# PART A

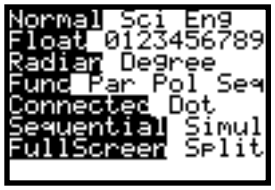
# TEXAS INSTRUMENTS TI-82/TI-83 GRAPHICS CALCULATORS

## Setup

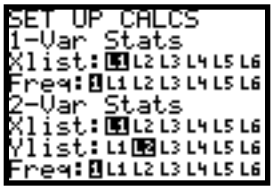
When using this *Guide*, you should always, unless instructed otherwise, use the calculator setup specified below:

**FOR THE TI-82** Before you begin, check the TI-82's basic setup by pressing [MODE]. Choose the settings shown in Figure 1. Check the statistical setup by pressing [STAT] [▶] (CALC) [3] (SetUp). Choose the settings shown in Figure 2. Check the window format by pressing [ENTER] [▶] (FORMAT), and choose the settings shown in Figure 3.

- If you do not have the darkened choices shown in each of the figures below, use the arrow keys to move the blinking cursor over the setting you want to choose and press [ENTER].
- Press [2nd] [MODE] (QUIT) to return to the home screen.




TI-82 Basic Setup
FIGURE 1



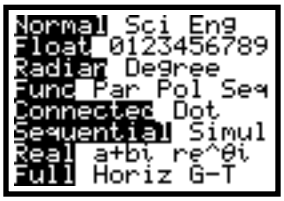

TI-82 Statistical Setup
FIGURE 2


TI-82 Window Setup
FIGURE 3

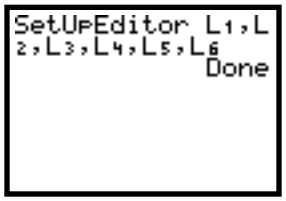
**FOR THE TI-83** Before you begin, check the TI-83's basic setup by pressing [MODE]. Choose the settings shown in Figure 4. Specify the statistical setup by pressing [2nd] [MODE] (QUIT) [STAT] [5] (SetUpEditor) followed by [2nd] [1] [,] [2nd] [2] [,] [2nd] [3] [,] [2nd] [4] [,] [,] [2nd] [6]. Choose the settings shown in Figure 2. Press [ENTER] to view the screen in Figure 5. Also,

check the window format by pressing 2nd ZOOM (FORMAT) , and choose the settings shown in Figure 6.

- If you do not have the darkened choices shown in each of the figures below, use the arrow keys to move the blinking cursor over the setting you want to choose and press ENTER .
- Press 2nd MODE (QUIT) to return to the home screen.




TI-83 Basic Setup
FIGURE 4




TI-83 Statistical Setup
FIGURE 5


TI-83 Window Setup
FIGURE 6

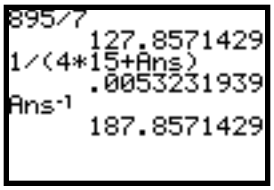
# Basic Operation

You should be familiar with the basic operation of your calculator. With calculator in hand, go through each of the following.

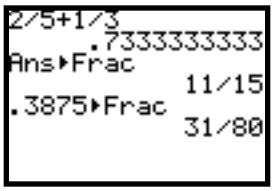
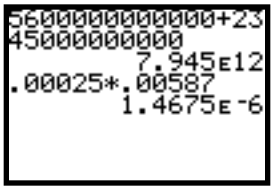
**1. CALCULATING** You can type in lengthy expressions; just make sure that you use parentheses when you are not sure of the calculator's order of operations. As a general rule, numerators and denominators of fractions and powers consisting of more than one term should be enclosed in parentheses.

| | |
|---|---|
| Evaluate $\dfrac{1}{4 * 15 + \frac{895}{7}}$.<br><br>Evaluate $\dfrac{(-3)^4 - 5}{8 + 1.456}$. (Use (–) for the negative symbol and – for the subtraction sign.) | 1/(4*15+895/7)<br>.0053231939<br>((-3)^4-5)/(8+1.<br>456)<br>8.037225042 |
| Evaluate $e^3*0.027$ and $e^{3*0.027}$.<br><br>The calculator will assume you mean the first expression unless you use parentheses around the two values in the exponent. (It is not necessary to type in the 0 before the decimal point.) | e^3*.027<br>.5423094969<br>e^(3*.027)<br>1.084370897 |

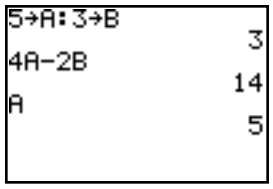
**2. USING THE *ANS* MEMORY** Instead of again typing an expression that was evaluated immediately prior, use the answer memory by pressing 2nd (–) (ANS) .

| | |
|---|---|
| Calculate $\left(\frac{1}{4*15 + \frac{895}{7}}\right)^{-1}$ using this nice shortcut.<br><br>If you wish to clear the home screen, press CLEAR . |  |

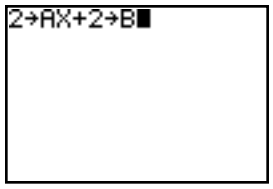
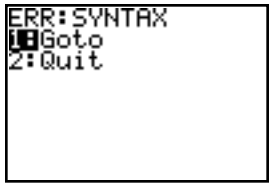
**3. ANSWER DISPLAY** When the denominator of a fraction has no more than three digits, your calculator can provide the answer in fraction form. When an answer is very large or very small, the calculator displays the result in scientific notation.

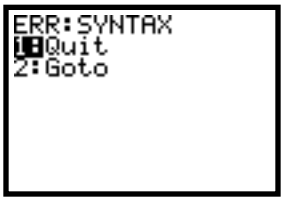
| | |
|---|---|
| The "to a fraction" key is obtained by pressing MATH 1 (‹Frac) . |  |
| The calculator's symbol for "times $10^{12}$" is È12. Thus, 7.945È12 means 7,945,000,000,000.<br><br>The result 1.4675È–6 means $1.4675*10^{-6}$, the scientific notation expression for 0.0000014675. |  |

**4. STORING VALUES** Sometimes it is beneficial to store numbers or expressions for later recall. To store a number, type the number on the display and press STO‹ ALPHA , type the letter in which you wish to store the value, and then press ENTER . To join several short commands together, use 2nd . (:).

| | |
|---|---|
| Store 5 in *A* and 3 in *B*, and then calculate 4 *A* – 2*B*.<br><br>To recall a value stored in a variable, use ALPHA to type the letter in which the expression or value is stored and then press ENTER . The value stays stored until you change it. |  |

**5. ERROR MESSAGES** When your input is incorrect, an error message is displayed.

| | |
|---|---|
| If you have more than one command on a line without the commands separated by a colon (:), an error message results when you press ENTER . |  |
| **TI-82** Choose 1 (Goto) to position the cursor to the place the error occurred so that you can correct the mistake or choose 2 (Quit) to begin a new line on the home screen. |  |

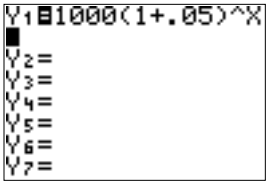
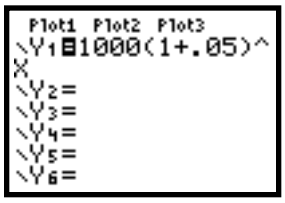
| | |
|---|---|
| **TI-83** Choose 2 (Goto) to position the cursor to the place the error occurred so that you can correct the mistake or choose 3 (Quit) to begin a new line on the home screen. |  |

# Chapter 1 Ingredients of Change: Functions and Linear Models

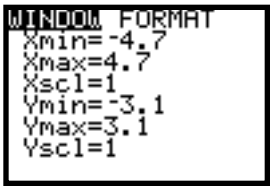
## 1.1 Fundamentals of Modeling

There are many uses for a function that is entered in the graphing list. Graphing the function in an appropriate viewing window is one of these. Because you must enter all functions on one line (that is, you cannot write fractions and exponents the same way you do on paper) it is very important to have a good understanding of the calculator's order of operations and to use parentheses whenever they are needed.

**1.1.1 ENTERING AN EQUATION IN THE GRAPHING LIST** Press [Y=] to access the graphing list. The graphing list contains space for 10 equations, and the output variables are called by the names Y1, Y2, ..., and Yo. When you intend to graph an equation you enter in the list, you must use X as the input variable.

| | |
|---|---|
| If there are any previously entered equations that you will no longer use, delete them from the graphing list. | Position the cursor on the line with the equation, and press [CLEAR] . |
| **TI 82** Suppose you want to graph $A = 1000(1 + 0.05)^t$.<br>For convenience, we use the first, or Y1 , location in the list. We intend to graph this equation, so enter the right hand side as 1000(1 + 0.05)^X.<br>(Type X by pressing [X,T,θ], not the times sign [X] .) |  |
| **TI 83** Suppose you want to graph $A = 1000(1 + 0.05)^t$.<br>For convenience, we use the first, or Y1 , location in the list. We intend to graph this equation, so enter the right hand side as 1000(1 + 0.05)^X.<br>(Type X by pressing [X,T,θ,n], not the times sign [X] .)<br>Plot1, Plot2, and Plot3 at the top of the Y= list should not be darkened. If any of them are, use [▲] until you are on the darkened plot name. Press [ENTER] to make the name(s) not dark. |  |

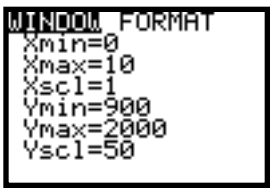
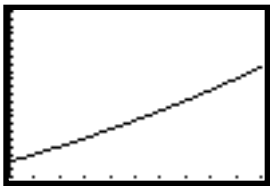
**1.1.2 DRAWING A GRAPH** If you have not already done so, enter the equation in the Y= list using X as the input variable before drawing a graph. We now draw the graph of $y = 1000(1 + 0.05)^x$.

| | |
|---|---|
| Press ZOOM 4 (ZDecimal) .<br><br>Notice that the graphics screen is blank. |  |
| Press WINDOW to see the view set by ZDecimal.<br><br>Xmin and Xmax are the settings of the left and right edges of the viewing screen, and Ymin and Ymax are the settings for the lower and upper edges of the viewing screen.<br><br>Xscl and Yscl set the spacing between the tick marks on the $x$- and $y$-axes.<br><br>The view you see is $-4.7 \le x \le 4.7$, $-3.1 \le y \le 3.1$. |  |

Follow the procedures shown in either 1.1.3 or 1.1.4 to draw a graph with your calculator. Whenever you draw a graph, you have the option of manually changing the view or having the calculator automatically find a view of the graph.

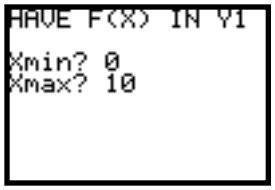
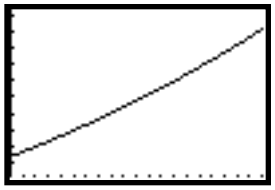
### 1.1.3 MANUALLY CHANGING THE VIEW OF A GRAPH

If you do not have a good view of the graph or if you do not see the graph, change the view with one of the ZOOM options or manually set the WINDOW. (We later discuss the ZOOM options.)

| | |
|---|---|
| **TI-82** Press WINDOW ▽, and set Xmin to 0, Xmax to 10, leave Xscl at 1, set Ymin to 900, Ymax to 2000, and Yscl to 50. |  |
| **TI-83** Press WINDOW and set Xmin to 0, Xmax to 10, leave Xscl at 1, set Ymin to 900, Ymax to 2000, and Yscl to 50.<br><br>For all applications in this *Guide*, have Xres set to 1. |  |
| **Both** Press GRAPH to draw the graph of Y1 = 1000(1 + 0.05)^X using the new view. |  |

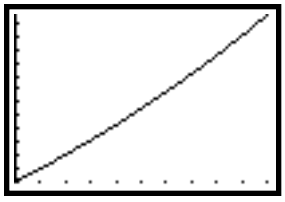
### 1.1.4 TI-82: AUTOMATICALLY CHANGING THE VIEW OF A GRAPH

If your view of the graph is not good or if you do not see the graph, change the view using the TI-82 program AUTOSCL. If you do not have this program, either enter it now using the code given in the TI-82 Appendix or have someone transfer it to you from another calculator.

| | |
|---|---|
| *Caution:* When using this TI-82 program, the function you are graphing must be entered in the Y1 location of the Y= graphing list. If other functions are entered in the graphing list, this program will *not* find an appropriate view for all the functions. | Y1= $1000(1 + 0.05)^x$<br>(Delete other functions that may be entered in the other locations in the Y= list.) |
| Press PRGM followed by the number corresponding to the location of program AUTOSCL. Press ENTER .<br>*Note:* Your program list may or may not look exactly like the one that is shown to the right. |  |
| You are asked to enter Xmin, the value at which the left side of the view is set. Type 0 and press ENTER .<br>Next, you are asked to enter Xmax, the value at which the right side of the view is set. Type 10 and press ENTER . |  |
| Program AUTOSCL now draws the graph.<br>*Note:* In some cases, the graph drawn by the program will not be the best view. If this happens, follow the instructions in part 8 to manually set Ymin and Ymax (and/or the scale values) to obtain a better view. |  |

### 1.1.4 TI-83: AUTOMATICALLY CHANGING THE VIEW OF THE GRAPH

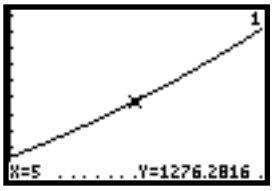
If your view of the graph is not good or if you do not see the graph, change the view using the built-in autoscaling feature of the TI-83. This option will automatically find a view to see all the functions that you have turned on in the graphing list.

| | |
|---|---|
| Be sure the function you are graphing, $y = 1000(1 + 0.05)^x$, is entered in the Y1 location of the Y= list. (Delete all other functions that may be entered in other locations.)<br>Press WINDOW , set Xmin to 0 and Xmax to 10. (It does not matter what values are set in the Ymin and Ymax positions.)<br>Press ZOOM (0: ZoomFit) ENTER . |  |
| The TI-83 automatically sets the vertical view and (based on the Xmin and Xmax you set) draws a graph of the function. |  |

**1.1.5 TRACING** You can display the coordinates of certain points on the graph by tracing. The $x$-values shown when you trace depend on the horizontal view that you choose, and the $y$-values are calculated by substituting the $x$-values into the equation that is being graphed.

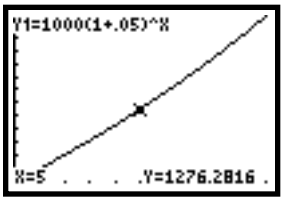
**TI-82** Press TRACE, use ▷ to move the trace cursor to the right, and use ◁ to move the trace cursor to the left.

The number 1 in the upper right hand corner of the screen tells you that you are tracing on the equation in Y1.

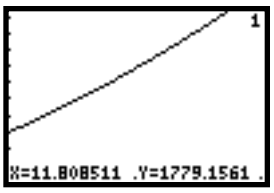



**TI-83** Press TRACE, use ▷ to move the trace cursor to the right, and use ◁ to move the trace cursor to the left.

The equation that you are tracing appears at the top of the graphing screen.




**Both** Trace past the edge of the screen and notice that even though you cannot see the trace cursor, the $x$- and $y$- values of points on the line are still displayed at the bottom of the screen. Also notice that the graph scrolls to the left or right as you move the cursor past the edge of the current viewing screen.

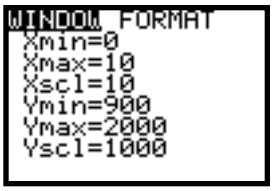



**1.1.6 ESTIMATING OUTPUTS** You can estimate outputs from the graph using TRACE. It is important to realize that such outputs are *never* exact values unless the displayed $x$-value is *identically* the same as the value of the input variable.

Estimate the value of $A$ where $A = 1000(1 + 0.05)^x$ when $x = 5$, $x = 7$, and $x = 10$.

Press WINDOW. If you do not have the settings shown to the right, reset to these values.

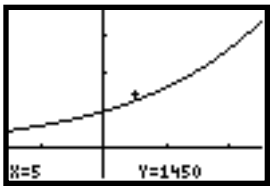
(*Note:* **TI-83** windows do not have FORMAT at the top of this screen.)




Press GRAPH. After the graph is drawn, press ZOOM 3 (Zoom Out) ENTER.

After the zoomed graph is drawn, again press ENTER to enlarge your view of the graph.

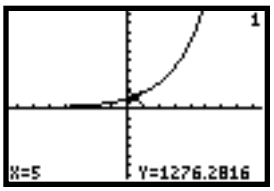
(Press WINDOW and observe the values now defining the graphics screen.) Press GRAPH.




Note that (5, 1450) is a point on the screen, *not* a point on the graph of the function.

Press TRACE and use ▷ to move as close as you can to $x = 5$. (Your screen may look slightly different than the one shown to the right.)

Continue pressing ▷ and notice that the values 7 and 10 cannot be obtained by tracing in this view. Therefore, choose values close to these numbers to obtain *estimates* such as $A$ is approximately \$1386.80 when $x = 7$ and $A$ is about \$1637.37 when $x = 10$.

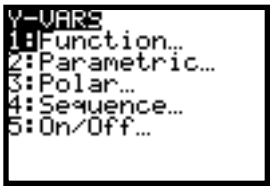
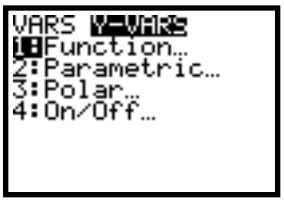
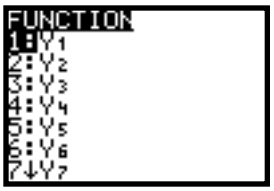
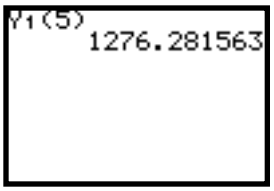
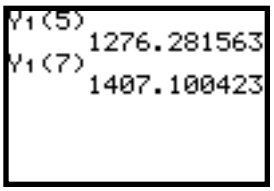


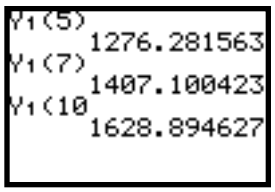

Because the number 5, *not* a value close to 5 is shown, $A = \$1276.28$ when $x = 5$.

- If you had used the original WINDOW with Xmax = 10 and traced, you should obtain the *exact* value $A = 1500$ when $x = 10$ because 10, not a value close to 10, is shown when tracing.

- If you want "nice, friendly" values displayed for $x$ when tracing, set Xmin and Xmax so that Xmax – Xmin is a multiple of 9.4, the width of the ZDecimal viewing screen. For instance, if you set Xmin = 0 and Xmax = 18.8 in the example above, the *exact* values when $x = 5$, $x = 7$, and $x = 10$ are displayed when you trace since 18.8 = 2(9.4). Try it!

**1.1.7 EVALUATING OUTPUTS** The values obtained by this evaluation process are *actual* output values of the equation, not estimated values such as those generally obtained by tracing. Begin by entering the equation whose output you want to evaluate in the Y= list.

| | |
|---|---|
| Using $x$ as the input variable, enter the function in the Y= list. Return to the home screen by pressing [2nd] [MODE] (QUIT) as many times as necessary. | Y1= $1000(1 + 0.05)^x$ (You could use any of the 10 function locations.) |
| **TI-82** Go to the Y-VARS menu by pressing [2nd] [VARS] (Y-VARS). |  |
| **TI 83** Go to the Y-VARS menu by pressing [VARS] [▷] (Y-VARS). |  |
| **Both** Choose 1: Function by pressing [1] or [ENTER], and choose 1: Y1 by pressing [1] or [ENTER]. (To choose another Y= location, simply press the number corresponding to that function.) |  |
| Y1 shows on your screen. Type the $x$-value at which you want to evaluate the equation, and press [ENTER]. Now, evaluate Y1 at $x = 5$. (*Note:* You can, but do not have to, type in the *closing* parentheses on the right.) |  |
| Evaluate Y1 at $x = 7$ by recalling the previous entry with [2nd] [ENTER] (ENTRY), edit the 5 to 7 by pressing [◁] [◁] and typing over the 5, and press [ENTER]. |  |

| | |
|---|---|
| Evaluate Y1 at $x = 10$ by recalling the previous entry with 2nd ENTER (ENTRY) , edit the 7 to 10 by pressing ◀ ◀ and typing over the 7, and press ENTER . |   |

## 1.2 Functions and Graphs

When you are asked to *estimate* or *approximate* an output or an input value, you can use your calculator in the following ways:

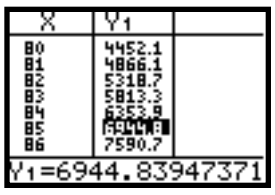
- tracing a graph (Sections 1.1.5, 1.1.6)
- close values obtained from a table of function values (End of Section 1.2.2)

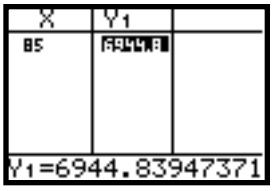
When you are asked to *find* or *determine* an output or an input value, you should use your calculator in the following ways:

- evaluating an output on the home screen (Section 1.1.7)
- find a value using the AUTO or ASK features of the table (Section 1.2.1)
- determine an input using the solver (Section 1.2.2)

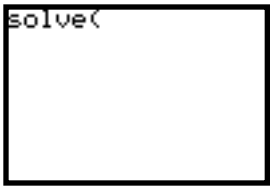
**1.2.1 DETERMINING OUTPUTS** Function outputs can be determined by evaluating on the home screen, as discussed in 1.1.7. You can also evaluate functions using the calculator's TABLE. When you use the table, you can ask for specific output values corresponding to the inputs you enter or generate a list of input values that begin with TblMin and differ by ΔTbl and their corresponding outputs.

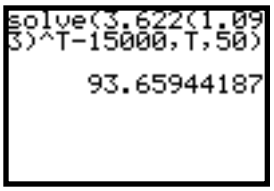
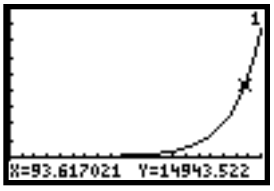
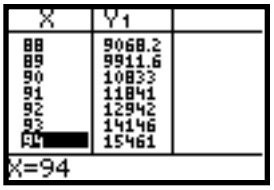
Let's use the TABLE to determine the output of the function $v(t) = 3.622(1.093)^t$ when $t$ =85. Even though you could use any of the function locations, we choose to use Y1. Press Y= , clear the function locations, and enter 3.622(1 .093)^X in location Y1 of the Y= list.

| | |
|---|---|
| After entering the function $v(t)$ in Y1, choose the TABLE SETUP menu. | Press 2nd WINDOW (TblSet) . |
| To generate a list of values beginning with an input of 80 with the table values differing by 1, enter 80 in the TblMin location, 1 in the ΔTbl location, and choose AUTO in the Indpnt: and Depend: locations.<br>Remember that you "choose" a particular setting by positioning the blinking cursor over that setting and pressing ENTER . |   |
| Press 2nd GRAPH (TABLE) , and observe the list of input and output values.<br>Notice that you can scroll through the table with ▼, ▶, ▲, and/or ◀.<br>The table values may be rounded in the table display. You can see more of the output by moving to the value and looking at the bottom of the screen. |   |

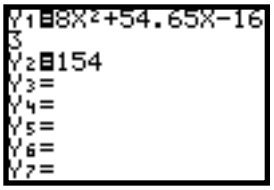
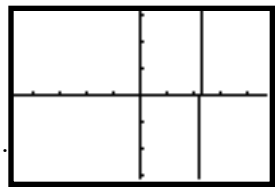
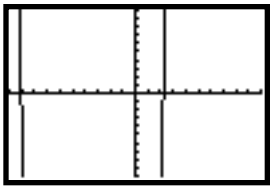
| | |
|---|---|
| Return to the TABLE SETUP menu with 2nd WINDOW (TblSet) . To compute specific outputs rather than a list of values, choose ASK in the Indpnt: location.<br>(When using ASK, the settings for TblMin and ΔTbl do not matter.) |  |
| Press 2nd GRAPH (TABLE) , type in the $x$-value(s) at which the function is to be evaluated, and press ENTER .<br>You can scroll through the table with ▽, ▷, △, and/or ◁. Unwanted input entries can be cleared with DEL .<br>Using any of these methods, we see that $v(85) \approx \$6945$. |  |

**1.2.2 SOLVING FOR INPUT VALUES** Your calculator solves for the input values of any equation that you have put in the form *"expression = 0"*. The expression can, but does not have to, use X as the input variable. However, you must specify the variable you are using.

| | |
|---|---|
| **TI-82** The form of the expression you type in the solver is<br>*Solve(expression, variable, initial guess)*. | You will use the solve command throughout this course. |
| Press 2nd MODE (QUIT) to return to the home screen.<br>Access the MATH menu with MATH . Use ▽ to locate 0: solve(. |  |
| **TI-83** The TI-83 gives you two methods of solving for input variables.<br>**METHOD 1:** The expression you type in your calculator is of the form *Solve(expression, variable, initial guess)*. | This method is very similar to that for the TI-82. The main difference is in the location of the solve command. |
| Return to the home screen with 2nd MODE (QUIT) .<br>Access the CATALOG menu with 2nd 0 (CATALOG) .<br>Press LN to access the list of commands beginning with S (because LN is the key with S written above it). Use ▽ to locate solve(. |  |
| **Both** Press ENTER to copy the instruction to the home screen.<br>Suppose we want to solve $v(t) = 3.622(1.093)^t$ for $t$ when $v = \$15{,}000$. |  |

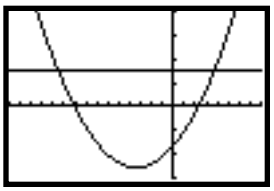
| | |
|---|---|
| Since the equation you enter is *"expression = 0"*, subtract 15,000 from both sides of the equation to obtain<br>$0 = 15{,}000 - 15{,}000 = 3.622(1.093)^t - 15{,}000$<br>Tell the calculator the variable with ALPHA 4 (T), provide a guess, and press ENTER. |  |
| Note that your *guess* can be obtained by drawing a graph of $3.622(1.093)^t$ and tracing until you have an estimate of where the output is 15,000.<br>(Remember that to graph any function, you must rewrite it so that the input variable is $x$.) |  |
| You could also use the AUTO setting in the TABLE and scroll through the table until a value near the estimated output is found.<br>Your guess is not extremely important unless the equation has more than one solution. In that case, the calculator will return the answer that is closest to your guess. (See below.) |  |

If there is more than one solution to an equation, you need to give the solver an approximate location for each answer. Suppose you are given $q(x) = 8x^2 + 54.65x - 163$ and asked to find what input(s) correspond to an output of $q(x) = 154$. (The procedure outlined below also applies to finding where two functions are equal.)

| | |
|---|---|
| Enter $8x^2 + 54.65x - 163$ in one location, say Y1, and 154 in another location, say Y2, in the Y= list.<br>(Remember that if the input variable in the equation is not $x$, you must rewrite the equation in terms of $x$ to graph using the Y= list.) |  |
| To better obtain a guess as to where Y1 equals (intersects) Y2, graph the equations.<br>If you are not told where you want to view the graph, begin by pressing ZOOM 4 (ZDecimal) or ZOOM 6 (ZStandard).<br>You want to see a "good" graph, that is, one that shows all the important features. In this case, the important features are where Y1 and Y2 intersect.<br>The top graph was obtained with ZDecimal and the bottom graph with ZStandard. Neither graph on the right is a good graph for viewing the intersections. |  <br>  |

To improve the view, press [WINDOW] and change the settings to Xmin = ⁻15, Xmax = 8, Ymin = ⁻300, and Ymax = 400 . Draw the graph with [GRAPH] .

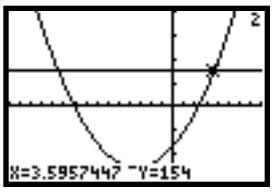
(There are many other windows that work just as well as the one shown to the right. Also, instead of setting a window manually, you could use program AUTOSCL on the TI-82 or use ZoomFit on the TI-83.)



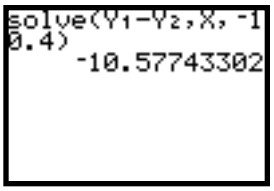
Press [TRACE] and use [▷] and/or [◁] to move along the graph of the equation in Y1.

Press [▽] to jump from the graph of Y1 to the graph of Y2. Tracing reveals that guesses for the input values where these two graph intersect are X ≈ ⁻10.4 ,X ≈3.6.

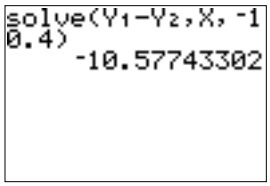
Return to the home screen with [2nd] [MODE] (QUIT) .




**TI-82** Enter the expression on the right with the key-strokes
**Error!**

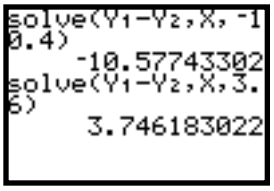



**TI-83** Enter the expression on the right with the key-strokes [2nd] [0] (CATALOG) [LN] , use [▽] to locate (solve( ), and press [ENTER] [VARS] [▷] (Y-VARS) [1] (Function) [1] (Y1) [–] [VARS] [▷] (Y-VARS) [1] (Function) [2] (Y2) [,] [X,T,θ,n] [,] [(-)] 10.4 [)] [ENTER] .

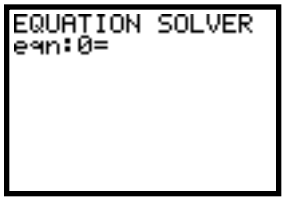
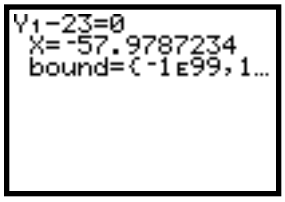
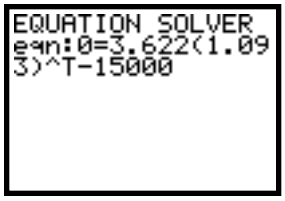
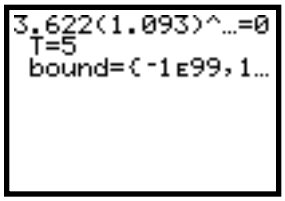
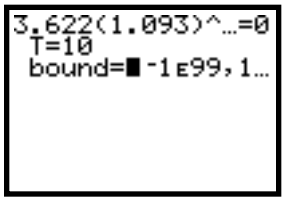


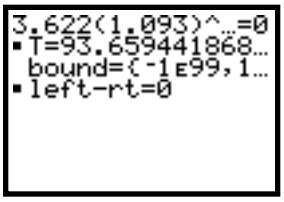

**Both** Recall the last expression you typed with [2nd] [ENTER] (ENTRY) . Use [◁] to edit ⁻10.4 to the guess for the second intersection point, 3.6. Press [ENTER] to solve.

The two solutions to the equation, reported to four decimal places, are $x = -10.5774$ and $x = 3.7462$.




The TI-83 offers a second method of solving that you may find more convenient than the method previously discussed.

| | |
|---|---|
| **TI-83** This second method of solving can be used instead of the first method anytime you need to solve for an input variable or find where two expressions are equal.<br>**METHOD 2:** The equation containing the unknown quantity must have all terms on the left-hand side and a 0 on the right-hand side or vice-versa.) | This method uses the equation solver that is built into the TI-83.<br>You must, like in the first method, enter an expression that equals 0. |
| Return to the home screen with [2nd] [MODE] (QUIT) .<br>Access the solver by pressing [MATH] [0] . If there are no equations stored in the solver, you will see the screen displayed on the right -- or |  |
| -- if the solver has been used previously, you will see a screen something like the one shown on the right.<br>If this is the case, press [▲] [CLEAR] and you should then have the screen shown in the previous box. |  |
| Let us return to the example where we are solving $v(t) = 3.622(1.093)^t$ for $t$ when $v = \$15{,}000$.<br>Since the equation you enter is "eqn = *0*", subtract 15,000 from both sides of the equation $15{,}000 = 3.622(1.093)^t$, and enter the expression shown on the right. |  |
| Press [ENTER] or [▼]. (Note: To return to the equation for editing purposes, press [▲] until the previous screen reappears.)<br>With the cursor covering the 5 in the T location, enter a guess, say 10. (You could use the default guess that automatically appears.) |  |
| Press [ENTER] or [▼] and the cursor moves to the bound location. These are the values between which the TI-83 searches for a solution. You do not have to change these values unless you get an error message or you want a quicker search for the solution.<br>*Therefore, you can often skip this step.* |  |

| | |
|---|---|
| Move the cursor to the location of the variable for which you are solving. (In this example, T.)<br><br>Press [ALPHA] [ENTER] (SOLVE) . (Notice the dot that appears next to the T and by the last line on this screen. This means a solution has been found.)<br><br>The bottom line on the screen, "left-rt = 0", indicates the value found for T is an exact solution since both sides of the equation evaluate to the same quantity. |  |

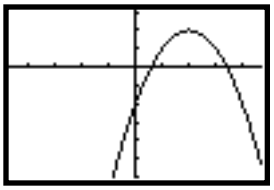
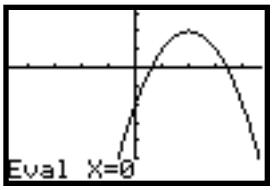
**TI-83 Note:** Remember the following when using the equation solver:

- You can use functions stored in the Y= list in the SOLVER, but you must rewrite the function so that $x$ is the input variable. At the eqn: 0= prompt, enter the location of the function using the VARS (Y-VARS) menu. For instance, if Y1 = 3.622(1.093)^X , enter Y1 – 15000 after the eqn: 0= in the equation solver.
- If a solution continues beyond the edge of the screen, you see "…" to the right of the value. Be certain that you use [▶] to scroll to the end of the number. The value may be given in scientific notation, and the portion that you cannot see determines the location of the decimal point. (See *Basic Operation, #3*, of this *Guide*.)

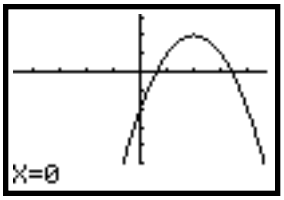
**1.2.3 GRAPHICALLY FINDING INTERCEPTS** Finding where a function graph crosses the vertical and horizontal axis can be done graphically as well as by the methods indicated in 1.2.2 of this *Guide*. Remember the process by which we find intercepts:

- To find the $y$-intercept of a function $y = f(x)$, set $x$=0 and solve the resulting equation.
- To find the $x$-intercept of a function $y = f(x)$, set $y$=0 and solve the resulting equation.

Also remember that an $x$-intercept of a function $y = f(x)$ has the same value as the root or solution of the equation $f(x) = 0$.

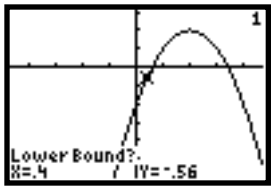
| | |
|---|---|
| Press [Y=] and clear all locations with [CLEAR] .<br><br>Enter $f(x) = 4x - x^2 - 2$ in Y1.<br><br>Draw the graph with [ZOOM] [4] (ZDecimal) and reset Ymin to −6 for a good view of all intercepts. |  |
| **TI-82** Even though it is very easy to find $f(0) = -2$, you can have the calculator find the $y$-intercept when the graph is on the screen by pressing [2nd] [TRACE] (CALC) [1] (value) . Type 0 at the Eval X= prompt, press [ENTER] , and view the $y$-intercept $f(0) = -2$. |  |

**TI-83** Even though it is very easy to see that $f(0) = -2$, you can have the calculator find the $y$-intercept while viewing the graph by pressing [2nd] [TRACE] (CALC) [1] (value) . Type 0 at the X= prompt, press [ENTER] , and view the $y$-intercept $f(0) = -2$.




**TI-82** To graphically find an $x$-intercept, i.e., a value of $x$ at which the graph crosses the horizontal axis, press [2nd] [TRACE] (CALC) [2] (root) . Press ▷ until you are close to, but still to the *left* of the leftmost $x$-intercept.

Press [ENTER] to mark the location of the *lower* bound for the $x$-intercept.

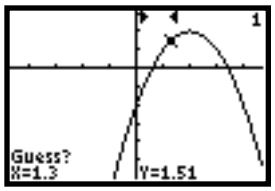



The TI-82 uses "lower" to mean "to the left of" the intercept.

Press ▷ until you are to the *right* of this $x$-intercept.

Press [ENTER] to mark the location of the *upper* bound for the $x$-intercept.

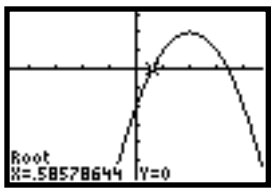
Press ◁ to move the cursor nearer to where the graph crosses the horizontal axis for the "guess" and press [ENTER] .




The TI-82 uses "upper" to mean "to the right of" the intercept.

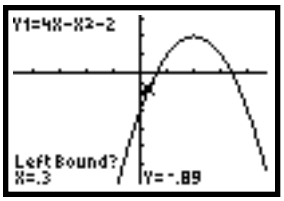
The value of the leftmost $x$-intercept is displayed as X = 0.58578644.

Repeat the above procedure to find the other $x$-intercept. Confirm that it is X = 3.4142136.




**TI-83** To graphically find an $x$-intercept, i.e., a value of $x$ at which the graph crosses the horizontal axis, press [2nd] [TRACE] (CALC) [2] (zero) .

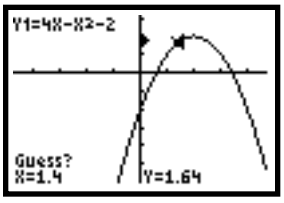
Press ▷ until you are close to, but still to the *left* of the leftmost $x$-intercept. Press [ENTER] to mark the location of the *left* bound for the $x$-intercept.




Press ▷ until you are to the *right* of this $x$-intercept.

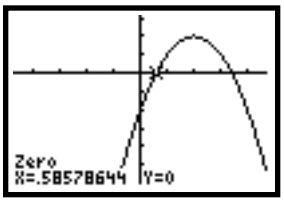
Press [ENTER] to mark the location of the *right* bound for the $x$-intercept.

For your "guess", press ◁ to move the cursor nearer to where the graph crosses the horizontal axis and press [ENTER] .



The value of the leftmost $x$-intercept is displayed as X = 0.58578644.

Repeat the above procedure to find the other $x$-intercept. Confirm that it is X = 3.4142136.




## 1.3 Constructed Functions

Your calculator can find output values of and graph combinations of functions in the same way that you do these things for a single function. The only additional information you need is how to enter constructed functions in the graphing list. Suppose that a function $f(x)$ has been entered in Y1 and a function $g(x)$ has been entered in Y2.

- Enter Y1 + Y2 in Y3 to obtain the sum function $(f+g)(x) = f(x) + g(x)$.
- Enter Y1 – Y2 in Y4 to obtain the sum function $(f-g)(x) = f(x) - g(x)$.
- Enter Y1*Y2 in Y5 to obtain the product function $(f \cdot g)(x) = f(x) * g(x)$.
- Enter Y1/Y2 in Y6 to obtain the quotient function $(f \div g)(x) = \dfrac{f(x)}{g(x)}$.
- Enter Y1(Y2 ) in Y7 to obtain the composite function $(f \circ g)(x) = f(g(x))$.

Your calculator will evaluate and graph these constructed functions. Although it will not give you an algebraic formula for a constructed function, you can check your algebra by evaluating the calculator-constructed function and your constructed function at several different points.

### 1.3.1 GRAPHING PIECEWISE CONTINUOUS FUNCTIONS

Piecewise continuous functions are used throughout the text. It is often helpful to use your calculator to graph and evaluate outputs of piecewise continuous functions. Consider the following example.

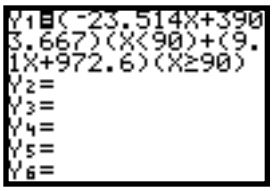
The population of West Virginia from 1985 through 1993 can be modeled by

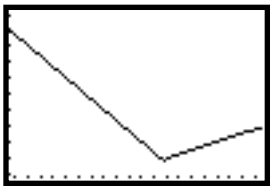
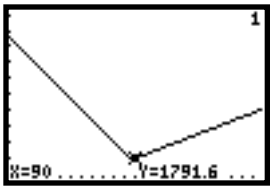
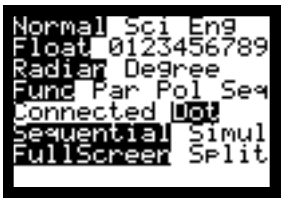
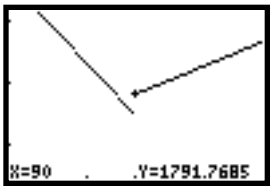
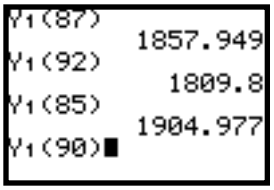
$$P(t) = \begin{cases} -23.514t + 3903.667 \text{ thousand people when } 85 \le t < 90 \\ 9.1t + 972.6 \text{ thousand people when } 90 \le t \le 93 \end{cases}$$

where $t$ is the number of years since 1900.

**TI-82** Enter the function $P(t)$, using $x$ as the input variable, in the Y1 location of the Y= list using the keystrokes

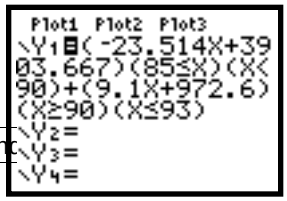
[(] [(–)] 23.514 [X,T,θ] [+] 3903.667 [)] [(] [X,T,θ] [2nd] [MATH] (TEST) [5] (<) 90 [)] [+] [(] 9.1 [X,T,θ] [+] 972.6 [)] [(] [X,T,θ] [2nd] [MATH] (TEST) [4] (≥) 90 [)]



| | |
|---|---|
| Notice that the function is defined only when the input is between 85 and 93. You could find $P(85)$ and $P(93)$ to help you set the vertical view. However, we choose to use program AUTOSCL. (See Section 1.1.4 of this *Guide*.)<br>When prompted, enter Xmin = 85 and Xmax = 93. The graph to the right is drawn by the program. |  |
| If you wish to see the "break" in the function where the two pieces join, the width of the screen must be a multiple of 9.4 and include 90.<br>Since 90 – 0.5(9.4) = 85.3 and 90 + 0.5(9.4) = 94.7, change Xmin and Xmax to these values and press GRAPH . |  |
| Because the two pieces are close together at $x = 90$, you may need to take a closer look to see the break. However, because the calculator draws graphs by connecting function outputs wherever the function is defined, it will connect the two pieces unless you tell it not to do so by pressing MODE , use ▽ and ▷ to choose Dot , and press ENTER . |  |
| Now, take a closer look with GRAPH and ZOOM 2 (Zoom In). To keep the point where the functions break in view, use ▽ to move the small cursor that appears in the middle of the screen down to where the two functions join before pressing ENTER to actually zoom in. |  |
| You can find function values by evaluating outputs on the home screen or using the table.<br>Do not forget to change the calculator's MODE setting back to Connected when you finish graphing the piecewise function. |  |
| **TI-83** The same procedure as given in the above steps for the TI-82 will also work for the TI-83. However, the TI-83 has some additional features that will make graphing of piecewise functions less complicated. | (See Section 6.1.2 of this *Guide* for an example showing how to fit a piecewise model to data.) |

Enter the function $P(t)$, using $x$ as the input variable, in the Y1 location of the Y= list using the keystrokes [(] [(–)] 23.514 [X,T,θ,n] [+] 3903.667 [)] [(] 85 [2nd] [MATH] (TEST) [6] (≤) [X,T,θ,n] [)] [(] [X,T,θ,n] [2nd] [MATH] (TEST) [5] (<) 90 [)] [+] [(] 9.1 [X,T,θ,n] [+] 972.6 [)] [(] [X,T,θ,n] [2nd] [MATH] (TEST) [4] (≥) 90 [)] [(] [X,T,θ,n] [2nd] [MATH] (TEST) [6] (≤) 93 [)]

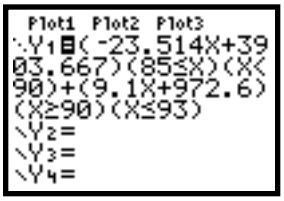
Notice that these keystrokes specify the complete input of the function $P$.




Each piece of the function and its corresponding input must be enclosed in parentheses.

This piecewise function "breaks" at $x = 90$. However, your calculator draws graphs by connecting function outputs wherever the function is defined, so it will connect the two pieces unless you tell it not to do. Whenever you draw graphs of piecewise functions, it is easier to set your calculator to Dot mode in the following manner.

Have the cursor on the first line of the function and press [◀] until you highlight the slanted line* to the *left* of Y1. Press [ENTER] six times.



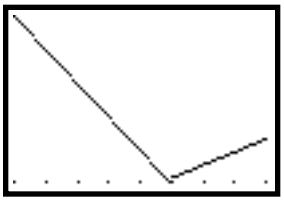

The dotted line to the left of Y1 indicates the graph will draw without joining the outputs of the function.

Notice that the function is defined only when the input is between 85 and 93. You could find $P(85)$ and $P(93)$ to help you set the vertical view. However, we choose to use ZoomFit. (See Section 1.1.4 of this *Guide*.)

Press [WINDOW], set Xmin to 85, and set Xmax to 93.

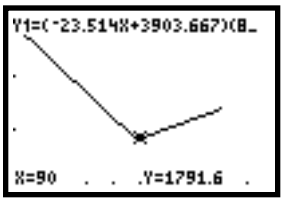
Press [ZOOM] [▲] (0: ZoomFit) [ENTER].

(The breaks you see in the left portion of the graph are because you have told the calculator not to connect outputs.)

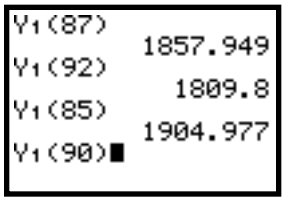


Even though you can see the "break" in the function where the two pieces join, you cannot trace to that point. To do this, the width of the screen must be a multiple of 9.4 and must include 90.

Since $90 - 0.5(9.4) = 85.3$ and $90 + 0.5(9.4) = 94.7$, change Xmin and Xmax to these values. Also change Ymin to 1750. Press [GRAPH].




* The different "graph styles" you can draw from this location are described in more detail on pages 3-9 through 3-10 in your TI-83 Owner's *Guidebook*.

| | |
|---|---|
| You can find function values by evaluating outputs on the home screen or using the table. |  |



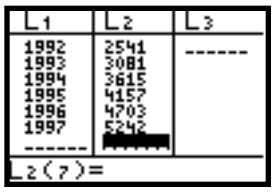
## 1.4 Linear Functions and Models

Actual real-world data is used throughout *Calculus Concepts*. It is necessary that you use your calculator to find a curve that models the data. Be very careful when you enter the data in your calculator because your model and all of your results depend on the values that you enter!

**1.4.1 ENTERING DATA** Press STAT 1 (EDIT) to access the six lists that hold data. You only see the first three lists, L1, L2, and L3, but you can access the other three, L4, L5, and L6, with ▷. (In this text, we usually use list L1 for the input data and list L2 for the output data.) If there are any data values in your lists, see 1.4.3 of this *Guide* and first delete any "old" data. (**TI-83** Note: If you do not see L1, L2, and so forth, return to the statistical setup instructions at the beginning of this *Guide*.)

Enter the following data:

| | | | | | | |
|---|---|---|---|---|---|---|
| *Year* | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
| *Tax* | 2541 | 3081 | 3615 | 4157 | 4703 | 5242 |

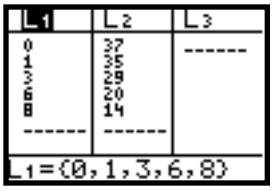
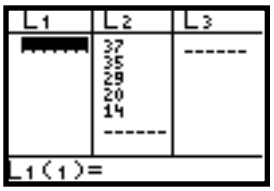
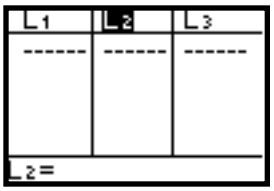
| | |
|---|---|
| Position the cursor in the first location in list L1. Enter the $x$-data into list L1 by typing the entries from top to bottom in the L1 column, pressing ENTER after each entry.<br>After typing the L1(5) value, 1997, use ▷ to go to the top of list L2. Enter the $y$-data into list L2 by typing the entries from top to bottom in the L2 column, pressing ENTER after each entry. |  |



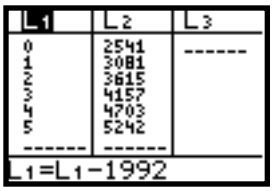
**1.4.2 EDITING DATA** If you incorrectly type a data value, use the cursor keys to darken the value you wish to correct and type the correct value. Press ENTER .

- To *insert* a data value, put the cursor over the value that will be directly below the one you will insert, and press 2nd DEL (INS) . The values in the list below the insertion point move down one location and a 0 is filled in at the insertion point. Type the data value to be inserted over the 0 and press ENTER . The 0 is replaced with the new value.
- To *delete* a single data value, move the cursor over the value you wish to delete, and press DEL . The values in the list below the deleted value move up one location.

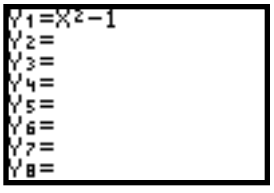
**1.4.3 DELETING OLD DATA** Whenever you enter new data in your calculator, you should first delete any previously-entered data. There are several ways to do this, and the most convenient method is illustrated below.

| | |
|---|---|
| Access the data lists with STAT 1 (EDIT) .<br><br>(You probably have different values in your lists if you are deleting "old" data.)<br><br>Use ▲ to move the cursor over the name L1. |  |
| Press CLEAR ENTER . |  |
| Use ▶ ▲ to move the cursor over the name L2.<br>Press CLEAR ENTER .<br><br>Repeat this procedure to clear data from any of the other lists you want to use. |  |

**1.4.4 ALIGNING DATA** Let's now return to the data you entered in Section 1.4.1 of this *Guide*. Suppose you want L1 to contain the number of years since a certain year (here, 1992) instead of actual years. That is, you want to *align* the $x$-data. In this example, you are to shift all the data values 1992 units to the left of where they currently are located.

| | |
|---|---|
| Position the cursor over the L1 at the top of the first column.<br><br>Replace the L1 values with L1 – 1992 values by pressing 2nd 1 (L1) – 1992 ENTER .<br><br>Instead of an actual year, the input now represents the number of years after 1992. |  |

**1.4.5 PLOTTING DATA** Any functions you have in the Y= list will graph when you plot data. Therefore, you should clear or turn them off before drawing a scatter plot.

| | |
|---|---|
| **TI-82** Access the Y= graphing list. If any entered function is no longer needed, clear it with CLEAR .<br><br>If you want the function to remain but do not want it to graph, position the cursor over the "=" and press ENTER . A function does not graph and cannot be used in the table when its equals sign is not darkened. |  <br>A "turned off" function. |

Press 2nd Y= (STAT PLOT) to display the STAT PLOTS screen.

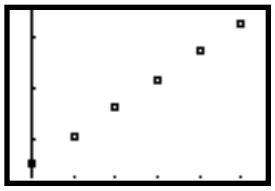
Note: When drawing a graph from the Y= list, you may get an error message or see a scatter plot of "old" data as well as the function graph. If so, turn off the STAT PLOTS with 4 (PlotsOff) ENTER .


On the STAT PLOTS screen, press ENTER to display the Plot1 screen, press ENTER to turn Plot1 "On", and select the options shown on the right.

(You can choose any of the three marks at the bottom of the screen.)

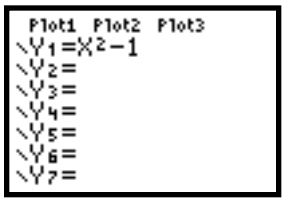

Press ZOOM 9 (ZoomStat) to have the calculator set an autoscaled view of the data and draw the scatter plot.

(ZoomStat does not reset the $x$ and $y$-axis tick marks. You should do this manually with WINDOW if you want different spacing between the marks.)



**TI-83** Access the Y= graphing list. If any entered function is no longer needed, clear it with CLEAR .

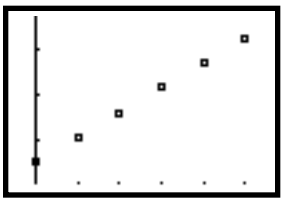
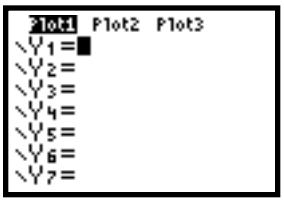
If you want the function to remain but do not want it to graph, position the cursor over the "=" and press ENTER . A function does not graph and cannot be used in the table when its equals sign is not darkened.




A "turned off" function.

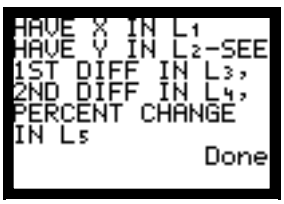
Press 2nd Y= (STAT PLOT) to display the STAT PLOTS screen. (Your screen may not look exactly like this one.)

Note: When drawing a graph from the Y= list, you may get an error message or see a scatter plot of "old" data as well as the function graph. If so, turn off the STAT PLOTS with 4 (PlotsOff) ENTER .

| | |
|---|---|
| On the STAT PLOTS screen, press ENTER to display the Plot1 screen, press ENTER to turn Plot1 "On", and select the options shown on the right.<br><br>(You can choose any of the three marks at the bottom of the screen.) |  |
| Press ZOOM 9 (ZoomStat) to have the calculator set an autoscaled view of the data and draw the scatter plot.<br><br>(ZoomStat does not reset the *x* and *y*-axis tick marks. You should do this manually with WINDOW if you want different spacing between the marks.) |  |
| Press Y= . Notice that "Plot1" at the top of the screen is now dark. This is because you have turned Plot1 "on". If you always put input data in list L1 and output data in list L2, you can turn the scatter plots off and on from the Y= screen rather than the stat plots screen from this point on.<br><br>To turn Plot1 off, use ▲ to move the cursor to the Plot1 position, and press ENTER . Reverse the process to turn Plot1 back on. |  <br>A scatter plot is turned *on* when its name on the Y= screen is darkened. |

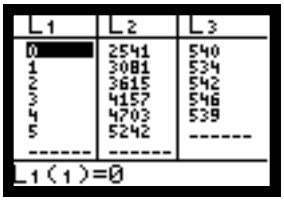
- TI-83 lists can be named and stored in the calculator's memory for later recall and use. If you do this and use the list by its stored name, you must use the name of the list in the stat plot setup or on the stat plot screen each time you change lists. Refer to Section 1.4.13 of this *Guide* and your *TI-83 Guidebook* for details.

**1.4.6 FINDING FIRST DIFFERENCES** When the input values are evenly spaced, use program DIFF to compute first differences in the output values. If the data are perfectly linear (*i.e.*, every data point falls on the graph of the line), the first differences in the output values are constant. If the first differences are "close" to constant, this is an indication that a linear model *may* be appropriate.

| | |
|---|---|
| Program DIFF is given in the TI-82/TI-83 Appendix. To run the program, press PRGM followed by the number of the location of the program and press ENTER . The message on the right appears on your screen.<br><br>(We use the information in L4 and L5 in the next chapter.) |  |

Press STAT 1 (EDIT) to view the first differences in list L1.

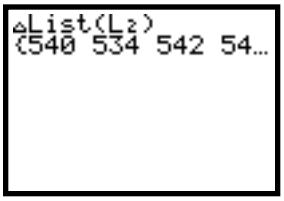
The first differences in L3 are not constant, but are "nearly constant". A linear model *might* be a good fit to the data.



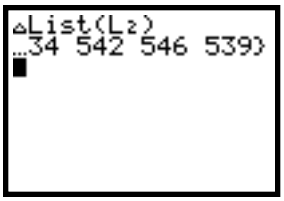

- Program DIFF **should not** be used for data with input (L1) values that are *not* evenly spaced. First differences give no information about a possible linear fit to data with inputs that are not the same distance apart. If you try to use program DIFF with input data that are not evenly spaced, the message INPUT VALUES NOT EVENLY SPACED appears and the program stops.

**TI-83** If you do not want to use program DIFF, you can use your TI-83 to compute first differences of any list.

Press 2nd STAT (LIST) ▷ (OPS)
**Error!**




Use ▷ to scroll to the right to see the remainder of the first differences. Use ◁ to scroll back to the left.



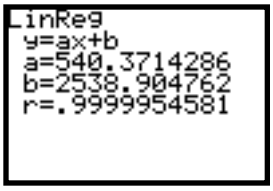

**1.4.7 FINDING A LINEAR MODEL** Use your calculator to obtain the linear model that best fits the data. Your calculator can find two different, but equivalent, forms of the linear model: $y = ax + b$ or $y = a + bx$. For convenience, we always choose the model $y = ax + b$.

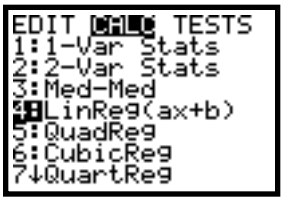
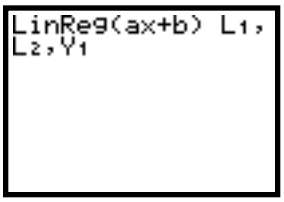
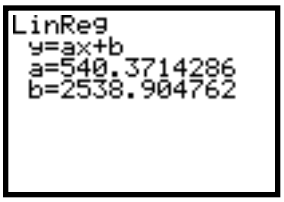
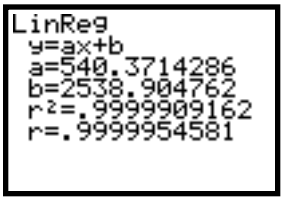
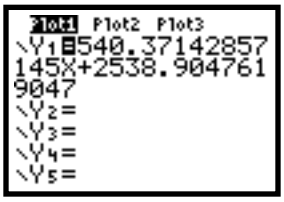
**TI-82** Press STAT ▷ (CALC) 5 (LinReg(ax+b)) ENTER .

*Note:* If you receive an error message, reset the statistical setup to that indicated on page A-1 of this *Guide*.


The linear model of best fit for the aligned tax data entered in Section 1.4.4 of this *Guide* is displayed on the home screen.

(The $r$ that is shown is called the *correlation coefficient*. It is something you will learn about in a statistics course and should be ignored in this course.)

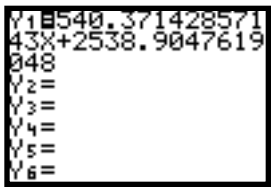


| | |
|---|---|
| **TI-83** Press [STAT] [▷] (CALC) [4] (LinReg(ax+b)) to copy the instruction to the home screen. |  |
| To have the calculator find the linear model of best fit using L1 as the input and L2 as the output and paste the model into the Y= list, type the following after the LinReg(ax+b) instruction:<br>[2nd] [1] (L1) [,] [2nd] [2] (L2) [,] [VARS] [▷] (Y-VARS) [1] (Function) [1] (Y1) . Press [ENTER] . |  <br>The model will be pasted into the location that you specify. |
| The linear model of best fit for the aligned tax data entered in Section 1.4.4 of this *Guide* is displayed on the home screen.<br><br>Note: It is not necessary to first clear any previously-entered function from the location of the Y= list. |  |
| Note: If you see the TI-83 screen shown to the right instead of the screen displayed above, turn off the diagnostics by pressing [2nd] [0] (CATALOG) [$x^{-1}$] , use [▽] to locate DiagnosticOff and press [ENTER] [ENTER] .<br><br>(The quantities $r^2$ and $r$ are used in a statistics course and should be ignored in this course.) |  |
| Press [Y=] to verify that the model has been pasted into the Y1 location of the graphing list.<br><br>*Note:* If you receive an error message when finding the model, reset the statistical setup to that indicated on page A-1 of this *Guide*. |  |

**1.4.8 PASTING A MODEL INTO THE FUNCTION LIST** The coefficients of the model found by the calculator should *not* be rounded. This is not a problem because the calculator will paste the entire model into the function list!

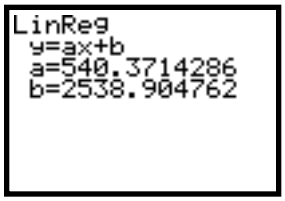
**TI-82** To paste a model in the graphing list, press [Y=] and clear any function in the Y1 location. With the cursor in the blank Y1 location, press [VARS] [5] (STATISTICS) [▷] [▷] (EQ) [7] (RegEQ) .

Remember "[VARS] [5] [▷] [▷] [7] ". You will use it many times!



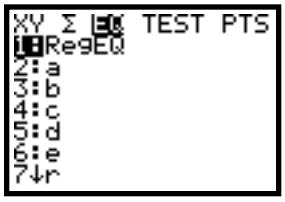

**TI-83 (optional)** One very nice feature of the TI-83 is that you can find the model and paste it in the function list all in one step as indicated in the previous section of this *Guide*. This is the recommended procedure.

However, if you wish to do this in two steps, you can. First, find the model with the command shown on the screen to the right. (If the input and output lists are not L1 and L2, respectively, you must specify the lists, input list first, behind the LinReg(ax+b) command.)



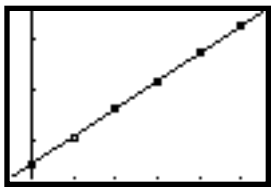

Second, press [Y=] and clear any function in the Y1 location. With the cursor in the blank Y1 location, press [VARS] [5] (STATISTICS) [▷] [▷] (EQ) [1] (RegEQ) .

Press [Y=] and verify that the linear model has been put in Y1.

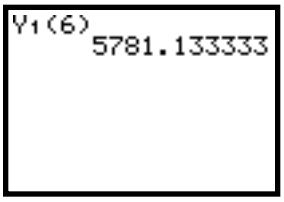
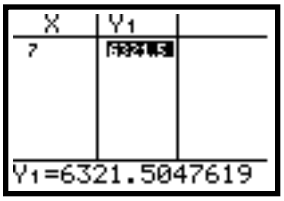



**1.4.9 GRAPHING A MODEL** After finding a model, you should always graph it on a scatter plot of the data to verify that the model provides a good fit to the data.

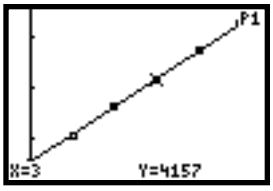
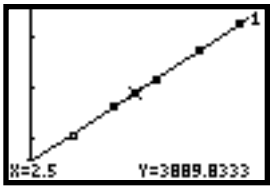
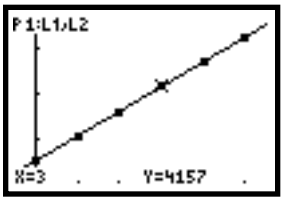
Press [GRAPH] to overdraw the model on the scatter plot.



**1.4.10 PREDICTIONS USING A MODEL** Use one of the methods described in Sections 1.1.7 or 1.2.1 of this *Guide* to evaluate the linear model at the desired input value. Remember, if you have aligned your data, the input value at which you evaluate the model may not be the value given in the question you are asked.

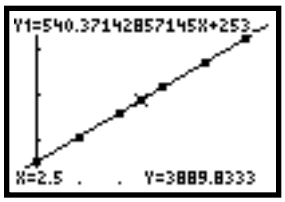
| | |
|---|---|
| Predict the tax owed in 1998 and 1999 where the tax is found using the linear model computed from the data given in Section 1.4.1 of this *Guide*:<br>Tax = 540.37143$t$ + 2538.90476 dollars and $t$ is the number of years since 1992.<br>Remember that you should always use the full model, *i.e.*, the function you pasted in Y1, for all computations. Note that 1998 is six years since 1992, so $x = 6$. |  <br>The 1998 tax is predicted to be about \$5781. |
| Predict the value of $y$ in 1999 using the TABLE. Note that 1999 is seven years since 1992, so $x = 7$. The 1999 tax is predicted to be approximately \$6322.<br>(You can type over $x$-values already in the table when using Indpnt: ASK, or you can press DEL to delete previously-entered values.) |  |

**1.4.11 COPYING GRAPHS TO PAPER** Your instructor may ask you to copy what is on your graphics screen to paper. If so, use the following to more accurately perform this task.

| | |
|---|---|
| **TI-82** Press GRAPH to return the graph to the screen.<br>Press TRACE and ▷ to trace the graph. The P1 in the upper right-hand corner of the screen indicates that you are tracing the scatter plot of the data. Use either these trace values or the data lists to mark the data points on your paper. |  |
| Press ▽ to move the trace cursor to the linear model graph. The 1 in the right-hand corner of the screen tells you which function you are tracing (in this case, Y1 ).<br>Use ▷ and/or ◁ to locate values that are as "nice" as possible and mark those points on your paper. Use a ruler to connect the model points and draw the line. |  |
| **TI-83** Press GRAPH to return the graph to the screen.<br>Press TRACE and ▷ to trace the graph. The P1:L1,L2 in the upper left-hand corner of the screen indicates that you are tracing the scatter plot of the data. Use either these trace values or the data lists to mark the data points on your paper. |  |

Press ▽ to move the trace cursor to the linear model graph. The equation at the top of the screen tells you which function you are tracing (in this case, Y1 ).

Use ▷ and/or ◁ to locate values that are as "nice" as possible and mark those points on your paper. Use a ruler to connect the model points and draw the line.




- If you are copying the graph of a continuous curve, rather than a straight line, to your paper, you need to trace as many points as necessary to see the shape of the curve and mark the points on your paper. Connect the points with a smooth curve.

**1.4.12 WHAT IS "BEST FIT"?** Even though your calculator easily computes the values $a$ and $b$ for the best fitting linear model $y = ax + b$, it is important to understand the method of least-squares and the conditions necessary for its application if you intend to use this model. You can explore the process of finding the line of best fit with program LSLINE. (Program LSLINE is given in the TI-82/TI-83 Appendix.) For your investigations of the least-squares process with this program, it is better to use data that is not perfectly linear and data for which you do *not* know the best-fitting line.

Before using program LSLINE, clear the Y= list and enter your data in lists L1 and L2. Next, draw a scatter plot. Press WINDOW and reset Xscl and Yscl so that you can use the tick marks to help identify points on the graphics screen. Press GRAPH to view the scatter plot.

To activate program LSLINE, press PRGM followed by the number of the location of the program, and press ENTER . The program first displays the scatter plot you constructed and pauses for you to view the screen.

- While the program is calculating, there is a small vertical line in the upper-right hand corner of the graphics screen that is dashed and "moving". The program pauses several times during execution. Whenever this happens, the small vertical line is "still" and you should press ENTER to resume execution after you have looked at the screen.

The program next asks you to find the $y$-intercept and slope of *some* line you estimate will go "through" the data. (You should not expect to guess the best fit line on your first try!) After you enter a guess for the $y$-intercept and slope, your line is drawn and the errors are shown as vertical line segments on the graph. (You may have to wait just a moment to see the vertical line segments before again pressing ENTER .)

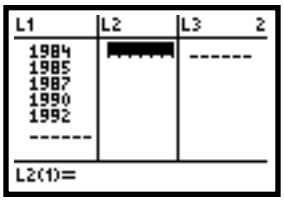
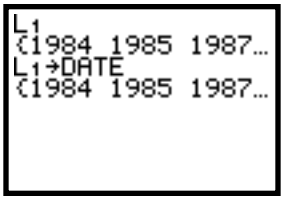
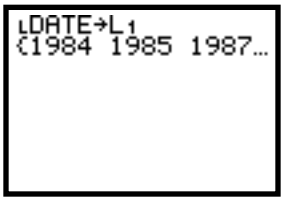
Next, the sum of squares of errors, SSE, is displayed for your line. Choose the TRY AGAIN? option by pressing 1 ENTER . Decide whether you want to move the $y$-intercept of the line or change its slope to improve the fit to the data. After you enter another guess for the $y$-intercept and/or slope, the process of viewing your line, the errors, and display of SSE is repeated. If the new value of SSE is smaller than the SSE for your first guess, you have improved the fit.

When it is felt that an SSE value close to the minimum value is found, you should press 2 at the TRY AGAIN? prompt. The program then overdraws the line of best fit on the graph for

comparison with your last attempt and shows the errors for the line of best fit. The coefficients $a$ and $b$ of the best-fitting linear model $y = ax + b$ are then displayed along with the minimum SSE. Use program LSLINE to explore the method of least squares to find the line of best fit.

### 1.4.13 NAMING DATA LISTS ON THE TI-83 (optional)

You may or may not want to use the additional features given below for data entered on the TI-83. You can name data (either input, output, or both) and store it in the calculator memory for later recall. For instance, suppose you wanted to name the list L1: 1984 1985 1987 1990 1992

| | |
|---|---|
| First, enter the data in the list L1.<br>Press [2nd] [MODE] (QUIT) to return to the home screen.<br>You can view any list from the home screen by typing its name and pressing [ENTER]. Enter [2nd] [1] (L1). |  |
| Pressing [▷] allows you to scroll through the list to see the portion that is not displayed.<br>Enter [2nd] [1] (L1) [STO‹] [2nd] [ALPHA] D A T E and press [ENTER] to store this list with the name DATE. |  |
| If you later want to access this list, press [2nd] [STAT] (LIST), and under NAMES, find DATE. Press the number corresponding to the location of the list, press [STO‹], and type the location you wish to move the list to (say, L1). Press [ENTER]. |  |

The original data remains in DATE. It is not deleted until you delete it using [2nd] [+] (MEM) [2] (Delete) [4] (List), move the cursor with [▽] to the location of DATE, and press [ENTER]. Press [2nd] [MODE] (QUIT) to return to the home screen.