TI-89 GRAPHING CALCULATOR

BASIC OPERATIONS

by

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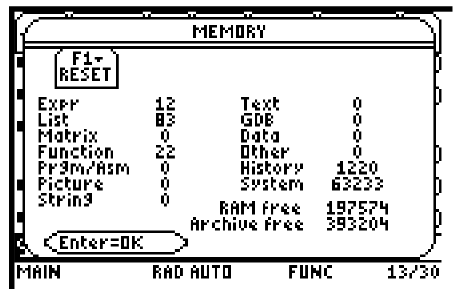
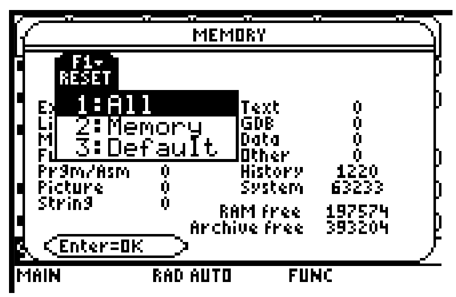
B-1 Getting Started

Press [ON] to turn on the calculator.

Press [2nd] [6] to get the `MEMORY` screen (shown at the right).



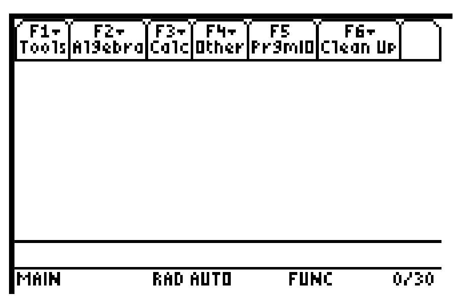
Press [F1] :Tools, press [1] :All and press [ENTER] .



The screen now has a toolbar across the top of the screen, two horizontal lines and some words at the bottom of the screen. The cursor should be flashing between the two horizontal lines at the bottom of the screen.

However, the screen may look blank. This is because the contrast setting may also have been reset and now needs to be adjusted.

The contrast may be too light or too dark. Hold down the green diamond in a green square key [◆] and press the [-] key to make the display lighter, or the [+] key to make the display darker.



> Press [◆] [-] to make the display lighter.
>
> Press [◆] [+] to make the display darker.

B-2 Home Screen, Toolbar, Special Keys, and Menus

Home Screen

The screen on which calculations are done and commands are entered is called the Home Screen. The toolbar is across the top of the screen. Access the tool bar by pressing the blue function keys directly below the screen (for F1 - F5) or pressing [2nd] and one of the three leftmost keys to access F6 - F8.

You can always get to this screen (aborting any calculations in progress) by pressing [HOME]

QUIT

or by pressing [2nd] [ESC] . From here on, this will be referred to as [2nd] [QUIT] in this manual.

> Clear the home screen by pressing [F1] :Tools [8] :Clear Home.
>
> Quit any calculations by pressing [2nd] [QUIT] .
>
> Clear the Entry Line by pressing [CLEAR] .

The line where the cursor is flashing is called the Entry Line.

The words at the bottom of the screen is called the Status Line. This shows the current state of the calculator.

[2nd]

This key must be pressed to access the operation above and to the left of a key. These operations are a yellow color on the face of the calculator. 2nd will appear at the bottom of the screen when this key is pressed.

> In this document, the functions on the face of the calculator above a key will be referred to in square boxes just as if the function was printed on the key cap. For example, [ANS] is the function above the [(-)] key.

[◆]

This key must be pressed to access the operation above and to the right of a key. These operations are printed in green on the face of the calculator.

[alpha]

This key is purple and must be pressed first to access the operation above and to the right of a key that are printed in purple on the face of the calculator. A lower case a is displayed at the bottom of the screen when this key is pressed.

[a-lock]

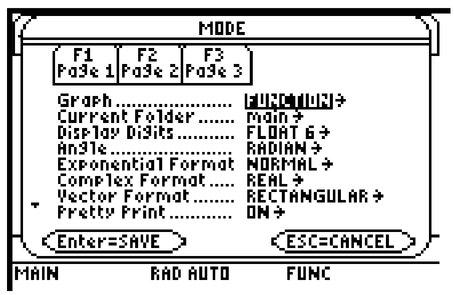
[2nd] [ALPHA] locks the calculator into alpha mode. The calculator will remain in alpha mode until the [ALPHA] is pressed again.

[ESC]

If the calculator displays a menu, this key allows you to exit the menu.

[MODE]

Press [MODE] . The items listed is the current setting. Use the right arrow key to select the item you wish to change. A menu will appear. Use the down arrow key to select the menu item and press [ENTER] to activate the selection.



Press [F1] , [F2] or [F3] to see the other pages of this menu. Press [ESC] to cancel and exit the menu.

The settings shown to the right are the default settings. This manual will assume the calculator has these settings unless the example specifically states to change them with the exception of numbers containing a decimal point being expressed to ten decimal places.

Note that AUTO setting (displayed at the bottom of the screen) for number presentation will cause numbers having fractions, *e*, π, or square roots to be expressed in symbolic form unless a number has been entered using a decimal point. A decimal point in the entry causes the answer to be expressed using a decimal point. The AUTO setting is on page 2 of the MODE screen.

Note, also, that the default setting is floating point (decimal point) form with digits. To get six decimal places, change to FIX 6. (See the Texas Instruments© TI-89 Guidebook, pages 22-23.)

<u>Menus</u>

The TI-8**Error!**

1. Using the arrow keys to highlight the selection and then pressing [ENTER] .
2. Pressing the number corresponding to the menu item.

In this document the menu items will be referred to using the key to be pressed followed by the meaning of the menu. For example, on the [◆] [GRAPH] menu [F2] [1] :Zoom Box refers to the first item on this menu.

B-3 Correcting Errors

It is easy to correct errors on the screen when entering data into the calculator. To do so use the arrow keys, the [←] , [2nd] [INS] and/or [◆] [DEL] .

[◀] or [▶]	Moves the cursor to the left or right one position.
[▲]	Moves the cursor up one line or replays the last executed input.
[▼]	Moves the cursor down one line.
[←]	Deletes one character to the left of the cursor.
[◆] [DEL]	Deletes one character to the right of the cursor.
[2nd] [INS]	Inserts one or more characters to the left of the cursor position.

B-4 Calculation

Example 1 Calculate $-8 + 9^2 - \left|\frac{3}{\sqrt{2}} - 5\right|$.

Turn the calculator on and press 2nd QUIT to return to the Home Screen. Press CLEAR to clear the Home Screen. Now we are ready to do a new calculation.

Numbers and characters are entered in the same order as you would read an expression. Do not press ENTER unless specifically instructed to do so in these examples. Keystrokes are written in a column but you should enter all the keystrokes without pressing the ENTER key until ENTER is displayed in the example.

Solution:

Keystrokes | *Screen Display* | *Explanation*

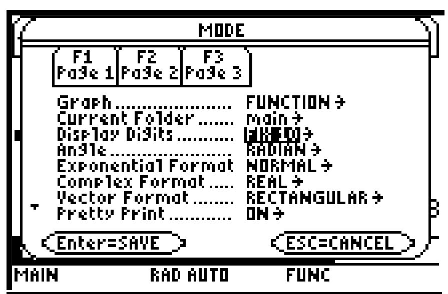
F1 :Tools 8 :Clear Home

CLEAR

It is a good idea to clear the screen before starting a calculation.

MODE ▼ ▼ ▶ ▲ ...

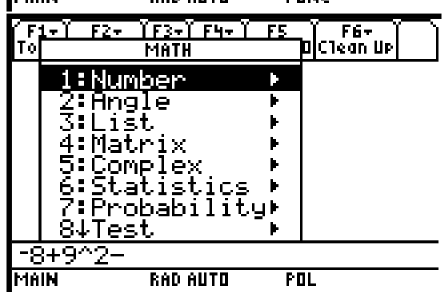
▲ ENTER ENTER



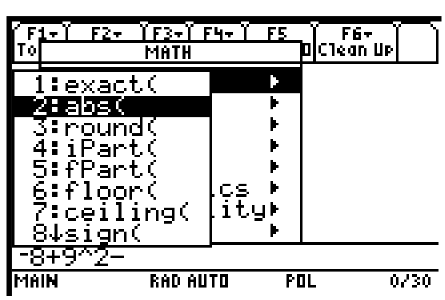
Set the decimal display to fixed 10 decimal places. Note that the default setting is FLOAT 6 which means six digits will be displayed in decimal notation. FIX 6 means that six decimal places will be displayed regardless of the number of digits.

(-) 8 + 9 ^ 2 -

2nd MATH



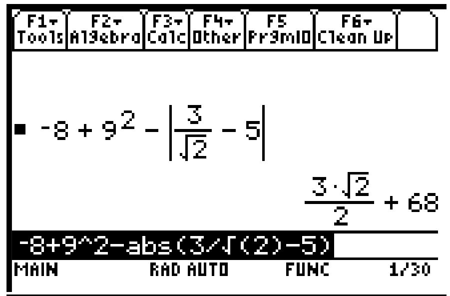
1 :Number 2 :abs(



Watch for parentheses that are entered automatically with the operation.

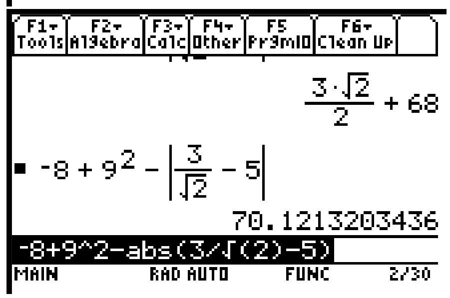
[3] [÷] [2nd] [√] [2] [)]

[-] [5] [)] [ENTER]



Notice that the solution is expressed in pretty print. This is the exact solution.

[◆] [ENTER]



Temporarily override the pretty print setting to get the decimal approximation.

B-5 Evaluation of an Algebraic Expression

Example 1 Evaluate $\frac{x^4 - 3a}{8w}$ for $x = \pi$, $a = \sqrt{3}$, and $w = 4!$.

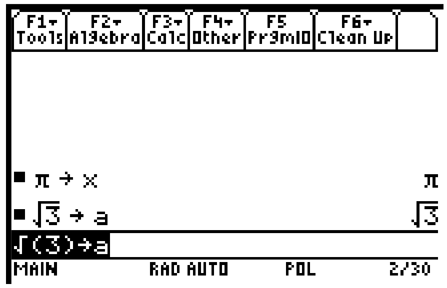
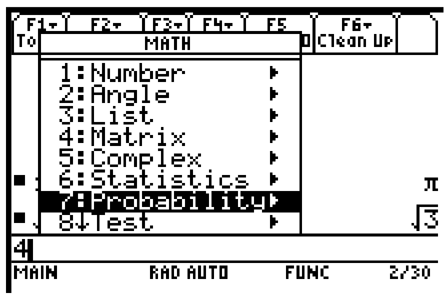
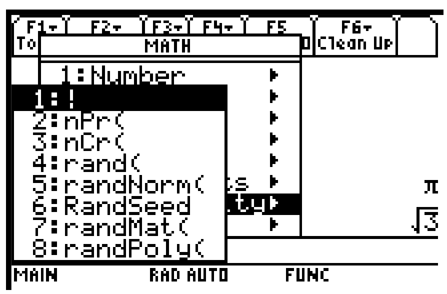
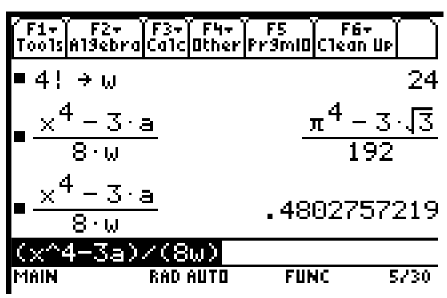
Two different methods can be used to evaluate algebraic expressions:

1. Store the values of the variable, enter the expression, and press [ENTER] to evaluate the expression for the stored values of the variables.
2. Store the expression and store the values of the variables. Recall the expression and press [ENTER] to evaluate the expression for the stored values of the variables.

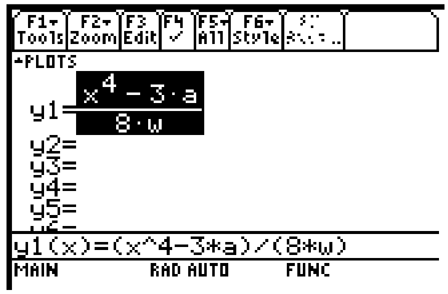
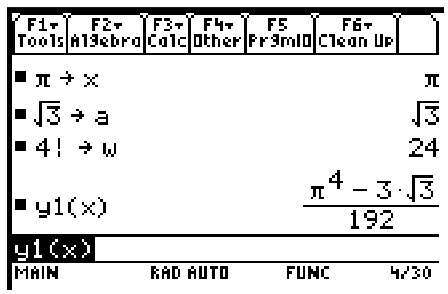
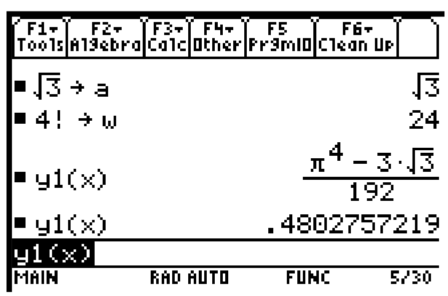
The advantage of the second method is that the expression can be easily evaluated for several different values of the variables.

Solution:

Method 1

Keystrokes	*Screen Display*	*Explanation*
[F1] [8] :Clear Home [CLEAR] [2nd] [π] [STO▸] [X] [ENTER] [2nd] [√] [3] [)] [STO▸] [ALPHA] [A] [ENTER]		Clear the screen. Store the values as variables.
[4] [2nd] [MATH]		
[7] :Probability [1] :! [STO▸] [ALPHA] [W] [ENTER]		
[(] [X] [^] [4] [-] [3] [ALPHA] [A] [)] [÷] [(] [8] [ALPHA] [W] [)] [ENTER] [◆] [ENTER]		Enter the expression and evaluate. Change the pretty print to decimal approximation.

Method 2

Keystrokes	*Screen Display*	*Explanation*
[F1] :Tools [8] :Clear Home [CLEAR] [◆] [Y=] [CLEAR] [(] [X] [^] [4] [-] [3] [ALPHA] [A] [)] [÷] [(] [8] [ALPHA] [W] [)] [ENTER] [▲] [F4] :√		Clear the screen. Enter the expression in the [Y=] list. Deselect y1 so that it will not graph. You can still evaluate the expression.
[2nd] [QUIT] [2nd] [π] [STO▸] [X] [ENTER] [2nd] [√] [3] [)] [STO▸] [ALPHA] [A] [ENTER] [4] [2nd] [MATH] [7] :Probability [1] :! [STO▸] [ALPHA] [W] [ENTER] [ALPHA] [Y] [1] [(] [X] [)] [ENTER] [◆] [ENTER]	 	Return to the Home Screen. Store the values as variables. Recall the expression and evaluate. Change the pretty print to decimal approximation.

Example 2 For $f(x) = 3x+5$ and $g(x) = \sqrt{x - \sqrt{x}}$ find $f(2) - g(2)$.

Solution: (Using Method 2 above.)

Keystrokes

[F1] :Tools

[8] :Clear Home [CLEAR]

[◆] [Y=] [CLEAR]

[3] [X] [+] [5] [ENTER]

[CLEAR]

[2nd] [√] [X] [-]

[2nd] [√] [X] [)] [)] [ENTER]

[2nd] [QUIT]

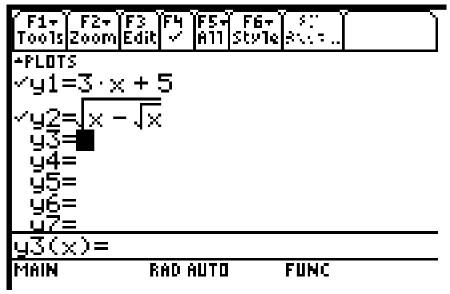
[2] [STO▸] [X] [ENTER]

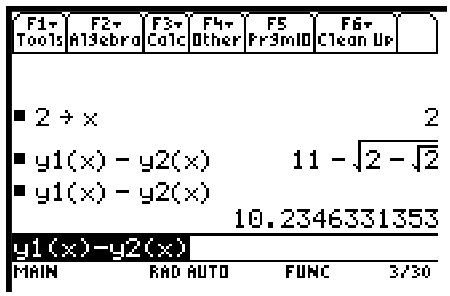
[Y] [1] [(] [X] [)] [-]

[Y] [2] [(] [X] [)] [ENTER]

[◆] [ENTER]

Screen Display





Explanation

Clear the screen.

Clear y1 and store $f(x)$ as y1.

Clear y2 and store $g(x)$ as y2.

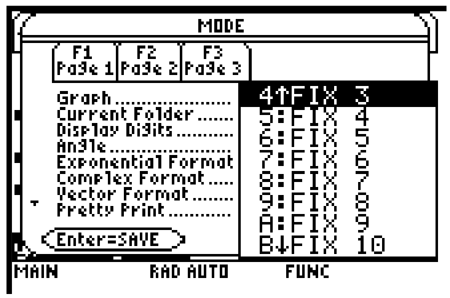
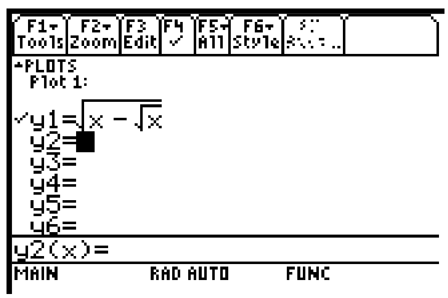
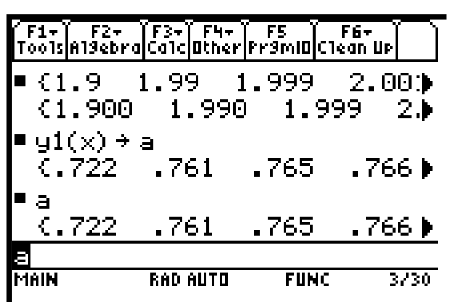
Return to the Home Screen.

Store 2 as X.

Algebraically form $f(x) - g(x)$ and evaluate at $x = 2$.

Example 3 Evaluate the function $g(x) = \sqrt{x - \sqrt{x}}$ to three decimal places for x = 1.900, 1.990, 1.999, 2.001, 2.010, and 2.100 using a list.

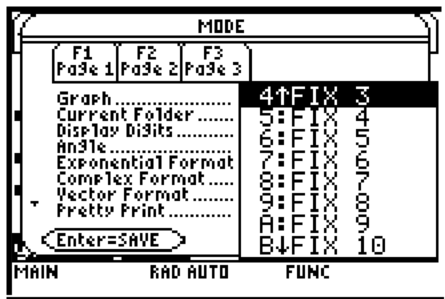
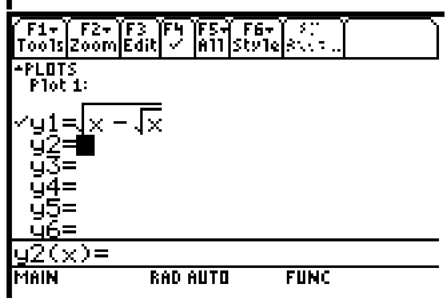
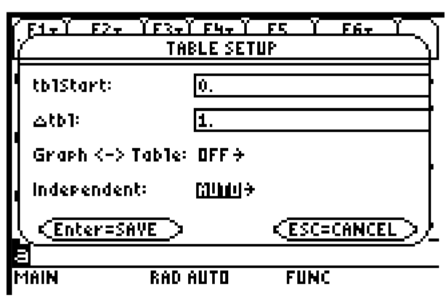
Solution: Store the expression in the calculator as was done in Example 2 above. Store the values of x in a list and simultaneously evaluate the expression for each value of x as shown below.

Keystrokes	*Screen Display*	*Explanation*
[F1] :Tools [8] :Clear Home [CLEAR]		Clear the Home screen.
[MODE] [▼] [▼] [▶] [4] :FIX 3		Change the mode to fixed three decimal places. Return to the Home Screen.
[ENTER] [◆] [Y=] [▲] ... [▲] [CLEAR] [▼] [CLEAR] …		Use the up arrow to get to Y1. Clear all entries on the [Y=] list using the arrow keys and [CLEAR] .
[2nd] [√] [X] [-] [2nd] [√] [X] [)] [)] [ENTER]		Store the expression as y1.
[2nd] [QUIT]		Return to the Home Screen.
[2nd] [{] [1.900] [,] [1.990] [,] [1.999] [,] [2.001] [,] [2.010] [,] [2.100] [2nd] [}] [STO▶] [X] [ENTER]		Store the values of x in the list X.
[Y] [1] [(] [X] [)] [STO▶] [ALPHA] [A] [ENTER]		Calculate the value of the expression stored as y1 for the values of x in list X and store as A. To view the results, use the [◀] and [▶] keys.
[ALPHA] [A] [ENTER]		To recall A, press [ALPHA] [A] . The results are 0.722, 0.761, 0.765, 0.766, 0.770, and 0.807.

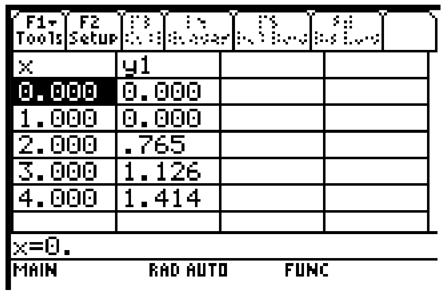
Example 4

Evaluate the expression $g(x) = \sqrt{x - \sqrt{x}}$ to three decimal places for values of x at each integer from 0 to 10 using a table.

Solution: First store the expression in the Y= list. Set the table parameters to begin at x = 0 and to have an increment of 1. Get the table.

Keystrokes	*Screen Display*	*Explanation*
[F1] :Tools [8] :Clear Home [CLEAR]		Clear the Home Screen.
[MODE] [▼] [▼] [▶] [4] :FIX 3		Change the mode for fixed decimal places to three decimal places.
[ENTER]		Return to the Home Screen.
[◆] [Y=] [▲] ...[▲] [CLEAR] [▼] [CLEAR] …		Use the up arrow to get to y1. Clear all entries on the [Y=] list using the arrow keys and [CLEAR] .
[2nd] [√] [X] [-] [2nd] [√] [X] [)] [)] [ENTER]		Store the expression as y1.
[2nd] [QUIT]		Return to the Home Screen.
[◆] [TblSet] [0] [ENTER] [▼] [1] [ENTER] [▼] [▼]		Set the table to begin evaluating the expression at x = 0 with a step size of 1. Set the calculator to automatically display values of x and y1.
[ENTER] [ENTER]		Return to the Home Screen.

[◆] [TABLE] [▼] ...[▼]



Get the table. Arrow down to see more of the table,

The highlighted value will appear at the bottom of the table.

[MODE] [▼] [▼] [▶]

[ALPHA] [O] :FLOAT 10

When finished viewing the table, set the mode for numbers to Float 10.

[2nd] [QUIT]

Return to the Home Screen.

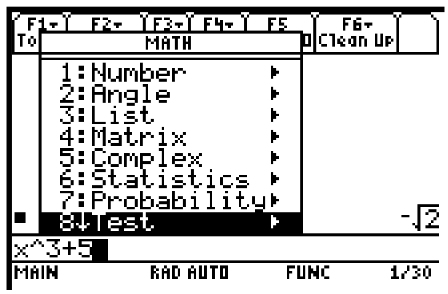
B-6 Testing Inequalities in One Variable

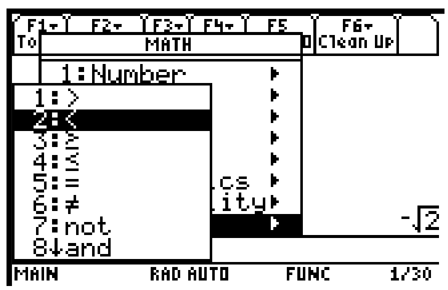
Example 1 Determine whether or not $x^3 + 5 < 3x^4 - x$ is true for $x = -\sqrt{2}$.

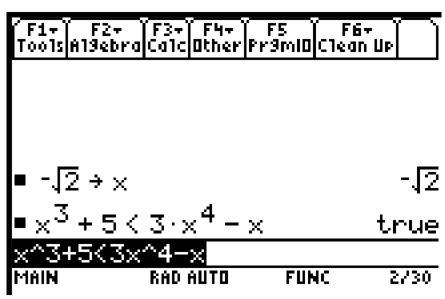
Solution:

Keystrokes	*Explanation*
[2nd] [QUIT]	Return to the Home Screen and clear it.
[F1] [8] :Clear Home	Store the value for x.
[CLEAR]	
[MODE] [▼] [▼] [▶]	Set the mode to FIX 10.
[ALPHA] [B] :FIX 10	Enter the expression.
[ENTER]	
[(-)] [2nd] [√] [2] [)] [STO▶]	
[X] [ENTER]	
[X] [^] [3] [+] [5]	
[2nd] [MATH]	
[8] :Test	
[2] :< [3] [X] [^] [4] [-] [X]	The result of true indicates the expression is true for this value of x.
[ENTER]	

Screen Display



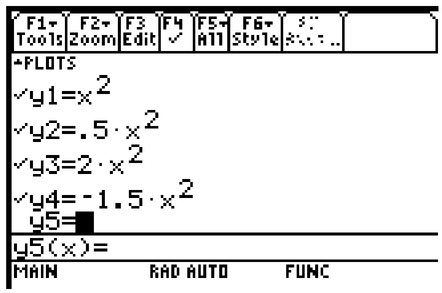
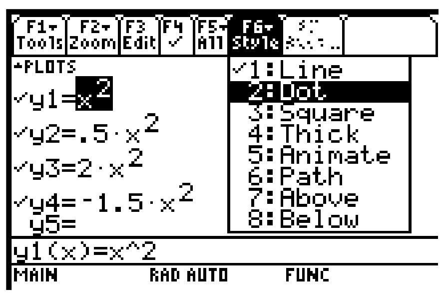


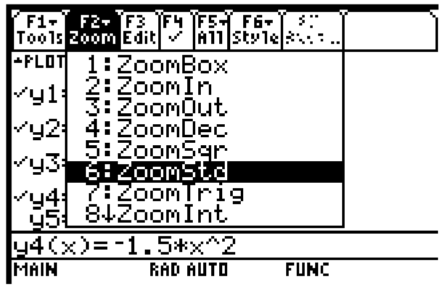


B-7 Graphing, the ZStandard Graphing Screen, and Style of Graph

<u>Example 1</u> Graph $y = x^2$, $y = .5x^2$, $y = 2x^2$, and $y = -1.5x^2$ on the same coordinate axes. Graph the first function with a dotted line, the second function with a thin line, the third function with a thick line, and the fourth function with a thin line.

Solution:

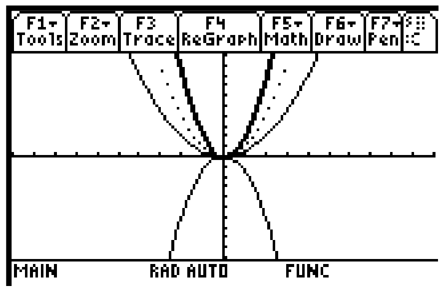
Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Return to the Home Screen and clear.
[F1] [8] :Clear Home [CLEAR]		
[◆] [Y=]		
[CLEAR] [X] [^] [2] [ENTER]		Clear the existing function and store the first function as y1.
[CLEAR] [.5]		
[X] [^] [2] [ENTER]		Clear and store the second function as y2.
[CLEAR] [2] [X] [^] [2]		Clear and store the third function as y3.
[ENTER]		
[CLEAR] [(-)] [1.5] [X] [^] [2]		Clear and store the fourth function as y4.
[ENTER]		Get the graph style menu.
[▲] [▲] [▲] [▲] [2nd] [F6]		
[2] :Dot		Change the style for y1 to a dotted line.
[▼] [2nd] [F6] [1] :Line		Change the style for y2 to a line.
[▼] [2nd] [F6] [4] :Thick		Change the style for y3 to a thick line.
[▼] [2nd] [F6] [1] :Line		Change the style for y4 to a line.



Get the zoom menu. Press 6 to get the ZStandard option and graph the functions.

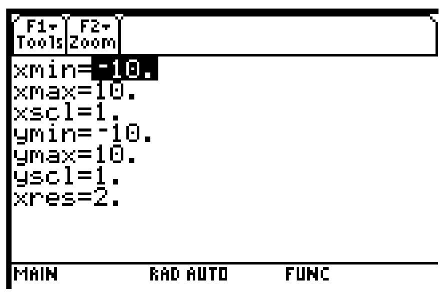
Note the ZStandard option automatically sets the graph screen dimentions at $-10 \le x \le 10$ and $-10 \le y \le 10$.

[F2] [6] :ZoomStd



Get the window display to check this.

[◆] [WINDOW]



The ZStandard screen automatically sets the graph for $-10 \le x \le 10$ and $-10 \le y \le 10$. Press [WINDOW] to see this.

These window dimensions will be denoted as [-10, 10]1 by [-10, 10]1 in this document.

The graphs will be plotted in order: y1, then y2, then y3, then y4, …
If there is more than one function graphed, the up [▲] and down [▼] arrow keys allow you to move between the graphs displayed when tracing.

B-8 TRACE, ZOOM, WINDOW, Zero, Intersect and Solver

[F3] :Trace allows you to observe both the *x* and *y* coordinate of a point on the graph as the cursor moves along the graph of the function. If there is more than one function graphed the up [▲] and down [▼] arrow keys allow you to move between the graphs displayed.

[F2] :Zoom will magnify a graph so the coordinates of a point can be approximated with greater accuracy.

Ways to find the *x* value of an equation with two variables for a given *y* value are:

1. Zoom in by changing the WINDOW dimensions.
2. Zoom in by seting the Zoom Factors and using Zoom In from the ZOOM menu.
3. Zoom in by using the Zoom Box feature of the calculator.
4. Use the Zero feature of the calculator.
5. Use the Intersect feature of the calculator.
6. Use the Solver feature of the calculator.

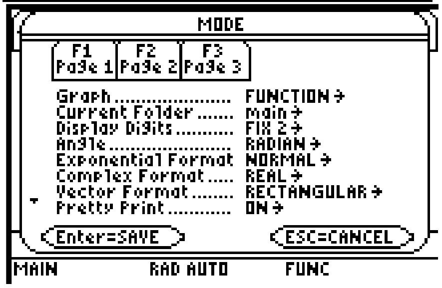
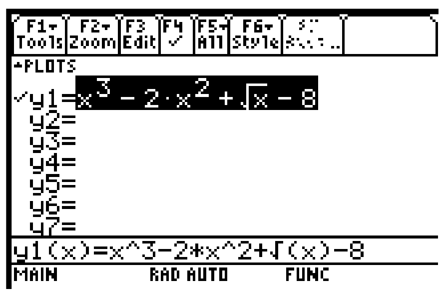
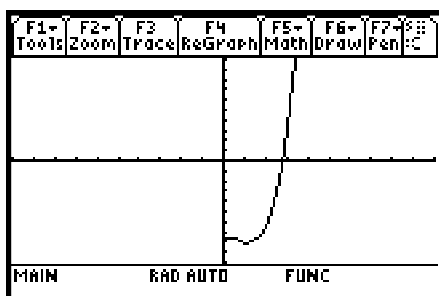
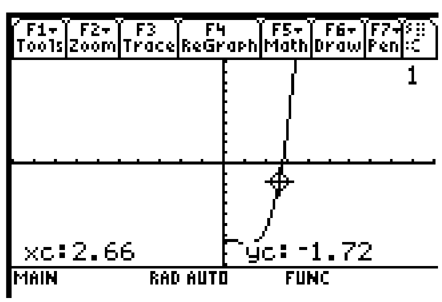
Three methods to zoom in are:

1. Change the WINDOW dimensions using [◆] [WINDOW] .
2. Use the [2] :Zoom In option on the [F2] :Zoom menu in conjunction with [F2] :Zoom [ALPHA] [C] :Set Factors.
3. Use the [1] :ZoomBox option on the [F2] :Zoom menu.

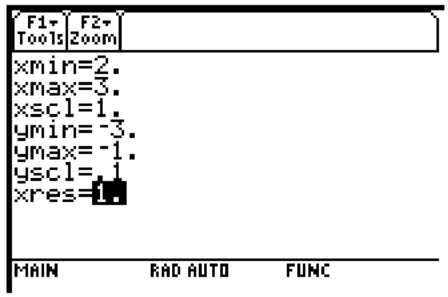
Example 1 Approximate the value of x to two decimal places if $y = -1.58$ for
$$y = x^3 - 2x^2 + \sqrt{x} - 8.$$

Solution:

Method 1 Change the WINDOW dimensions.

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT] [F1] [8] :Clear Home [CLEAR] [MODE] [▼] [▼] [▶] [3] :FIX 2 [ENTER]		Clear the Home Screen and change the number of decimal places to 2.
[◆] [Y=] [CLEAR] [X] [^] [3] [-] [2] [X] [^] [2] [+] [2nd] [√] [X] [)] [-] [8] [ENTER] [▲]		Clear all functions in the [Y=] list. Enter the function as y1. Use the up arrow to highlight the function so you can see how it was entered on the Entry Line.
[◆] [WINDOW] [F2] [6] :ZoomStd		Graph using the standard window.
[F3] :Trace [▶] …[▶]		Get the [TRACE] function and press the right arrow repeatedly until the new type of cursor gives a y value close to -1.58. The closest point is (2.66, -1.72).

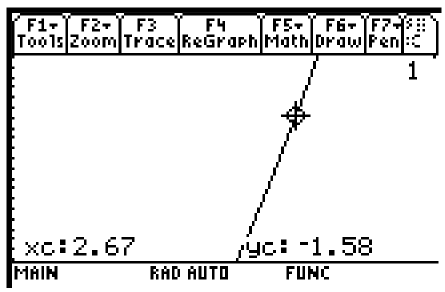
[◆] [WINDOW] [2]
[ENTER] [3] [ENTER] [.1]
[ENTER] [(-)] [3] [ENTER]
[(-)] [1] [ENTER] [.1]
[ENTER] [1]



The *x* coordinate is between 2 and 3. So we set the [WINDOW] at $2 \le x \le 3$ with scale marks every .1 by $-3 \le y \le -1$ with scale marks every .1. This will be written as [2, 3].1 by [-3, -1].1.

Also, set the xRes to 1. This means that the calculator will calculate a value for *y* for each value for *x* for which there is a column of pixels on the graph screen.

[◆] [GRAPH]
[F3] :Trace [▶] …[▶]



Get the [TRACE] function and press the right arrow repeatedly until the new type of cursor gives a *y* value close to -1.58. The closest point is (2.67, -1.58).

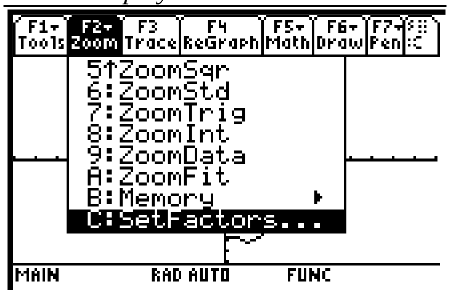
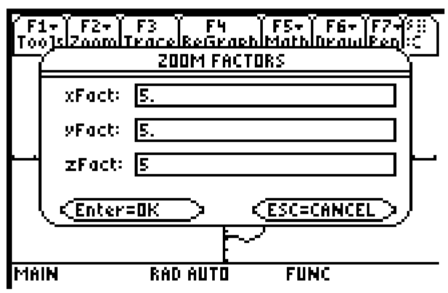
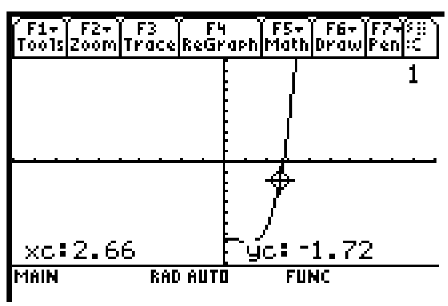
Hence the desired value for *x* is approximately 2.67.

> When using [TRACE], the initial position of the cursor is at the midpoint of the *x* values used for xMin and xMax. Hence, you may need to press the right or left arrow key repeatedly before the cursor becomes visible on a graph.

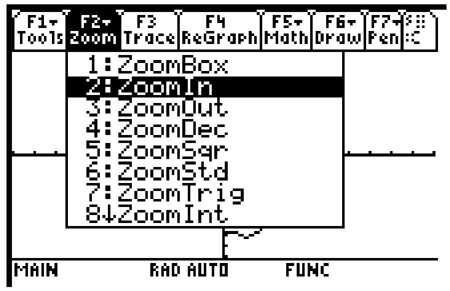
> Occasionally you will see the word BUSY in the lower righthand corner. This means the calculator is working. Wait until BUSY disappears before continuing.

Method 2 Use the [2] :Zoom In option on the [F2] :Zoom menu.

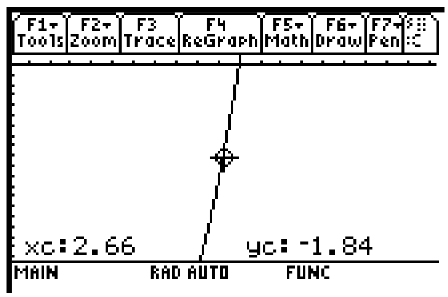
Return to the Home Screen, Clear, enter the function in the [Y=] list (see Method 1 of this example).

Keystrokes	*Screen Display*	*Explanation*
[◆] [WINDOW] [F2] :Zoom [6] :ZoomStd [F2] [ALPHA]		Graph the function using the standard graphing screen. Magnification factors need to be set.
[C] :SetFactors… [5] [▼] [5] [▼] [5] [ENTER]		For this example let us set them at 5 for both horizontal and vertical directions.
[ENTER] [F3] :Trace [▶] … [▶]		Get the [TRACE] function and move the cursor using the arrow keys to the point (2.66, -1.72).

[F2] :Zoom [2] :ZoomIn

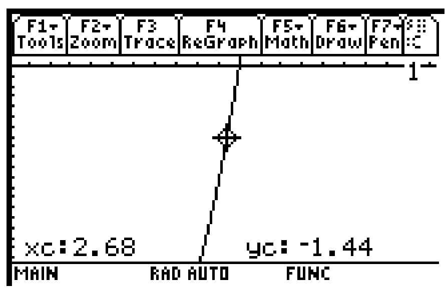


[ENTER]

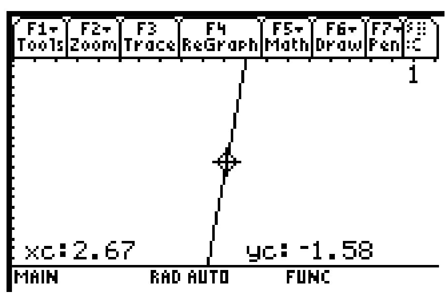


Press [2] :ZoomIn and move the cursor to (2.66, -1.84) for the center. Press [ENTER] .

[F3] :Trace [▶] …[▶]



Use [TRACE] again to get a new estimate for *x*. The new estimate is 2.68.



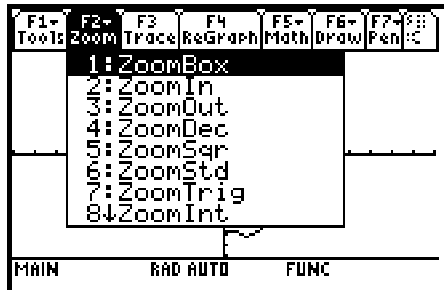
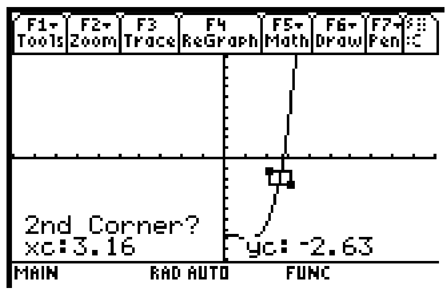
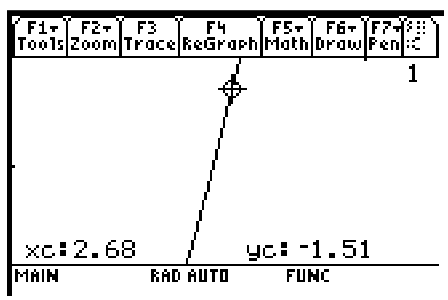
Repeat the trace and zoom procedure until you get a value for the *x* coordinate accurate to two decimal places for $y = -1.58$.

After several zooms your should have a screen similar to the one shown at the left.

The point has coordinates (2.67, -1.58). Hence the desired value for *x* is approximately 2.67.

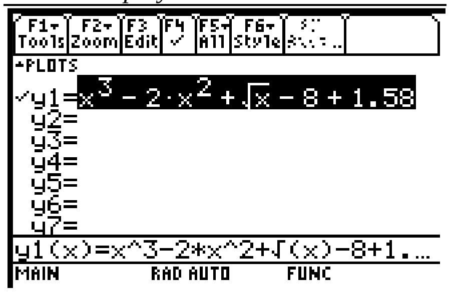
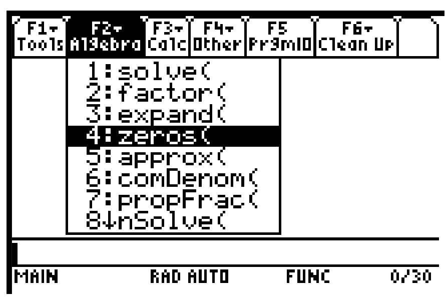
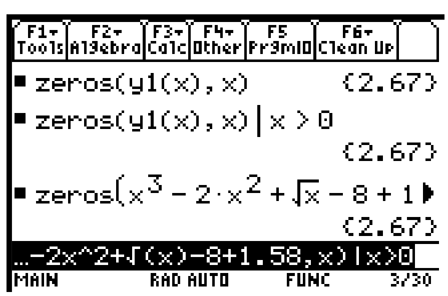
Method 3 Use the [1] :Box option on the [ZOOM] menu.

Return to the Home Screen, clear, enter the function in the Y= list (see Method 1 of this example).

Keystrokes	*Screen Display*	*Explanation*
[◆] [WINDOW] [F2] :Zoom [6] :ZoomStd [F2] Zoom		Graph the function using the standard graphing screen. Get [ZoomBox] feature.
[1] :ZoomBox [▶] …[▼] [ENTER] [▼] …[▶] [ENTER]		Use the arrow keys until the cursor is a little to the left and above the point we are trying to find, say at (2.15, -1.32). Press [ENTER] . This anchors the upper left corner of the box. Now use the arrow keys to locate the lower right corner of the box, say at (3.16, -2.63).
[F3] :Trace [▶] …[▼] [ENTER]		Press [ENTER] to get the new display. Use [F3] :TRACE to see the coordinates of the point on the graph where *y* is closest to -1.58. This point is (2.68, -1.51). Repeat the [ZoomBox] procedure to get the *x* value of 2.67.

Repeat using [TRACE] and [ZoomBox] until you get a value for the *y* coordinate accurate to two decimal places. The point has coordinates (2.67, -1.58). Hence the desired value for *x* is approximately 2.67.

Method 4 Use the zeros(feature of the calculator.

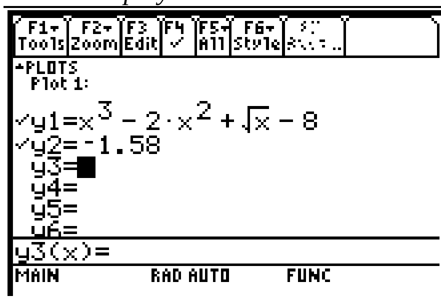
Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT] [F1] :Tools [8] :Clear Home [CLEAR] [◆] [Y=] [CLEAR] [X] [^] [3] [-] [2] [X] [^] [2] [+] [2nd] [√] [X] [)] [-] [8] [+] [1.58] [ENTER] [▲]		Clear the Home Screen. Algebraically set the expression involving *x* equal to -1.58, the value of *y*. $x^3 - 2x^2 + \sqrt{x} - 8 = -1.58$ Now change the equation so it is equal to zero. $x^3 - 2x^2 + \sqrt{x} - 8 + 1.58 = 0$. Use the up arrow to see the Entry Line. Enter the left side of the equation into the function list.
[2nd] [QUIT]		Return to the Home Screen.
[F2] :Algebra [4] :zeros [Y] [1] [(] [X] [)] [,] [X] [)] [ENTER] or [F2] :Algebra [4] :zeros [Y] [1] [(] [X] [)] [,] [X] [)] [|] [X] [2nd] [MATH] [8] :Test [1] :> [0] [ENTER] or [F2] :Algebra [4] :zeros [X] [^] [3] [-] [2] [X] [^] [2] [+] [2nd] [√] [X] [)] [-] [8] [+] [1.58] [,] [X] [)] [|] [X] [2nd] [MATH] [8] :Test [1] :> [0] [ENTER]	 	Get the zero feature. The the place where the expression is stored or the expression itself can be used. Also, you can specify which interval on *x* is to be used. Both of these are shown in the display screen to the left. The solution is *x* = 2.67.

Method 5 Use the Intersection feature of the calculator.

Return to the Home Screen, clear, enter the function in the Y= list (see Method 1 of this example).

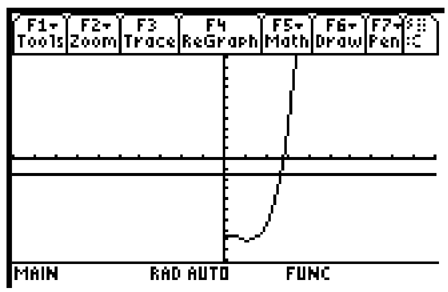
Keystrokes | *Screen Display* | *Explanation*

[(-)] [1.58] [ENTER]



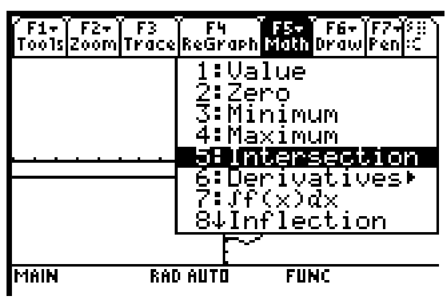
Enter the function as Y1 and enter -1.58 as Y2 in the function list.

[F2] :Zoom [6] :Zoom Std



Graph the function using the standard graphing screen.

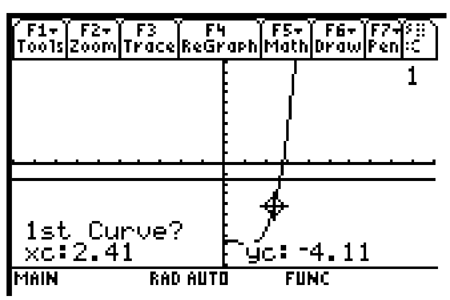
[F5] :Math



Get the intersection feature.

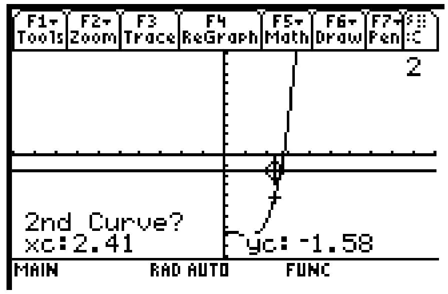
[5] :Intersection

[◀] or [▶] [ENTER]



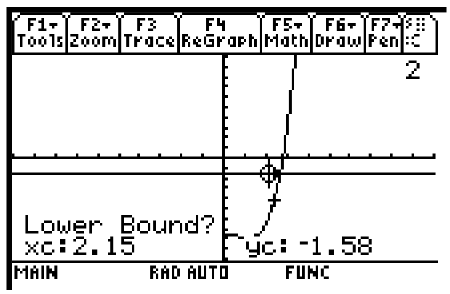
Place the cursor at a point first graph near the point c intersection and press [ENTER] .

◀ or ▶ ENTER



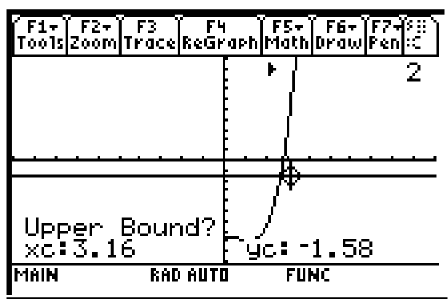
Place the cursor at a point on the second graph near the intersection point and press ENTER .

◀ …▶ ENTER

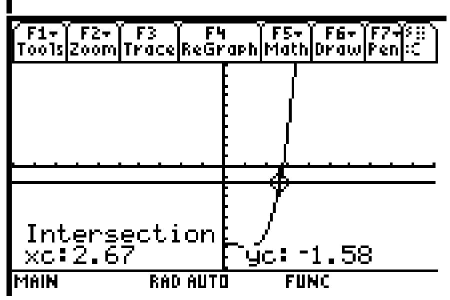


Move the cursor to a value of *x* less than the intersection point and press ENTER for the Lower Bound on *x*.

◀ or ▶ ENTER

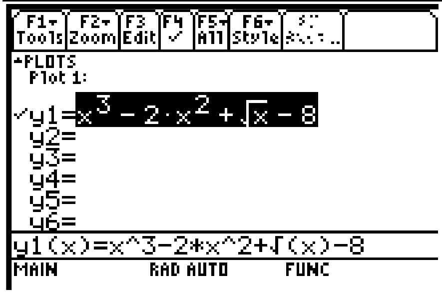
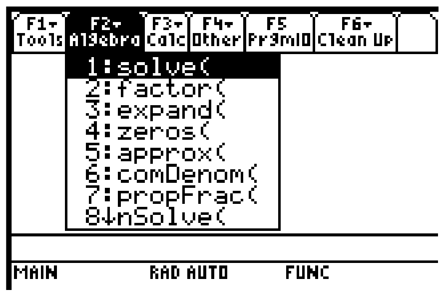
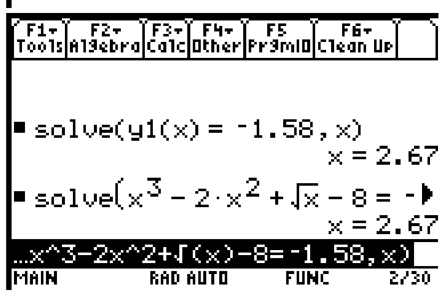


Move the cursor to a value of *x* greater than the *x* coordinate of the intersection point and press ENTER for the Upper Bound on *x*.



The intersection point is (2.67, -1.58). Hence the desired value for *x* is approximately 2.67.

<u>Method 6</u> Use the Solver feature of the calculator

Keystrokes	*Screen Display*	*Explanation*
2nd QUIT F1 8 :Clear Home CLEAR		Return to the Home Screen and clear it.
◆ Y= CLEAR X ^ 3 - 2 X ^ 2 + 2nd √ X) - 8 ENTER		Clear all expressions in the Y= list. Enter the function as y1 in the function list.
2nd QUIT F2 :Algebra 1 :solve(		Get the solve(from the Algebra list.
Y 1 (X) = (-) 1.58 , X) ENTER		Recall y1 from the function list and set it equal to -1.58.
or		Note that the expression itself could have been entered in the solve(expression. Both methods are shown to the left.
2nd QUIT F2 :Algebra 1 :solve(X ^ 3 - 2 X ^ 2 + 2nd √ X) - 8 = (-) 1.58 , X) ENTER ▲		The desired value for *x* is approximately 2.67.

B-9 Determining the WINDOW Dimensions and Scale Marks

There are several ways to determine the limits of the *x* and *y* axes to be used in setting the WINDOW. Three are described below:

1. Graph using the default setting of the calculator and zoom out. The disadvantage of this method is that often the function cannot be seen at either the default settings or the zoomed out settings of the WINDOW.

2. Evaluate the function for several values of *x*. Make a first estimate of the window dimensions based on these values.

3. Analyze the leading coefficient and/or the constant terms.

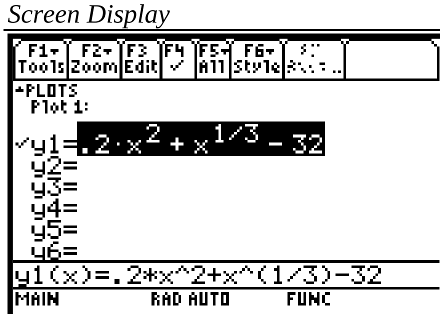
A good number to use for the scale marks is one that yields about 20 marks across the axis. For example if the WINDOW is [-30, 30] for an axis then a good scale value is (30-(-30))/20 or 3.

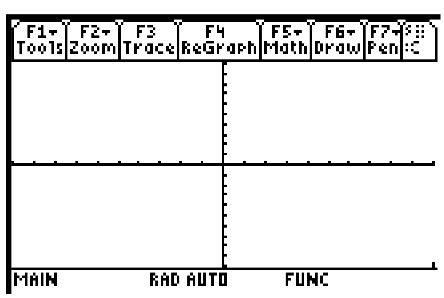
Example 1 Graph the function $f(x) = .2x^2 + \sqrt[3]{x} - 32$.

Solution:

Method 1 Use the default setting and zoom out.

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Return to the Home Screen and clear it.
[F1] :Tools		
[8] :Clear Home [CLEAR]		
[◆] [Y=]		Clear all expressions in the [Y=] list. Enter the function as y1 in the function list.
[CLEAR] [.2] [X] [^]		
[2] [+] [X] [^]		
[(] [1] [÷] [3] [)] [-] [32]		
[ENTER] [▲]		
[F2] :Zoom [6] :ZoomStd		Nothing is seen on the graph screen because no part of this curve is in this WINDOW.





[F2] :Zoom

[ALPHA] [C] :SetFactors...

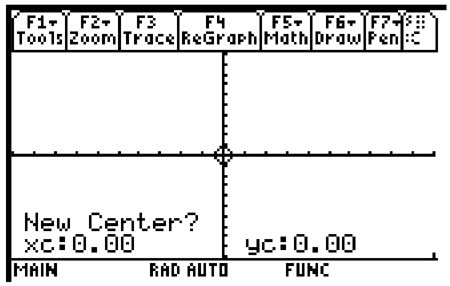
[4] [▼] [4] [▼] [4]

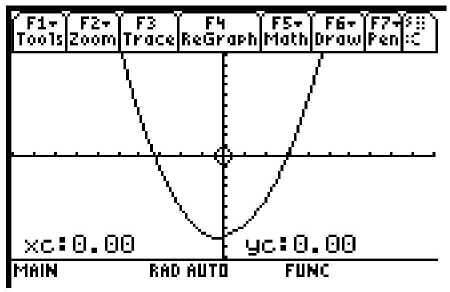
[ENTER] [ENTER]

[F2] :Zoom [3] :Zoom Out

[▼] …[▶]

[ENTER]

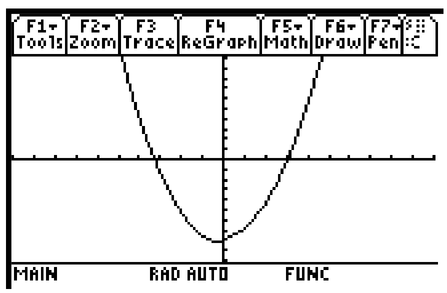




Set the zoom factors to 4. See Section 8, Example 1, Method 2 of this document.
Then get the ZoomOut option and use the arrow keys to move the cursor to the point you wish to be the center of the new zoom screen. We chose (0, 0). The cursor will be a flashing circle with a + sign in it.

Zooming out shows a parabolic shaped curve.

[ESC]



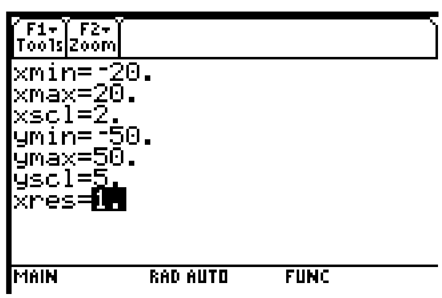
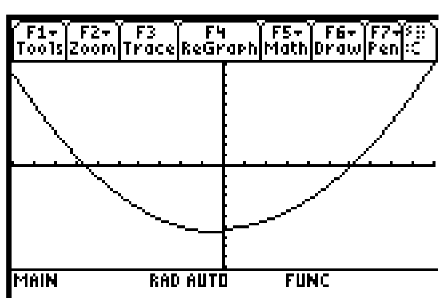
Pressing [ESC] will remove the cursor and escape the [F2] :Zoom menu.

Method 2 Enter the function and evaluate the function for several values of *x*. (See Section B-5 on how to evaluate a function at given values of *x*.)

x	f(*x*)
-20	45.3
-10	-14.2
0	-32.0
10	-9.8
20	50.7

Analyzing this table indicates that a good WINDOW to start with is [-20,20]2 by [-50,50]5.

Note the scale is chosen so that about 20 scale marks will be displayed along each of the axes. The scale is chosen as 2 for the *x* axis since [20-(-20)]/20=2 and 5 for the *y* axis since [50-(-50)]/20=5.

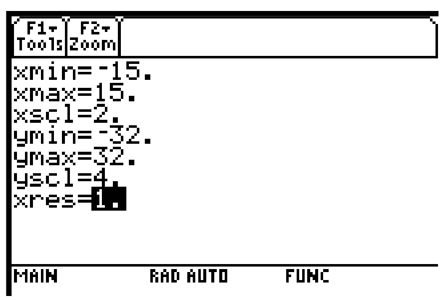
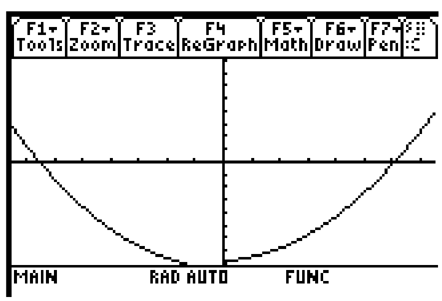
Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Return to the Home Screen and clear it.
[F1] [8] :Clear Home [CLEAR]		
[◆] [Y=]		Clear all expressions in the [Y] = list. Enter the function as y1 in the function list.
[CLEAR] [.2] [X] [^]		
[2] [+] [X] [^]		
[(] [1] [÷] [3] [)] [-] [32]		
[◆] [WINDOW] [(-)] [20]		Set the window dimensions to [-20, 20]2 by [-50, 50]5 with a resolution of 1.
[ENTER] [20] [ENTER] [2]		
[ENTER] [(-)] [50] [ENTER]		
[50] [ENTER] [5] [ENTER]		
[1] [ENTER]		
[◆] [GRAPH]		Graph the function.

Method 3 Analyze the leading coefficient and constant terms.
Since the leading coefficient is .2 the first term will increase .2 units for each 1 unit x^2 increases or 2 units for each 10 units x^2 increases. This means that the first term will increase for every $\sqrt{10}$ (or about 3 units increase) in x. A first choice for the x axis limits can be found using:

$$\frac{10\times \text{(unit increase in } x)}{\text{(first term increase)}} = \frac{10\times 3}{2} = 15$$

A first choice for the scale on the x axis (having about 20 marks on the axis) can be found using $\frac{\text{xmax}-\text{xmin}}{20} = \frac{15-(-15)}{20} = 1.5$ (round to 2). So the limits on the x axis could be [-15,15]2.

A first choice for the y axis limits could be ±(constant term). The scale for the y axis can be found using $\frac{\text{ymax}-\text{ymin}}{20} = \frac{32-(-32)}{20} = 3.2$ (round to 4). So a first choice for the y axis limits could be [-32,32]4. Hence a good first setting for the WINDOW is [-15,15]2 by [-32,32]4.

Keystrokes	*Screen Display*	*Explanation*
2nd QUIT		Return to the Home Screen and clear it.
F1 8 :Clear Home CLEAR		
◆ Y= CLEAR .2 X ^ 2 + X ^ (1 ÷ 3) - 32		Clear all expressions in the Y= list. Enter the function as y1 in the function list.
◆ WINDOW (-) 15 ENTER 15 ENTER 2 ENTER (-) 32 ENTER 32 ENTER 4 ENTER 1 ENTER		Set the window dimensions to [-20, 20]2 by [-50, 50]5 with a resolution of 1.
◆ GRAPH		Graph the function.

A good choice for the **scale** is so that about 20 marks appear along the axis. This is $\frac{\text{Xmax}-\text{Xmin}}{20}$ (rounded up to the next integer) for the x axis and $\frac{\text{Ymax}-\text{Ymin}}{20}$ (rounded up to the next integer) for the y axis.

B-10 Piecewise-Defined Functions and Conditional Statements

There are two methods to graph piecewise-defined functions:

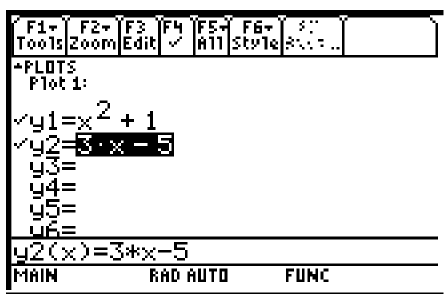
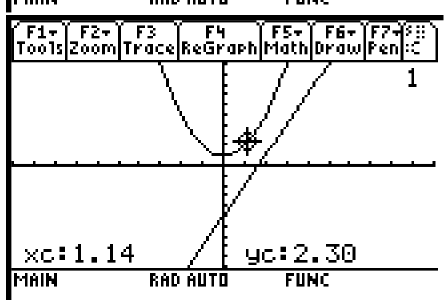
1. Graph each piece of the function separately as an entire function on the same coordinate axes. Use trace and zoom to locate the partition value on each of the graphs.

2. Store each piece of the function separately but include a conditional statement following the expression which will restrict the values of *x* at which the function will be graphed. Then graph all pieces on the same coordinate axes.

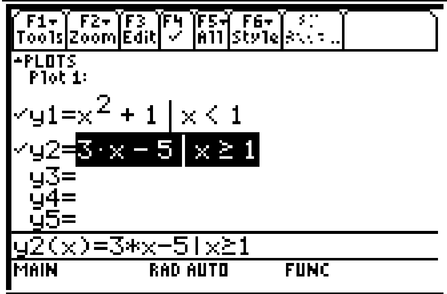
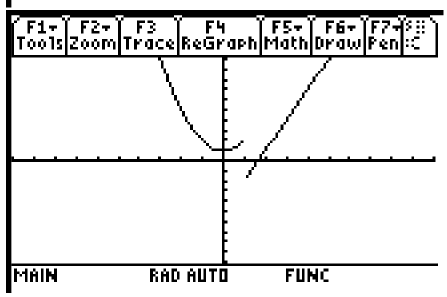
Example 1 Graph $f(x) = \begin{cases} x^2 + 1 & x < 1 \\ 3x - 5 & x \geq 1 \end{cases}$

Solution:

Method 1

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Return to the Home Screen and clear it.
[F1] :Tools		
[8] :Clear Home [CLEAR]		Clear all expressions in the [Y=] list.
[◆] [Y=] [CLEAR] [X] [^] [2] [+] [1] [ENTER] [CLEAR] [3] [X] [-] [5] [ENTER] [▲]		Store the functions as y1 and y1. Graph. Both functions will be displayed.
[F2] :Zoom [6] :ZoomStd [F3] :Trace [▶] [▶] [▶] [▶]		Use trace and zoom to find the point on the graphs where *x*=1. One such point is (1.14, 2.30). When drawing this curve on paper, place an open circle as the endpoint of the piece of the graph not including *x*=1 and a closed circle as the endpoint of the piece of the graph including *x*=1.

Method 2

Keystrokes	*Screen Display*	*Explanation*
[◆] [Y=] [CLEAR] [X] [^]		Return to the Home Screen and clear it.
[2] [+] [1] [|] [X]		Clear all expressions in the [Y=] list.
[2nd] [MATH] [8] :Test		Store the functions as y1 and y2 each with a condition.
[2] :< [1] [ENTER]		
[CLEAR] [3] [X] [-] [5]		
[|] [X]		Graph using the standard screen dimensions.
[2nd] [MATH] [8] :Test		
[3] :≥ [1] [ENTER]		When drawing this curve on paper, place an open circle on as the endpoint of the piece of the graph <u>not</u> including x=1 and a closed circle as the endpoint of the piece of the graph including x=1.
[F2] :Zoom [6] :ZoomStd		

B-13 Solving Equations in One Variable

There are four methods for approximating the solution of an equation:

1. Write the equation as an expression equal to zero. Graph *y*=(the expression). Find the *x* intercepts. These *x* values are the solution to the equation. This can be done using any of the methods described in Section B-8 of this document. The intersect feature can be used by storing 0 as y2. The solve(feature of the calculator is shown below.

2. Write the equation as an expression equal to zero. Graph *y*=(the expression). Find the *x* intercepts. These *x* values are the solution to the equation. This can be done using any of the methods described in Section B-8 of this document. The intersect feature can be used by storing 0 as y2. The zero((*x* intercept) feature of the calculator is shown below.

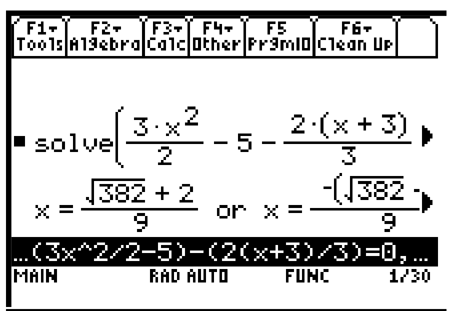
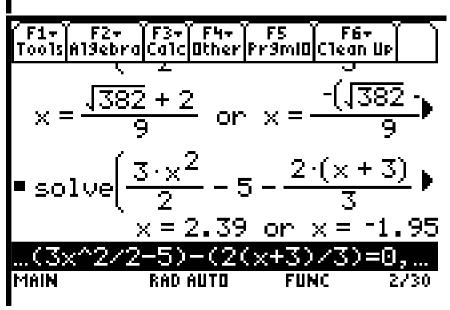
3. Graph *y*=(left side of the equation) and *y*=(right side of the equation) on the same coordinate axes. The *x* coordinate of the points of intersection are the solutions to the equation. The *x* coordinate of the point of intersection can be done using the solve(.

4. Graph *y*=(left side of the equation) and *y*=(right side of the equation) on the same coordinate axes. The *x* coordinate of the points of intersection are the solutions to the equation. The point of intersection can be done using the intersect feature of the calculator.

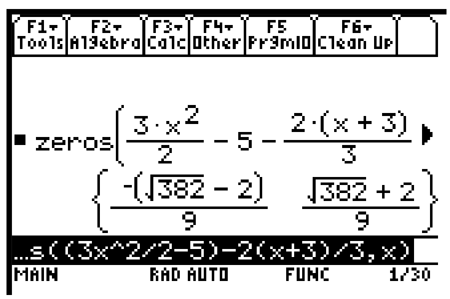
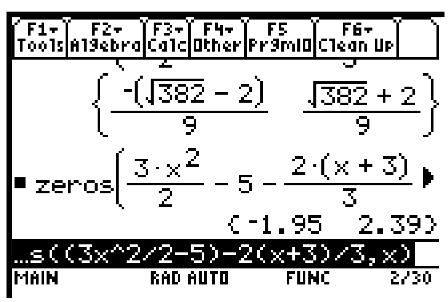
Example 1 Solve, to two decimal places, $\frac{3x^2}{2} - 5 = \frac{2(x+3)}{3}$.

Solution:

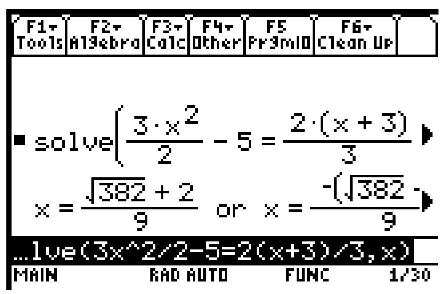
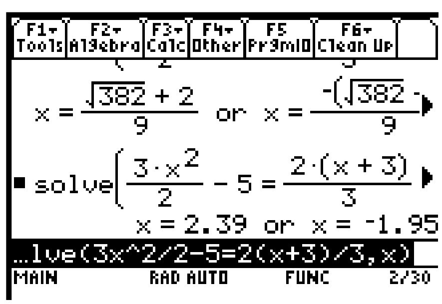
Method 1 Using solve(

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT] [F1] :Tools [8] :Clear Home [CLEAR] [MODE] [▼] [▼] [▶] [3] :FIX 2 [ENTER]		Clear the Home Screen and change the number of decimal places to 2.
[F2] :algebra [1] :solve([(] [3] [X] [^] [2] [÷] [2] [-] [5] [)] [-] [(] [2] [(] [X] [+] [3] [)] [÷] [3] [)] [=] [0] [,] [X] [)] [ENTER]		The keystrokes given require the function to be entered in the Solver command. You could store the left and right side of the equation as y1 and y2 and put y1-y2 as the left side in this command. The calculator expresses the answer as pretty print (exact answer) since the calculator is set in auto mode.
[◆] [ENTER]		Temporarily override the auto mode to get the decimal approximation. The approximate solutions to this equation are -1.95 and 2.39, rounded to two decimal places.

Method 2 Using zeros((*x* intercept)

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT] [F1] [8] :Clear Home [CLEAR] [MODE] [▼] [▼] [▶] [3] :FIX 2 [ENTER]		Clear the Home Screen and change the number of decimal places to 2.
[F2] :algebra [4] :zeros([(] [3] [X] [^] [2] [÷] [2] [-] [5] [)] [-] [(] [2] [(] [X] [+] [3] [)] [÷] [3] [)] [,] [X] [)] [ENTER]		The keystrokes given require the function to be entered in the Solver command. You could store the left and right side of the equation as y1 and y2 and put y1-y2 as the left side in this command. The calculator expresses the answer as pretty print (exact answer) since the calculator is set in auto mode. Temporarily override the auto mode to get the decimal approximation.
[◆] [ENTER]		The approximate solutions to this equation are -1.95 and 2.39, rounded to two decimal places.

<u>Method 3</u> Using solve(

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT] [F1] [8] :Clear Home [CLEAR] [MODE] [▼] [▼] [▶] [3] :FIX 2 [ENTER]		Clear the Home Screen and change the number of decimal places to 2.
[F2] :algebra [1] :solve([(] [3] [X] [^] [2] [÷] [2] [-] [5] [)] [=] [(] [2] [(] [X] [+] [3] [)] [÷] [3] [)] [,] [X] [)] [ENTER]		The keystrokes given require the function to be entered in the Solver command. You could store the left and right side of the equation as y1 and y2 and put y1=y2 in this command. The calculator expresses the answer as pretty print (exact answer) since the calculator is set in auto mode.
[◆] [ENTER]		Temporarily override the auto mode to get the decimal approximation. The approximate solutions to this equation are -1.95 and 2.39, rounded to two decimal places.

Method 4 Using Intersection

Graph $y = \frac{3x^2}{2} - 5$ and $y = \frac{2(x+3)}{3}$ on the same coordinate axes and find the *x* coordinate of their points of intersection.

Keystrokes

[2nd] [QUIT]

[F1] [8] :Clear Home

[CLEAR]

[MODE] [▼] [▼] [▶]

[3] :FIX 2 [ENTER]

[◆] [Y=]

[3] [X] [^] [2] [÷] [2] [-] [5]

[ENTER]

[2] [(] [X] [+] [3] [)] [÷] [3]

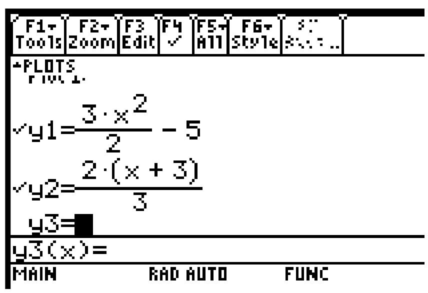
[ENTER]

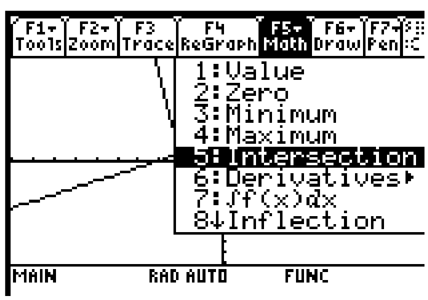
[F2] :Zoom [6] :ZoomStd

[F5] :Math

[5] :Intersection

Screen Display





Explanation

Clear the Home Screen and change the number of decimal places to 2, and place the result in row 2.

Enter the expressions as y1 and y2 in the [Y=] list.

Get the Intersection feature from the Math menu.

Press [ENTER] to select y1 as the first curve.

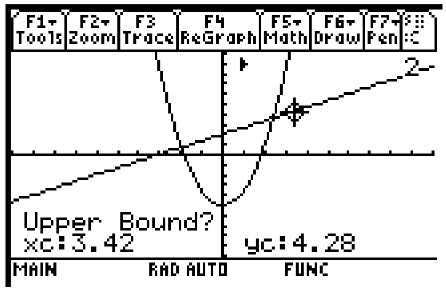
Press [ENTER] to select y2 as the second curve.

Move the cursor to the left of the intersection point and press [ENTER] to select the Lower Bound for *x*.

ENTER ENTER

▶ ...▶ ENTER

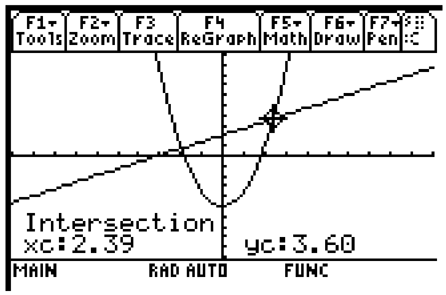
▶ ...▶



Move the cursor to the right of the intersection point and press ENTER to select the Upper Bound for *x* and to get the intersection point.

The intersection point is (2,.39, 3.60). Hence one solution to the equation is 2.39.

ENTER



Repeat to get the other intersection point.

The two solutions to the equation are 2.39 and -1.95. to two decimal place accuracy.

B-13 Solving Inequalities in One Variable

Two methods for approximating the solution of an inequality using graphing are:

1. Write the inequality with zero on one side of the inequality sign. Graph y=(the expression). Find the x intercepts. The solution will be an inequality with the x values (x intercepts) as the cut-off numbers. The points of intersection can be found using the solve(or zero(feature of the calculator. See Section B-13 of this document.

2. Graph y=(left side of the inequality) and y=(right side of the inequality) on the same coordinate axes. The x coordinate of the points of intersection are the solutions to the equation. Identify which side of the x value satisfies the inequality by observing the graphs of the two functions.
   The points of intersection can be found using solve(or using the intersect feature of the calculator.

Example 1 Approximate the solution to $\frac{3x^2}{2} - 5 \le \frac{2(x+3)}{3}$. Use two decimal place accuracy.

Solution:

Method 1

Write the equation as $\left(\frac{3x^2}{2} - 5\right) - \left(\frac{2(x+3)}{3}\right) \le 0$. Graph $y = \left(\frac{3x^2}{2} - 5\right) - \left(\frac{2(x+3)}{3}\right)$ and find the x intercepts. This was done in Section B-13, Example 1, Method 2 of this document.

The x intercepts are -1.95 and 2.39. The solution to the inequality is the interval on x for which the graph is below the x axis. The solution is $-1.95 \le x \le 2.39$.

Method 2 Graph $y = \frac{3x^2}{2} - 5$ and $y = \frac{2(x+3)}{3}$ on the same coordinate axes and find the x coordinate of their points of intersection. See Section B-13 Example 1 Method 3 of this document. The x coordinate of the points of intersections are -1.95 and 2.39. We see that the parabola is below the line for $-1.95 \le x \le 2.39$. Hence the inequality is satisfied for $-1.95 \le x \le 2.39$.

To test this inequality, choose -2 as a test value. Evaluating the original inequality using the calculator yields a "false" answer which means the inequality is not true for this value of x. (See Section B-6 of this document.) Repeat the testing using 0 and 3. We see that the inequality is true for x=0 and false for x=3. Hence the inequality is satisfied for $-1.95 \le x \le 2.39$.

B-13 Storing an Expression That Will Not Graph

Example 1 Store the expression $B^2 - 4AC$ so that it will not be graphed but so that it can be evaluated at any time. Evaluate, to three decimal places, this expression for A=3, B=2.58, and $C=\sqrt{3}$.

Solution:

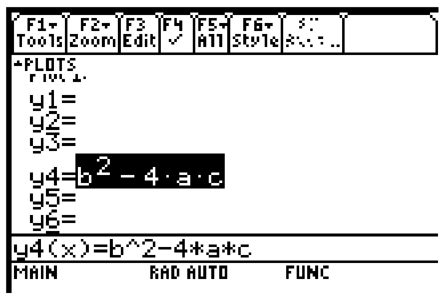
Keystrokes — *Screen Display* — *Explanation*

[2nd] [QUIT]
[F1] :Tools
[8] :Clear Home [CLEAR]
[MODE] [▼] [▼] [▶]
[4] :FIX 3 [ENTER]

Clear the Home Screen and change the number of decimal places to 3.

Clear all expressions from the Y= list.

[◆] [Y=] [CLEAR] [▼] [▼] [▼]
[ALPHA] [B] [^] [2] [-] [4]
[ALPHA] [A] [x] [ALPHA] [C]
[ENTER] [▲] [F4] :√
[ENTER] [▲]

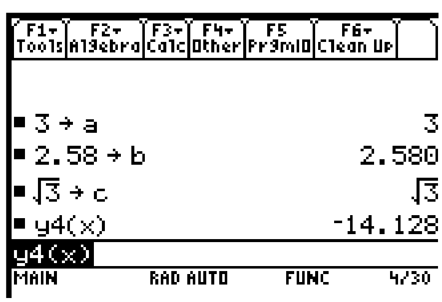


Select y4. Enter the expression.

[2nd] [QUIT] [CLEAR]
[3] [STO▶] [ALPHA] [A]
[ENTER]

Return to the Home Screen and clear the Entry Line.

[2.58] [STO▶] [ALPHA] [B]
[ENTER]
[2nd] [√] [3] [)] [STO▶]
[ALPHA] [C] [ENTER]
[Y] [4] [(] [X] [)] [ENTER]



Store the value of the variables.

Recall the function from the function list. The value of the expression is -14.138 rounded to three decimal places.

B-14 Permutations and Combinations

Example 1 Find (A) $P_{10,3}$ and (B) $C_{13,4}$ or $\binom{13}{4}$.

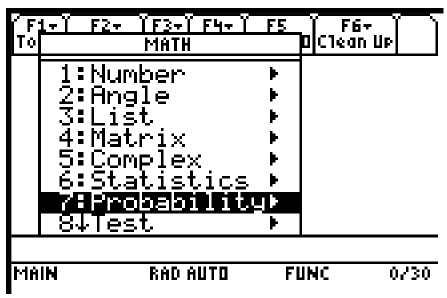
***Solution (A) and (B)*:**

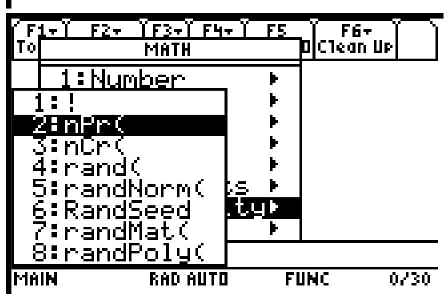
The quantity $P_{10,3}$ can be found by using the definition $\frac{10!}{7!}$ or using the built-in function nPr.

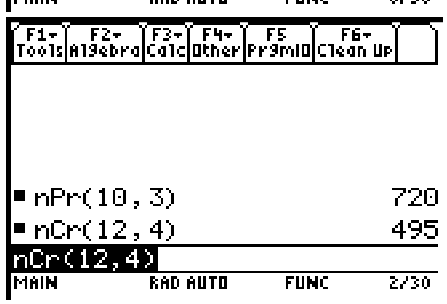
Similarly for $C_{13,4}$ or $\binom{13}{4}$.

Keystrokes	*Explanation*
[2nd] [QUIT]	Return to the Home Screen and clear.
[F1] :Tools	
[8] :Clear Home [CLEAR]	
[2nd] [MATH]	Choose nPr and press [ENTER] .
[7] :Probability	
[2] :nPr([10] [,] [3] [)]	Enter the numbers separated by a comma and press [ENTER] .
[ENTER]	Repeat for nCr.
[2nd] [MATH]	The results are:
[7] :Probability	$P_{10,3}$ = 720
[3] :nCr([13] [,] [4] [)]	$C_{13,4}$ = 495
[ENTER]	

Screen Display







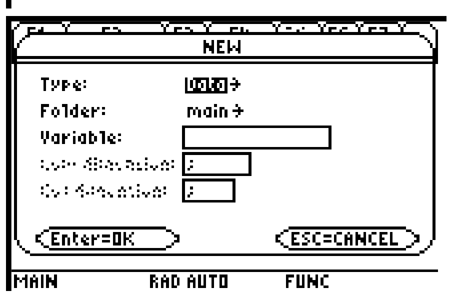
B-15 Matrices

Example 1 Given the matrices

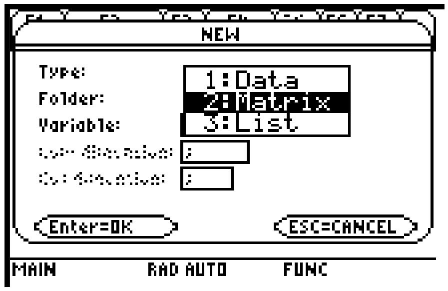
$$A = \begin{bmatrix} 1 & -2 \\ 3 & 0 \\ 5 & -8 \end{bmatrix} \quad B = \begin{bmatrix} 2 & 1 & 5 \\ 3 & 2 & -1 \\ 0 & 8 & -3 \end{bmatrix} \quad C = \begin{bmatrix} 1 \\ -5 \\ 10 \end{bmatrix}$$

Find (A) $-3BC$ (B) B^{-1} (C) A^{T} (D) det B

Solution (A):

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Return to the Home Screen.
[2nd] [MEM] [F1] :RESET [1] :ALL [ENTER] :YES		Clear the memory so new variables can be defined.
[MODE] [▼] [▼] [▶] [4] :FIX 3 [ENTER]		Change the number of decimal places to 3 and return to the Home Screen.
[APPS] [6] :Data/Matrix Editor		Get the [APPS] menu and select Data/Matrix Editor by pressing 6.
[3] :New...		Select new by pressing 3.
		

[▶] [2] :Matrix

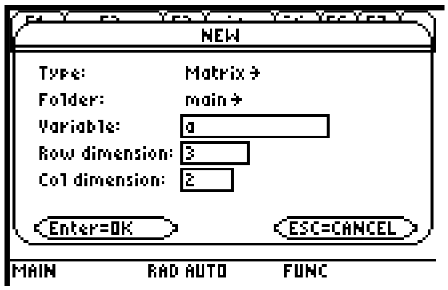


Select Matrix from the Type menu.

[▼] [▼] [alpha] [A]

[▼] [3] [▼] [2]

[ENTER] [ENTER]



We will store in the main folder. Name the matrix A. Matrix A will have 3 rows and 2 columns. You should get a screen as shown to the left.

If you get an error message, begin again by resetting the memory. Usually the problem is that the variable A is already in use.

Enter the elements of the matrix A.

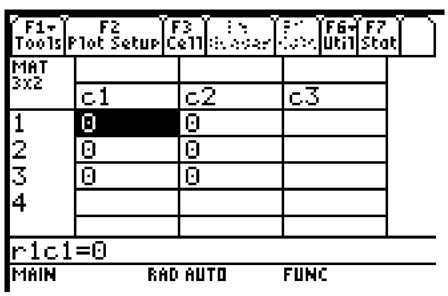
[1] [ENTER]

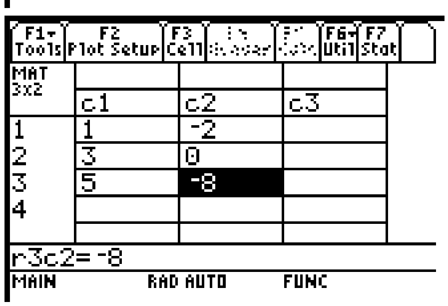
[(-)] [2] [ENTER]

[3] [ENTER] [0] [ENTER]

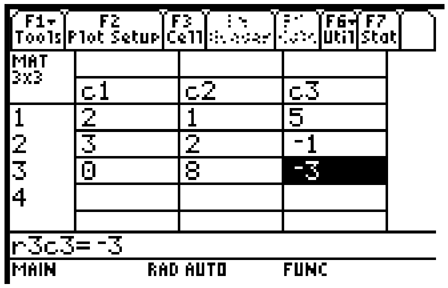
[5] [ENTER]

[(-)] [8] [ENTER]



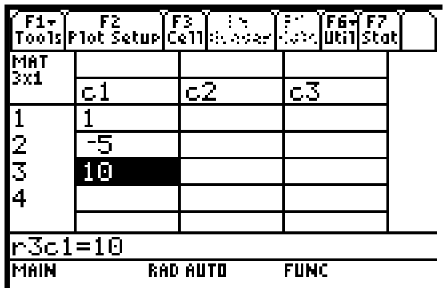


[2nd] [QUIT]



Return to the Home Screen.

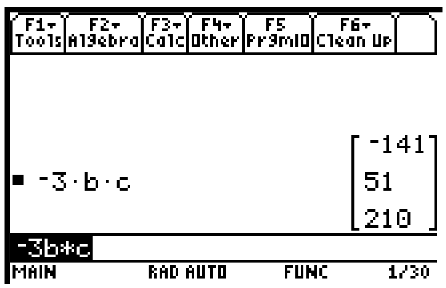
Get the matrix menu again and and repeat the procedure to enter matrices B and C.



[2nd] [QUIT]

[(-)] [3] [x] [alpha] [B]

[x] [alpha] [C] [ENTER]



Return to the home screen to do calculations.

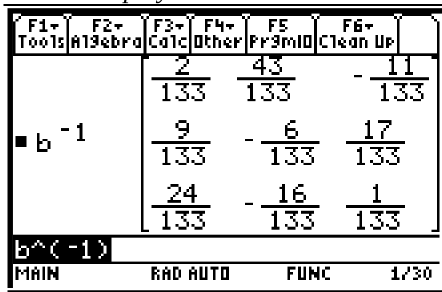
Operations are entered as usual.

Solution (B):

Keystrokes | *Screen Display* | *Explanation*

[alpha] [B] [^] [(] [(-)] [1] [)]

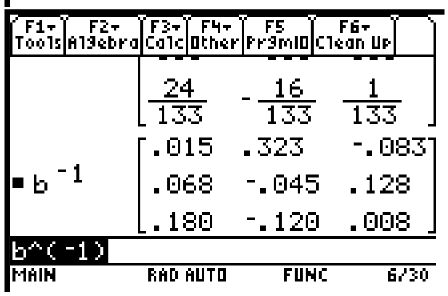
[ENTER]



Notice the way inverses are found. The rest of the matrix can be seen using the right arrow keys.

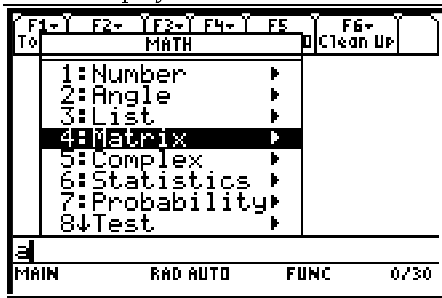
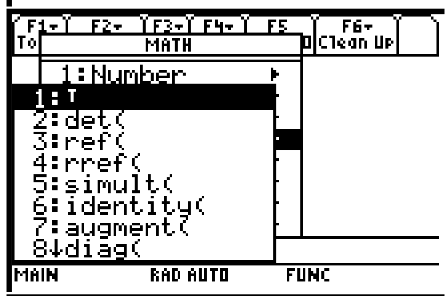
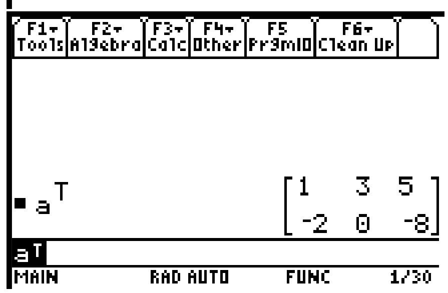
The solution is given in pretty print form.

[◆] [ENTER]



Override the pretty print to get solution as 3 decimal places.

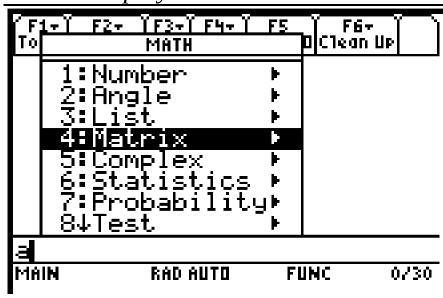
Solution (C):

Keystrokes	*Screen Display*	*Explanation*
[alpha] [A] [2nd] [MATH] [4] :Matrix		Get the matrix operations list from the MATH menu.
[1] :^{T} [ENTER]	 	Choose the transpose from the MATRX MATH menu.

Solution (D):

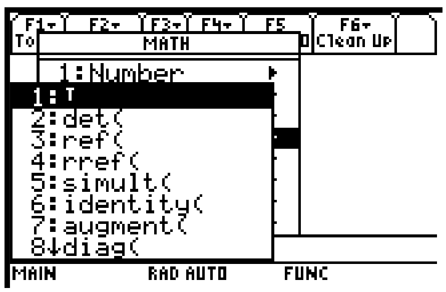
Keystrokes | *Screen Display* | *Explanation*

[2nd] [MATH] [4] :Matrix



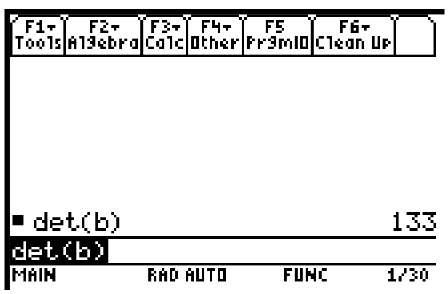
Get the matrix operations list from the [MATH] menu.

[2] :det(



Choose the determinant from the [MATH] MATRX menu.

[alpha] [B] [)] [ENTER]



The determinant of matrix B is 133.

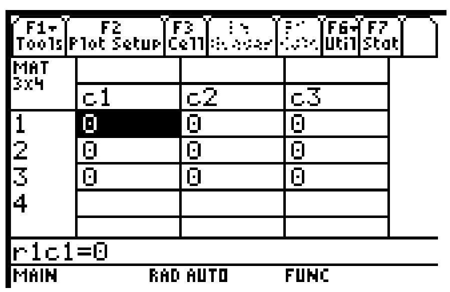
Example 2 Find the reduced form of matrix $\begin{bmatrix} 2 & 1 & 5 & 1 \\ 3 & 2 & -1 & -5 \\ 0 & 8 & -3 & 10 \end{bmatrix}$.

Solution:

There are two methods that can be used:

1. Use the row operations individually.
2. Use rref(from the MATRX MATH menu.

Method 1 Using row operations

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Return to the Home Screen.
[2nd] [MEM] [F1] :RESET [1] :ALL [ENTER] :YES		Clear the memory so new variables can be defined.
[MODE] [▼] [▼] [▶] [4] :FIX 3 [ENTER]		Change the number of decimal places to 3 and return to the Home Screen.
[APPS] [6] :Data/Matrix Editor		Get the [APPS] menu and select Data/Matrix Editor by pressing 6.
[3] :New... [▶] [2] :Matrix [▼] [▼] [alpha] [A] [▼] [3] [▼] [4] [ENTER] [ENTER]		Select new by pressing 3. Select Matrix and enter A for the matrix name with dimensions 3x4.

[2] [ENTER] [1] [ENTER]

[5] [ENTER] [1] [ENTER]

[3] [ENTER] [2] [ENTER]

etc.

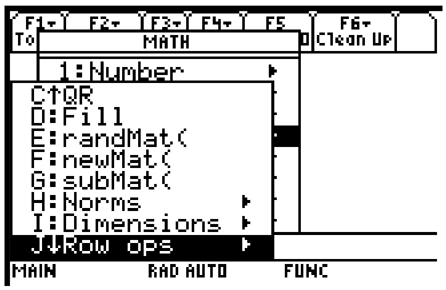
Enter the elements row by row.

[2nd] [QUIT]

When all elements are entered, press [2nd] [QUIT] to get the Home Screen.

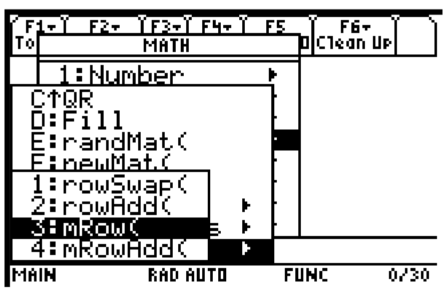
[2nd] [MATH] [4] :Matrix

[alpha] [J] :Row ops



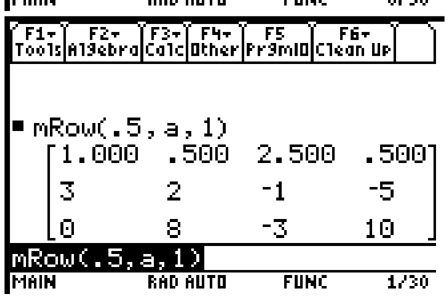
Display the matrix from the MATRX menu.

[3] :mRow(



[.5] [,] [alpha] [A] [,] [1] [)]

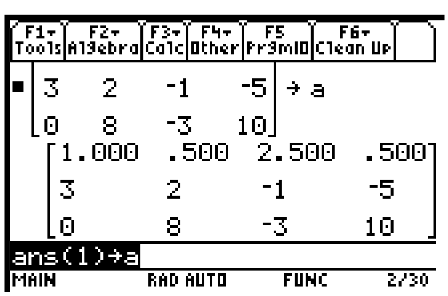
[ENTER]



Multiply row 1 of matrix A by .5. Another way to say this that might help to remember the order of entries within the parentheses is to think: .5 times matrix A row 1.

[STO▸] [alpha] [A]

[ENTER]



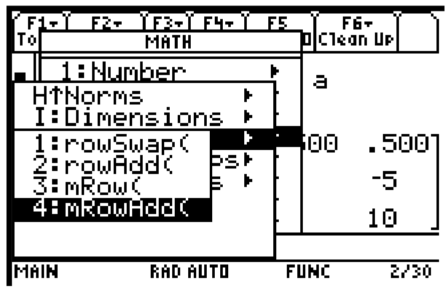
Store the result in matrix A location. It is a good idea to store the answer.

However, if you make a mistake and the new matrix is not stored, you will need to start over from the beginning.

[2nd] [MATH] [4] :Matrix

[alpha] [J] :Row ops

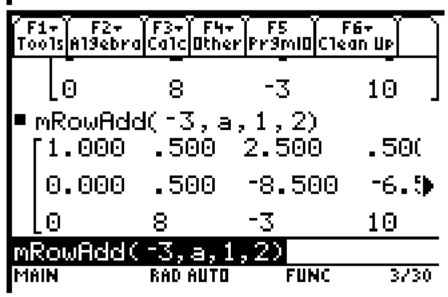
[4] :mRowAdd(



Multiply -3 times matrix A row 1 to add to row 2.

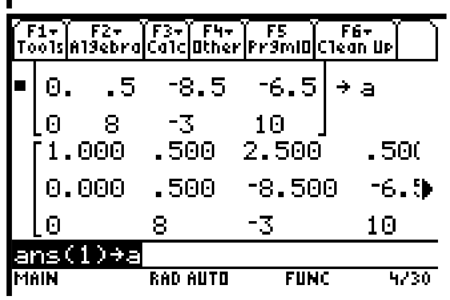
[(-)] [3] [,] [alpha] [a] [,]

[1] [,] [2] [)] [ENTER]



[STO▸] [alpha] [A]

[ENTER]



Store the result as matrix A.

[2nd] [MATH] [4] :Matrix

[alpha] [J] :Row ops

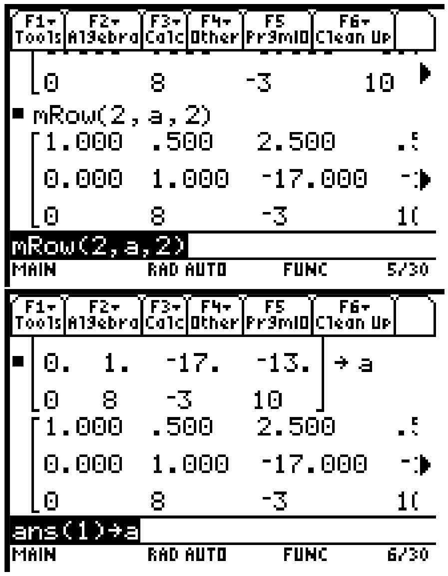
[3] :mRow(

[2] [,] [alpha] [a] [,]

[2] [)] [ENTER]

[STO▸] [alpha] [A]

[ENTER]



2 times matrix A row 2.

Use the right arrow keys to see the rest of the matrix.

Continue using row operations to arrive at the reduced form of $\begin{bmatrix} 1 & 0 & 0 & -2.428... \\ 0 & 1 & 0 & 1.571... \\ 0 & 0 & 1 & .857... \end{bmatrix}$.

Thus the solution to the system of equations is x = -2.428, y = 1.571, and z = 0.857.

NOTE:

To swap rows of a matrix use [2nd] [MATH] [4] :Matrix [alpha] [J] :Row ops

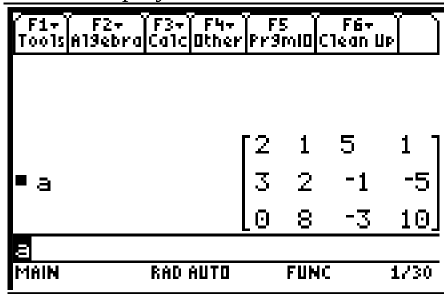
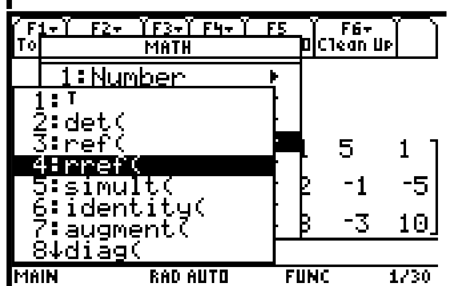
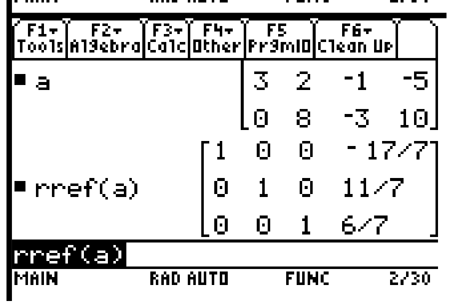
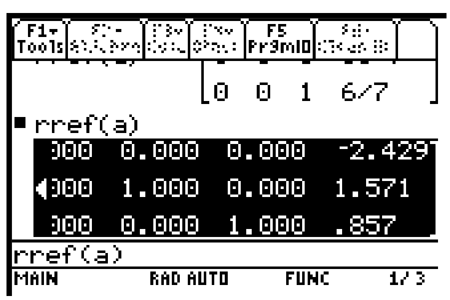
[1] :rowSwap(. To swap rows 2 and 3 in matrix [A] use rowSwap(A,2,3).

To add one row to another use [2nd] [MATH] [4] :Matrix [alpha] [J] :Row ops

[2] :rowAdd(. To add rows 2 and 3 in matrix [A] and place the result in row 3 use rowAdd(A,2,3).

Method 2 Using rref(from the [MATH] MATRX menu

Enter the elements in the matrix as done in Method 1.

Keystrokes	*Screen Display*	*Explanation*
[alpha] [A] [ENTER]		Enter the matrix mode and enter the elements of the matrix.
[2nd] [MATH] [4] :Matrix [4] :rref(		Select the rref(command.
[alpha] [A] [)] [ENTER]		Recall matrix A. This command will give the row-echelon form of matrix A, which has the identity matrix in the first three columns and constants as the fourth column. The solution is given in pretty print form.
[◆] [ENTER]		Override the pretty print to get solution as 3 decimal places. Use the arrow keys to see the rest of the matrix.

Hence if a system of equations is

$$\begin{aligned} 2x_1 + x_2 + 5x_3 &= 1 \\ 3x_1 + 2x_2 - x_3 &= -5 \\ 8x_2 - 3x_3 &= 10 \end{aligned}$$

with augmented coefficient matrix

$$\begin{bmatrix} 2 & 1 & 5 & 1 \\ 3 & 2 & -1 & -5 \\ 0 & 8 & -3 & 10 \end{bmatrix}$$

the solution, rounded to three decimal places, of the system of equations is

$$\begin{aligned} x_1 &= -2.429 \\ x_2 &= 1.571 \\ x_3 &= .857 \end{aligned}$$

B-16 Graphing an Inequality

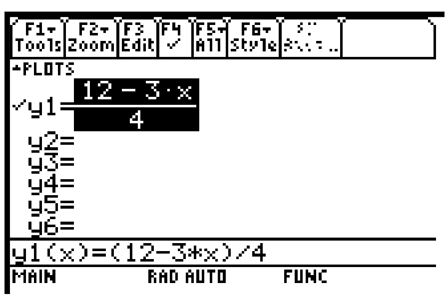
To graph an inequality:

- Change the inequality sign to an equals sign.
- Solve the equation for *y*.
- Enter this expression in the function list on the calculator. This is the boundary curve.
- Determine the half-plane by choosing a test point not on the boundary curve and substituting the test value into the original inequality. This can be done using paper and pencil.
- Graph the boundary curve using the appropriate shade option on the calculator to get a shaded graph.

Example 1 Graph $3x + 4y \le 13$.

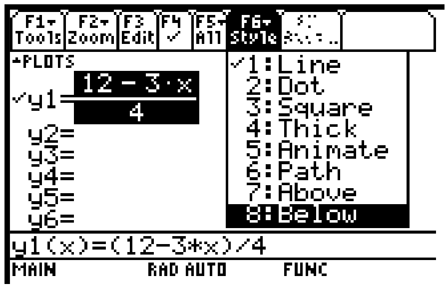
Solution:

Changing the inequality sign to an equals sign yields $3x + 4y = 13$.
Solving this equation for *y* yields $y = (13 - 3x)/4$.
Determine the correct half-plane by substituting the point (0,0) into the original inequality. We have $3(0) + 4(0) \le 13$, which is a true statement. Hence the point (0, 0) is in the solution set of the inequality. So we want the lower half-plane plus the line.

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Return to the Home Screen.
[2nd] [MEM] [F1] :RESET		Reset the memory.
[1] :ALL [ENTER] :YES		
[◆] [Y=] [CLEAR] [(] [13] [-] [3] [X] [)] [÷] [4] [ENTER] [▲]		Graph 3*x*+4*y*=13 by first writing as *y*=(13-3*x*)/4. Store the expression in the [Y=] list after clearing any existing expressions. Determine the half-plane by choosing the point (0, 0) and substituting into the inequality **by hand** using paper and pencil. 3x0+4x0<13 is a true statement. The inequality is true for this point. Hence, we want the lower half-plane.

2nd F6 :Style

8 :Below

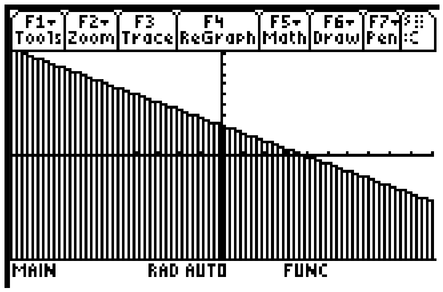


Use the style selection to shade the lower part of the graph.

Note that the √ at the left of y1 is not displayed after selecting 8 :Below.

F2 :Zoom

6 :ZoomStd

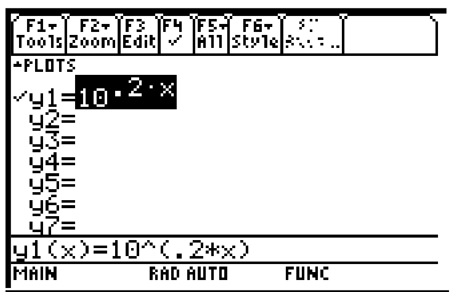
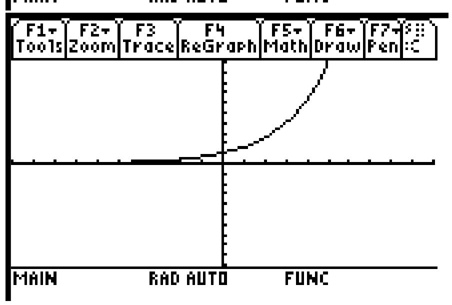


Graph the function.

B-17 Exponential and Hyperbolic Functions

Example 1 Graph $y = 10^{0.2x}$

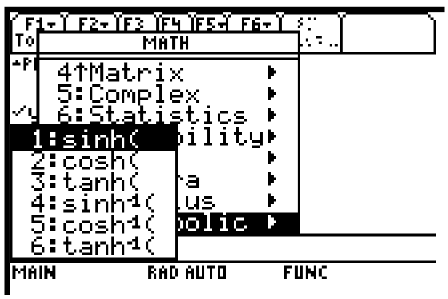
Solution:

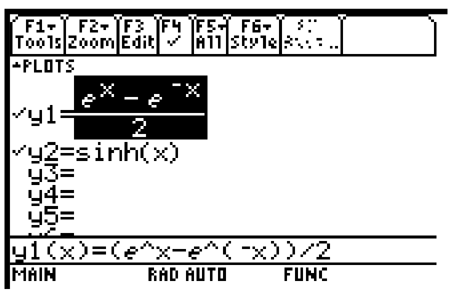
Keystrokes	*Screen Display*	*Explanation*
2nd QUIT		Return to the Home Screen and clear.
F1 :Tools 8 :Clear Home		
CLEAR		
◆ Y= CLEAR		Store the function in the Y= list and graph.
10 ^ (.2		
X)		
ENTER ▲		Use the up arrow to highlight the function. Now the entry line will also be displayed.
F2 :Zoom 6 :ZoomStd		Graph the function.

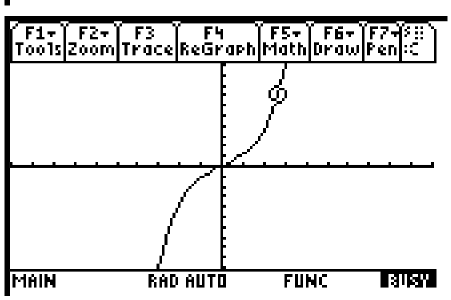
Example 2 Graph $y = \dfrac{e^{x} - e^{-x}}{2}$. [NOTE: This is the hyperbolic sine, sinh *x*.]

Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Return to the Home Screen and clear.
[F1] :Tools [8] :Clear Home		Store the function and graph.
[◆] [Y=] [CLEAR]		
[(] [◆] [e^x] [X] [)]		
[-] [◆] [e^x] [(-)] [X] [)] [)]		This is also the hyperbolic sine. So we could use sinh from the catalog list.
[÷] [2] [ENTER]		
[2nd] [MATH] [alpha] [B]		Get the sinh from the MATH Hyperbolic list.
[1] :sinh([X] [)] [ENTER]		Store it as y2. Enter X as the variable.
[2nd] [F6] :Style [5] :Animate		Change the style to Animate.
[F2] :Zoom [6] :ZoomStd		Watch closely and you will see the O tracing the graph of y1.







B-18 Scientific Notation, Significant Digits, and Fixed Number of Decimal Places

Example 1 Calculate, to ten decimal places, $(-8.513\times10^{-3})(1.58235\times10^{2})$. Enter numbers in scientific notation. Express your answer in scientific notation.

Solution:

Keystrokes | *Screen Display* | *Explanation*

[2nd] [QUIT] — Clear the Home Screen.

[F1] :Tools [8] :Clear Home

[CLEAR]

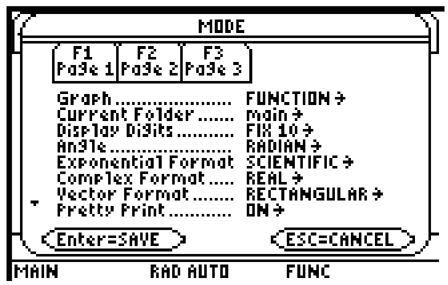
[MODE] [▼] [▼] [▶]

[alpha] [B] :FIX 10

[▼] [▼] [▶]

[2] :SCIENTIFIC

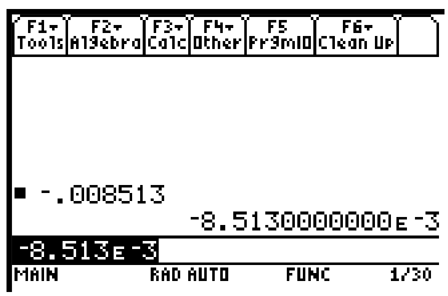
[ENTER]



Set the mode to 10 decimal places and scientific notation.

[(-)] [8.513] [EE] [(-)] [3]

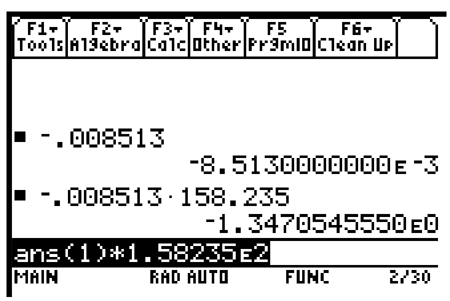
[ENTER]



Enter the first number. The number displayed is not in scientific notation. (It is not necessary to press [ENTER] at this point. This is done here to show how the numbers are displayed on the screen.)

[×] [1.58235] [EE] [2]

[ENTER]



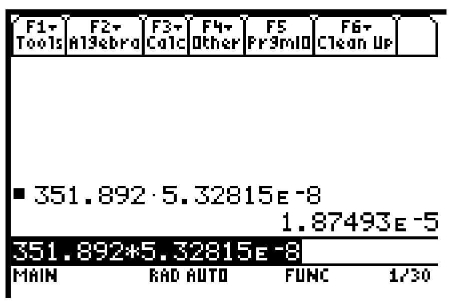
Multiply by the second number.

The answer is -1.3470545550, to ten decimal places.

Example 2 Set the scientific notation to six significant digits and calculate $(351.892)(5.32815\times10^{-8})$.

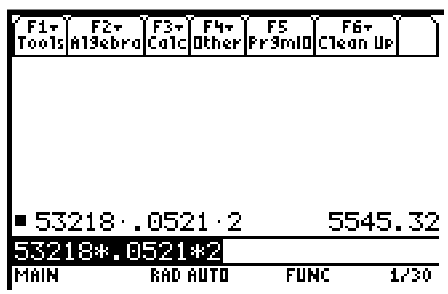
Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Clear the Home Screen.
[F1] :Tools [8] :Clear Home		
[CLEAR]		
[MODE] [▼] [▼] [▶] [alpha]		Select Float 6 and Scientific notation.
[K] :FLOAT 6		Return to the Home Screen.
[▼] [▼] [▶]		
[2] :SCIENTIFIC		Enter the numbers.
[ENTER]		Note the result is displayed in scientific notation with six significant digits.
[351.892] [×] [5.32815]		
[EE] [(-)] [8] [ENTER]		



Example 3 Fix the number of decimal places at 2 and calculate the interest earned on \$53,218.00 in two years when invested at 5.21% simple interest.

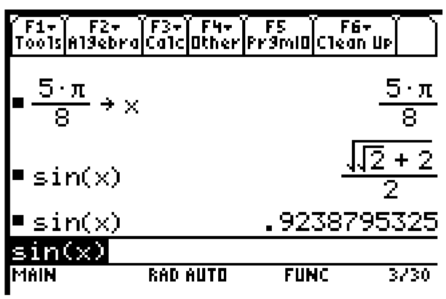
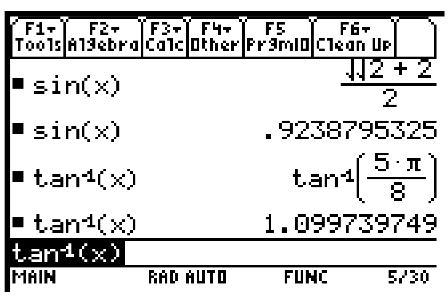
Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Choose normal notation with 2 fixed decimal points.
[F1] :Tools [8] :Clear Home		
[CLEAR]		Return to the Home Screen.
[MODE] [▼] [▼] [▶]		
[3] :FIX 2		
[▼] [▼] [▶] [1] :NORMAL		
[ENTER]		Only two decimal places are shown in the answer. The interest is \$5545.32.
[53218] [×] [.0521] [×] [2]		
[ENTER]		

B-19 Angles and Trigonometric Functions

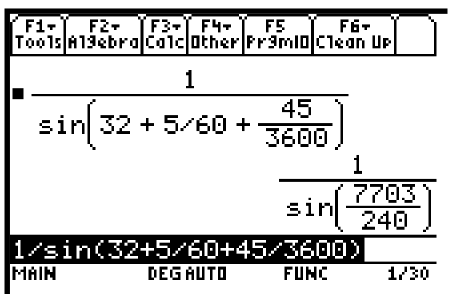
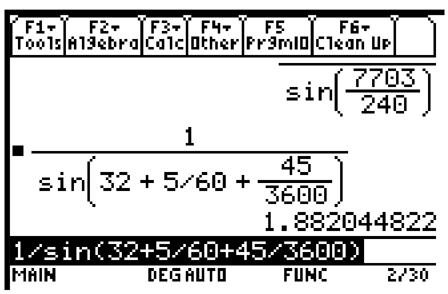
Example 1 Evaluate $f(x) = \sin x$ and $g(x) = \tan^{-1} x$ at $x = \frac{5\pi}{8}$. Use 10 significant digits.

Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Set the mode to Float with 10 digits.
[F1] :Tools [8] :Clear Home		Since the angle measure is given in radians, set the calculator for radian measure before starting calculations.
[CLEAR]		
[MODE] [▼] [▼] [▶] [alpha]		
[O] :FLOAT 10		
[▼] [▶] [1] :RADIAN		
[▼] [▶] [1] :NORMAL		Return to the Home Screen.
[ENTER] [2nd] [QUIT]		
[5] [2nd] [π] [÷] [8]		Store $\frac{5\pi}{8}$ as *x*.
[STO▶] [X] [ENTER]		Get sine function and evaluate.
[2nd] [SIN] [X] [)] [ENTER]		
[◆] [ENTER]		Override the pretty print to get the decimal approximation.
[◆] [TAN^{-1}] [X] [)]		Get the inverse tangent function and evaluate.
[ENTER]		
[◆] [ENTER]		

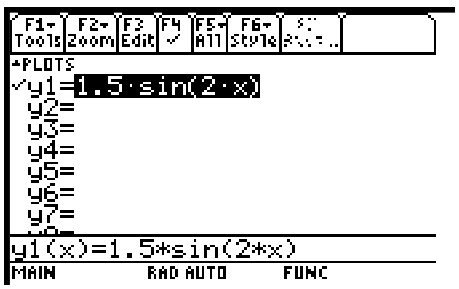
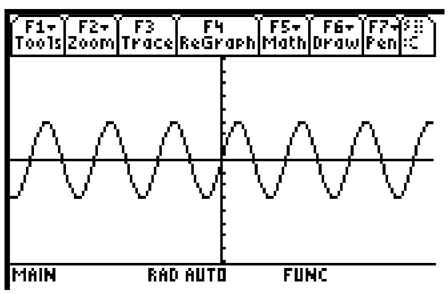
Example 2 Evaluate $f(x) = \csc x$ at $x = 32°\ 5'\ 45''$. Express answer using 10 significant digits.

Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Set the mode to Float 10.
[F1] :Tools [8] :Clear Home		
[CLEAR]		Since the angle measure is given in degrees, set the calculator for degree measure before starting calculations.
[MODE] [▼] [▼] [▶] [alpha]		
[O] :FLOAT 10		
[▼] [▶] [2] :DEGREE		Return to the Home Screen.
[▼] [▶] [1] :NORMAL		Use $\frac{1}{\sin x}$ to evaluate csc *x*.
[ENTER]		
[1] [÷] [2nd] [SIN] [32] [+] [5] [÷] [60] [+] [45] [÷] [3600] [)] [ENTER]		Change the minutes and seconds to decimal values while entering the angle measure.
[◆] [ENTER]		Override the pretty print format to get the decimal approximation.

Example 3 Graph $f(x) = 1.5 \sin 2x$.

Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT]		Set [MODE] to Radian measure.
[F1] :Tools [8] :Clear Home		
[CLEAR]		
[MODE] [▼] [▼] [▼] [▶]		
[1] :RADIAN [ENTER]		
[◆] [Y=] [CLEAR]		Clear all expressions stored in the [Y=] list.
[1.5] [2nd] [SIN] [2] [X] [)]		Store $f(x)$ as y1.
[ENTER] [▲]		Use the up arrow to highlight y1 and to see the entry line input.
[F2] :Zoom [7] :ZoomTrig		Use the trigonometric option on the ZOOM menu to get tick marks set at radian measures on the horizontal axis since the angle measure is in radians.
		Press [◆] [WINDOW] to see the [WINDOW] dimensions are [-10.34…, 10.34…]1.57… by [-4, 4].5.

Example 4 Graph $g(x) = 3\tan^{-1}(.2x)$.

Solution:

Keystrokes | *Screen Display* | *Explanation*

[2nd] [QUIT]

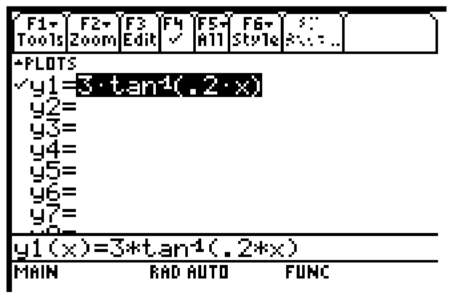
[F1] :Tools [8] :Clear Home

[CLEAR]

Return to the Home Screen and clear.

[◆] [Y=] [CLEAR]

[3] [◆] [TAN^{-1}] [.2] [X] [)]



Store $g(x)$ as y1.

[◆] [WINDOW]

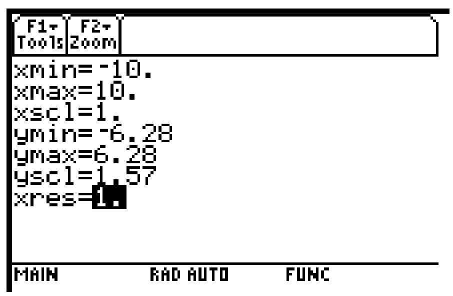
[(-)] [10] [ENTER]

[10] [ENTER] [1] [ENTER]

[(-)] [6.28] [ENTER]

[6.28] [ENTER] [1.57]

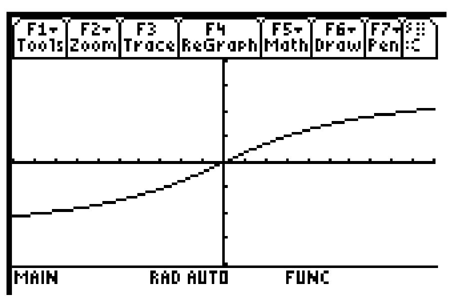
[1] [ENTER]



Set the [WINDOW] dimensions to [-10, 10]1 by [-6.28, 6.28]1.57

[2nd] [QUIT]

[◆] [GRAPH]

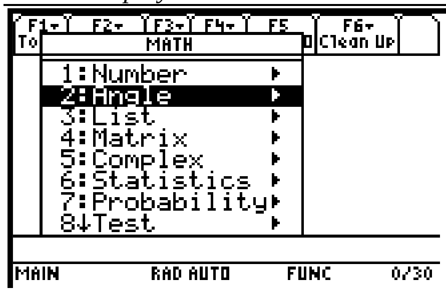
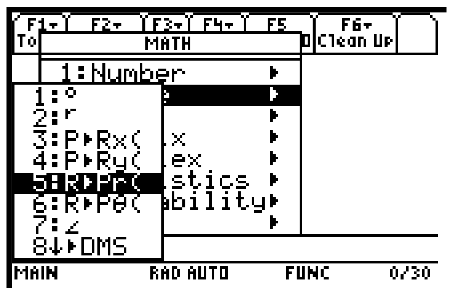
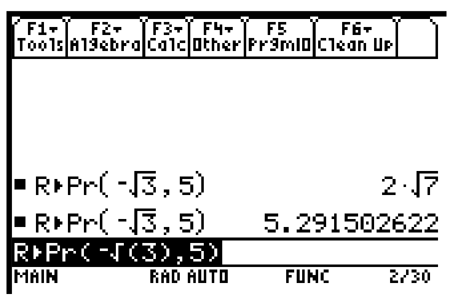
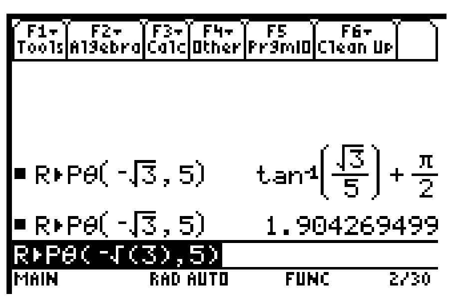


Graph the function.

B-20 Polar Coordinates and Polar Graphs

Example 1 Change the rectangular coordinates $(-\sqrt{3}, 5)$ to polar form with $r \geq 0$ and $0 \leq \theta \leq 2\pi$.

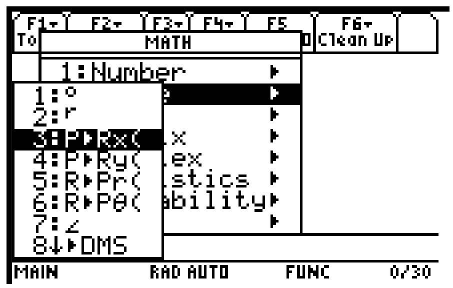
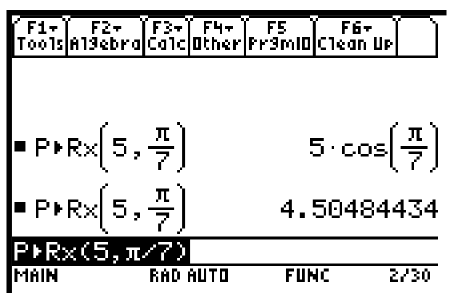
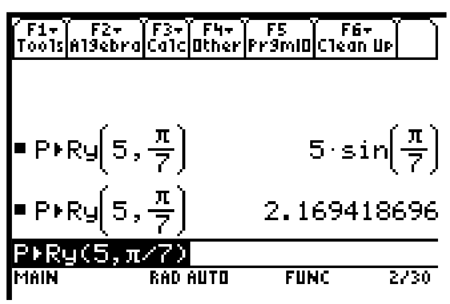
Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT] [F1] :Tools [8] :Clear Home [CLEAR] [2nd] [MATH] [2] :Angle		Return to the Home Screen and clear. Get the Angle option from the [MATH] menu.
[5] :R▸Pr(		Get the Angle menu. Choose rectangular to polar conversion that displays the *r* value.
[(-)] [2nd] [√] [3] [)] [,] [5] [)] [ENTER] [◆] [ENTER]		Enter the value of *x* and *y* coordinates. The displayed value is *r*.
[2nd] [MATH] [2] :Angle [6] :R▸Pθ([(-)] [2nd] [√] [3] [)] [,] [5] [)] [ENTER] [◆] [ENTER]		Get the Angle menu again. Choose the rectangular to polar conversion that displays the value of *θ.* Enter the value of *x* and *y* coordinates. The displayed value is *θ.*

The polar coordinates are (5.29, 1.90) to two decimal places.

Example 2 Change the polar coordinates (5, π/7) to rectangular coordinates.

Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT] [F1] :Tools [8] :Clear Home		Return to the Home Screen and clear.
[CLEAR] [2nd] [MATH] [2] :Angle [3] :P▸Rx(		Get the angle menu. Choose polar to rectangular conversion that displays the value of *x*.
[5] [,] [2nd] [π] [÷] [7] [)] [ENTER] [◆] [ENTER]		Enter the value of *r* and *θ*. The displayed value is *x*.
[CLEAR] [2nd] [MATH] [2] :Angle [4] :P▸Ry([5] [,] [2nd] [ ] [÷] [7] [)] [ENTER] [◆] [ENTER]		Get the angle menu again. Choose polar to rectangular conversion that displays the value of *y*. Enter the value of *r* and *θ*. The displayed value is *y*.

The rectangular coordinates are (4.50, 2.17) to two decimal places.

Example 3 Find the value of r for $r = 5 - 5\sin\theta$ at $\theta = \frac{\pi}{7}$.

Solution:

Keystrokes | *Screen Display* | *Explanation*

[2nd] [QUIT]

Return to the Home Screen and clear.

[F1] :Tools [8] :Clear Home

[CLEAR]

[2nd] [π] [÷] [7] [STO▸]

[2nd] [CHAR] [1] :Greek

[9] :θ [ENTER]

Store $\frac{\pi}{7}$ as θ .

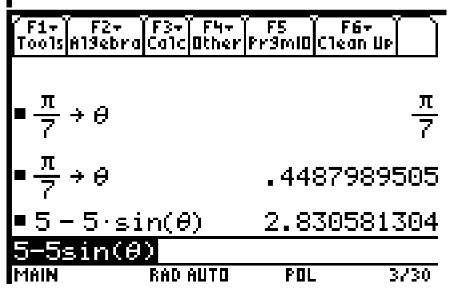
[◆] [ENTER]

[5] [-] [5] [2nd] [SIN]

[2nd] [CHAR]

[1] :Greek [9] :θ [)]

[ENTER]

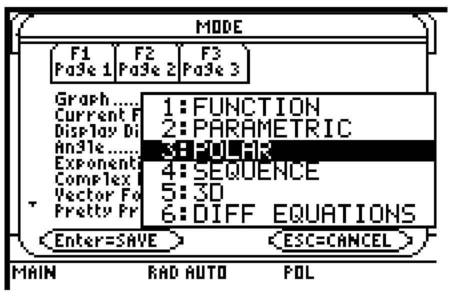
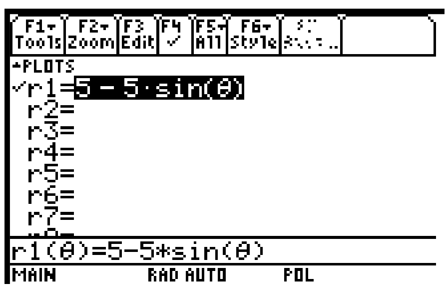


Enter $5 - 5\sin\theta$ and evaluate.

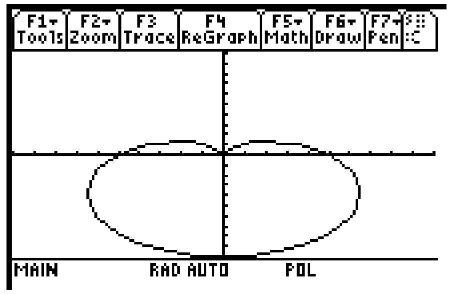
Example 4 Graph $r = 5 - 5\sin\theta$

Polar equations can be graphed by using the polar graphing mode of the calculator.

Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT] [F1] :Tools [8] :Clear Home		Return to the Home Screen and clear.
[CLEAR] [MODE] [▶] [3] :POLAR [ENTER]		Select polar mode.
[◆] [Y=] [5] [-] [5] [2nd] [SIN] [2nd] [CHAR] [1] :Greek [9] :θ [)] [ENTER]		Get the [Y=] list and enter the function as r1.

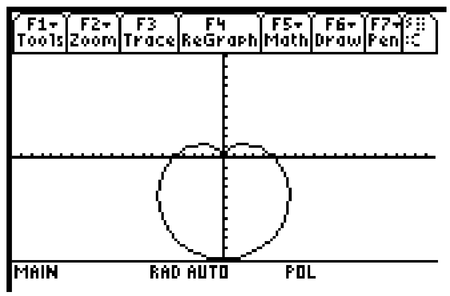
[F2] :Zoom [6] :ZoomStd



Graph using the standard dimensions for the window.

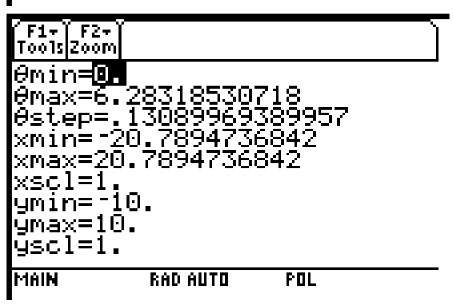
The graph on the standard screen is slightly distorted since the scale marks on the *y* axis are closer together than the scale marks on the *x* axis.

[F2] :Zoom [5] :ZoomSqr



The square option on the Zoom Menu makes the scale marks the same distance apart on both axes.

[◆] [WINDOW]



Press [◆] [WINDOW] to see how the window dimensions are changed.