

This appendix contains some keystroke suggestions for many graphing calculator operations that are featured in this text. The keystrokes are for the TI-83 and TI-83 Plus calculators. The descriptions in the margin are the same as those used in the text and are arranged alphabetically. Please see your manual for additional information about your calculator.

Basic Operations

Numerical calculations are performed on the **home screen**. You can always return to the home screen by pressing **2nd** **QUIT**. Pressing **CLEAR** erases the home screen.

To evaluate the expression $-2(3 + 5) - 8 \div 4$, use the following keystrokes.

(-) 2 **(** 3 **+** 5 **)** **-** 8 **÷** 4 **ENTER**

Note: There is a difference between the key to enter a negative number, **(-)**, and the key for subtraction, **-**. You cannot use these keys interchangeably.

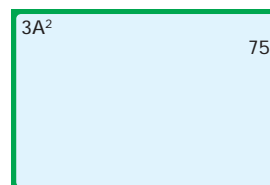
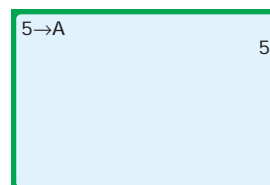
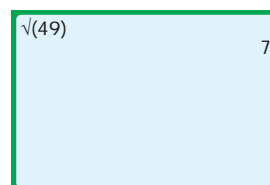
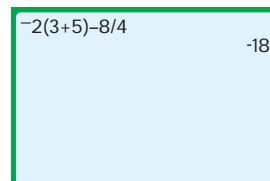
The **2nd** key is used to access the commands in gold writing above a key. For instance, to evaluate the $\sqrt{49}$, press **2nd** **√** 49 **)** **ENTER**.

The **ALPHA** key is used to place a letter on the screen. One reason to do this is to store a value of a variable. The following keystrokes give A the value of 5.

5 **STO** **ALPHA** **A** **ENTER**

This value is now available in calculations. For instance, we can find the value of $3a^2$ by using the following keystrokes: 3 **ALPHA** **A** **x²**. To display the value of the variable on the screen, press **2nd** **RCL** **ALPHA** **A**.

Note: When you use the **ALPHA** key, only capital letters are available on the TI-83 calculator.

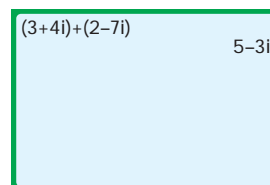
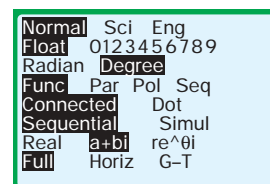


Complex Numbers

To perform operations on complex numbers, first press **MODE** and then use the arrow keys to select **a+bi**. Then press **ENTER** **2nd** **QUIT**.

Addition of complex numbers To add $(3 + 4i) + (2 - 7i)$, use the keystrokes

(3 **+** 4 **2nd** **i** **)** **+**
(2 **-** 7 **2nd** **i** **)** **ENTER**



Division of complex numbers. To divide $\frac{26 + 2i}{2 + 4i}$, use the keystrokes $(26 + 2 \text{ 2nd } i) \div (2 + 4 \text{ 2nd } i) \text{ ENTER}$.

Note: Operations for subtraction and multiplication are similar.

$(26+2i)/(2+4i)$ 3-5i

Additional operations on complex numbers can be found by selecting CPX under the MATH key.

To find the absolute value of $2 - 5i$, press

MATH (scroll to CPX) (scroll to abs) ENTER (2 - 5 $\text{ 2nd } i$) ENTER .

MATH NUM CPX PRB
1: conj(
2: real(
3: imag(
4: angle(
5: abs(
6: Rect
7: Polar
abs(2-5i) 5.385164807

Correlation Coefficient

The value of the correlation coefficient for a regression equation calculation is not shown unless the DiagnosticOn feature is enabled. To enable this feature, press $\text{ 2nd } \text{ CATALOG } \text{ D}$ (scroll to DiagnosticOn) $\text{ ENTER } \text{ ENTER}$.

CATALOG A
DependAsk
DependAuto
det(
DiagnosticOff
DiagnosticOn
dim(
Disp

DiagnosticOn Done

To calculate the correlation coefficient, proceed as if calculating a regression equation.

Evaluating Functions

TAKE NOTE

Use the down arrow key to scroll past Y_7 to see Y_8 , Y_9 , and Y_0 .

There are various methods of evaluating a function but all methods require that the expression be entered as one of the ten functions Y_1 to Y_0 . To evaluate $f(x) = \frac{x^2}{x-1}$ when $x = -3$, enter the expression into, for instance, Y_1 , and then press $\text{ VARS } \blacktriangleright 11$ $(\leftarrow) 3$ ENTER .

Note: If you try to evaluate a function at a number that is not in the domain of the function, you will get an error message. For instance, 1 is not in the domain of $f(x) = \frac{x^2}{x-1}$. If we try to evaluate the function at 1, the error screen at the right appears.

Plot1 Plot2 Plot3
 $Y_1 = X^2/(X-1)$
 $Y_2 =$
 $Y_3 = Y_1(-3)$ -2.25
 $Y_4 =$
 $Y_5 =$
 $Y_6 =$
 $Y_7 =$

$Y_1(1)$
ERR:DIVIDE BY 0
1: Quit
2: Goto

Evaluating Variable Expressions

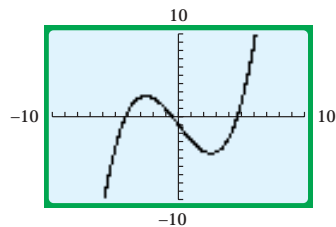
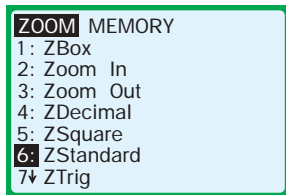
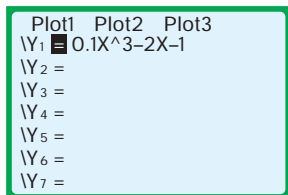
To evaluate a variable expression, first store the values of each variable. Then enter the variable expression. For instance, to evaluate $s^2 + 2s/l$ when $s = 4$ and $l = 5$, use the following keystrokes.

4 $\text{ STO } \blacktriangleright$ $\text{ ALPHA } S$ ENTER 5 $\text{ STO } \blacktriangleright$ $\text{ ALPHA } L$ ENTER $\text{ ALPHA } S$
 $x^2 + 2 \text{ ALPHA } S \text{ ALPHA } L \text{ ENTER}$

4 \rightarrow S 4
5 \rightarrow L 5
 S^2+2SL 56

Graph To graph a function, use the **Y=** key to enter the expression for the function, select a suitable viewing window, and then press **GRAPH**. For instance, to graph $f(x) = 0.1x^3 - 2x - 1$ in the standard viewing window, use the following keystrokes.

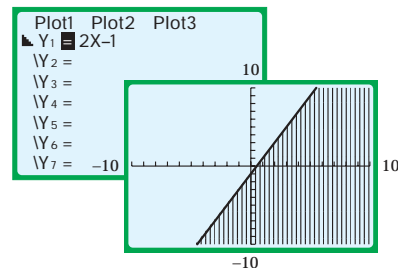
Y= 0.1 **X,T,θ,n** **^** 3 **-** 2 **X,T,θ,n** **-** 1 **ZOOM** (scroll to 6) **ENTER**



Note: For the keystrokes above, you do not have to scroll to 6. Alternatively, use **ZOOM** 6. This will select the standard viewing window and automatically start the graph. Use the **WINDOW** key to create a custom window for a graph.

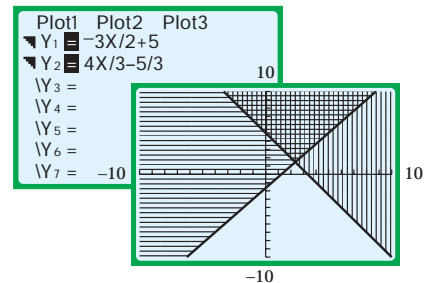
Graphing Inequalities

To illustrate this feature, we will graph $y \leq 2x - 1$. Enter $2x - 1$ into Y_1 . Because $y \leq 2x - 1$, we want to shade below the graph. Move the cursor to the left of Y_1 and press **ENTER** three times. Press **GRAPH**.



Note: To shade above the graph, move the cursor to the left of Y_1 and press **ENTER** two times. An inequality with the symbol \leq or \geq should be graphed with a solid line, and an inequality with the symbol $<$ or $>$ should be graphed with a dashed line. However, the graph of a linear inequality on a graphing calculator does not distinguish between a solid line and a dashed line.

To graph the solution set of a system of inequalities, solve each inequality for y and graph each inequality. The solution set is the intersection of the two inequalities. The solution set of $\begin{cases} 3x + 2y > 10 \\ 4x - 3y \leq 5 \end{cases}$ is shown at the right.



Intersect The INTERSECT feature is used to solve a system of equations. To illustrate this feature, we will use the system of equations $\begin{cases} 2x - 3y = 13 \\ 3x + 4y = -6 \end{cases}$

Note: Some equations can be solved by this method. See the section “Solve an equation” below. Also, this method is used to find a number in the domain of a function for a given number in the range. See the section “Find a domain element.”

Solve each of the equations in the system of equations for y . In this case, we have $y = \frac{2}{3}x - \frac{13}{3}$ and $y = -\frac{3}{4}x - \frac{3}{2}$.

Use the Y-editor to enter $\frac{2}{3}x - \frac{13}{3}$ into Y_1 and $-\frac{3}{4}x - \frac{3}{2}$ into Y_2 . Graph the two functions in the standard viewing window. (If the window does not show the point of intersection of the two graphs, adjust the window until you can see the point of intersection.)

Press 2nd **CALC** (scroll to 5, intersect) **ENTER**.

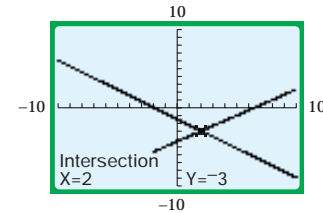
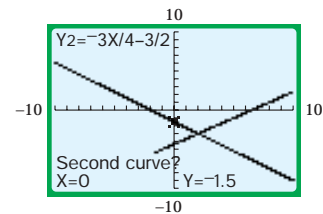
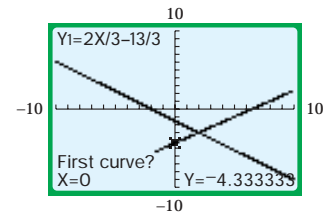
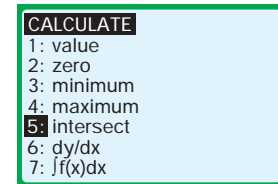
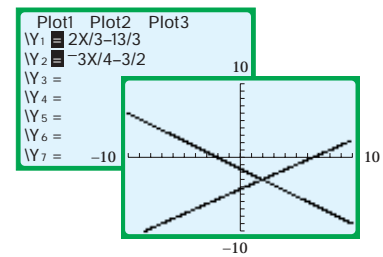
Alternatively, you can just press 2nd **CALC** 5.

First curve? is shown at the bottom of the screen and identifies one of the two graphs on the screen. Press **ENTER**.

Second curve? is shown at the bottom of the screen and identifies the second of the two graphs on the screen. Press **ENTER**.

Guess? shown at the bottom of the screen asks you to use the left or right arrow key to move the cursor to the *approximate* location of the point of intersection. (If there are two or more points of intersection, it does not matter which one you choose first.) Press **ENTER**.

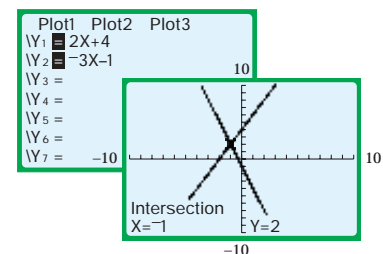
The solution of the system of equations is $(2, -3)$.



Solve an equation To illustrate the steps involved, we will solve the equation $2x + 4 = -3x - 1$. The idea is to write the equation as the system of equations $y = 2x + 4$ and $y = -3x - 1$ and then use the steps for solving a system of equations.

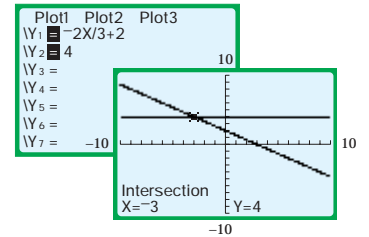
Use the Y-editor to enter the left and right sides of the equation into Y_1 and Y_2 . Graph the two functions and then follow the steps for Intersect.

The solution is -1 , the x -coordinate of the point of intersection.



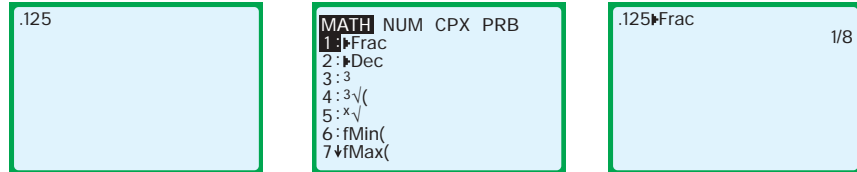
Find a domain element For this example, we will find a number in the domain of $f(x) = -\frac{2}{3}x + 2$ that corresponds to 4 in the range of the function. This is like solving the system of equations $y = -\frac{2}{3}x + 2$ and $y = 4$.

Use the Y= editor to enter the expression for the function in Y₁ and the desired output, 4, in Y₂. Graph the two functions and then follow the steps for Intersect.

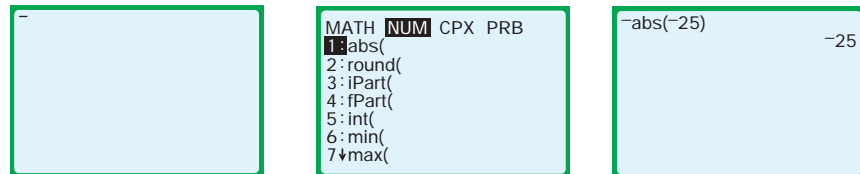


The point of intersection is (-3, 4). The number -3 in the domain of f produces an output of 4 in the range of f .

Math Pressing **MATH** gives you access to many built-in functions. The following keystrokes will convert 0.125 to a fraction: $.125$ **MATH** 1 **ENTER**.



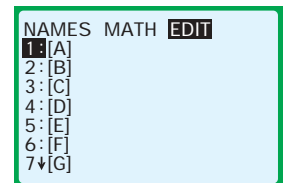
Additional built-in functions under **MATH** can be found by pressing **MATH** **▶**. For instance, to evaluate $-|-25|$, press **(-)** **MATH** **▶** 1 **(-)** 25 **)** **ENTER**.



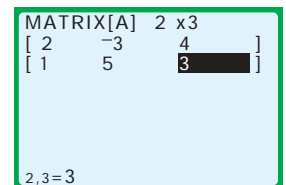
See your owner's manual for assistance with other functions under the **MATH** key.

Matrix On a TI-83, **matrix operations** are accessed by pressing **MATRIX**. On a TI-83 Plus, press **2nd** **MATRIX** to access the matrix menu.

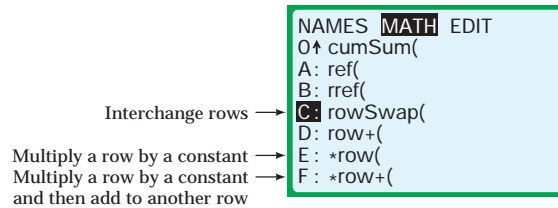
To enter the elements of a matrix, select the matrix key. Then use the right arrow to select EDIT. Now use the down arrow key to select the name of the matrix. There are 10 matrices with names A through J. By pressing the down arrow key, you can see the additional names. Once you have selected the name of the matrix, press **ENTER**.



For instance, to enter the matrix $\begin{bmatrix} 2 & -3 & 4 \\ 1 & 5 & 3 \end{bmatrix}$ with 2 rows and 3 columns, access the matrix menu, arrow right to EDIT, and press **ENTER**. Now enter the dimension and the elements of the matrix, pressing **ENTER** after each number. You can change an element by using the arrow keys to select that element. After you have entered all the elements, press **2nd** **QUIT** to return to the home screen.



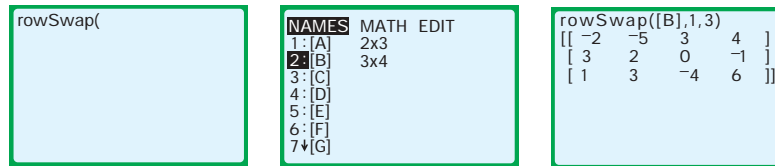
Elementary row operations Elementary row operations are performed by selecting MATH from the matrix menu. Use the down arrow key to scroll to those operations. Your screen should look something like this:



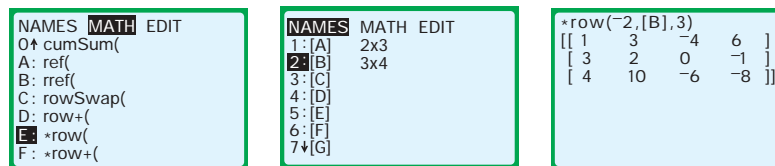
The operation row+(shown by D: is to add two rows. This is really the same as F: where the constant is 1.

Here are keystrokes for each elementary row operation. We will use the matrix $\begin{bmatrix} 1 & 3 & -4 & 6 \\ 3 & 2 & 0 & -1 \\ -2 & -5 & 3 & 4 \end{bmatrix}$ for this demonstration and assume it is stored in matrix [B].

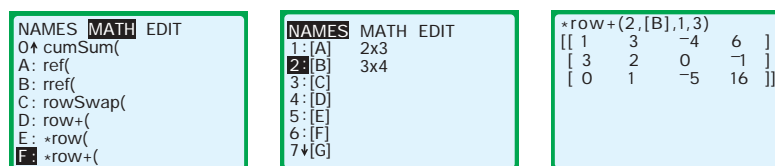
Interchange rows: Access the matrix menu and highlight MATH. Scroll down to C:rowSwap(. Press **ENTER**. Access the matrix menu. Scroll to [B]; then press **ENTER**. Press **↶** 1 **↶** 3 **)** **ENTER**. (This interchanges row 1 and row 3. Change these numbers to interchange other rows.)



Multiply a row by a constant: Access the matrix menu and highlight MATH. Scroll down to E:*row(. Press **ENTER** **(←)** 2. (This is the constant that will multiply a row.) Press **↶**. Access the matrix menu. Scroll to [B] and then press **ENTER**. Press **↶** 3 **)** **ENTER**. (Row 3 is being multiplied.)



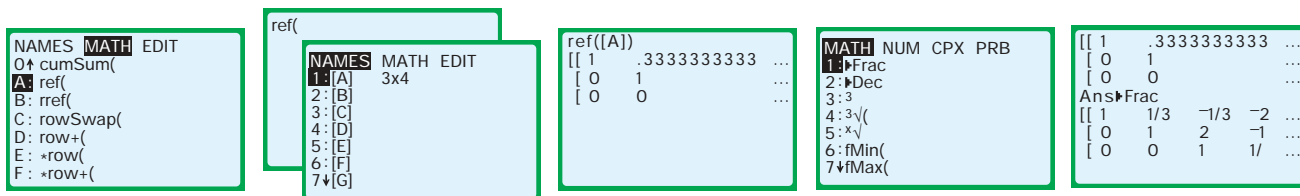
Multiply a row by a constant and then add it to another row: Access the matrix menu and highlight MATH. Scroll down to F:*row+(). Press **ENTER** 2. (This is the constant that will multiply a row.) Press **↶**. Access the matrix menu. Scroll to [B]; then press **ENTER**. Press **↶** 1 **↶** 3 **)** **ENTER**. (Row 1 is being multiplied by 2 and then added to row 3.)



Row echelon form The $\text{ref}()$ function performs all of the elementary row operations on a matrix and directly produces a row echelon form of a matrix. The abbreviation ref stands for **row echelon form**.

To write $\begin{bmatrix} 2 & 1 & 3 & -1 \\ 1 & 3 & 5 & -1 \\ -3 & -1 & 1 & 2 \end{bmatrix}$ in row echelon form, enter the matrix in, for instance, [A].

Press 2nd **QUIT**. Then access the matrix menu and highlight MATH, scroll to $\text{ref}()$ and press ENTER , access the matrix menu, select [A], and press ENTER $\text{)$ ENTER . This will produce a matrix in row echelon form. Pressing MATH **1** ENTER will rewrite the matrix with fractions rather than decimals. (See MATH for assistance with the fraction command.)



Min and Max

The local minimum and the local maximum values of a function are calculated by accessing the CALC menu. For this demonstration, we will find the minimum value and the maximum value of $f(x) = 0.2x^3 + 0.3x^2 - 3.6x + 2$.

Enter the function into Y_1 . Press 2nd **CALC** (scroll to 3 for minimum of the function) ENTER .

Alternatively, you can just press 2nd **CALC** 3.

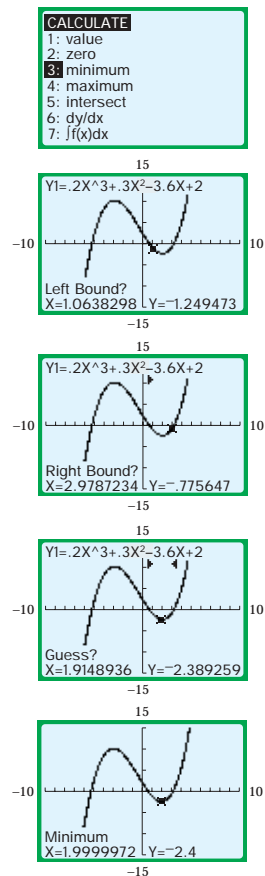
Left Bound? shown at the bottom of the screen asks you to use the left or right arrow key to move the cursor to the *left* of the minimum. Press ENTER .

Right Bound? shown at the bottom of the screen asks you to use the left or right arrow key to move the cursor to the *right* of the minimum. Press ENTER .

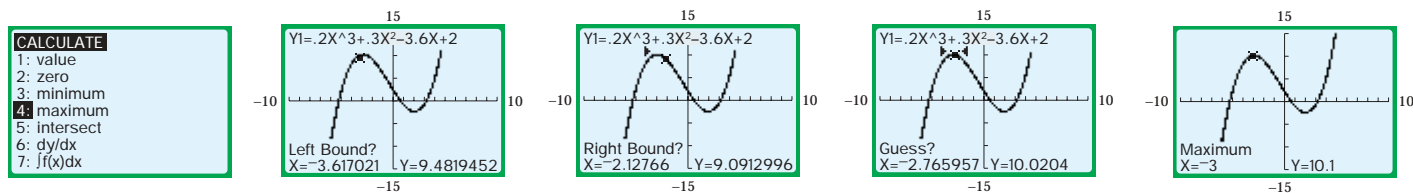
Guess? shown at the bottom of the screen asks you to use the left or right arrow key to move the cursor to the *approximate* location of the minimum. Press ENTER .

The minimum value of the function is the y -coordinate. For this example, the minimum value of the function is -2.4 .

The x -coordinate for the minimum is 2. However, because of rounding errors in the calculation, it is shown as a number close to 2.



To find the maximum value of the function, follow the same steps as above except select maximum under the CALC menu. The screens for this calculation are shown below.



The maximum value of the function is 10.1.

Radical Expressions

To evaluate a square-root expression, press $\sqrt{}$.

For instance, to evaluate $0.15\sqrt{p^2 + 4p + 10}$ when $p = 100,000$, first store 100,000 in P. Then press $0.15 \sqrt{\text{ALPHA} P x^2 + 4 \text{ALPHA} P + 10}$.

100000→P	100000
$0.15\sqrt{(P^2+4P+10)}$	15000.3

To evaluate a radical expression other than a square root, access $\sqrt[x]{}$ by pressing $\sqrt{}$. For instance, to evaluate $\sqrt[4]{67}$, press 4 (the index of the radical) $\sqrt{}$ (scroll to 5) $\sqrt{}$ 67.

MATH	NUM	CPX	PRB
1: Frac			
2: Dec			
3: 3			
4: 3√($4^x\sqrt{67}$		2.861005553
5: x√			
6: fMin(
7: fMax(

Regression

For the discussion of linear regression, we will use the data in this table.

Temperature, x (in °C)	20	35	50	60	75	90	100
Grams of sugar, y	50	80	120	145	175	205	230

All calculations and graphs involving statistical data begin by entering the data using the Edit option, which is accessed by pressing STAT .

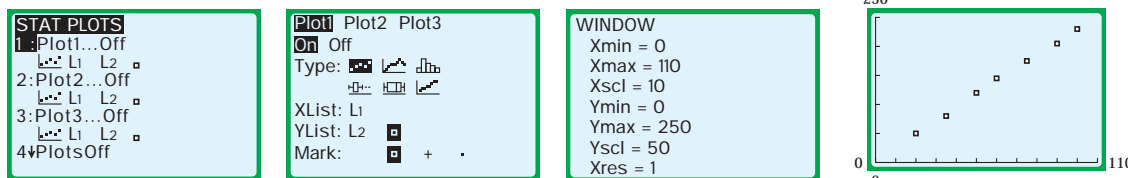
For the data above, press STAT to access the statistics menu. Press 1 to Edit or enter data. To delete data already in a list, press the up arrow until the cursor is highlighting the list name. For instance, to delete data in L1, highlight L1. Then press CLEAR and ENTER . Now enter each value of the independent variable in L1, pressing ENTER after each entry. Use the up and down arrow keys to change a value. When all values of the independent variable are entered, press ENTER . This will put you in the next column to enter the values of the dependent variable in L2.

EDIT	CALC	TESTS
1: Edit...		
2: SortA(
3: SortD(
4: ClrList		
5: SetUpEditor		

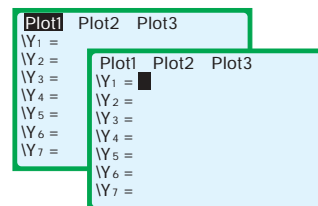
L1	L2	L3	2
20	50		----
35	80		
50	120		
60	145		
75	175		
90	205		
100	230		
L2(7) = 230			

Create a scatter diagram Press 2nd STATPLOT (use the down arrow key to select Plot1, Plot2, or Plot3) ENTER . Use arrow keys to move the cursor to ON and then press ENTER . The first graph type is for a scatter diagram. Move the cursor over that symbol and press ENTER . Be sure that Xlist and Ylist are the names of the lists into which you stored data. You can change these by press-

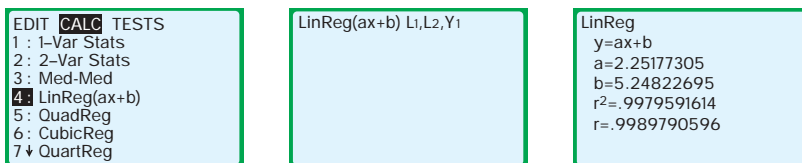
ing **2nd** and then selecting the appropriate list, **L1** through **L6**. Prepare to graph the data by adjusting the viewing window by pressing **WINDOW** and entering appropriate values. Now press **GRAPH**.



Note: You can tell that STAT PLOTS is active by pressing **Y=**. For one screen at the right, observe that PLOT1 is highlighted, indicating it is active. To turn STAT PLOTS off, use the up arrow key to highlight it, and then press **ENTER**. Now use the arrow key to move the cursor to the right of the equals sign for Y_1 .

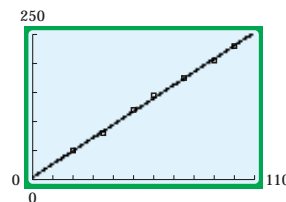


Find a linear regression equation Press **STAT** (scroll to 4) **ENTER** **2nd** **L1** **,** **2nd** **L2** **,** **VAR** **1** **1** **ENTER**. The values of the slope and y -intercept of the linear regression equation will be displayed on the screen. If DiagnosticOn is enabled (see Correlation coefficient), then the coefficient of determination r^2 and the correlation coefficient r are also shown.

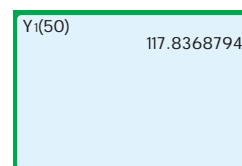


Note: If data are stored in L_1 and L_2 , the keystrokes **2nd** **L1** **,** **2nd** **L2** are not necessary. The keystrokes **VAR** **1** **1** **ENTER** place the regression equation in Y_1 . These keystrokes are not necessary but are helpful if you need to graph the regression equation or evaluate the equation at a given value of the independent variable. See below for more details.

Graph a linear regression equation Press **STAT** (scroll to 4) **ENTER** **2nd** **L1** **,** **2nd** **L2** **,** **VAR** **1** **1** **ENTER**. This will store the regression equation in Y_1 . Now press **GRAPH**. It may be necessary to adjust the viewing window.



Evaluate a regression equation Complete the steps to graph a regression equation, but do not graph the equation. To evaluate the equation when $x = 50$, press **VAR** **1** **(** **50** **)** **ENTER**.



Other regression equations can be calculated. For instance, to find a regression equation of the form $y = ax^b$, called a power regression equation, enter the data and then select PwrReg from the CALC menu under the **STAT** menu.

L1	L2	L3	2
1	2.5	-----	
2	3.2		
3	7.75		
4	16.3		
5	32.4		
6	61.8		

L2(7) =			

EDIT	CALC	TESTS
7	↑	QuartReg
8	:	LinReg(a+bx)
9	:	LnReg
0	:	ExpReg
A	:	PwrReg
B	:	Logistic
C	:	SinReg

PwrReg Y1

PwrReg
y=a*x^b
a=1.533042316
b=1.817355148
r^2=.8907910201
r=.9438172599

Note: Because the data were entered into L1 and L2, it was not necessary to include them in PwrReg. We did include the optional Y1. This is good practice because it makes evaluating and graphing a regression equation much easier.

Scientific Notation

To enter a number in scientific notation, use **2nd** **EE**. For instance, to find $\frac{3.45 \times 10^{-12}}{1.5 \times 10^{25}}$, press 3.45 **2nd** **EE** (-) 12 **÷** 1.5 **2nd** **EE** 25 **ENTER**. The answer is 2.3×10^{-37} .

3.45E-12/1.5E25	2.3E-37
-----------------	---------

Sequences and Series

The terms of a sequence and the sum of a series can be calculated by using the **2nd** **LIST** feature.

Store a sequence A sequence is stored in one of the lists L1 through L6. For instance, to store the sequence 1, 3, 5, 7, 9 in L1, use the following keystrokes.

2nd { 1 , 3 , 5 , 7 , 9 } **2nd** } **STO** **2nd** **L1** **ENTER**

{1,3,5,7,9}→L1	{1,3,5,7,9}
----------------	-------------

Display the terms of a sequence The terms of a sequence are displayed by using the function seq(expression, variable, begin, end, increment). For instance, to display the 3rd through 8th terms of the sequence given by $a_n = n^2 + 6$, enter the following keystrokes.

2nd **LIST** (scroll to 5)
ENTER X,T,θ,n **x**² **+** 6
2nd X,T,θ,n **3** **→** **8**
2nd **1** **ENTER** **STO** **2nd** **L1** **ENTER**

NAMES	OPS	MATH
1:	SortA(
2:	SortD(
3:	dim(seq(X ² +6,X,3,8,1)
4:	Fill((15 22 31 42 55...)
5:	seq(
6:	cumSum(
7:	ΔList(

The keystrokes **STO** **2nd** **L1** **ENTER** store the terms of the sequence in L1. This is not necessary but is sometimes helpful if additional work will be done with that sequence.

Find a sequence of partial sums To find a sequence of partial sums, use the cumSum(function. For instance, to find the sequence of partial sums for 2, 4, 6, 8, 10, use the following keystrokes.

2nd **LIST** (scroll to 6)
ENTER **2nd** { 2 , 4 , 6 , 8 , 10 } **2nd** } **ENTER**

NAMES	OPS	MATH
1:	SortA(
2:	SortD(
3:	dim(cumSum({2,4,6,8,10})
4:	Fill({2 6 12 20 30}
5:	seq(
6:	cumSum(
7:	ΔList(

If a sequence is stored as a list in L_1 , then the sequence of partial sums can be calculated by pressing 2nd LIST (scroll to 6 [or press 6]) ENTER 2nd L_1 ENTER .

Find the sum of a series The sum of a series is calculated using $\text{sum}\langle\text{list}, \text{start}, \text{end}\rangle$. For instance, to find $\sum_{n=3}^6 (n^2 + 2)$, enter the following keystrokes.

2nd LIST (scroll to 5)
 ENTER 2nd LIST (scroll to 5 [or press 5])
 ENTER X,T,O,n x^2 $+$ 2 $,$ X,T,O,n 3
 $,$ 6 $,$ 1 ENTER

Table There are three steps in creating an input/output table for a function. First use the Y= editor to input the function. The second step is setting up the table, and the third step is displaying the table.

To set up the table, press 2nd TBLSET . TblStart is the first value of the independent variable in the input/output table. ΔTbl is the difference between successive values. Setting this to 1 means that, for this table, the input values are $-2, -1, 0, 1, 2, \dots$. If $\Delta\text{Tbl} = 0.5$, then the input values are $-2, -1.5, -1, -0.5, 0, 0.5, \dots$

Indpnt is the independent variable. When this is set to Auto, values of the independent variable are automatically entered into the table. Depend is the dependent variable. When this is set to Auto, values of the dependent variable are automatically entered into the table.

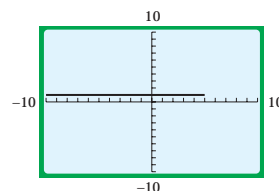
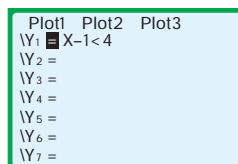
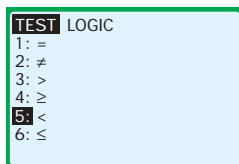
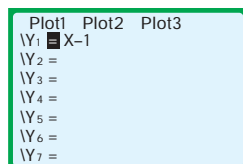
To display the table, press 2nd TABLE . An input/output table for $f(x) = x^2 - 1$ is shown at the right.

Once the table is on the screen, the up and down arrow keys can be used to display more values in the table. For the table at the right, we used the up arrow key to move to $x = -7$.

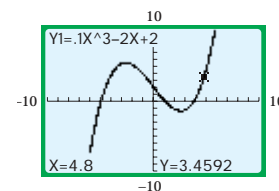
An input/output table for any given input can be created by selecting Ask for the independent variable. The table at the right shows an input/output table for $f(x) = \frac{4x}{x-2}$ for selected values of x . Note the word ERROR when 2 was entered. This occurred because f is not defined when $x = 2$.

Note: Using the table feature in Ask mode is the same as evaluating a function for given values of the independent variable. For instance, from the table at the right, we have $f(4) = 8$.

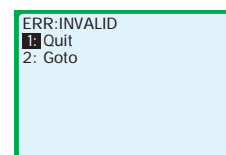
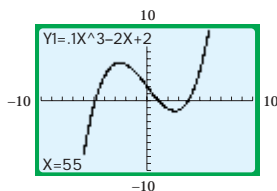
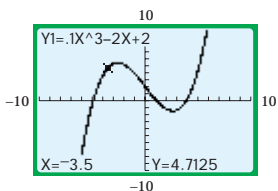
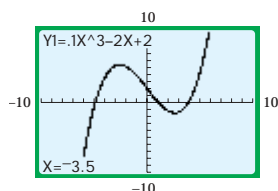
Test The TEST feature has many uses, one of which is to graph the solution set of a linear inequality in one variable. To illustrate this feature, we will graph the solution set of $x - 1 < 4$. Press Y= $\text{X,T,}\theta,n$ — 1 2nd TEST (scroll to 5) ENTER 4 GRAPH.



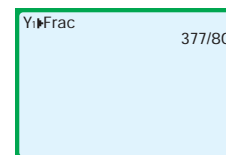
Trace Once a graph is drawn, pressing TRACE will place a cursor on the screen, and the coordinates of the point below the cursor are shown at the bottom of the screen. Use the left and right arrow keys to move the cursor along the graph. For the graph at the right, we have $f(4.8) = 3.4592$, where $f(x) = 0.1x^3 - 2x + 2$ is shown at the top left of the screen.



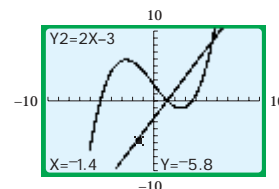
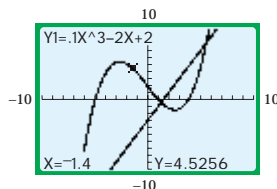
In TRACE mode, you can evaluate a function at any value of the independent variable that is within Xmin and Xmax. To do this, first graph the function. Now press TRACE (the value of x) ENTER. For the graph at the left below, we used $x = -3.5$. If a value of x is chosen outside the window, an error message is displayed.



In the example above where we entered -3.5 for x , the value of the function was calculated as 4.7125 . This means that $f(-3.5) = 4.7125$. The keystrokes 2nd QUIT VAR 11 MATH 1 ENTER will convert the decimal value to a fraction.

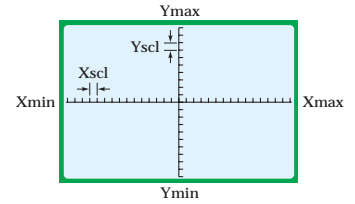


When the TRACE feature is used with two or more graphs, the up and down arrow keys are used to move between the graphs. The graphs below are for the functions $f(x) = 0.1x^3 - 2x + 2$ and $g(x) = 2x - 3$. By using the up and down arrows, we can place the cursor on either graph. The right and left arrows are used to move along the graph.



Window The viewing window for a graph is controlled by pressing WINDOW. Xmin and Xmax are the minimum value and maximum value, respectively, of the independent variable shown on the graph. Xscl is the distance between tic marks

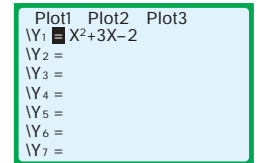
on the x -axis. Ymin and Ymax are the minimum value and maximum value, respectively, of the dependent variable shown on the graph. Yscl is the distance between tic marks on the y -axis. Leave Xres as 1.



Note: In the standard viewing window, the distance between tic marks on the x -axis is different from the distance between tic marks on the y -axis. This will distort a graph. A more accurate picture of a graph can be created by using a square viewing window. See ZOOM.

Y=

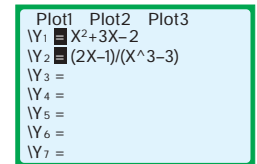
The **Y=** editor is used to enter the expression for a function. There are ten possible functions, labeled Y_1 to Y_0 , that can be active at any one time. For instance, to enter $f(x) = x^2 + 3x - 2$ as Y_1 , use the following keystrokes.



Y= **X,T,θ,n** **x²** **+** **3** **X,T,θ,n** **-** **2**

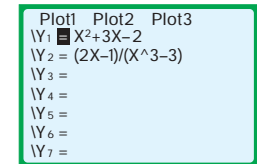
Note: If an expression is already entered for Y_1 , place the cursor anywhere on that expression and press **CLEAR**.

To enter $s = \frac{2v - 1}{v^3 - 3}$ into Y_2 , place the cursor to the right of the equals sign for Y_2 . Then press **(** **2** **X,T,θ,n** **-** **1** **)** **÷** **(** **X,T,θ,n** **^** **3** **-** **3** **)**.

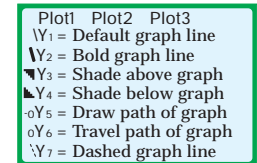


Note: When we enter an equation, the independent variable, v in the expression above, is entered using **X,T,θ,n**. The dependent variable, s in the expression above, is one of Y_1 to Y_0 . Also note the use of parentheses to ensure the correct order of operations.

Observe the black rectangle that covers the equals sign for the two examples we have shown. This rectangle means that the function is “active.” If we were to press **GRAPH**, then the graph of both functions would appear. You can make a function inactive by using the arrow keys to move the cursor over the equals sign of that function and then pressing **ENTER**. This will remove the black rectangle. We have done that for Y_2 , as shown at the right. Now if **GRAPH** is pressed, only Y_1 will be graphed.



It is also possible to control the appearance of the graph by moving the cursor on the **Y=** screen to the left of any Y . With the cursor in this position, pressing **ENTER** will change the appearance of the graph. The options are shown at the right.



Zero

The ZERO feature of a graphing calculator is used for various calculations: to find the x -intercepts of a function, to solve some equations, and to find the zero of a function.

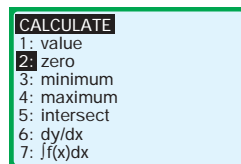
x-intercepts To illustrate the procedure for finding x -intercepts, we will use $f(x) = x^2 + x - 2$.

First, use the Y-editor to enter the expression for the function and then graph the function in the standard viewing window. (It may be necessary to adjust this window so that the intercepts are visible). Once the graph is displayed, use the keystrokes below to find the x -intercepts of the graph of the function.

Press 2nd **CALC** (scroll to 2 for zero of the function)

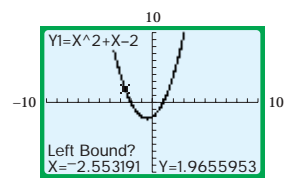
ENTER .

Alternatively, you can just press 2nd **CALC** 2.



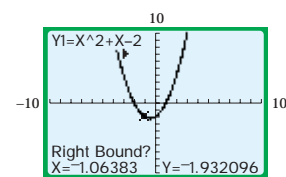
Left Bound? shown at the bottom of the screen asks you to use the left or right arrow key to move the cursor to the *left* of the desired x -intercept. Press

ENTER .



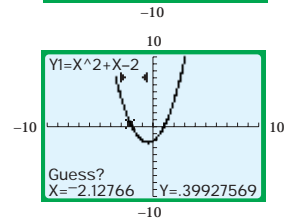
Right Bound? shown at the bottom of the screen asks you to use the left or right arrow key to move the cursor to the *right* of the desired x -intercept. Press

ENTER .



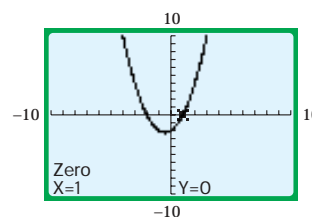
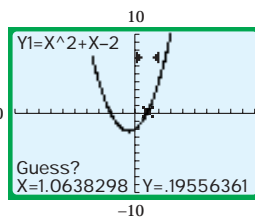
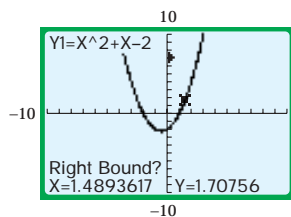
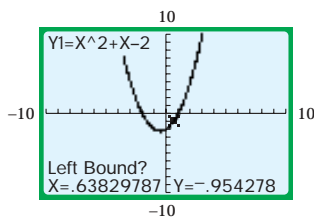
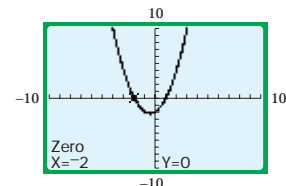
Guess? shown at the bottom of the screen asks you to use the left or right arrow key to move the cursor to the *approximate* location of the desired x -intercept. Press

ENTER .



The x -coordinate of an x -intercept is -2 . Therefore, an x -intercept is $(-2, 0)$.

To find the other x -intercept, follow the same steps as above. The screens for this calculation are shown below.



A second x -intercept is $(1, 0)$.

Solve an equation To use the ZERO feature to solve an equation, first rewrite the equation with all terms on one side. For instance, one way to solve $x^3 - x + 1 = -2x + 3$ is first to rewrite the equation as $x^3 + x - 2 = 0$. Enter $x^3 + x - 2$ into Y_1 and then follow the steps for finding x -intercepts.

Find the real zeros of a function To find the real zeros of a function, follow the steps for finding x -intercepts.

Zoom Pressing **ZOOM** allows you to select some preset viewing windows. This key also gives you access to ZBox, Zoom In, and Zoom Out. These functions enable you to redraw a selected portion of a graph in a new window. Some windows used frequently in this text are shown below.

ZOOM MEMORY	WINDOW
1: ZBox	Xmin = -4.7
2: Zoom In	Xmax = 4.7
3: Zoom Out	Xscl = 1
4 : ZDecimal	Ymin = -3.1
5: ZSquare	Ymax = 3.1
6: ZStandard	Yscl = 1
7↓ ZTrig	Xres = 1

ZOOM MEMORY	WINDOW
1: ZBox	Xmin = -15.16129...
2: Zoom In	Xmax = 15.161290...
3: Zoom Out	Xscl = 1
4: ZDecimal	Ymin = -10
5 : ZSquare	Ymax = 10
6: ZStandard	Yscl = 1
7↓ ZTrig	Xres = 1

ZOOM MEMORY	WINDOW
1: ZBox	Xmin = -10
2: Zoom In	Xmax = 10
3: Zoom Out	Xscl = 1
4: ZDecimal	Ymin = -10
5: ZSquare	Ymax = 10
6 : ZStandard	Yscl = 1
7↓ ZTrig	Xres = 1

ZOOM MEMORY	WINDOW
4 ↑ ZDecimal	Xmin = -47
5: ZSquare	Xmax = 47
6: ZStandard	Xscl = 10
7: ZTrig	Ymin = -31
8 : ZInteger	Ymax = 31
9: ZoomStat	Yscl = 10
0: ZoomFit	Xres = 1

