Keystroke Guide for the TI-83/84 Calculator Series

A

This appendix is designed to help you effectively use your Tl-83 or Tl-84 series calculator to explore the mathematical ideas and applications in this textbook. The keystrokes for both the Tl-83 and Tl-84 families of calculators are the same. Only the colors of the keys differ.

Review Sections A.1–A.4 to learn about the basic operations you can perform on your calculator, especially if you are a new user. These sections are prerequisite to the later material in the appendix, which shows specific keystrokes for corresponding examples in the textbook. Keystrokes are grouped by main topics, such as "graphing functions" or "solving equations."

Today's calculators have many features, and so there is often more than one way to work a problem. Most of the keystrokes in this appendix illustrate only one technique, but you should feel free to explore other ways to accomplish the same task.

A.1 Keys on Your Calculator

The row of buttons just below the screen is used to create graphs and tables. See Figure 1 (taken from the TI-84).

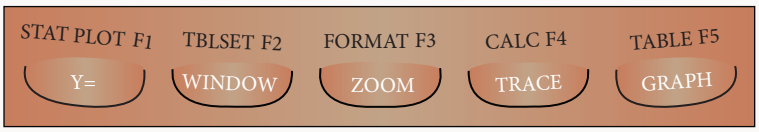


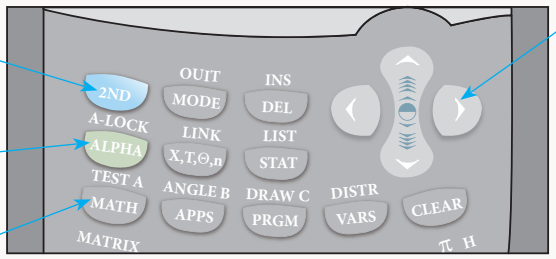
Figure 1

A second set of keys is used for navigation and to access various mathematical functions. See Figure 2. On the TI-84, blue is used for the 2nd function keys. On the TI-83, yellow is used for the 2nd function keys.

The 2nd key accesses the blue function above each key on the TI-84.

The ALPHA key accesses the green letter or character above each key on the TI-84.

The MATH key brings up a menu with various mathematical functions.



Arrow keys move the cursor on the screen.

Figure 2

Throughout this appendix, the keystrokes corresponding to the functions above a key will be denoted by 2nd KEY (Name of function above key). For example, the keystroke for the CALCULATE menu will be given by 2nd TRACE (CALC).

A.2 Getting Started

Initializing Your Calculator

Calculator On/Off Turn the calculator *on* with the ON button. Turn the calculator *off* with the 2nd ON (OFF) button.

Home Screen When you turn the calculator on, the *Home Screen* is displayed. This is where you enter expressions and instructions to compute numeric results. You can always get to the Home Screen from another window mode by pressing 2nd MODE (QUIT). Press (CLEAR) to clear the Home Screen.

The Cursor A blinking box called a *cursor* determines the current position on the screen and is moved around by the arrow keys.

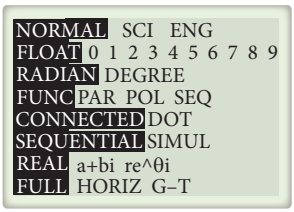


Figure 3

Changing the Screen Contrast Press 2nd and the up arrow key to make the display darker, or press 2nd and the down arrow key to make it lighter.

Initializing the MODE In the MODE menu, accessed by pressing MODE, highlight the first entry in each row unless directed to do otherwise. See Figure 3. Press 2nd MODE (QUIT) to exit the MODE menu.

Arithmetic Operations

Calculations Key in the expression in the Home Screen and then press ENTER. The standard arithmetic operation symbols are used.

Subtraction Symbol and Negative Sign These are *different* keys. To enter a *negative number*, use (−). This key appears directly beneath the 3 key. To *subtract*, use −, directly above the + key.

Order of Operations Working outward from the inner parentheses, operations are performed from left to right. Exponentiation and any operations under a radical symbol are evaluated first, followed by multiplications and divisions, and then additions and subtractions.

If you want to change the algebraic order, you must use parentheses. Parentheses also must be used around the numerator and denominator in fractions. See Section 1.1 for more information.

Example 1 **Evaluating Simple Expressions**

Use a calculator to evaluate the following.

a. $2 + 4 \cdot 5 - 3$

b. $\dfrac{5 + 4}{1 + 2}$

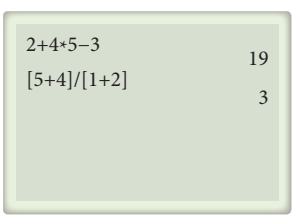


Figure 4

Solution

a. Press **2** + **4** × **5** − **3**. The answer is **19**. See Figure 4.

b. Press (**5** + **4**) ÷ (**1** + **2**). The answer is **3**. Note that the numerator and denominator must be entered using parentheses. See Figure 4.

Menus and Submenus

The TI-83 and TI-84 Plus operate using *menus* and *submenus*. When you press a menu key such as MATH on the calculator, the submenus are listed in the top row of the screen. The highlighted submenu is displayed. Use the right and left arrow keys to move to the other submenus. To exit a menu, press 2nd MODE (QUIT). The following example shows how to access a menu or submenu item.

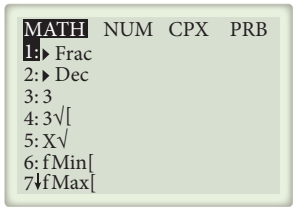


Figure 5

Example 2 **Using the MATH Menu**

Change $\frac{-49}{8}$ into decimal form using the MATH menu.

Solution There are two ways to access a MATH menu item. Use whichever you prefer. The keystrokes in this appendix use Method A to access menu items.

Method A Use a number to select the menu item. Enter (−) **49** ÷ **8** on the Home Screen. Press MATH and then **2** for 2 : ▸Dec. Press ENTER. The answer is **−6.125**. See Figure 5.

Method B Use an arrow key to select the menu item. Enter (−) **49** ÷ **8** on the Home Screen. Press MATH and use the down arrow key to move to 2 : ▸Dec. Press ENTER ENTER. The answer is **−6.125**.

A.3 Editing and Deleting

The following explains how to edit entries in the command line.

Change the Current Entry Move the blinking cursor to the current entry and type in the new entry, which replaces the old entry.

Delete the Current Entry Move the cursor to the character and press DEL.

Insert a New Entry Move the cursor to the character after the insertion point and press 2nd DEL (INS) to type in new text or symbols.

Edit a Previous Entry In the Home Screen, press 2nd ENTER (ENTRY) to recall the latest entry, and edit it as explained above. You may continue to press 2nd ENTER (ENTRY) to recall even earlier entries.

Clear Data To completely delete data from memory, press 2nd + (MEM) and then 2 for 2 : Delete and delete from any of the given menus. Press 2nd MODE (QUIT) to exit the menu.

A.4 Entering and Evaluating Common Expressions

Expressions can be entered on the Home Screen or in the equation editor by pressing the Y= editor. Expressions that can be readily evaluated are usually entered on the Home Screen. Order of operations always applies, so you must use parentheses if you wish to change the order. See Section 1.1 for details.

Your calculator contains many *built-in functions*, such as LN and e^x. Built-in functions can be accessed via the keyboard, the various menus, or the Catalog, which is a menu containing an alphabetical list of all functions. When using built-in functions, a left parenthesis is often included so that you only have to enter the input value and then type the right parenthesis to complete the expression.

The following table illustrates various examples of entering expressions. You may not yet have studied the expressions for numbers 8–14, but you can come back to them as needed.

EXPRESSION (ENTERED ON HOME SCREEN)	EXAMPLE	KEYSTORKES (PRESS ENTER AFTER EACH ENTRY)
1. Rational expression	$\frac{2}{x-1}$	2 ÷ (X, T, θ, n − 1)
2. Change decimal to fraction	0.5	0.5 MATH; press 1 for 1:►Frac
3. Absolute value	$\lvert 5 \rvert$	MATH ▷; press 1 for 1:abs (and then press 5 and)
4. Square root	$\sqrt{12}$	2nd x^2($\sqrt{\ }$) 12)
5. Root from MATH menu	$\sqrt[4]{16}$	4 MATH; press 5 for 5:$\sqrt[x]{\ }$ and then press (16)
Root from Home Screen	$\sqrt[4]{16}$	16 ^ (1 ÷ 4)
6. Square	6^2	6 x^2 *or* 6 ^ 2
7. Power	x^7	X, T, θ, n ^ 7
8. Natural exponential function	e^3	2nd LN (e^x) 3)
9. Natural logarithm	$\ln(x-2)$	LN X, T, θ, n − 2)
10. Common logarithm	$\log(x+1)$	LOG X, T, θ, n + 1)
11. Logarithm to base b (use change-of-base formula)	$\log_2 x$	(LN X, T, θ, n) ÷ (LN 2)
12. Factorial	7!	7 MATH ▷ ▷ ▷; press 4 for 4:!
13. Combination	${}_8C_4$	8 MATH ▷ ▷ ▷; press 3 for 3:nCr and then press 4
14. Permutation	${}_8P_3$	8 MATH ▷ ▷ ▷; press 2 for 2:nPr and then press 3
15. Scientific notation	3×10^4	3 2nd , (EE) 4

Evaluating Variable Expressions

You can store the value of a variable and then use it to evaluate expressions. From the Home Screen, you can assign the variable any name from A to Z.

Example 1 **Evaluating an Expression Containing One Variable**

Assign the value of −1 to the variable A and evaluate $2A^2 + 4A - 1$. Then evaluate the expression for A = 3.

Solution Access the Home Screen.

1. Store the value of −1 by pressing (−) 1 STO ALPHA A ENTER.
2. Enter the expression as follows: 2 ALPHA A ^ 2 + 4 ALPHA A − 1 ENTER. The calculator will display the answer of **−3**. See Figure 6.

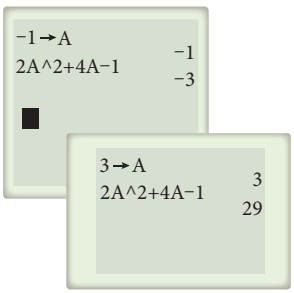


Figure 6

3. If you want to evaluate the expression for A = 3, store the value of 3 in A as follows: 3 STO ALPHA A ENTER. Now recall the variable expression by pressing 2nd ENTER (ENTRY) 2nd ENTER (ENTRY) ENTER. The answer is **29**. See Figure 6.

You can also evaluate expressions containing more than one variable.

Example 2 Evaluating an Expression Containing Many Variables

Evaluate the expression $\frac{A + 2B^2}{3C}$ for A = −2, B = 1, and C = $\frac{1}{2}$.

Solution

1. Assign a value to each variable:

(−) 2 STO ALPHA A ALPHA : 1 STO ALPHA B ALPHA :
1 ÷ 2 STO ALPHA C ENTER

Only the value of C is displayed, but the other values will be stored in memory. The colon allows you to enter multiple statements on one line.

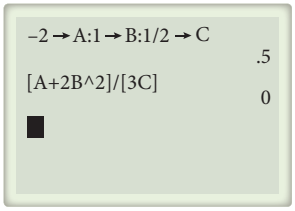


Figure 7

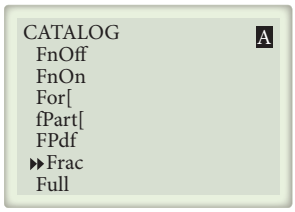
2. Enter the expression:

(ALPHA A + 2 ALPHA B ^ 2) ÷ (3 C) ENTER

The answer of **0** is displayed. See Figure 7. The fractional expression must be entered using parentheses to separate the numerator and denominator. You can change the values of the variables and reevaluate the expression as shown in the previous example.

Using the CATALOG Function

The CATALOG function, the function above the **0** key, is an alphabetic list of all the functions and symbols available on the calculator. Most of them are in a menu or on the keyboard, but you can use the CATALOG when you forget which menu you need.



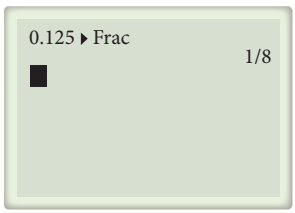


Figure 8

Example 3 Using the CATALOG

Use the CATALOG to convert 0.125 to a fraction.

Solution

1. Enter 0.125 on the Home Screen: **0.125**.

2. Press 2nd 0 (CATALOG). Since you want to convert to a fraction, your function begins with the letter F. Press COS (F). You do not need to press ALPHA or 2nd because the CATALOG is set up to directly accept alphabetical input. Use ▽ to scroll to the command ▸Frac.

3. Press ENTER ENTER. The answer $\frac{1}{8}$ is displayed. See Figure 8.

A.5 Entering and Evaluating Functions

You must enter functions into the Y = Editor in order to generate tables and graphs. Once the function is entered, it can be evaluated at different values of the input variable. When defining a function in the Y = Editor, only X is allowed as the input variable. If your function uses a different letter for the input variable, you must rewrite the function in terms of X before entering it into the Y = Editor.

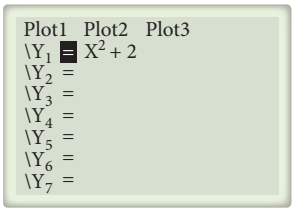


Figure 9

Example 1 **Evaluating a Function**

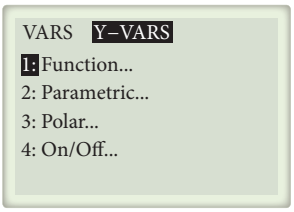
Enter the function $f(x) = x^2 + 2$ and find $f(3)$ and $f(-1)$.

Solution

1. Press [Y=] to access the editor. In the Y = Editor, enter the definition for Y_1 as follows: [X, T, θ, n] [^] **2** [+] **2**. Note that the equal sign is highlighted. See Figure 9.

2. To evaluate Y_1 (3):

- **a.** Press [2nd] [MODE (QUIT)] to return to the Home Screen.
- **b.** To access the function Y_1, press [VARS] and use the right arrow key to highlight the Y–VARS submenu.
- **c.** Press **1** to access the FUNCTION menu and press **1** for the function Y_1. This is the only way to access any named function.
- **d.** You will now be on the Home Screen showing Y_1. Complete the expression by typing [(] **3** [)] [ENTER]. The answer, **11**, is displayed. See Figure 10.



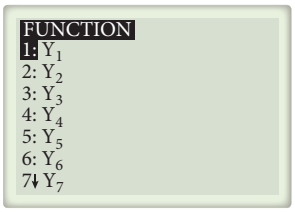


Figure 10

3. To evaluate $Y_1(-1)$, press [2nd] [ENTER (ENTRY)] to recall the previous line. Move the cursor to highlight 3, delete it, and replace it with [(–)] **1**. Press [ENTER] to get the answer, **3**.

Alternate Method Enter the function as in Step 1. You can use the TABLE menu in ASK mode to evaluate a function. See Section A.6 for details.

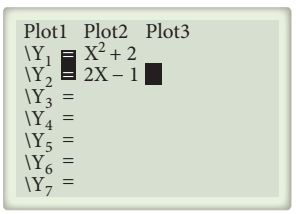


Figure 11

Selecting and Deselecting Functions in the Y = Editor Move the cursor to the equal sign and press [ENTER]. When the equal sign is highlighted, the function is selected. When it is not highlighted, the function is not selected.

You can enter more than one function in the Y = Editor. Figure 11 shows two functions entered in the Y = Editor.

Deleting Functions in the Y = Editor Move the cursor to the right of the equal sign of the function you wish to delete. Press [CLEAR].

A.6 Building a Table

To create a table of values for a function, use the commands 2nd GRAPH (TABLE) and 2nd WINDOW (TBLSET). The function *must* be entered using the Y = Editor.

Example 1 Generating a Table Automatically

Display a table of values for $f(x) = \frac{2}{3}x - 2$, $x = -5, -4, -3, \ldots$.

Solution

1. Press Y= and enter the function as Y_1:

   (2 ÷ 3) X, T, θ, n − 2. See Figure 12.

2. Press 2nd WINDOW (TBLSET). Fill in the following:
   - `Tblstart` = (−) 5; Δ `Tbl` = 1
   - Highlight `Auto` for both `Indpnt:` and `Depend:` options. This sets the beginning X value and the change in each X value. The highlighted `Auto` option for the independent variable will automatically generate the X values.
   - Press 2nd GRAPH (TABLE). See Figure 13.

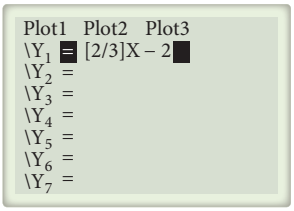


Figure 12

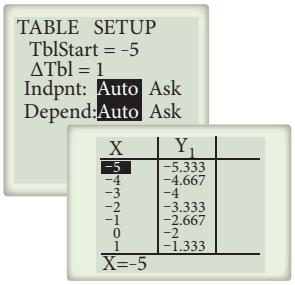


Figure 13 Generating tables

Example 2 shows how to manually enter the values for the independent variable.

Example 2 Generating a Table Manually

Display a table of values for $f(x) = \sqrt{4 - x}$, $x = 4, 3, 2, 0, -1, -5$.

Solution

1. In the Y = Editor, enter the function as Y_1. See Figure 14.

   2nd x²(√) 4 − X, T, θ, n)

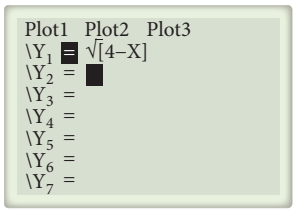


Figure 14

2. Press 2nd WINDOW (TBLSET). Fill in the following:
   - `Tblstart` = (−) 5 ; Δ`Tbl` = 1
   - Highlight `Ask` for `Indpnt` and `Auto` for `Depend`. The Ask option for the independent variable is highlighted to manually generate the X values. See Figure 15.

3. Press 2nd GRAPH (TABLE). The table is displayed with no entries. Move the cursor to the first entry position in the X input column to enter the X values. Press

   (−) 5 ENTER (−) 1 ENTER 0 ENTER 2 ENTER 3 ENTER 4 ENTER.

   As each input value is entered, the corresponding output value appears in the Y_1 column. See Figure 15.

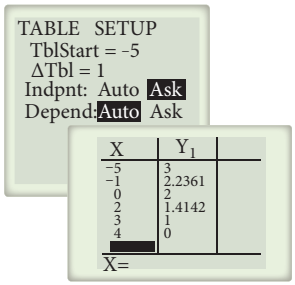


Figure 15

A.7 Graphing Linear, Quadratic, and Piecewise-Defined Functions

To graph a function on a calculator, first enter the function in the Y = Editor. Then choose a window setting by specifying the minimum and maximum values of x and y. You can use a table of values to help you determine these values. Window settings are abbreviated as **[Xmax, Xmin] (Xscl)** by **[Ymax, Ymin] (Yscl)** Xscl and Yscl define the distance between the tick marks on the x- and y-axes, respectively. If Xscl = 1 or Yscl = 1, these values will be omitted from the keystroke sequence.

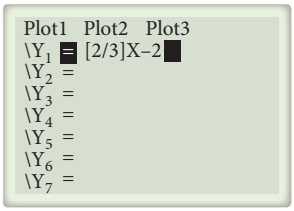


Figure 16

Example 1 Graphing a Function

Graph $y = \frac{2}{3}x - 2$ by using a table of values to choose an appropriate window.

Solution

1. Enter the function. Press [Y=] [(] **2** [÷] **3** [)] [X, T, θ, n] [−] **2** to enter the function as Y_1 in the equation editor. See Figure 16.

2. Generate the table. Press [2nd] [WINDOW (TBLSET)] and fill in the following: `Tblstart` = **−5**; `ΔTbl` = **1**; highlight `Auto` for both `Indpnt:` and `Depend:` and press [2nd] [GRAPH (TABLE)]. See Figure 17.

3. Scroll through the table. The function crosses the x-axis at (3, 0) and the y-axis at (0, −2). These values must be displayed in the window. A window size of [−7, 7] by [−7, 5] will show the x- and y-intercepts and also give a good view of the graph. Other choices are also possible.

4. Enter the window dimensions by pressing [WINDOW]. Then set `Xmin` = [(−)] 7, `Xmax` = 7, `Xscl` = 1 and `Ymin` = [(−)] 7, `Ymax` = 5, `Yscl` = 1. Press [GRAPH]. The graph in Figure 18 is displayed.

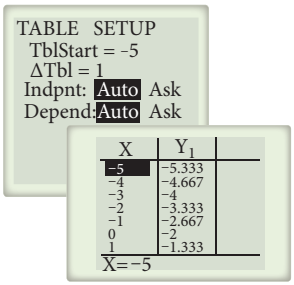


Figure 17

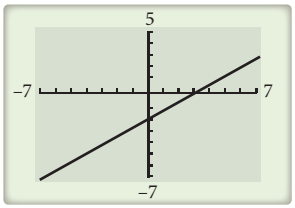


Figure 18

You can also graph a function by using built-in window settings accessed from the [ZOOM] menu. This will be discussed in the following section.

Example 2 Built-in Window Settings

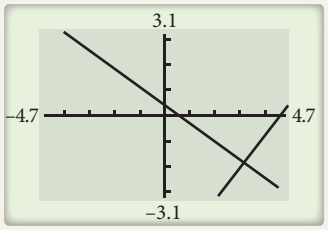
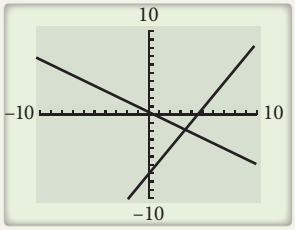
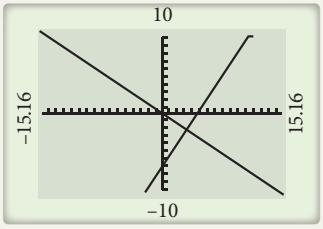
Graph the lines $y = -\frac{2}{3}x + \frac{1}{3}$ and $y = \frac{3}{2}x - 7$ using the decimal, standard, and square window settings.

Solution

1. Press [Y=] and enter [(−)] **2** [÷] **3** [X, T, θ, n] [+] **1** [÷] 3 [ENTER] for Y_1.

2. For Y_2, enter **3** [÷] **2** [X, T, θ, n] [−] **7** [ENTER].

3. The keystrokes for each type of window are summarized in the following table.

DECIMAL	STANDARD	SQUARE
Press ZOOM and then **4**.	Press ZOOM and then **6**.	Press ZOOM and then **5**.
		
The lines look perpendicular. The units on both axes have the same size. However, the window size is not big enough.	The lines do not look perpendicular. The units on each axis have different sizes.	The lines look perpendicular. The units on both axes have the same size.

To see the true shape of a circle, an ellipse, or any other figure, you will need to use a decimal or a square window.

Example 3 **Graphing a Quadratic Function**

Graph the function $f(x) = x^2 + x - 12$.

Solution

1. Enter the function as Y_1 in the equation editor by pressing

Y= X, T, θ, n x^2 + X, T, θ, n − **12**.

If you simply press ZOOM **6** to graph in a standard window, you will not obtain a complete picture. Part of the parabola will be cut off. See Figure 19. Since the graph of this function is a parabola, the vertex should be visible on your graph.

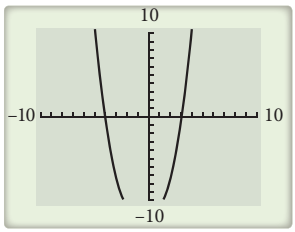


Figure 19

2. Generate a table of values to help you locate the vertex. Press 2nd WINDOW (TBLSET) and fill in the following: `Tblstart` = (−) **10**, `ΔTbl` = **1**, highlight `Auto` for both `Indpnt:` and `Depend:`. Press 2nd GRAPH (TABLE). Refer to Section B.6 for more details. Scrolling through the table, you can see that the Y_1 values decrease until X = 0 and then start to increase. The vertex is near the point (0, −12). See Figure 20.

3. Press WINDOW and enter window settings such as [−10, 10] by [−14, 10] or something similar. See Figure 21.

4. Press GRAPH and a complete graph is displayed. See Figure 22.

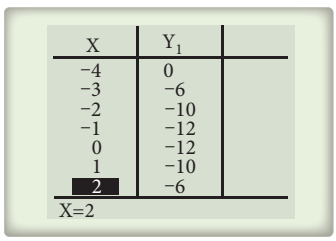


Figure 20

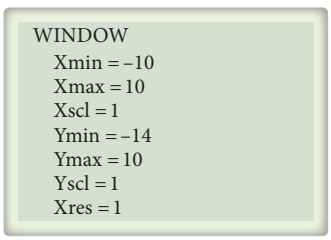


Figure 21

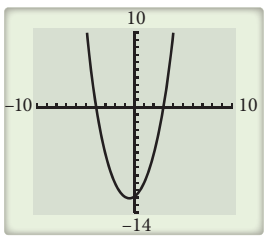


Figure 22

Example 4 Graphing a Piecewise-Defined Function

Graph the piecewise-defined function $H(x) = \begin{cases} 3, & x < 1 \\ 1 + x, & x \geq 1 \end{cases}$.

Solution

1. Assign a different name to each piece of the function in the Y = Editor and state the x values for which each piece is defined. In the Y = Editor, enter

$$Y_1 = 3 \; (\; \boxed{\text{X, T, } \theta, n} \; \boxed{\text{2nd}} \; \boxed{\text{MATH (TEST)}} \; .$$

Press 5 to choose 5 : <. Then enter **1**).

Enter $Y_2 =$ (**1** + X, T, θ, n) (X, T, θ, n 2nd MATH (TEST). Press **4** for 4 : ≥.

Then enter **1**). See Figure 23.

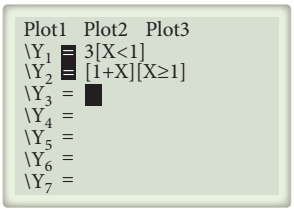


Figure 23

2. Press ZOOM **6** to get the graph. See Figure 24.

3. At $x = 1$, the function jumps from 3 to 2, and the screen may show a line connecting these values. This is not part of the actual graph. To keep the calculator from connecting across the jump, press MODE and set the mode to DOT. Now press GRAPH. See Figures 25 and 26.

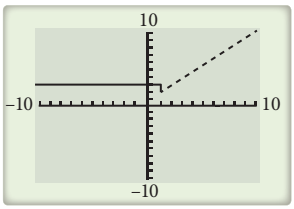


Figure 24

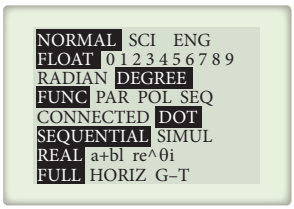


Figure 25

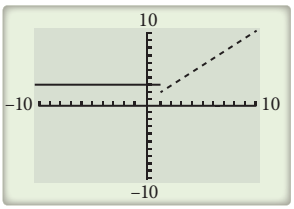


Figure 26

To describe an interval such as $1 \leq x \leq 3$ for a piecewise-defined function, you must rewrite the interval as $x \geq 1$ *and* $x \leq 3$. To enter *and*, press 2nd MATH (TEST) and select the LOGIC submenu. Press 1 for 1:and.

A.8 Graphing Polynomials, Rational Functions, and Inequalities

For more complicated functions such as polynomials, you may have to try a few window settings before you get a reasonable view of the graph.

Example 1 Graphing a Polynomial Function

Graph the function $f(x) = (x - 6)^3(x + 2)^2$.

Solution

1. In the Y = Editor, enter

(X, T, θ, n − **6**) ^ **3** (x, T, θ, n + **2**) ^ **2**

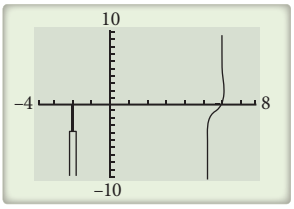


Figure 27

2. Since this polynomial has zeros at $x = 6$ and $x = -2$, choose Xmin and Xmax so that the zeros lie between them. Press WINDOW and choose the settings $[-4, 8]$ by $[-10, 10]$. Press GRAPH. Note that a part of the graph is cut off. See Figure 27.

3. Press ZOOM and press **0** for 0: ZoomFit to fit the y values. Now you can see the zeros and the end behavior of the function. See Figure 28.

4. To get a better view of the middle portion of the graph, press WINDOW and set `Ymin` = (−) **2000**, `Ymax` **= 2000**, `Yscl` **= 500** and press GRAPH. The graph shown in Figure 29 is displayed. The zeros, end behavior, and shape of the graph between the zeros are now visible on the screen.

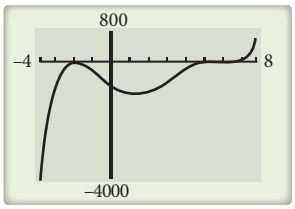


Figure 28

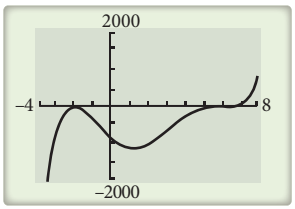


Figure 29

Example 2 shows how to graph a rational function.

Example 2 **Graphing a Rational Function**

Graph $f(x) = \frac{1}{x-1}$ in a standard window.

Solution

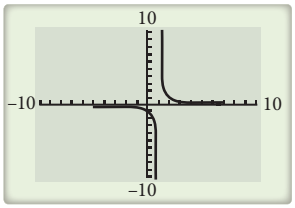


Figure 30

1. Enter $Y_1 = 1/(X - 1)$ in the Y = Editor. Note that you *must* enclose the denominator $X - 1$ in parentheses. Press ZOOM and then **6** for `6:ZStandard` to get the graph in Figure 30 in the standard window.

2. Some older calculator models will show a vertical line that connects the negative and positive portions of the graph. To get around this, you can set the mode to DOT by pressing MODE, selecting `DOT`, and then pressing ENTER. Press GRAPH to display the function again in the standard window. Make sure you reset the mode to CONNECTED for graphing other types of functions.

Graphing Inequalities

You can shade the area above or below a function entered in the Y = Editor by using the marker setting to the left of the function.

Example 3 **Graphing a System of Inequalities**

Graph the following system of inequalities.

$$\begin{cases} y \geq x \\ y \leq -x \end{cases}$$

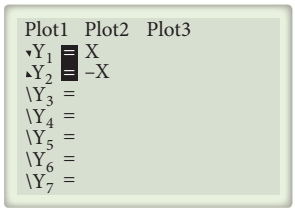


Figure 31

Solution To satisfy this system of inequalities, we must shade the area above $y = x$ and below $y = -x$.

1. In the Y = Editor, enter X, T, θ, n in Y_1 and then use the ◁ key to move to the leftmost end of the screen. Press ENTER ENTER to activate the "shade above" command. See Figure 31.

2. In the Y = Editor, enter (−) X, T, θ, n in Y_2 and then use the ◁ key to move to the leftmost end of the screen. Press ENTER ENTER ENTER to activate the "shade below" command. See Figure 31.

3. Press ZOOM **6** to graph. The region in the xy plane satisfying both inequalities is shaded, along with both the horizontal and vertical lines. See Figure 32.

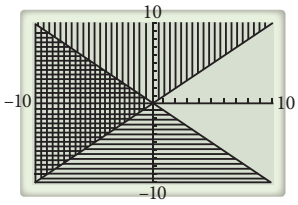


Figure 32

A.9 Solving Equations

There are two ways to solve an equation on a graphing calculator. One is by calculating the zero(s) of the corresponding functions and the other is by finding the intersection of the graphs of the two functions.

Solving an Equation Using the ZERO Feature

To solve an equation using the ZERO feature, you first must write the equation in the form $f(x) = 0$. You then proceed to find the zero(s).

Example 1 **Solving a Quadratic Equation Using the ZERO Feature**

Find all real number solutions of $3x^2 - 6x - 1 = 0$.

Solution Solving the equation is the same as finding the real zeros of $f(x) = 3x^2 - 6x - 1$.

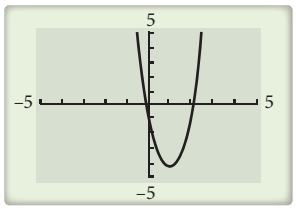


Figure 33

1. In the Y = Editor, enter $Y_1 =$ **3** [x, T, θ, n] [x^2] [−] **6** [x, T, θ, n] [−] **1**.
2. Press [WINDOW] and use a window setting of [−5, 5] by [−5, 5]. If needed, refer to Section A.7 for more details. See Figure 33.
3. Press [2nd] [TRACE (CALC)] to display the CALCULATE menu.
4. Press 2 for `2:zero` to find a real zero. You are prompted for a left bound. Move the arrow key to the left of one of the zeros and press [ENTER]. See Figure 34.
5. You are now prompted for a right bound. Use [▷] to move to the right of the zero on the graph and press [ENTER]. See Figure 35.

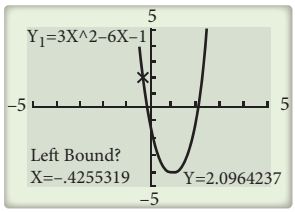


Figure 34

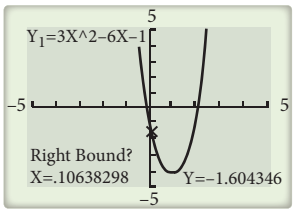


Figure 35

6. Now you will need a guess for the zero. See Figure 36. Move the cursor very near to the zero on the graph and press [ENTER]. **The zero is $x \approx -0.1547005$.** See Figure 37. The other zero, at $x \approx 2.1547005$, can be found similarly.

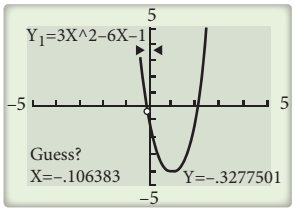


Figure 36

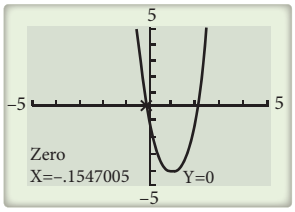


Figure 37

Solving an Equation Using the INTERSECT Feature

You can also solve an equation by using the `intersect` option from the CALCULATE menu.

Example 2 **Solving an Equation Using the INTERSECT Feature**

Solve the equation $2x + 1 = -3x + 11$.

Solution Solving this equation is the same as finding the intersection of the lines $y_1 = 2x + 1$ and $y_2 = -3x + 11$.

1. In the Y = Editor, enter $Y_1 = 2x + 1$ and $Y_2 = -3x + 11$. Use the (−) key to enter the negative sign. Press ZOOM **6** to graph in the standard window. See Section A.7 for details.
2. Press 2nd TRACE (CALC) to display the CALCULATE menu.
3. Press 5 for `5:intersect` to find the intersection point(s).
4. Press ENTER when asked for the first and second curves. See Figure 38.
5. Now you will need a guess for the intersection point. See Figure 39. Move the cursor very near to the intersection point on the graph and press ENTER. The intersection is at $x = 2$, $y = 5$, or (2, 5). See Figure 40.

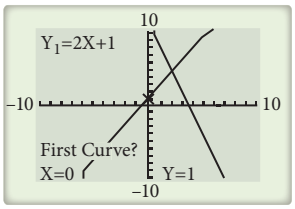


Figure 38

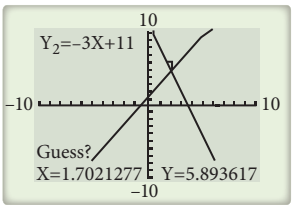


Figure 39

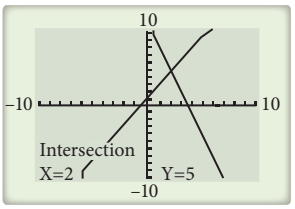


Figure 40

A.10 Finding the Maximum and Minimum of a Function

To obtain the maximum and minimum values of a function, also referred to as turning points or extrema, use the CALCULATE menu.

Example 1 **Determining Local Extrema**

Find the local maximum and minimum values of $f(x) = -2x^4 + 8x^2$.

Solution

1. Enter $Y_1 = -2x^4 + 8x^2$ in the Y = Editor and graph the function in the standard window. See Section A.7 for basic graphing details.
2. To get a better view of the locations of the maxima and minima, adjust the window size to $[-5, 5]$ by $[-10, 10]$. For other problems, you may have to adjust the window size first just to see the maxima and minima. See Figure 41.
3. Each extremum must be computed separately. To calculate the maximum in the first quadrant, press 2nd TRACE (CALC) and then 4 for `4:maximum`. You are prompted for `Left Bound`. See Figure 42.

4. Use the left or right arrow keys to move to the *left* of this maximum. Press ENTER.

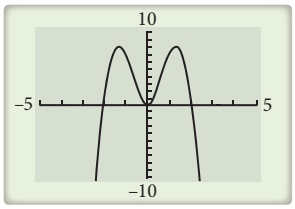


Figure 41

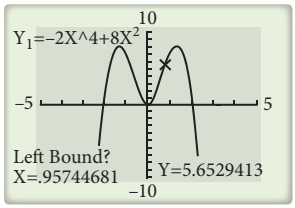


Figure 42

5. You are next prompted for `Right Bound`. Use the left or right arrow keys to move to the *right* of this maximum. Press ENTER. Note that ▶ and ◀ show the interval on which the calculator program looks for a maximum See Figure 43.

6. You are now prompted for `Guess`. See Figure 44. Move the cursor very close to the maximum on the graph and press ENTER. **The maximum is at $x \approx 1.414214$, $y = 8$.** See Figure 45. Similarly, the other maximum can be found at $x \approx -1.414214$, $y = 8$. You can also find that the minimum is at $x = 0$, $y = 0$.

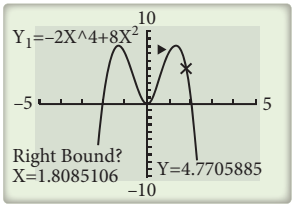


Figure 43

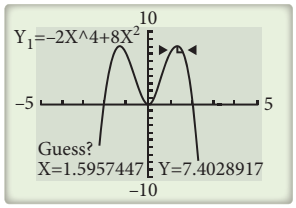


Figure 44

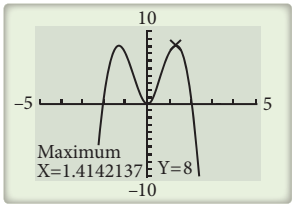


Figure 45

A.11 Complex Numbers

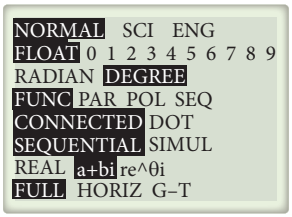


Figure 46

To enter complex numbers into the calculator, you first must set the mode to $a + bi$ by accessing the MODE menu. Move the arrow keys until $a + bi$ is highlighted. Press ENTER. See Figure 46. Press 2nd MODE (QUIT) to exit the menu.

The imaginary number $i = \sqrt{-1}$ is accessed by pressing 2nd . (*i*), on the bottom row of the keyboard. For instance, to enter $2 + 3i$ from the Home Screen, press 2 + 3 2nd . (*i*).

Example 1 **Operations with Complex Numbers**

a. Subtract: $(1 + i) - (2 - i)$

b. Multiply: $(1 + 3i)(2 - 4i)$

c. Find the conjugate of $1 + 2i$.

d. Divide: $\dfrac{2}{-3 + 2i}$.

Solution

All of the following operations are entered in the Home Screen.

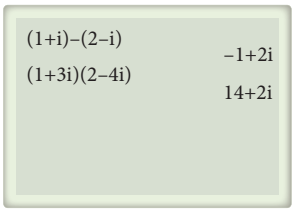


Figure 47

a. Enter (**1** + 2nd . (*i*)) – (**2** – 2nd .(*i*)) ENTER. The result is $-\mathbf{1} + \mathbf{2}i$. See Figure 47.

b. Enter (**1** + **3** 2nd . (*i*)) (**2** – **4** 2nd . (*i*)) ENTER. The result is $\mathbf{14} + \mathbf{2}i$. See Figure 47.

c. Press MATH ▷ ▷ to highlight CPX. Press **1** for `1:conj` (and enter **1** + **2** 2nd . (*i*)) ENTER. The result is $\mathbf{1} - \mathbf{2}i$. See Figure 48 and Figure 49.

d. Enter **2** ÷ ((–) **3** + **2** 2nd . (*i*)) ENTER. Press MATH **1** to access `▸1:Frac` and press ENTER. The result is $\frac{-6}{13} - \frac{4}{13}i$. See Figure 50.

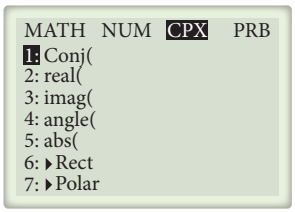


Figure 48

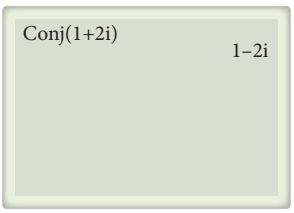


Figure 49

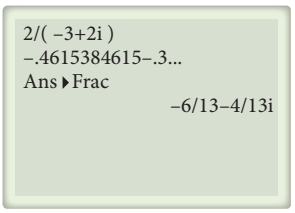


Figure 50

A.12 Fitting Curves to Data (Regression)

You can use the graphing calculator to fit a line or curve through a set of data points. This procedure is referred to as **curve-fitting** or **regression**.

Body Weight (grams)	Heart Weight (grams)
281.58	1.0353
285.03	1.0534
290.03	1.0726
295.16	1.1034
300.63	1.1842
313.46	1.2673

Example 1 **Modeling the Relation Between Body Weight and Organ Weight**

The table at the left gives the body weights of laboratory rats and the corresponding weights of their hearts, in grams. All data points are given to five decimal places. (*Source:* NASA Life Sciences Data Archive, 2005)

Find an expression for the *linear* function that best fits the given data points, and graph the function.

Solution

1. Enter the data into the calculator as follows.

a. Press STAT 1 to display the list editor. Clear any existing data from each list by pressing △ CLEAR ENTER.

b. Highlight the first entry position in `L1`. Enter the values for the independent variable, body weight, here. Enter **281.58** ENTER **285.03** ENTER **290.03** ENTER **295.16** ENTER **300.63** ENTER **313.46** ENTER.

c. Use the arrow keys to highlight the first position in `L2`. Enter **1.0353** ENTER **1.0534** ENTER **1.0726** ENTER **1.1034** ENTER **1.1842** ENTER **1.2673** ENTER. The table in Figure 51 is displayed.

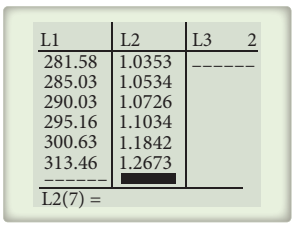


Figure 51

2. Construct the graph.

a. Press [Y=] and turn off or clear any functions.

b. Press [2nd] [Y = (STAT PLOT)] **1** to select `1:Plot1`.

c. Highlight `On` and press [ENTER] to turn Plot 1 on. See Figure 52.

d. Highlight the following selections and press [ENTER]. See Figure 52.

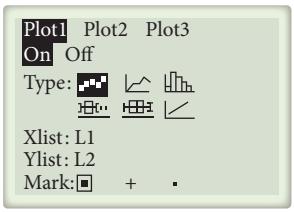


Figure 52

```
Type: Scatter Plot
      (the first icon)
Xlist: L1
Ylist: L2
Mark: °
```

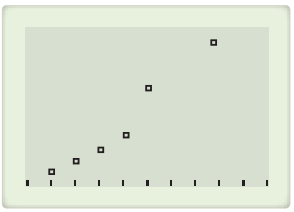


Figure 53

e. Press [ZOOM] **9** for `9:ZoomStat` for the scatter plot of the data. See Figure 53.

3. Find the linear function of best fit.

a. Press [STAT] [▷] to display the CALCULATE menu.

b. Press **4** to select regression type `4:LinReg (ax+b)` and then press [ENTER]. The regression coefficients and equation are displayed. See Figure 54. The linear equation of best fit is

$$y \approx 0.0075854x - 1.1131.$$

4. To plot the line of best fit, you must first copy the equation into the Y = Editor and then graph.

a. Press [Y=] to display the equation editor. Move to an empty space.

b. Press [VARS] **5** to access `5: Statistics`. Press [▷] [▷] to move to `EQ` and then press 1 for `1:RegEQ`. The current regression equation will be copied to the Y = Editor.

c. Press [GRAPH]. See Figure 55.

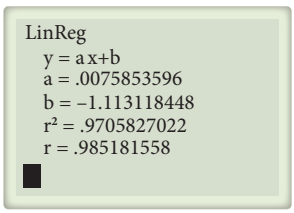


Figure 54

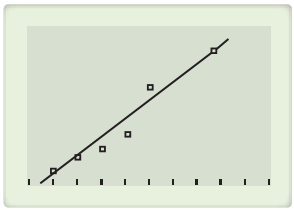


Figure 55

To fit functions other than linear functions to a data set, follow the same steps as in the previous example, but use the corresponding number for the desired regression type in Step 3(b). For example, you can find a quadratic function of best fit by pressing 5 in Step 3(b).

A.13 Matrices

To enter matrices, access the matrix menu by pressing [2nd] [x^{-1} (MATRIX)]. (On the TI-83, enter [MATRX].)

Example 1 **Entering Matrices**

Enter the matrix $\begin{bmatrix} 3 & 1 & -10 & -8 \\ 1 & 1 & -2 & -4 \\ -2 & 0 & 9 & 5 \end{bmatrix}$ as matrix A.

Solution

1. Press [2nd] [x^{-1} (MATRIX)] [▷] [▷] to access the EDIT submenu.

2. Press 1 to select `L : [A]`. The row dimension is highlighted. Now press 3[ENTER]. Next, the column dimension is highlighted. Press 4[ENTER]. You have requested a 3×4 matrix. See Figure 56.

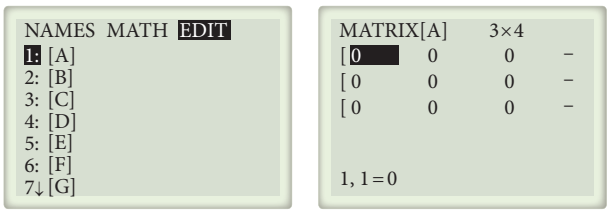


Figure 56

3. The first position is highlighted. Enter the individual elements of the matrix as follows.

a. Press **3**[ENTER].

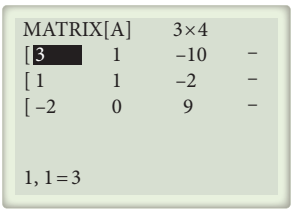


Figure 57

b. The second position in row 1 is highlighted. Press **1**[ENTER].

c. The third position in row 1 is highlighted. Press [(–)] **10**[ENTER].

Continue in this manner until all the elements have been entered. The entire matrix does not fit on one screen. See Figure 57. Press [▷] to view the last column of the matrix.

4. Press [2nd] [MODE (QUIT)] to save the matrix. To access the matrix A from the Home Screen, press [2nd] [x^{-1} (MATRIX)]. Select the NAMES submenu. Press **1** to select `1:[A]` and then press [ENTER]. You can also just press [ENTER] [ENTER] since `1:` is already selected. The matrix A now appears on the Home Screen. See Figure 58.

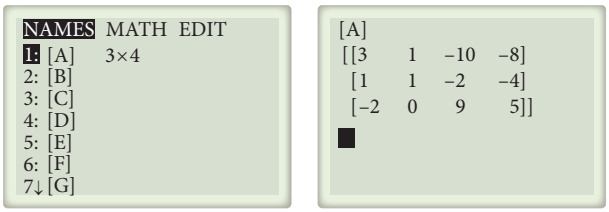


Figure 58

Gauss-Jordan Elimination

Your calculator will compute the reduced row echelon form, abbreviated rref, of a matrix using Gauss-Jordan elimination.

Example 2 Gauss-Jordan Elimination

Solve the following system of equations.

$$3x + y - 10z = -8$$
$$x + y - 2z = -4$$
$$-2x + 9z = 5$$

Solution

1. The augmented matrix for this system is the matrix from the previous example. Enter it as matrix `A` if you have not already done so.

2. From the Home Screen, Press [2nd] [x^{-1} (MATRIX)]. Press [▷] to highlight `MATH`. Press [ALPHA] **B** to access the command `B: rref`. You will see `rref` on the Home Screen. See Figure 59.

3. Input the name of the matrix by pressing [2nd] [x^{-1} (MATRIX)]. Select the `NAMES` submenu. Press **1** to select `1: [A]`. Close the parentheses by pressing [)] [ENTER].

4. The matrix in Figure 60 is displayed. You can read off the answers: $x = 2$, $y = -4$, and $z = 1$.

Figure 59 Figure 60

Matrix Arithmetic and Inverses

To perform arithmetic with matrices on the calculator, first enter and store the matrices in the MATRIX menu, as shown in Example 1. The arithmetic operations are performed on the Home Screen, with the matrices pasted in from the `MATRIX ▶ NAMES` submenu.

Example 3 Matrix Arithmetic

Let A, B, and C be given as follows.

$$A = \begin{bmatrix} 1 & -1 & 0 \\ 2 & -5 & 1 \end{bmatrix}, B = \begin{bmatrix} 2 & -2 \\ -1 & 4.2 \\ 2 & -6 \end{bmatrix}, C = \begin{bmatrix} 0 & -4 \\ 2 & 6 \\ 0 & 1 \end{bmatrix}$$

Find the following.

a. B + C **b.** AC

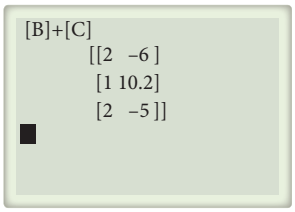


Figure 61

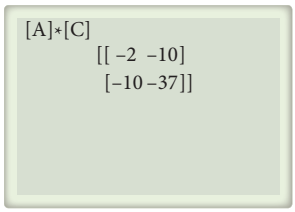


Figure 62

Solution Enter the matrices A, B, and C using the technique described in Example 1. Then do the following.

a. On the Home Screen, press 2nd x^{-1} (MATRIX). Choose B in the NAMES submenu by pressing 2. Press +. Press 2nd x^{-1} (MATRIX) and press 3 to choose C in the NAMES submenu. Press ENTER to perform the computation. See Figure 61. An error message will be displayed if you try to add or subtract matrices of unequal dimensions.

b. On the Home Screen, press 2nd x^{-1} (MATRIX). Choose A in the NAMES submenu by pressing **1**. Press the × sign. Press 2nd x^{-1} (MATRIX) and press **3** to choose C in the NAMES submenu. Press ENTER to perform the computation. See Figure 62.

Matrix Inverses and Determinants

Example 4 Finding a Matrix Inverse and a Determinant

Find the inverse and determinant of the square matrix

$$A = \begin{bmatrix} 3 & 3 & 9 \\ 1 & 0 & 2 \\ -2 & 3 & 0 \end{bmatrix}.$$

Solution

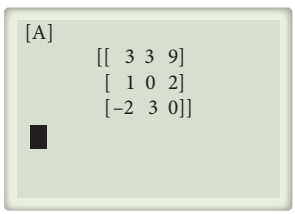


Figure 63

1. Enter the matrix A as directed in Example 1. On the Home Screen, display A by pressing 2nd x^{-1} (MATRIX) and then choose A by pressing 1. See Figure 63.
2. To find the inverse, press x^{-1} (MATRIX) ENTER. Only part of the matrix shows on the screen. Use the left and right arrow keys to scroll through the rest of the matrix.
3. To change the decimals to fractions, press MATH **1** for ▶1:Frac and then press ENTER. See Figure 64.
4. To check your work, store the inverse in B as follows. Press 2nd (−) (ANS) STO▶ 2nd x^{-1} (MATRIX). Press 2 to store in 2: [B] and press ENTER.
   Multiply matrix A by its inverse B as instructed in the section on matrix arithmetic. You should see the identity matrix.
5. To compute det(A), press 2nd x^{-1} (MATRIX). Press ▷ to highlight MATH. Then press **1** for 1: det(. Display the matrix name A as in Step 1, and press) ENTER. The answer is **−3**. See Figure 65.

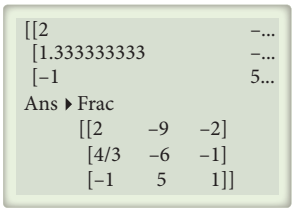


Figure 64

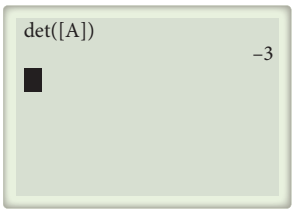


Figure 65

A.14 Sequences and Series

To plot sequences, you must change a setting in the MODE menu:

1. Press MODE ▽ ▽ ▽ ▷ ▷ ▷ to highlight `Seq`.
2. Press ENTER 2nd MODE (QUIT). Remember to change back to FUNCTION mode once you finish working with sequences.

Example 1 **Entering and Graphing a Sequence**

Graph the sequence defined by $u(n) = 100 + 5n$, $n = 0, 1, 2, 3, ..., 30$.

Solution Make sure you have set the calculator to SEQUENCE mode as outlined in the beginning of this section.

1. In the Y = Editor, set `nMin` to 0. Then enter $100 + 5n$ for $u(n)$. The variable n is entered by pressing X, T, θ, n. Since $n = 0$ is the minimum n value, enter u(nMin) = 100. See Figure 66.
2. Press 2nd GRAPH (TABLE) to see a table of values, as shown in Figure 67.
3. The plot will start at $n = 0$ and end at $n = 30$. From the table, the $u(n)$ values range from 100 to 250. Enter the data as shown in the following screens and press GRAPH. See Figure 68.

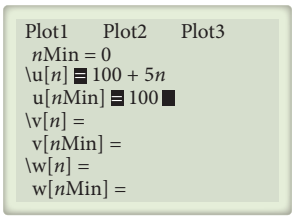


Figure 66

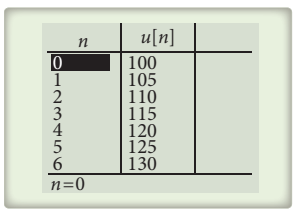


Figure 67

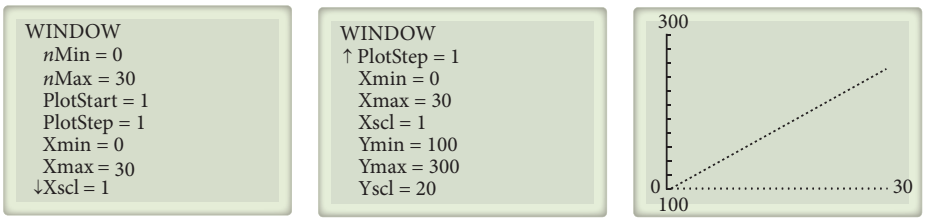


Figure 68

Example 2 **Summing the Terms of a Sequence**

Find the sum of the first 11 terms of the sequence defined by $a_j = 2 + 3j$, $j = 0, 1, 2....$

Solution From the Home Screen, press 2nd STAT (LIST) ▷ ▷ **5** to choose the `sum` function. Then press 2nd STAT (LIST) ▷ **5** to choose the `seq` function. Enter

2 + **3** X, T, θ, n , X, T, θ, n , 0 , **10**)) ENTER.

The answer is **187**. See Figure 69.

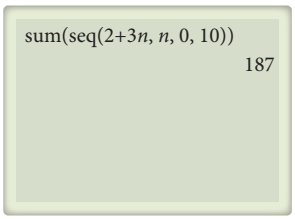


Figure 69

A.15 Trigonometry

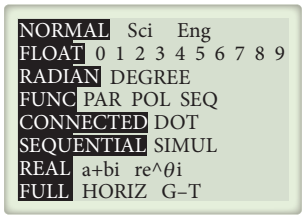


Figure 70

Trigonometric functions can be applied to angles specified in degrees or radians. You should be careful to set the calculator in the correct mode. Press MODE to get the screen in Figure 70. Select either RADIAN or DEGREE in the menu and press ENTER. This will set the calculator in the appropriate mode. Press 2nd MODE (QUIT) to exit the menu.

Entering Trigonometric Functions You can access the sine, cosine, and tangent functions by pressing SIN, COS, and TAN, respectively, and then entering the angle measure.

Entering Inverse Trigonometric Functions You can access the inverse sine, inverse cosine, and inverse tangent functions by pressing 2nd SIN (SIN^{-1}), 2nd COS (COS^{-1}), and 2nd TAN (TAN^{-1}), respectively, and then entering the angle measure. Figures 71 and 72 show sample calculations on the Home Screen in RADIAN and DEGREE mode, respectively.

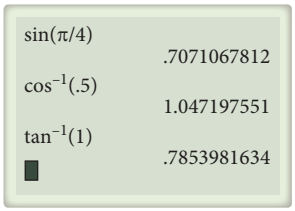


Figure 71

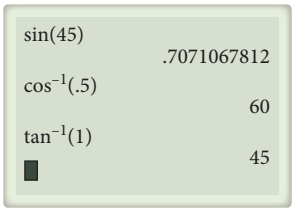


Figure 72

Example 1 **Decimal and DMS Notation**

With the calculator in DEGREE mode, convert

a. 10° 15′ 30″ to decimal degrees.

b. 43.23° to degrees, minutes, seconds (DMS).

Solution

a. To enter an angle with degrees, minutes, and seconds, first go to the Home Screen.

1. Enter **10** 2nd APPS (ANGLE) to access the ANGLE menu. (On a TI-83, enter **10** 2nd MATRX (ANGLE) to access the ANGLE menu.) Press **1** to enter the degree symbol. See Figure 73.
2. Next, enter **15** 2nd APPS (ANGLE). From the ANGLE menu, press **2** to enter the minute symbol.
3. Finally, press **30** ALPHA + (″) (ENTER). The answer is **10.25833333**. See Figure 73.

Figure 73

b. From the Home Screen, do the following: enter **43.23** 2nd APPS (ANGLE) to access the ANGLE menu. Press 4 ENTER to choose the 4:▶ DMS function. The answer is **43° 13′ 48″**. See Figure 74.

Figure 74

You graph trigonometric functions the same way as other functions: enter the function in the equation editor, choose an appropriate window, and graph. A special window setting for trigonometric functions appears under the ZOOM menu.

Example 2 **Graphing Trigonometric Functions**

Graph $Y_1 = \sin 2x$ using the special window for trigonometric functions.

Solution

1. Make sure the calculator is in RADIAN mode. Press Y= SIN 2 X, T, θ, *n*).

2. Press ZOOM 7 to access 7:ZTrig, the default trigonometric window. The graph is shown in Figure B. 15.6. The current window setting can be displayed by pressing WINDOW. The default setting for this window is Xmin $= -2\pi$, Xmax $= 2\pi$, Xscl $= \frac{\pi}{2}$, Ymin $= -4$, Ymax $= 4$, Yscl $= 1$. See Figure 75.

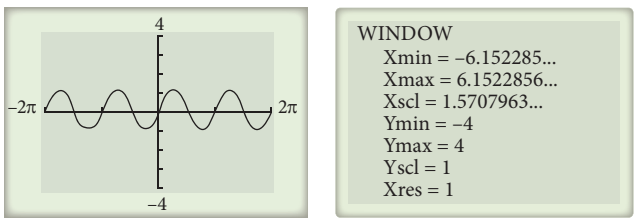
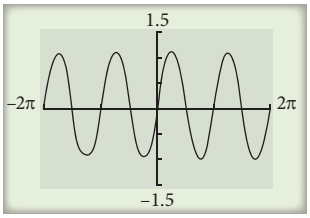


Figure 75

3. Since the amplitude of this function is only 1, change the window setting so that Ymin $= -1.5$, Ymax $= 1.5$, Yscl $= 0.25$ and press GRAPH again. This gives the graph in Figure 76.



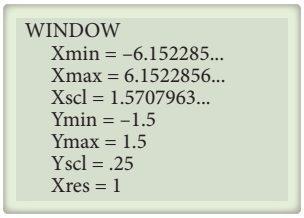


Figure 76

Polar Equations To graph polar equations, you must first set the calculator in POLAR mode. Press MODE and press the down arrow key until you get to the fourth line. Select POL for polar mode and press ENTER. Press 2nd MODE (QUIT) to exit the menu. See Figure 77.

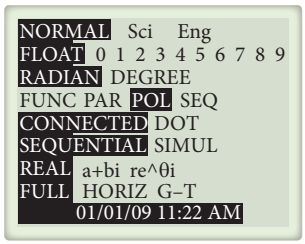


Figure 77

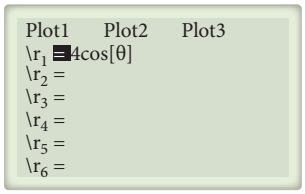


Figure 78

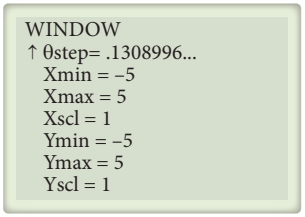


Figure 79

Example 3 **Graphing Polar Equations**

Graph $r = 4 \cos 2\theta$.

Solution

1. Make sure the calculator is in RADIAN and POLAR modes. Press Y= 4 COS 2 X, T, θ, n). See Figure 78.

2. Press WINDOW. We set θ min $= 0$, θ max $= 2\pi$, θ step $= \frac{\pi}{24}$. This gives the range of values for θ. Since r ranges between -4 and 4, the physical window dimensions were set to Xmin $= -5$, Xmax $= 5$, Xscl $= 1$ and Ymin $= -5$, Ymax $= 5$, Yscl $= 1$. See Figure 79.

3. Press GRAPH to get the graph in Figure 80. Note that the graph looks slightly squashed—this is because the window is not a square window. To get the correct scaling, press ZOOM 5 for the 5: Square option. See Figure 81.

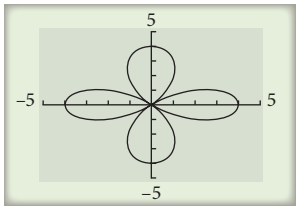


Figure 80

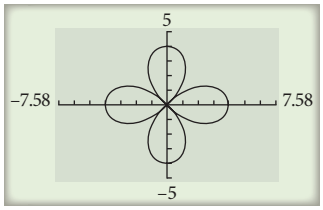


Figure 81

Magnitude of a Complex Number To find the magnitude of a complex number so that it can be written in polar form, first make sure that the calculator is in the $a + bi$ mode. See Section A.11.

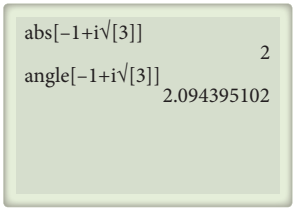


Figure 82

To find the magnitude of $-1 + i\sqrt{3}$, from the Home Screen press MATH ▷ ▷ to select the CPX menu. Press 5 for `5:abs(`. Press (−) 1 + 2nd .(*i*) 2nd x^2(√) 3)) ENTER. The answer is **2**. See Figure 82.

Angle of a Complex Number To find the angle of $-1 + i\sqrt{3}$, from the Home Screen press MATH ▷ ▷ to select the CPX menu. Press **4** for `4:angle(`. Press (−) **1** + 2nd . (*i*) 2nd x^2 (√) 3)) ENTER. The answer is approximately **2.0944**, in radians. See Figure 82.

A.16 Parametric Equations

To graph parametric equations, you must first set the calculator in PARAMETRIC mode. Press MODE and press the down arrow key until you get to the fourth line. Select PAR for parametric mode and press ENTER. Press 2nd MODE (QUIT) to exit the menu. See Figure 83.

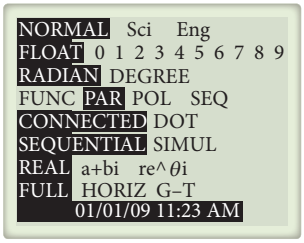


Figure 83

Example 1 **Graphing Parametric Equations**

Graph $x = t - 1$, $y = t^2$ for $-2 \le t \le 3$.

Solution

1. First, make sure the calculator is in PARAMETRIC mode. In the Y = Editor, for X_{1T}, press X, T, θ, *n* − **1**. For Y_{1T}, press X, T, θ, *n* x^2. See Figure 84.
2. Press WINDOW. Enter Tmin = −2, Tmax = 3, Xmin = −10, Xmax = 10, Ymin = −10, Ymax = 10. Leave Tstep, Xscl, and Yscl to their default values. See Figure 85.
3. Press GRAPH to obtain the graph in Figure 86.

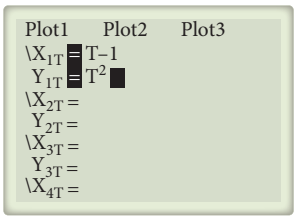


Figure 84

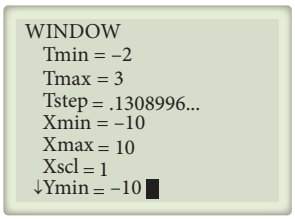


Figure 85

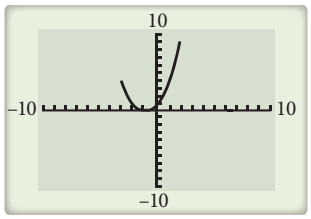


Figure 86

A.17 Graphing Conics

To graph conic sections, use the APPS key on the calculator, as shown in the following example.

Example 1 **Graphing an Ellipse**

$$\text{Graph } \frac{(x-1)^2}{3^2} + \frac{(y+2)^2}{4^2} = 1$$

Solution

1. Press APPS, and select 8 : Conics, as shown in Figure 87.

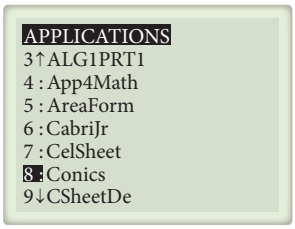


Figure 87

2. Then select 2 : `Ellipse`, since we are graphing an ellipse. Next, choose Option 2 and press ENTER, since the major axis is vertical. See Figure 88.

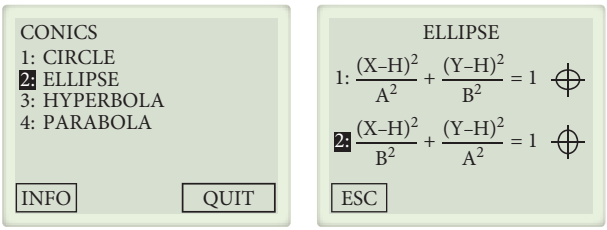


Figure 88

3. Enter the values for A, B, H, K, for the equation $\frac{(x-1)^2}{3^2} + \frac{(y+2)^2}{4^2} = 1$, as shown in Figure 89.

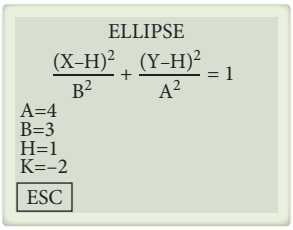


Figure 89

4. Press GRAPH to obtain the graph in Figure 90.

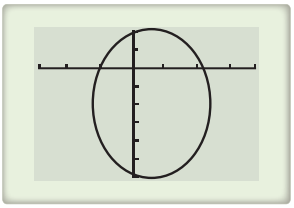


Figure 90