful than a descriptive sentence.

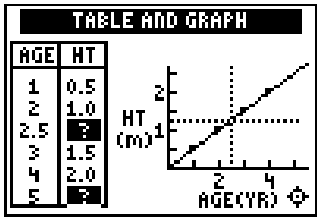
Extension

Ask students to think of other types of data that they would like to view in table and graph form. Then ask them to think of some types of data where that wouldn't be quite so helpful. If they aren't sure, point out that in this graph, the height and the age are both meaningful, correlated numbers (variables). Based on one number (variable), they can make predictions about the unknown half of a pair. If they measured the height of four classmates (a single variable), would a table and graph help them in predicting the height of a fifth classmate, or would that be better predicted by a calculation of statistical measures such as the mean or median of the four data points?

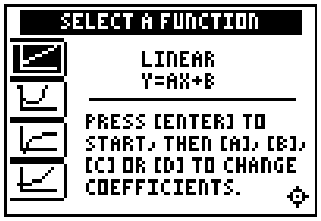
Concepts (cont.)

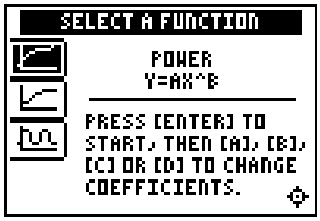
The concept of using a table and/or graph to predict values between and beyond observation points by visualizing a line connecting the points is presented.

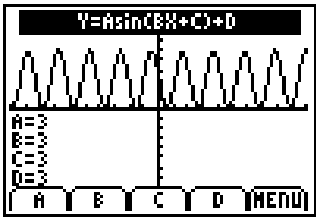




Students explore the effect of varying each of the coefficients in the equations that define seven common function types (linear, quadratic, logarithmic, exponential, power, logistic, sinusoidal).







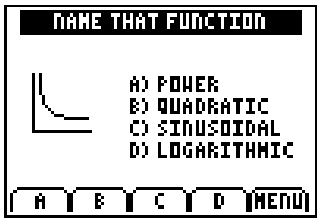
When the student selects a function by pressing ENTER, the function is displayed on the graph screen, with all parameters equal to 3. The student can reduce the value of the parameter by 1 each time he or she presses ⟨**A**⟩, ⟨**B**⟩, ⟨**C**⟩, or ⟨**D**⟩ associated with the matching parameter. The parameter values cycle through the limited range from 3 to -1 (3, 2, 1, 0 -1, -2, -3, 3, 2, . . .). When finished exploring a particular function, the student can select ⟨**MENU**⟩ to return to the menu and select a new function.

Extension

Suggest that students experiment to determine which parameters to change (and to what values) to make the function as flat as possible and as close to the X axis as possible.

Activity—Name that Function

This activity provides students with practice in identifying common functions by their typical plot "shapes." Seven problems are presented (the order varies each time).



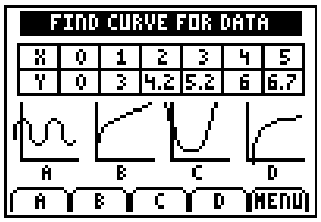
Students press ⟨**A**⟩, ⟨**B**⟩, ⟨**C**⟩, or ⟨**D**⟩ to select the correct answer. They earn 20 points for the correct answer on the first try, 10 points on the second try, up to a maximum 140 points. Tell students if you wish them to record their scores and if they can repeat the activity to improve their scores.

Activity—Name that Function (cont.)

After each problem, students can select ⟨**MORE**⟩ to try another problem. At any time they can select ⟨**MENU**⟩ to return to the **ACTIVITIES** menu. If a student is having trouble, you can suggest that he or she select ⟨**MENU**⟩ and begin the activity again. The cumulative score is displayed during the entire activity. The score displays after the activity is over; the student can press any key to return to the **ACTIVITIES** menu.

Activity—Dangerous Curves Ahead

This activity provides students with practice in matching data pairs with common functions. Seven problems are presented (the order varies each time).



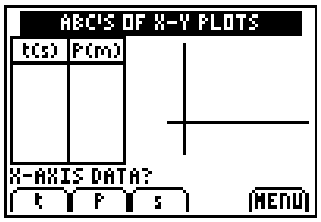
Students press ⟨**A**⟩, ⟨**B**⟩, ⟨**C**⟩, or ⟨**D**⟩ to select the correct answer. They earn 20 points for the correct answer on the first try, 10 points on the second try, up to a maximum 140 points. Tell students if you wish them to record their scores and if they can repeat the activity to improve their scores.

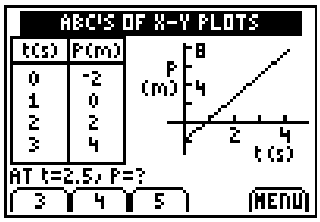
After each problem, students can select ⟨**MORE**⟩ to try another problem. At any time they can select ⟨**MENU**⟩ to return to the **ACTIVITIES** menu. If a student is having trouble, you can suggest that he or she select ⟨**MENU**⟩ and begin the activity again. The cumulative score is displayed during the entire activity. The score displays after the activity is over; the student can press any key to return to the **ACTIVITIES** menu.

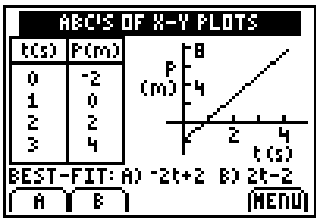
Activity—ABC's of XY-Graphs

In this activity, students go through the process of constructing the X-Y plot of a line. They select the correct answer to each of the following steps as the graph is built.

- X-axis data
- X-axis units
- Y-axis data
- Y-axis units
- Initial position
- Value of P when t = 3
- Value of P when t = 2.5
- Best-fit line







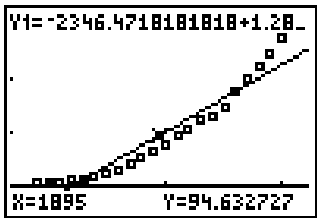
Try-It!™ on Your TI-83 Plus

This Try-It! activity requires the use of the Science Tools application. This free application came with the Fundamental Topics in Science application and is accessible from the **SCIENCE CHAPTERS** menu, but it must be loaded separately.

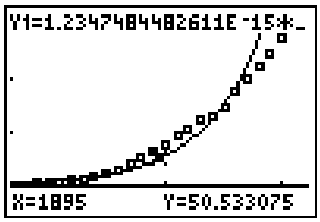
Students use the **DATA/GRAPHS WIZARD** in **SCIENCE TOOLS** to learn about data modeling and curve fitting, with a population-growth example. They enter the data, plot it as a scatter plot, and fit three curves to it. They write an analysis for each describing how well the curve matches the data visually, record the r^2 for linear and exponential regressions, and discuss how well the curve would fit the data in the year 2200.

Census data is from chart at http://www.census.gov/dmd/www/resapport/states/unitedstates.pdf, also found in US Census Bureau, *Statistical Abstract of the United States: 2000*, Table 1. A pdf version of this publication is at http://www.census.gov/statab/www. It has hundreds of statistical tables on topics from Retail Prescription Drug Sales to Infant Mortality Rates that provide data for trend analysis (click on the Bookmark tab in Adobe® Acrobat® Reader).

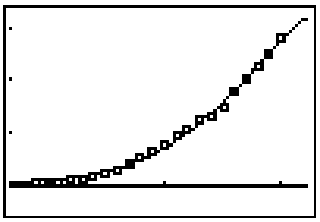
Projections are from http://www.census.gov/population/projections/nation/summary/np-t6-a.txt, which also gives figures on how births, deaths, and migration affect these totals.



linear regression
r^2 = .920



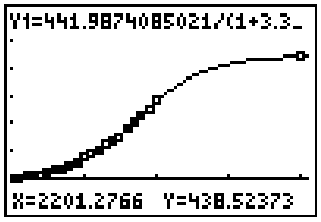
exponential regression
r^2 = .965

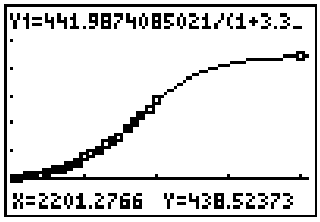


logistic regression
no r^2 or R^2

Logistic model **Y=c/(1+ae^(-bx))**

Y=441.9874085021/(1+ 3.3566497254812E18*e^(-0.02157773212114X))





Extension

Let students look for a best-fit curve for life expectancy based on year of birth using the figures below. (This is more complete data than shown in the **INTRODUCTION**.)

Year of birth	Life expectancy in US	Year of birth	Life expectancy in US
1900	47.3	1950	68.2
1910	50.0	1960	69.7
1920	54.1	1970	70.8
1930	59.7	1980	73.7
1940	62.9	1990	75.4

Data from National Vital Statistics Report, Vol. 47, No. 28, 32–33.

Space is provided for written answers on the Try-It! sheets, but if the students are keeping journals, you may wish to direct them to record their responses in their journals instead.

Note: The calculator features are described more fully in the *TI-83 Plus* guidebook. The **SCIENCE TOOLS** application is described more fully in the *TI-83 Plus Science Tools* user guide.

Name _____
Date _____

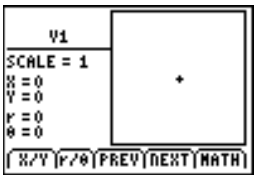
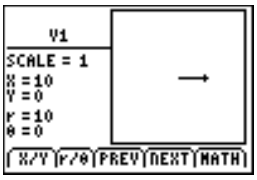
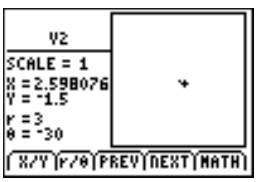
6: Vectors — Try-It!™ on Your TI-83 Plus

Solve a vector problem by hand

A ship heads due east with speed of 10 kilometers per hour with respect to the water. The current is 30 degrees south of east at 3 kilometers per hour. Sketch the vectors and find the actual course and speed of this ship with respect to the ground. Show your work.

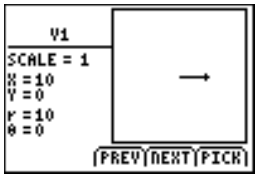
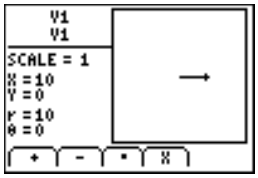
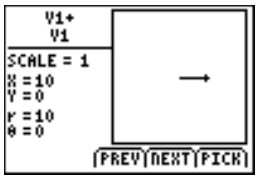
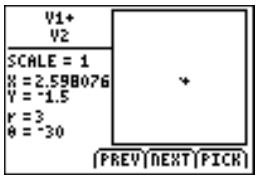
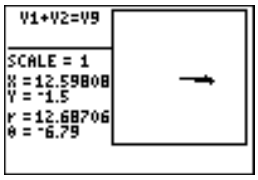
Define vectors in the Vector Calculator

Now use the **VECTOR CALCULATOR** to explore the same problem.

To Do This	Press	Display
1. Display the **SCIENCE TOOLS** menu. **Note:** You also can access the **SCIENCE TOOLS** menu from the **SCIENCE CHAPTERS** menu.	If necessary, exit **FunSci** APPS Select **SciTools** ENTER to leave the title page	
2. Display the **VECTOR CALCULATOR** screen. On this screen, the tail of the vector is positioned at point (0,0). You may create or edit a vector in three ways: ▸ Entering the head as (x,y). ▸ Entering the head as (r,θ). ▸ Using the cursor keys.	**4:VECTOR CALCULATOR**	
3. Enter a vector, **V1**, describing the ship's initial speed and course heading.	⟨**r/θ**⟩ **10** ENTER **0** ENTER ⟨**VIEW**⟩	
4. Enter a second vector, **V2**, describing the current. **Note:** Angles in the fourth and third quadrants are designated as -1 through -180.	⟨**NEXT**⟩ ⟨**r/θ**⟩ **3** ENTER (-) **30** ENTER ⟨**VIEW**⟩	

Name _____
Date _____

Add vectors in the Vector Calculator

To Do This	Press	Display
1. Select vector math. The vector **V1** is displayed.	⟨**MATH**⟩	
2. Pick this vector. The keys change to the four basic math functions.	⟨**PICK**⟩	
3. Select addition. The vector **V1** is displayed again.	⟨**+**⟩	
4. Go to vector **V2**.	⟨**NEXT**⟩	
5. Pick this vector. The two vectors are added and the result is displayed and stored in **V9**.	⟨**PICK**⟩	

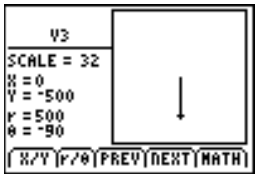
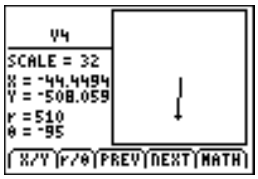
Name _____
Date _____

Solve a vector problem by hand

A plane heads due south with indicated airspeed of 500 kilometers per hour. The plane's actual course and speed are 5 degrees west of south at 510 kilometers per hour. Sketch the vectors and find the wind velocity. Show your work.

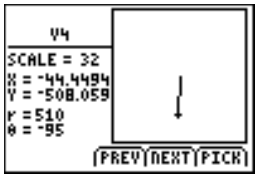
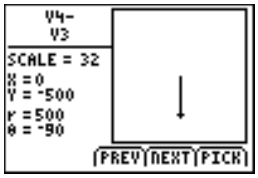
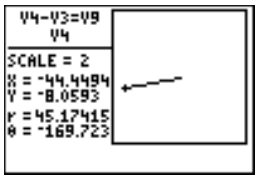
Define vectors in the Vector Calculator

Now use the **VECTOR CALCULATOR** to explore the same problem.

To Do This	Press	Display
1. Leave vector math.	2nd [QUIT] 2nd [QUIT]	
2. Go to **V3**. This leaves the vectors in **V1** and **V2** as defined above.	⟨**NEXT**⟩ ⟨**NEXT**⟩	
3. Enter the plane's heading in **V3** using **X** and **Y**.	⟨**X/Y**⟩ **0** ENTER (-) **500** ENTER ⟨**VIEW**⟩	
4. Enter the plane's actual speed and course in **V4**.	⟨**NEXT**⟩ ⟨**r/θ**⟩ **510** ENTER (-) **95** ENTER ⟨**VIEW**⟩	

Name _____
Date _____

Subtract vectors in the Vector Calculator

To Do This	Press	Display
1. Select vector math. The vector **V1** is displayed. 2. Go to **V4**.	⟨**MATH**⟩ ⟨**NEXT**⟩ ⟨**NEXT**⟩ ⟨**NEXT**⟩	
3. Indicate **V4** minus **V3**.	⟨**PICK**⟩ ⟨−⟩ ⟨**PREV**⟩	
4. Complete the calculation. The resultant vector (the wind velocity) is displayed and stored in **V9**. Notice that the zoom factor is adjusted to fit the vector in the window.	⟨**PICK**⟩	

Which direction is the wind blowing?

Objectives

Upon completion of this section, students should be able to:

- Draw a vector in the X-Y plane given magnitude and direction (specified in degrees or cardinal directions: North, South, East, or West).
- Resolve vectors into perpendicular components.
- Add and subtract two or more vectors.
- Multiply a scalar and a vector.
- Multiply two vectors (scalar and vector products).

Relevant National Science Education Standards

From Science as Inquiry—Content Standard A:

Use Technology and Mathematics to Improve Investigations and Communications. *Mathematics is essential in scientific inquiry. Mathematical tools and models guide and improve the posing of questions, gathering data, constructing explanations and communicating results.*

Common Student Errors

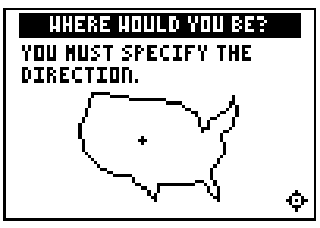
Students generally have difficulty understanding that direction is fundamental to a vector quantity; it is not sufficient to merely specify magnitude of a quantity such as velocity. The **INTRODUCTION** helps emphasize this point to them, but you may need to remind them to "remember the map" if they forget to include direction in later vector operations.

Using the Fundamental Topics in Science Application

To begin the application, press APPS, select **FunSci**, and press any key. The displayed Table of Contents page shows the last place the student was in **FUNDAMENTAL TOPICS** or **SCIENCE TOOLS**. The student may need to press ⟨**UP**⟩ one or more times to go to the Science Chapters Table of Contents and then select **1:FUNDAMENTAL TOPICS**, **6:VECTORS**, **1:INTRODUCTION** to begin. You may need to tell students how to navigate the application, if they are not yet familiar with it, or print Navigating Fundamental Topics in Science on pages viii–x of the Introduction.

Introduction

This section explores the concept that both magnitude and direction are important and necessary when describing certain physical quantities (vectors). A displacement example is used to illustrate this concept.



Concepts

Students explore basic vector operations. Definitions and graphical examples are provided for:

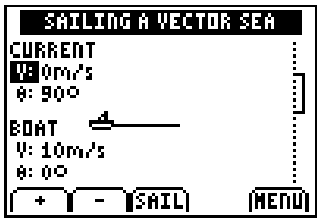
- Resultant of vector addition
- Subtraction
- Multiplication
- Resolution of a vector into two perpendicular components

Note: Numeric examples round the results to the appropriate number of significant figures. Students can review significant figures in **PRECISION & ACCURACY** if needed.

Activity— Sailing a Vector Sea

The challenge is to sail the boat to a dock on the other side of a body of water. Students can adjust one or more of the following elements:

- Speed of the current (range from 0 to 5 m/sec)
- Direction of the current (90° or -90°)
- Speed of the boat (range from 0 to 10 m/sec)
- Heading of the boat (-45° through 45° in 5° increments)



▲ and ▼ moves to the element to change.
⟨+⟩ increments and ⟨-⟩ decrements a value.

The vector changes as the values are increased or decreased. Remind students that when velocity is zero, the vector is a point.

Once the vectors are set, the student can press ⟨**SAIL**⟩, and the boat sails along the resultant velocity vector (the vector obtained from the vector addition of the current vector and the boat vector).

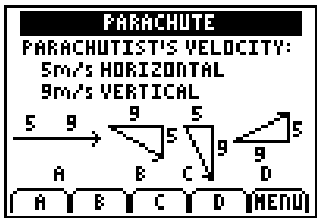
- If the boat misses the dock, the student can press ⟨**MORE**⟩ to modify one or more of the entered parameters.
- If the boat reaches the dock, the student can press ⟨**MORE**⟩ to play again or press ⟨**MENU**⟩ to return to the **ACTIVITIES** menu.

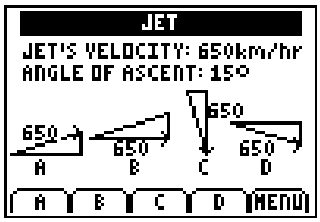
Direct students to experiment with different values for each of the elements.

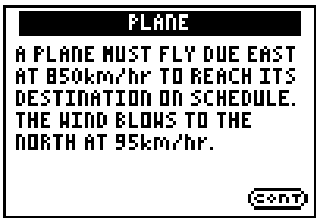
Activity—Vector Resolution for the New Year

This activity provides practice in visualizing vector resolution. Three problems, that of a parachutist, a jet, and a plane are presented. For each of the problems, the student is asked three questions about vector resolution. This activity does not have scoring.

Students can select ⟨**MENU**⟩ to return to the **ACTIVITIES** menu. If a student is having trouble, you can suggest that he or she select ⟨**MENU**⟩ and begin the activity again.







Try-It!™ on Your TI-83 Plus

This Try-It! activity requires the use of the Science Tools application. This free application came with the Fundamental Topics in Science application and is accessible from the **SCIENCE CHAPTERS** menu, but it must be loaded separately.

Students gain experience entering, viewing, and performing basic vector operations using the **VECTOR CALCULATOR**.

Space is provided for written answers on the Try-It! sheets, but if the students are keeping journals, you may wish to direct them to record their responses in their journals instead.

Note: The **SCIENCE TOOLS** application is described more fully in the *TI–83 Plus Science Tools* user guide.

TIp™ 1: Resetting Your Calculator

You can easily reset all default, or factory, settings on your calculator from the **MEMORY** menu. Resetting the default settings ensures that all calculators show exactly the same results in the same form.

Resetting defaults does not erase any lists, programs, or variables stored in memory.

Note: You should reset your calculator's default settings to ensure that the results you see on your calculator will match the results in all example screens in the TIps.

Resetting your calculator to the defaults	For more information
Resets all mode and window format defaults.	TIp 2: *Adjusting Your Calculator Settings*
Turns off function plots.	TIp 3: *Graphing a Function in the Standard Window*
Resets window values to **ZStandard**.	TIp 5: *Adjusting the Viewing Window*
Turns off statistical plots.	TIp 7: *Creating a Statistical Plot*

Calculator Keys Used in This TIp

2nd [MEM] **7:Reset 2:Defaults 2:Reset**

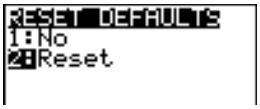
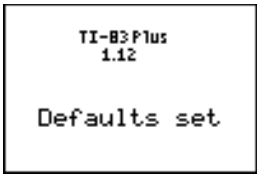
TIp Highlights

Your calculator contains many settings that control the interpretation of results and graphs. For example, you can control how the calculator:

- Displays mathematical results (for example, with floating or fixed decimal notation).
- Interprets and displays graphs and statistical plots (for example, scale of the **X**-axis and **Y**-axis).

Try-It!™ on Your TI-83 Plus

Reset the calculator defaults.

To Do This	Press	Display
1. Display the **MEMORY** menu and select **Reset**.	2nd [MEM] **7:Reset**	
2. Select **Defaults**.	**2:Defaults**	
3. Select **Reset** to reset the calculator.	**2:Reset**	
4. Clear the screen and return to the Home screen.	CLEAR	

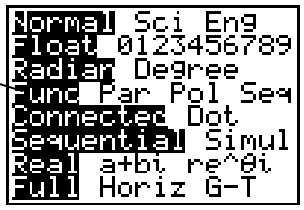
You are now ready to work through the TIps. Remember, resetting the calculator ensures that you get the same results shown in all TIps examples.

After you become familiar with your calculator, it will not be necessary to reset it every time because you will know how you have changed the settings, and you will understand the results the calculator displays in light of those changes.

TIp™ 2: Adjusting Your Calculator Settings

You can control how the calculator displays results and graphs by changing settings. For example, the mode settings screen is displayed below. The highlighted settings are the ones that are selected.

All highlighted settings are selected.



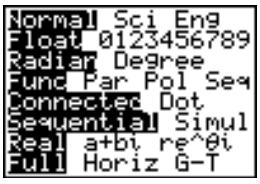
Calculator Keys Used in This TIp

- MODE
- 2nd [FORMAT]

TIp Highlights

This TIp shows how to change settings on two frequently-used screens—the mode screen and the window format screen. For more information about settings, see the calculator guidebook.

- Mode (MODE) settings determine how the calculator interprets and/or displays numbers and results.
- Window format (2nd [FORMAT]) settings determine how the calculator interprets and/or displays graphs.



Mode screen

Window Format Screen

In the Try-It!™ example, you will select new calculator settings following these main steps.

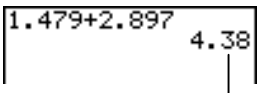
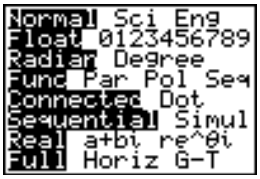
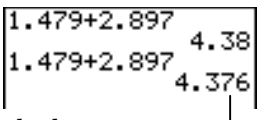
1. Display the setting screen.
2. Press ▼, ▲, ◀, or ▶, as necessary, to highlight the setting you want to select.
3. Press ENTER to select it.

Note: The examples in the next section assume that the calculator has been reset to the default settings as described in TIp 1: *Resetting Your Calculator.*

Try-It!™ on Your TI-83 Plus

Change a Mode Setting

Change the mode setting so that results display to 2 decimal places.

To Do This	Press	Display
1. Display the mode settings screen.	MODE	
2. Change the decimal notation setting from **Float** to **2**.	▼ until **Float** is highlighted ▶ until **2** is highlighted ENTER to select	
3. Press 2nd [QUIT] to return to the Home screen, and clear the current line, if needed. **Tip:** Pressing 2nd [QUIT] always takes you back to the Home screen, except in the Fundamental Topics in Science application.	2nd [QUIT] CLEAR	
4. Calculate 1.479 + 2.897.	**1 . 4 7 9 +** **2 . 8 9 7** ENTER	 The calculator rounds the result to 2 decimal places.
5. Change the decimal notation setting back to **Float**. **Note: Float** displays a number up to 10 digits.	MODE ▼ until **Float** is highlighted ENTER to select	
6. Return to the Home screen.	2nd [QUIT]	
7. Calculate 1.479 + 2.897 again.	2nd [ENTRY] to display the previous entry ENTER	 The calculator displays up to 10 digits.

Try-It!™ on Your TI-83 Plus (continued)

Change a Window Format Setting

To display a grid on the graph screen, select **GridOn** from the window format screen.

To Do This	Press	Display
1. Display the window format screen.	2nd [FORMAT]	
2. Change the grid setting from **GridOff** to **GridOn**.	▼ until **GridOff** is highlighted ▶ until **GridOn** is highlighted ENTER to select	
3. Show the graph screen. Notice both the grid and axes are on.	GRAPH	

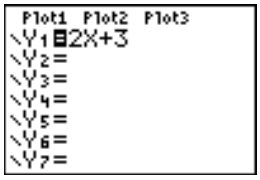
On Your Own

- Change your mode setting (MODE) to scientific notation (**Sci**). Do some calculations on the Home screen. Try **25∗63**. Notice how the calculator displays scientific notation. Is this the way you write scientific notation? Explain how this setting affects your results.

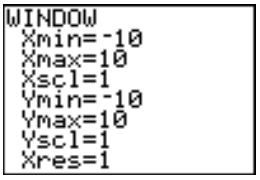
- Turn the grid off on the graph screen. Check this by pressing GRAPH.

TIp™ 3: Graphing a Function in the Standard Window

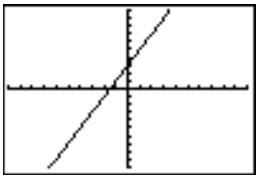
You can graph a function on the graph screen. First, enter the function in the Y= editor, and then you can graph the function in the standard graphing window.



Y1=2x+3 in the Y= editor



Standard Graphing Window



Graph of **Y1=2x+3**

Calculator Keys Used in This TIp

- Y=
- GRAPH
- TRACE

TIp Highlights

In the Try-It!™ example, you will graph a function following these main steps.

1. Enter the function in the Y= editor (Y=).
2. Graph the function on the graph screen (GRAPH).

   Note: If you reset your calculator defaults (TIp 1: *Resetting Your Calculator*), the graphing window sets up the following boundaries for the **X** and **Y** values: $-10 \le \mathbf{X} \le 10$ and $-10 \le \mathbf{Y} \le 10$.

3. Press TRACE. Then press ▶ or ◀ to move the cursor from one plotted point to another. Tracing the graph displays the (**X,Y**) values at the bottom of the screen.

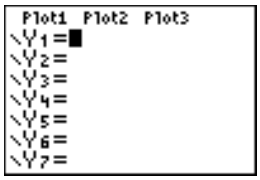
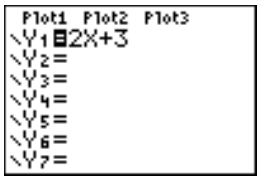
For some functions, the graphing window has to be adjusted so that you can see your graph. This TIp uses the standard window settings ($-10 \le \mathbf{X} \le 10$ and $-10 \le \mathbf{Y} \le 10$). The function selected for the example on the next page displays the graph in this window. For more information on adjusting window settings on the **WINDOW** menu, see TIp 5: *Adjusting the Viewing Window*.

Note: The examples in the next section assume that the calculator has been reset to the default settings as described in TIp 1: *Resetting Your Calculator.*

Try-It!™ on Your TI-83 Plus

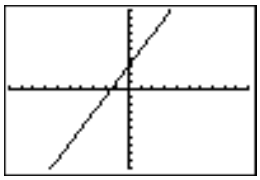
Enter the Function

Enter y = 2x + 3 as **Y1=2X+3** in the Y= editor.

To Do This	Press	Display
1. Enter the Y= editor.	Y=	
2. Clear **Y1** and enter the function, **2X+3**. **Note:** The equal sign next to the function is highlighted. This means that the function is selected or turned on and will be graphed. If other functions are selected, press ▼ and ◄ as necessary to position the cursor over the = sign and press enter to turn off the function.	CLEAR **2** X,T,Θ,n **+** **3**	

Display the Graph

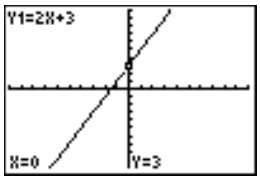
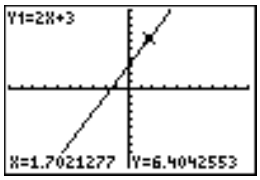
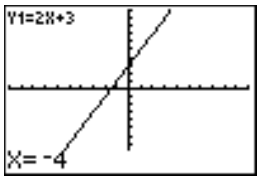
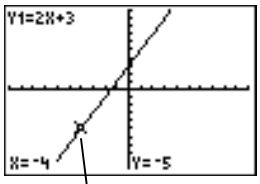
Display the graph of **Y1=2X+3** on the graph screen.

To Do This	Press	Display
1. Display the graph.	GRAPH	

Try-It!™ on Your TI-83 Plus (continued)

Trace the Graph

Trace the (**X**,**Y**) values for **Y1=2X+3** on the graph screen.

To Do This	Press	Display
1. Enter trace mode.	TRACE	
2. Trace the (**X**,**Y**) values along the graph. **X** and **Y** values display at the bottom of the screen.	▶ and ◀	
3. Quickly find **Y** when **X=-4**.	(-) **4**	
4. Notice that when **X=-4** then **Y=-5**.	ENTER	 Cursor moves to (-4, -5).

On Your Own

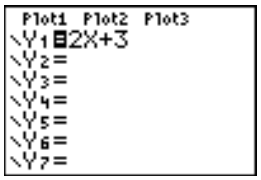
- Display a grid on the graph screen by selecting **GridOn** in the window format screen (2nd [FORMAT]).
- Define **Y2= -X+6**.
- Graph **Y1=2X+3** and **Y2= -X+6** at the same time and compare. Now trace along each function to find the point of intersection. Record the point of intersection.

  Hint: Use ▼ and ▲ to move between functions.
- Graph **Y2** only.

  Hint: You must deselect **Y1** so that the calculator does not graph it. To deselect **Y1**, highlight its equal sign (**=**) in the Y= editor with the cursor, and then press ENTER. Notice the equal sign is no longer highlighted.

TIp™ 4: Creating a Table

You can automatically create a table of values (**X**,**Y**) based on functions in the Y= editor. For example, if **Y=2X+3** is defined in the Y= editor, a corresponding table of (**X**,**Y**) values could look like this:



Y1=2x+3 in the Y= editor

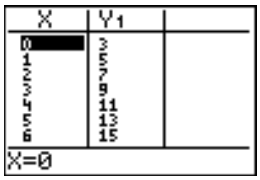


Table for **Y1=2x+3**

Calculator Keys Used in This TIp

- 2nd [TABLE]
- 2nd [TBLSET]

TIp Highlights

In the Try-It!™ example, you will display the table values (**X**,**Y**) for a function defined in the Y= editor following these main steps.

1. Define a function (**Y1=2X+3**) in the Y= editor (Y=).
2. Set up your table in the **TABLE SETUP** screen (2nd [TBLSET]).
3. Display the table (2nd [TABLE]).

The following settings in the table setup (2nd [TBLSET]) screen determine how the table is displayed.

- **TblStart** — First **X** value.
- **ΔTbl** — Amount by which **X** values increase and decrease (for example, if **ΔTbl=5**, then **X** values increase or decrease by 5).
- **Auto** or **Ask** — Allows you to choose whether or not to display automatically the independent (X) or dependent (Y) variable values.

For more information about table settings, see the calculator guidebook.

Note: The examples in the next section assume that the calculator has been reset to the default settings as described in TIp 1: *Resetting Your Calculator.*

Try-It!™ on Your TI-83 Plus

Enter the Function

Enter **Y1=2X+3** in the Y= editor ([Y=]). See TIp 3: *Graphing a Function in the Standard Window* for step-by-step instructions for defining functions. Your Y= editor should look like this.

Change the Table Settings

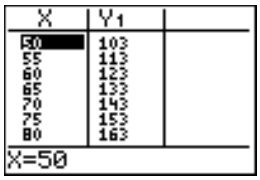
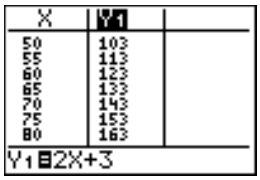
Define the following settings for your table: **TblStart=50** and **ΔTbl=5**.

To Do This	Press	Display
1. Display the table setup screen.	[2nd] [TBLSET]	
2. Change the following settings: **TblStart=50**, **ΔTbl=5**. **Note: Indpnt:Auto** and **Depend:Auto** are the defaults.	[CLEAR] **50** [▼] [CLEAR] **5**	

Try-It!™ on Your TI-83 Plus (continued)

Display the Table

Display the table for **Y1=2X+3** on the graph screen.

To Do This	Press	Display
1. Display the table.	2nd [TABLE]	
2. Scroll through the table values with the arrow keys. **Note:** Notice that when you press ▲ and move to the top of the **Y1** column, the cursor moves to **Y1** instead of displaying **Y**-values that are off the screen. The function is displayed on the edit line and can be changed.	◄, ►, ▼, or ▲ as necessary	

On Your Own

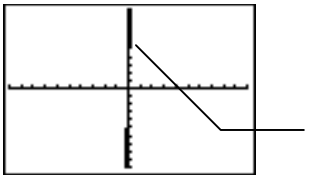
- Try to display more (**X,Y**) values. Set **ΔTbl=1** (pronounced "delta table") and display the table again. Then set **ΔTbl=.1** and display the table. Notice how the table values differ.
- Enter **Y2=⁻X+6** in the Y= editor. Display the table of values for both **Y1** and **Y2**. Is **Y1** ever equal to **Y2**?

  Hint: Set **TblStart=0** and **ΔTbl =1** and search through the table.
- Change the mode (MODE) setting from **Normal** to **Sci**. Display the table. Notice how this affects the table values.
- Go to the table setup screen and figure out what the **Depend: Ask** setting does.

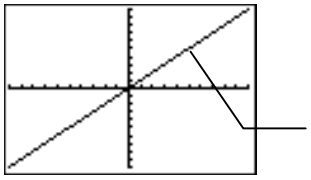
  Hint: To reveal an invisible **Y** value in the table, place the cursor on that space and press ENTER.

TIp™ 5: Adjusting the Viewing Window

You can adjust the viewing window for a specific graph. For example, with the **ZStandard** viewing window default values of $-10 \le X \le 10$ and $-10 \le Y \le 10$, the graph of **Y1=50X** appears as shown in the screen below on the left. **Y** increases so rapidly in relation to **X** that this line is not easily seen in this window. You can adjust the window (WINDOW) values by scaling the **X** axis and **Y** axis to see the graph in a better perspective.



Y1=50X viewed with the default window values.



Y1=50X viewed with adjusted window values.

Calculator Keys Used in This TIp

- WINDOW
- ZOOM

TIp Highlights

Window values put specific boundaries on the graph screen. **ZOOM** (ZOOM) functions automatically adjust window values for you; however, you can manually set window values using the window (WINDOW) menu. You can set minimum and maximum **X** and **Y** values (**Xmin**, **Xmax, Ymin**, and **Ymax**), and you can set the scale (distance between tick marks) of the **X** axis and **Y** axis (**Xscl** and **Yscl**).

In the Try-It!™ example, you will adjust the viewing window values in two ways.

- Automatically adjust them by selecting a zoom function from the **ZOOM** (ZOOM) menu.
- Manually adjust them using the window (WINDOW) menu.

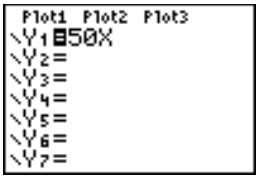
In the example that follows, you see how to change window (WINDOW) values to see a different perspective of the graph of **Y1=50X**.

Note: The examples in the next section assume that the calculator has been reset to the default settings as described in TIp 1: *Resetting Your Calculator*.

Try-It!™ on Your TI-83 Plus

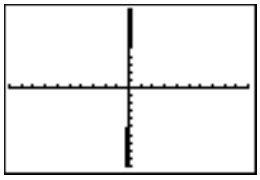
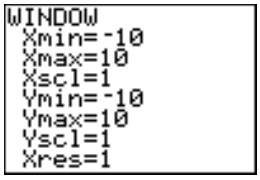
Enter the Function

Enter **Y1=50X** in the Y= editor ([Y=]). See TIp 3: *Graphing a Function in the Standard Window* for step-by-step instructions for defining functions. Your Y= editor should look like this.



Display the Function on the Graph Screen

Note: The window values shown here are the default window values, also equivalent to **ZStandard** ([ZOOM]) (-10 ≤ **X** ≤ 10; -10 ≤ **Y** ≤ 10).

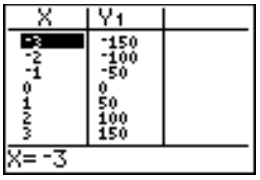
To Do This	Press	Display
1. Graph **Y1**.	[GRAPH]	
2. Display the window settings menu. **Note:** This window shows (**X**,**Y**) values so that -10 ≤ **X** ≤ 10 and -10 ≤ **Y** ≤ 10. This is equivalent to the default **ZStandard** setting.	[WINDOW]	

Define a Different Viewing Window for Your Graph

View the table of (**X**,**Y**) values created by **Y1**=**50X** to help you redefine window values. Start the table at -3 and increment the values by 1. See TIp 4: *Creating a Table* for step-by-step instructions for creating a table.

Tip: You can choose any **X** values for the table. For this exercise, you view a table of values when -3 ≤ **X** ≤ 3. When you set the table to start at -3 with increments of 1, you can see the relationship between **X** and **Y** near the origin of the graph.

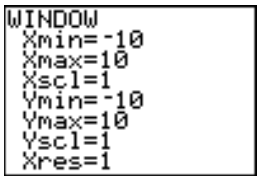
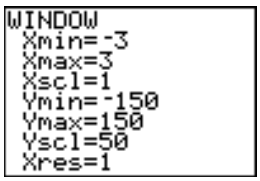
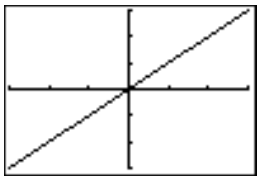
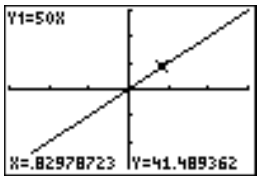
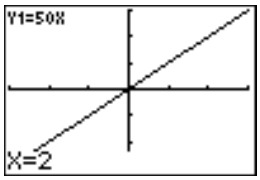
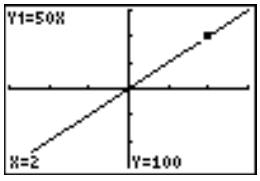
Your table should look like this:



Try-It!™ on Your TI-83 Plus (continued)

Define a Different Viewing Window for Your Graph (continued)

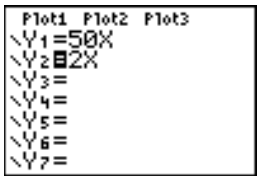
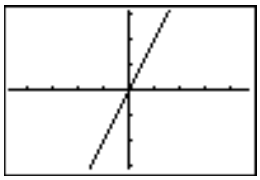
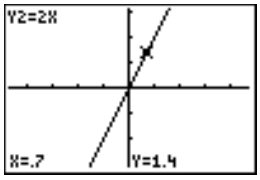
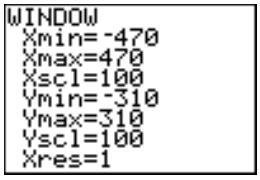
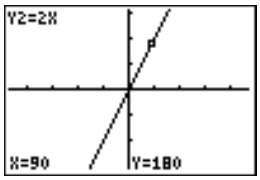
Notice in the table that when $-3 \le X \le 3$, the **Y** values range from $-150 \le Y \le 150$. Since **Y** increases by 50 each time **X** increases by 1, you can set the **Yscl** to 50 and leave **Xscl** set at 1. Now, create a window to see the graph for this domain and range by changing the window values.

To Do This	Press	Display
1. Display the window settings screen.	WINDOW	
2. Define the values so that **Xmin = -3, Xmax = 3, Xscl = 1,Ymin = -150**, **Ymax = 150**, and **Yscl = 50**. **Note:** This changes the settings so that: $-3 \le X \le 3$ and $-150 \le Y \le 150$. Since **Xscl=1** and **Yscl=50**, there is one unit between each tick mark on the **X** axis and 50 units between each tick mark on the **Y** axis.	(−) **3** ▼ (to **Xmax**) **3** ▼ (to **Ymin**) (−) **150** ▼ (to **Ymax**) **150** ▼ (to **Yscl**) **50**	
3. Graph **Y1=50X** in this different window. **Note:** Remember that each tick mark on the **X** axis represents 1 unit, while each one on the **Y** axis represents 50. It's always important to know the scale of your graphs so that you understand the graph you are viewing.	GRAPH	
4. Trace the graph. **Note:** Each tick mark on the **X** axis is 1 and on the **Y** axis is 50.	TRACE ◄ or ► as necessary	
5. Display the **Y** value when **X=2**. **Tip:** You can go directly to any coordinate pair on the graph by entering the value you want.	**2** ENTER	 

Try-It!™ on Your TI-83 Plus (continued)

Using ZDecimal—the Friendly Window

- Display and trace the graph **Y_2=2x**, using **ZDecimal** window values. **ZDecimal** lets you trace the **X** values by tenths (.1, .2, .3, …).
- Multiply **Xmin**, **Xmax**, **Xscl**, **Ymin**, **Ymax,** and **Yscl** by 100 in the window menu, and trace the function. This lets you trace the **X** values by tens.

To Do This	Press	Display
1. Turn off the graph and table of **Y_1=50X** and enter **Y_2=2x** in the Y= editor.	Y= ◄ ENTER ▼ ► CLEAR **2** X,T,Θ,*n*	
2. Graph **Y_2=2x** using **ZDecimal** window values.	ZOOM ▼ until **ZDecimal** is highlighted ENTER	
3. Trace the graph. **Note:** Notice that the window is set up so that the **X** values are tracing by tenths.	TRACE ◄ or ► as necessary	
4. Multiply **Xmin, Xmax**, **Xscl**, **Ymin**, **Ymax**, and **Yscl** by 100. **Tip:** Press 2nd ► to move the cursor to the end of a window setting line. **Note:** See the calculator guidebook for details about **Xres**. It is not discussed in this TIp.	WINDOW Repeat for each value: 2nd ► × **100** ENTER	
5. Trace the graph. **Note:** Notice that the window is set up so that the **X** values are tracing by tens.	TRACE ◄ or ► as necessary	

On Your Own

Graph **Y_1=.1X**. How can you set an appropriate viewing window for this graph?

Hint: Make a table of values for **Y_1=.1X** and use the table information to change the window values. Try finding the best values to choose when $-5 \le X \le 5$. If **X=5**, **Y=.1(5)=.5**. Therefore, the **Y** values need to be very small. Try changing **Ymin**, **Ymax**, and **Yscl**.

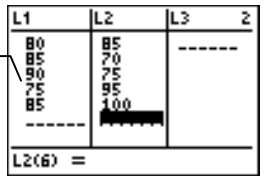
TIp™ 6: Using Lists

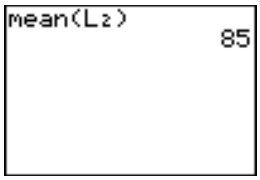
You can enter lists of different kinds of data into the list editor. For example, let's look at two students' test scores.

- Jamal's test scores are 80, 85, 90, 75, and 85.
- Jian's test scores are 85, 70, 75, 95, and 100.

You can create two separate lists in the list editor containing these scores. Then, on the Home screen, you can find the sum of the elements of both lists, and then divide by the number of elements (5) to calculate each student's test average or mean.

L1 lists Jamal's scores.





You can find the mean or median on the Home screen.

Calculator Keys Used in This TIp

- 2nd [CATALOG] (to access the **ClearAllLists** and **SetUpEditor** commands)
- 2nd [LIST], STAT

TIp Highlights

The TI-83 has two menus—**OPS** and **MATH**—that contain various list commands that help you find mean, median, and much more. For more information on all menu items, see the calculator guidebook.

2nd [LIST] ▶ ▶

In the TIp Try-It! example, you will use the **ClearAllLists** and **SetUpEditor** commands, which are located in the **CATALOG** (2nd [CATALOG]). These commands clear and set up the list editor as described below.

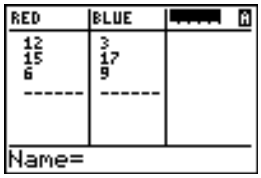
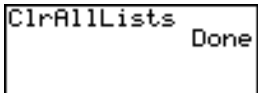
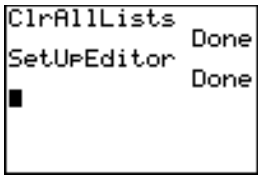
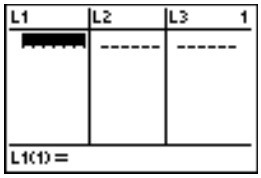
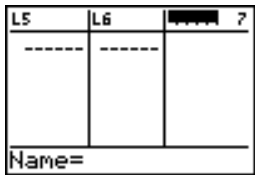
- **ClearAllLists** erases all elements of all existing lists on your calculator. The list names are still in memory, but the lists are empty. You cannot get the list elements back.
- **SetUpEditor** removes all list names from the list editor except the default list names, **L1** through **L6**. It also creates one blank list after **L6**.

Note: The examples in the next section assume that the calculator has been reset to the default settings as described in TIp 1: *Resetting Your Calculator*.

Try-It!™ on Your TI-83 Plus

Set Up the List Editor

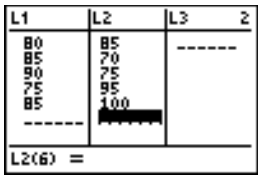
Use the commands **ClearAllLists** and **SetUpEditor** to reset the list editor.

To Do This	Press	Display
1. Display the list editor. **Note:** Your list editor may vary. The following commands will clear and set up lists **L1** through **L6** in your list editor.	STAT **1:Edit**	
2. Return to the Home screen and clear it. Then clear all lists in the list editor by selecting **ClearAllLists**. **Note:** This command clears all elements from the lists. The list names are still in memory, but the lists are empty. **Hint**: In the **CATALOG**, you can go to the first item starting with a particular letter: Press **C** (PRGM). Notice that you are already in **ALPHA** mode since the A displays in the upper right corner.	2nd [QUIT] CLEAR 2nd [CATALOG] ▼ until **ClrAllLists** is selected ENTER ENTER	 
3. Setup the list editor with **SetUpEditor**. **Hint:** You also can select **SetUpEditor** by pressing STAT **5**.	2nd [CATALOG] ▼ until you highlight **SetUpEditor** ENTER ENTER	 
4. Display the list editor. **Note:** Lists **L1** through **L6** appear and are clear, and there is a blank list following **L6**.	STAT **1:Edit**	 

Try-It!™ on Your TI-83 Plus (continued)

Enter the Lists

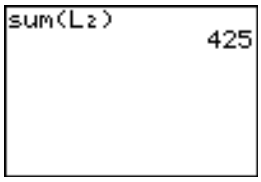
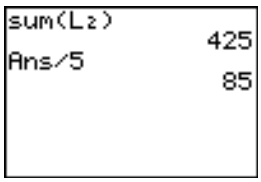
In the list editor, enter Jamal's scores as **L1={80,85,90,75,85}** and Jian's scores as **L2={85,70,75,95,100}**.

To Do This	Press	Display
1. Enter data into **L1**.	**80** ▼ **85** ▼ **90** ▼ **75** ▼ **85** ▼	
2. Enter data into **L2**.	▶ (to place the cursor under **L2**) **85** ▼ **70** ▼ **75** ▼ **95** ▼ **100** ▼	

Try-It!™ on Your TI-83 Plus (continued)

Display the Sum and Average of All Elements in a List

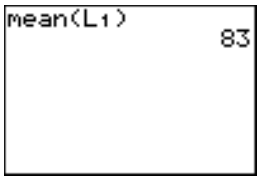
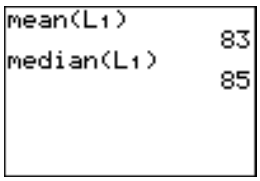
On the Home screen, find the sum of Jian's test scores (**L2**).

To Do This	Press	Display
1. Return to the Home screen and clear the current line, if needed. **Tip:** Once you exit the application, you can press 2nd [QUIT] to return to the Home screen from any menu or command.	2nd [QUIT] CLEAR	
2. Select **sum(** from the **MATH** menu.	2nd [LIST] ▶ ▶ **5:sum(**	
3. Select the list (**L2**) you want, and display the sum.	2nd [LIST] **2:L2**) ENTER	
4. Divide **L2** by 5 (the number of test scores) to find the average (or mean) of the list of the scores. **Note**: **Ans** is the previous *answer*, 425.	÷ **5** ENTER **Ans** = 425	

Try-It!™ on Your TI-83 Plus (continued)

Find the Mean and Median of a Set of Data

On the Home screen, find the mean and median of Jamal's test scores (**L1**).

To Do This	Press	Display
1. Return to the Home screen and clear the current line, if needed.	2nd [QUIT] CLEAR	
2. Select **mean(** from the **MATH** menu.	2nd [LIST] ▶ ▶ **3:mean(**	
3. Select the list (**L1**) that you want, and then calculate the mean.	2nd [LIST] **1:L1**) ENTER	
4. Select **median(** from the **MATH** menu.	2nd [LIST] ▶ ▶ **4:median(**	
5. Select the list (**L1**) that you want, and then display the median.	2nd [LIST] **1:L1**) ENTER	

Try-It!™ on Your TI-83 Plus (continued)

On Your Own

- Calculate the 1-variable statistics analysis for **L1** using the **1-Var Stats** command on the Home screen. Use the arrow keys (▼ and ▲) to view all of the information about **L1**.

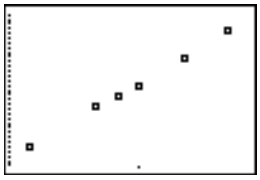
  Select the **1-Var Stats** command from the STAT **CALC** menu.

  Hint: Select the **1-Var Stats** command first, and then select **L1**. For more information about **1-Var Stats**, see the calculator guidebook.

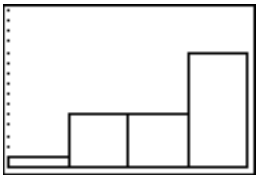
- If you are already familiar with statistical plots, find the quartile statistics in the list of data that was generated above, and draw a box plot of the data. For help, see TIp 7: *Creating a Statistical Plot*.

TIp™ 7: Creating a Statistical Plot

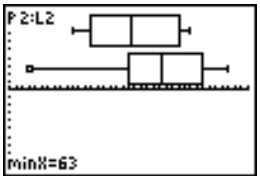
Statistical plots are graphs of data values that have been stored in lists. You can create several types of statistical plots, such as scatter plots, histograms, and box plots.



Scatter Plot



Histogram



Box Plot

Calculator Keys Used in This TIp

- 2nd [STAT PLOT]
- ZOOM **ZoomStat**

TIp Highlights

In the Try-It!™ example, you will graph a statistical plot following these main steps.

1. Enter all necessary lists in the list editor.
2. Define your statistical plot in the stat plot editor.
3. Display the statistical plot by pressing ZOOM (**ZoomStat**).

Pressing TRACE allows you to move the cursor from one plotted point to another using ▶ and ◀. It also displays the values (**X**,**Y**) at the bottom of the screen. For more information about statistical plot options, see the calculator guidebook.

Note: The examples in the next section assume that the calculator has been reset to the default settings as described in TIp 1: *Resetting Your Calculator.*

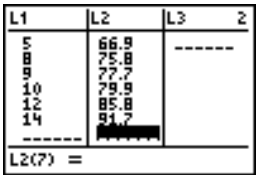
Try-It!™ on Your TI-83 Plus

You have collected the measurements (in inches) of how far a boy from age 5 to age 14 could throw a ball above his head. The following data was recorded. Create a scatter plot (⁘) based on these lists, where **L1** = Age in years and **L2** = Distance in inches.

Age in years (L1)	Distance in inches (L2)
5	66.9
8	75.8
9	77.7
10	79.9
12	85.8
14	91.7

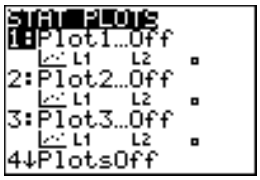
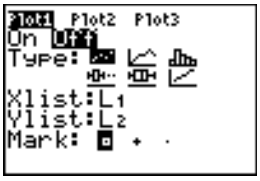
Enter the Lists in the List Editor

See TIp 6: *Using Lists* for step-by-step instructions for entering lists of data (remember to use **ClearAllLists** and **SetUpEditor**). Your list editor should look like this:



Define the Statistical Plot

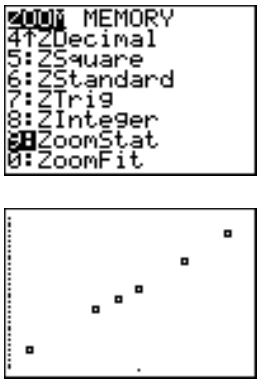
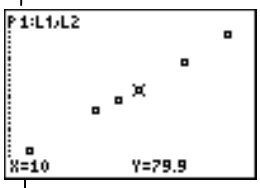
Define **Plot1** as a scatter (⁘) plot where **Xlist=L1** and **Ylist=L2**.

To Do This	Press	Display
1. Display the **STAT PLOTS** screen.	2nd [STAT PLOT]	
2. Display the **Plot1** settings screen.	**1:Plot1**	
3. Select **On** to turn on **Plot1**. **Note: Scatter** (⁘), is already selected because you reset the calculator for this TIp. **Xlist** and **Ylist** do not have to be changed because, by default, they already match our selected lists.	ENTER	

Try-It!™ on Your TI-83 Plus (continued)

Display the Statistical Plot on the Graph Screen

Display the statistical plot on the graph screen using the **ZoomStat** command and trace it.

To Do This	Press	Display
1. Select **ZoomStat** from the **ZOOM** menu.	ZOOM **9:ZoomStat**	
2. Trace along the statistical plot. **Note: P1:L1,L2** in the upper left corner shows that the lists **L1** and **L2** contain the data for the graph. The data points are displayed at the bottom of the screen.	TRACE ▶ or ◀ as necessary	**L1** and **L2** contain the data for this graph.  (**X,Y**) coordinates of the data point at the cursor location.

Try-It!™ on Your TI-83 Plus (continued)

On Your Own

1. Enter the following math test scores in **L1** and **L2**.

Scores (L1)	Frequency (L2)
99	4
96	4
92	3
88	2
84	3
78	2
74	2
70	1
66	1
64	1

2. Set up the histogram (▁▃▅▁) where **Xlist=L1** and **Freq=L2** in the **STAT PLOTS** menu.
3. Graph the histogram using **ZoomStat**, and then trace (TRACE) the histogram. Letter grades correspond to these test scores: A = 100–90; B = 89–80; C = 79–70; D = 69–60; F = 59–0. Did the graph display the way you expected? Why is it necessary to change the window values manually?
4. Change the window values manually to group the data in intervals of 10. Remember that you want the data grouped in intervals of 10 so you can see how many test scores fall into the grade categories given above. You can tell the calculator to do this by setting **Xscl=10** on the graphing window (WINDOW). **Xmin** should be a little less than the lowest score and **Xmax** should be a little higher than the highest score to display a nice graph. Try setting the window as **Xmin=50**, **Xmax=100**, **Ymin=** ⁻**4**, **Ymax=15**, and **Yscl=10**.
5. Graph and trace the histogram again to see why these settings show the grades grouped by scores that match the letter grades A, B, C, D, and F.

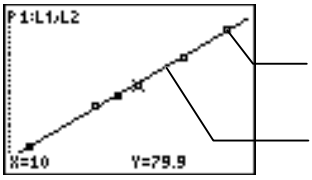
Hint: Remember that if you have functions defined and turned on in the Y= editor, the calculator graphs these at the same time as the stat plot. To turn off a function, highlight the = sign next to it, and then press ENTER.

You can also select **FnOff** to turn off all functions. To do this, press VARS ▸ **4:On/Off 2:FnOff**.

TIp™ 8: Finding the Best Line of Fit for a Set of Data

The TI-83 Plus has regression commands that automatically find the closest equation to your statistical plot data. The **LinReg(ax+b)** command finds the closest linear equation **y=ax+b** and displays the values for **a** (slope) and **b** (y-intercept) on the Home screen.

You can save this equation in the Y= editor so that you can graph the regression equation and the statistical plot data at the same time, and then compare the two.



Statistical plot data points

Linear Regression line based on statistical plot data

Calculator Keys Used in This TIp

STAT ▶ (**CALC** menu) **LinReg(ax+b)**

TIp Highlights

This TIp shows you how to use **LinReg(ax+b)** on the Home screen to find the linear regression of two list names, **XList** (L1) and **YList** (L2). You will use the same list values that you used to define the statistical plot.

Note: For more information about statistical plots, see TIp 7: *Creating a Statistical Plot.*

In the Try-It!™ example, you will find a linear regression following these main steps.

1. Select **LinReg(ax+b)** from the STAT **CALC** menu.
2. Enter the two list names that define the statistical plot.
3. Save the equation in the Y= editor.
4. Graph the statistical plot and the linear regression.

Note: The examples in the next section assume that the calculator has been reset to the default settings as described in TIp 1: *Resetting Your Calculator.*

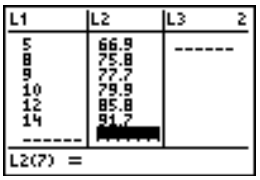
Try-It!™ on Your TI-83 Plus

You have collected the measurements (in inches) of how far a boy could throw a ball above his head from age 5 to age 14. The following data was recorded. Create a scatter ( ) plot based on these lists, where **Xlist=L1** and **YList= L2**.

Age in years (L1)	Distance in inches (L2)
5	66.9
8	75.8
9	77.7
10	79.9
12	85.8
14	91.7

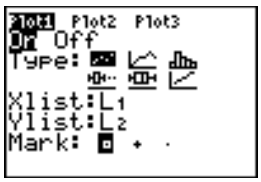
Enter the Lists for the Statistical Plot

See TIp 6: *Using Lists* for step-by-step instructions for entering lists of data. Your list editor should look like this:

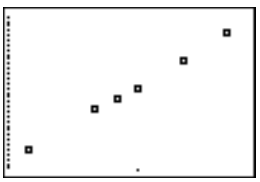


Create a Scatter Statistical Plot for L1 and L2

See TIp 7: *Creating a Statistical Plot* for step-by-step instructions for creating a scatter statistical plot. Your statistical plot editor and scatter plot (using **ZoomStat**) should look like this:



Stat Plot Editor

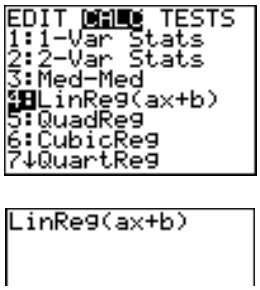
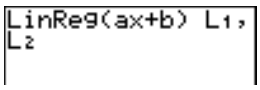
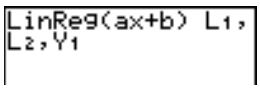
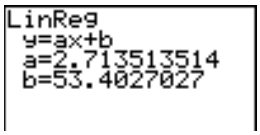
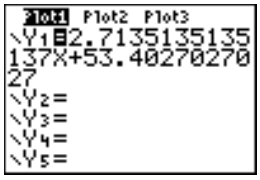


Graph of Plot

Try-It!™ on Your TI-83 Plus (continued)

Find the Linear Regression for the Scatter Plot

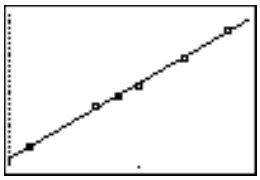
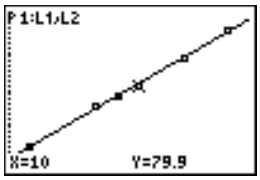
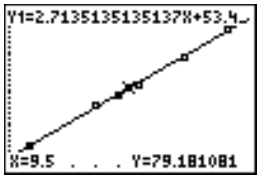
Find the regression (the line which best fits the data) for **L1** and **L2** using **LinReg(ax+b)**.

To Do This	Press	Display
1. Return to the Home screen, and clear it.	2nd [QUIT] CLEAR	
2. Select **LinReg(ax+b)** from the **STAT CALC** menu.	STAT ▶ **4:LinReg(ax+b)**	
3. Select the lists **L1** and **L2**.	2nd [LIST] **1:L1** , 2nd [LIST] **2:L2** ,	
4. Display **Y-VARS** menu. Then select the Y variable (**Y1**) from the **FUNCTION** menu. 5. Calculate the regression equation.	VARS ▶ **1:Function** **1:Y1** ENTER	 
6. Display the Y= editor. **Note**: Both **Y1** and **Plot1** are highlighted. This means that both graph and the plot are turned on.	Y=	

Try-It!™ on Your TI-83 Plus (continued)

Graph the Statistical Plot and the Linear Regression

Graph and trace the statistical plot and linear regression at the same time and compare them.

To Do This	Press	Display
1. Select the **ZoomStat** function to display the statistical plot and the regression on the graph screen at the same time.	ZOOM **9:ZoomStat**	 
2. Trace the function or the statistical plot. **Notes**: The function or plot being traced is displayed in the upper left corner of the screen. The **X** and **Y** coordinates display at the bottom of the screen.	TRACE ◄ or ► to trace a function ▲ and ▼ to move between functions	 Tracing along the stat plot  Tracing along the line

On Your Own

Use the function to predict approximately how far you think the boy can throw the ball above his head at 18 years old. Do you think the line will give a good idea of how high this person will be able to throw the ball when he is 35? Explain your thoughts.

Hint: Use the table to determine the value of Y_1 when **X=18**.

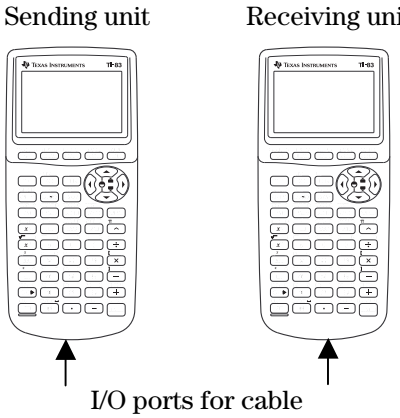
TIp™ 9: Sending and Receiving Data between Calculators

You can send and receive data between calculators using the **SEND** and **RECEIVE** menus.

To connect two calculators using the unit-to-unit cable, which comes packaged with your calculator, use the I/O (input/output) port located at the center of the bottom edge of the calculator.

- Insert either end of the unit-to-unit cable into the I/O calculator port.
- Insert the other end of the cable into the I/O port of the other calculator.

Tip: The cable must be ***firmly*** inserted into the I/O port. If you receive a "link error," make sure the cable is completely inserted.



Calculator Keys Used in This TIp

2nd [LINK]

TIp Highlights

You can send or receive many types of data such as lists, programs, pictures, and applications that can be shared.

To communicate between two calculators, you must set up one calculator to send the data and the other calculator to receive the data.

TIp Highlights (continued)

In the Try-It!™ example, you will link two calculators and send lists of data from one calculator to the other following these main steps.

Receiving Data

After you link the calculators using the unit-to-unit cable, set up one calculator to receive data by following these steps:

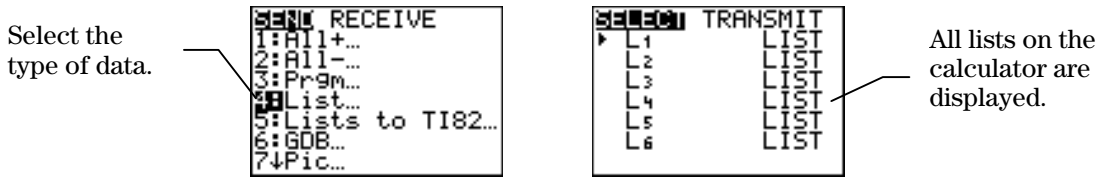
1. Press 2nd [LINK] to display the link menu.
2. Press ▶ to display the **RECEIVE** menu.
3. Select **1:Receive**. The message **Waiting…** and the busy indicator are displayed. The calculator is ready to receive transmitted items.

Sending Data

After you link the calculators using the unit-to-unit cable and have one calculator waiting to receive data, set up the other calculator to send data by following these steps:

1. Press 2nd [LINK] to display the link menu.
2. Select the type of data (for example, lists) that you want to send. The corresponding **SELECT** screen is displayed. Each **SELECT** screen is displayed initially with no items selected.

   Note: The **All+** menu item selects all items on your calculator that can be transmitted. The **All-** menu item deselects all items that you have selected to transmit.

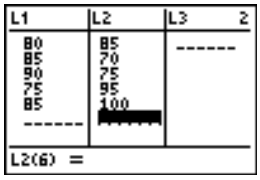
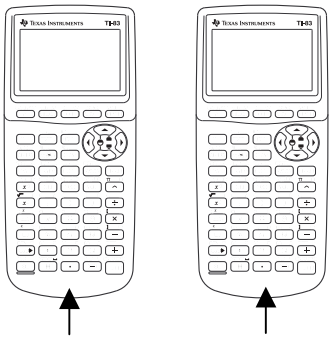
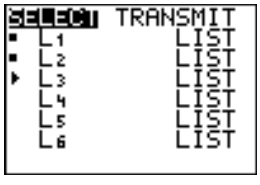


3. Press ▲ and ▼ to move the selection cursor (▶) to an item you want to select or deselect.
4. Press ENTER to select or deselect an item. Selected names are marked with a box (■). You can select more than one if you want.

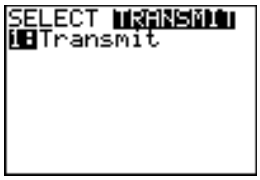
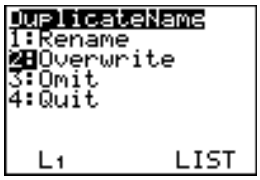
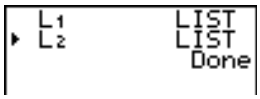
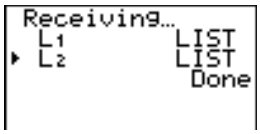
Try-It!™ on Your TI-83 Plus

Transfer **L1** and **L2** from one calculator to another one. Use **L1** and **L2** as defined in TIp 6: *Using Lists*.

- **L1={80,85,90,75,85}**
- **L2={85,70,75,95,100}**

To Do This	Press	Display
1. On the sending calculator, enter the lists above in the list editor.	STAT **1:Edit**	
2. Link the two calculators using the unit-to-unit cable.		Sending unit Receiving unit  Connect the calculators with the cable using the I/O ports.
3. On the receiving calculator, select **Receive**. Confirm that **Waiting…** is displayed on the screen. Your calculator is now ready to receive the lists.	2nd [LINK] ▶ **1:Receive**	
4. On the sending calculator, display the **SEND** menu, and then select **List**.	2nd [LINK] **4: List**	
5. Select **L1** and **L2**. **Note:** The selected lists are marked with a box (■).	ENTER ▼ ENTER	

Try-It!™ on Your TI-83 Plus (continued)

To Do This	Press	Display
6. Send the lists to the receiving calculator using the **TRANSMIT** menu.	▶ **1:Transmit**	
7. If the lists have been previously defined, the receiving calculator asks you if you want to: **1: Rename** **2: Overwrite** **3: Omit** **4: Quit** Select **Overwrite** for each list.	**2:Overwrite**	
The name and type of each data item are displayed line by line on the sending unit as the item is transmitted, and then on the receiving unit as each item is accepted. After both lists are transmitted, the message, **Done**, is displayed on both calculators.		 Sending calculator  Receiving calculator

On Your Own

- Enter a function in the Y= editor and send it to another calculator.

TIp™ 10: Managing Your Calculator's Memory

You can check available memory, manage memory, and get information about your calculator by selecting items from the 2nd [MEM] **MEMORY** menu. For example, you can find your calculator ID number, which is necessary for registering and installing some applications. A delete menu item lets you delete any type of data (variables, lists, programs, applications, etc.) so that you can set up your calculator with the information you need for your current classes. You can change the data for future classes.

Calculator Keys Used in This TIp

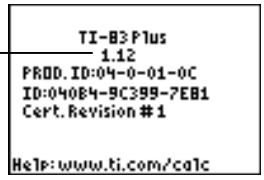
2nd [MEM]

TIp Highlights

The **About** screen displays:

- Your calculator operating system version number
- Your calculator ID number, which is used to register and install or reinstall an application

The operating system version number



As new operating system versions become available, you can download them from the Texas Instruments website. To obtain some applications from Texas Instruments, you must provide your calculator ID number, which is unique to your calculator.

The **Mem Mgmt/Del** menu item lets you delete variables, lists, programs, applications, etc., so that you can set up your calculator with the information you need for your current classes.

The **Reset** menu item lets you reset your calculator default settings. Resetting all RAM on your calculator:

- Restores memory to the factory settings.
- Deletes all programs.

Note: Resetting RAM does NOT erase applications.

To find out more about resetting defaults, see TIp 1: *Resetting Your Calculator*.

Try-It!™ on Your TI-83 Plus

Displaying the About Screen

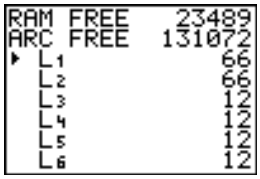
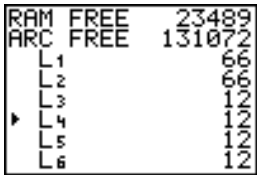
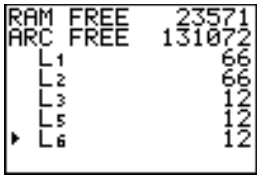
Display your calculator's **About** screen and find the operating system version number and the ID number.

To Do This	Press	Display
1. Select **About** from the **MEMORY** menu.	2nd [MEM] **1:About**	
2. Notice the operating system version number under the name of the calculator (**1.12**) and the **ID** number composed of 14 numbers and letters.		

Try-It!™ on Your TI-83 Plus (continued)

Deleting Items

Delete **L4** from your calculator's memory.

To Do This	Press	Display
1. Display the **MEMORY** menu and select **Mem Mgmt/Del**.	2nd [MEM] **2:Mem Mgmt/Del**	
2. Select the category, **List**. All existing lists on your calculator display on this screen and the number of bytes of RAM that they use (**L1=66** bytes, etc.).	**4:List**	 
3. Move the cursor so that it points to **L4**.	▼ to **L4**	
4. Delete **L4**. **Note:** Notice that no confirmation message displayed when you deleted this item. Confirmation messages only display when you delete an item from Flash ROM (an application) or when you delete an archived item. If an item has an asterisk (*) next to it, it is archived.	DEL	
5. **L4** no longer displays in the list editor. Use the arrow key (▶) to scroll through the lists. **Tip:** See TIp 6: *Using Lists* for information on how to use the **SetUpEditor** to put **L4** back into the list editor.	STAT **1:Edit** ▶