TI-86 GRAPHING CALCULATOR

BASIC OPERATIONS

by

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D-1 Getting Started

Press [ON] to turn on the calculator.

Press [CLEAR] to clear the screen.

Press [2nd] [+] to get the RESET menu. It will be displayed at the bottom of the screen. The menu is shown at the right.

```
RAM |DELET|RESET| TOL |ClrEnt
```

Press [F3] :RESET to get the reset menu. The first menu is now displayed in inverse shading on the line above the new menu.

```
RAM |DELET|RESET| TOL |ClrEnt
ALL | MEM |DFLTS|     |
```

Press [F1] :ALL to clear the memory.

You will get another menu with a message as shown at the right.

```
Are you sure?

    |     |     | YES |  NO
```

Press [F4] :YES to clear the memory.

The display should now show the message shown at the right.

```
Mem cleared
Defaults set
```

Press [CLEAR] to clear the screen.

> Press [2nd] [▲] to make the display darker.
>
> Press [2nd] [▼] to make the display lighter.

To check the battery power, press [2nd] [▲] and note the number that will appear in the upper right corner of the screen. If it is an 8 or 9, you should replace your batteries. The highest number is 9.

Press [CLEAR] to clear the screen.

Press [2nd] [OFF] to turn off the calculator.

D-2 Special Keys, Home Screen and Menus

[2nd]

The [2nd] key must be pressed to access the operation above and to the left of a key. A flashing up arrow [↑] is displayed as the cursor on the screen after [2nd] key is pressed.

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

[ALPHA]

This key must be pressed to access the operation above and to the right of a key. A flashing [A] is displayed as the cursor on the screen after the [ALPHA] key is pressed.

[ALPHA] [ALPHA]

ALPHA LOCK is engaged when the [ALPHA] key is pressed twice in succession. The calculator will remain locked in the alpha mode until the [ALPHA] key is pressed again. Alpha LOCK is useful when entering variable names that are more than one character. A variable name can be up to 8 characters in length.

Because of this feature, multiplication of variables need a multiplication symbol between the variables. AB refers to an individual variable. AxB (displayed as A*B on the calculator screen) refers to the variable A multiplied by the variable B.

[2nd] [alpha] and [2nd] [alpha] [ALPHA]

The key combination [2nd] [alpha] will produce lower case letters. Lower case letters are used as variables in expressions. Lower case letters are different from upper case letters in that they have different memory locations. Hence ab = 2 and AB = 5 are treated as different variables ab and AB, respectively.

MODE

Press 2nd MODE to access the mode screen. The highlighted items are currently active. Select the item you wish using the arrow keys. Press ENTER to activate the selection.

Type of notation for display of numbers.	Norm Sci Eng
Number of decimal places displayed.	Float 012345678901
Type of angle measure.	Radian Degree
Display format of complex numbers.	RectC PolarC
Function, polar, parametric, differential equation graphing.	Func Pol Param DifEq
Decimal, binary, octal or hexadecimal number base.	Dec Bin Oct Hex
Rectangular, cylindrical, or spherical vectors.	RectV CylV SphereV
Exact differentiation or numeric differentiation.	dxDer1 dxNDer

Home Screen

The blank screen is called the Home Screen. You can always get to this screen (aborting any calculations in progress) by pressing 2nd QUIT . QUIT is the function above the EXIT key.

Menus

The TI-86 graphing calculator uses menus for selection of specific functions. The items on the menus are displayed across the bottom of the screen. Several menus can be displayed at the same time.

Press the function key directly below the item on the menu you wish to choose. 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, F2 :WIND refers to the second item on the GRAPH menu. Press GRAPH to see this menu.

> In this document, a menu choice will be noted as the key to press followed by the meaning of the key. For example: F3 :RESET means to press the F3 key to choose RESET.

EXIT

Press this key to exit and remove the menu closest to the bottom of the screen.

D-3 Correcting Errors

It is easy to correct errors when entering data into the calculator by using the arrow keys, [INS], and [DEL] keys. You need to press [2nd] [INS] to insert a character before the cursor position.

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

D-4 Calculation

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

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*
[2nd] [QUIT] [CLEAR] [(-)] [8] [+] [9] [^] [2] [-] [2nd] [MATH] [F1] :NUM [F5] :abs [(] [3] [÷] [2nd] [√] [2] [-] [5] [)] [ENTER]	¯8+9^2-abs (3/√ 2-5) 70.1213203436	It is a good idea to clear the screen before starting a calculation. Enter numbers as you read the expression from left to right.

D-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:

1. Store the values of the variables and then enter the expression. When [ENTER] is pressed the expression is evaluated for the stored values of the variables.

2. Store the expression and store the values of the variables. Recall the expression. Press [ENTER] . The expression is evaluated 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*
[2nd] [QUIT] [CLEAR]	
[2nd] [π] [STO▶] [x-VAR] [ENTER]	π→X
	3.14159265359
[2nd] [√] [3] [STO▶] [A] [ENTER]	√ 3→A
	1.73205080757
[4] [2nd] [MATH] [F2] :PROB [F1] :! [STO▶] [W] [ENTER]	4!→W
	24

> In this document the notation [F1] :! refers to the menu item listed on the screen above the [F1] key.

[(] [x-VAR] [^] [4] [-] [3] [ALPHA] [A] [)] [÷]	(X^4-3A)/(8W)
[(] [8] [ALPHA] [W] [)] [ENTER]	.480275721934

> Note that [STO▶] automatically puts the calculator in ALPHA mode.

Method 2

Keystrokes	*Screen Display*
[2nd] [QUIT] [CLEAR] [CLEAR]	
[GRAPH] [F1] :y(x)= [CLEAR]	
[(] [x-VAR] [^] [4] [-] [3] [ALPHA] [A] [)]	`\y1=(X^4-3A)/(8W)`
[÷] [(] [8] [ALPHA] [W] [)] [2nd] [QUIT]	
[2nd] [π] [STO▶] [x-VAR] [ENTER]	π→X 3.14159265359
[2nd] [√] [3] [STO▶] [A] [ENTER]	√ 3→A 1.73205080757
[4] [2nd] [MATH] [F2] :PROB [F1] :! [STO▶] [W] [ENTER]	4!→W 24
[2nd] [alpha] [Y] [1] [ENTER]	\y1 .480275721934

> [2nd] [ALPHA] is needed to get lower case variables.

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

Solution: (Using Method 2 of Example 1 above.)

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT] [CLEAR]		Clear y1 and store *f*(*x*) as y1.
[GRAPH] [F1] :y(x)= [CLEAR]	\y1=3 x+5	The calculator automatically uses lower case x in functions.
[3] [x-VAR] [+] [5] [ENTER]		
[CLEAR] [2nd] [√] [(]	\y2=√ (x-√ x)	Clear y2 and store *g*(*x*) as y2.
[x-VAR] [-] [2nd] [√]		
[x-VAR] [)] [2nd] [QUIT]		

[2] [STO▶] [x-VAR] [ENTER]	2→x 2	Store 2 as x. The 2nd key is required to store 2 as a lower case x.
[2nd] [CATLG-VARS] [F2] :ALL [▼] …[▼] y1 [ENTER] [-] [2nd] [CATLG-VARS] [F2] :ALL [▼] …[▼] y2 [ENTER] [ENTER]	y1-y2 10.2346331153	Use arrow keys to select y1 from the list of variables. Algebraically form $f(x) - g(x)$ and evaluate at $x = 2$. Note: The functions y1 and y2 can be selected from the list of variables or entered into the calculator directly. (See Section D-5 Example 1 above.)

D-6 Testing Inequalities in One Variable

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

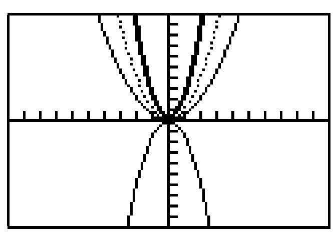
Solution:

Keystrokes	*Screen Display*	*Explanation*
[(-)] [2nd] [√] [2] [STO▶] [x-VAR] [ENTER]	⁻√ 2→X -1.41421356237	Store the value for *X*.
[x-VAR] [^] [3] [+] [5] [2nd] [TEST] [F2] :< [3] [x-VAR] [^] [4] [-] [x-VAR] [ENTER]	X^3+5<3 X^4-X 1	Enter the expression. The result of 1 indicates that the expression is true for this value of *x*. If a 0 was displayed, the expression would be false. The expression could have been stored as y1 and then evaluated as in Section D-5 Example 2 Method 2 of this document.

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

Example 1 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*
[CLEAR] [EXIT] [2nd] [STAT] [F3] :PLOT [F5] :PlOff [ENTER]		Clear the screen and exit all menus. Turn all statistics plots off.
[GRAPH] [F1] :y(x)= [CLEAR] [F1] :x [x^2] [MORE] [F3] :STYLE		Clear the existing function and store the first function as y1.
... [F3] :STYLE [ENTER]	⋱ y1=x2	Press F3 repeatedly until the style at the left of y1 is a thin line.
[CLEAR] [.5] [x-VAR] [x2] [F3] :STYLE ... [F3] :STYLE [ENTER]	\y2=.5x2	Clear and store the second function as y2. Press F3 repeatedly until the style at the left of y1 is a dotted line.
[CLEAR] [2] [x-VAR] [x2] [F3] :STYLE ... [F3] :STYLE	▚ y3=2X2	Clear and store the third function as y3. Change the style to a thick line.
[ENTER] [CLEAR] [(-)] [1.5] [x-VAR] [x2] [ENTER]	\y4=⁻1.5x2	Clear and store the fourth function as y4. Change the style to a thin line.
[EXIT] [F3] :ZOOM [F4] :ZSTD		Choose the Standard option from the [ZOOM] menu.

The Standard screen automatically sets the graph for $-10 < x < 10$ and $-10 < y < 10$.
Press [GRAPH] [F2] :WIND to see this.

The graphs will be plotted in order: y1, then y2, then y3, etc.

Occasionally you will see a vertical bar of moving dots in the upper right corner. This means the calculator is working. Wait until the dots have stopped before continuing.

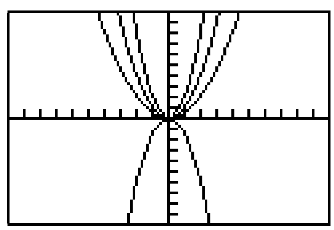
Be sure the statistice plots are turned off when graphing a function. The keystrokes to do this are:

[2nd] [STAT] [F3] :PLOT [F5] :PlOff [ENTER]

Another method that can be used to graph several functions where a coefficient or constant term has several values. This method uses the LIST feature of the calculator.

Example 2 Repeat Example 1 using LIST. Plot all functions with a thin line.

Solution:

Keystrokes	*Screen Display*	*Explanation*
[GRAPH] [F1] :y(x)=	Plot1 Plot2 Plot3 \y1=	Look at the top of the screen after you press GRAPH.
[▲] [▶] [ENTER]	Plot1 Plot2 Plot3 \y1=	If any of the plots are hightlighed, use the up arrow, press enter to turn the plot off, and press the down arrow to return to the function list. Plot2 is shown highlighted in the screen display to the left.
[GRAPH] [F1] :y(x)= [CLEAR] … [2nd] [LIST] [F1] :{ [1] [,] [.5] [,] [2] [,] [(-)] [1.5] [F2] :} [EXIT] [F1] :x [x^2] [MORE]	\y1={1,.5,2,-1.5}x^2	Clear all of the existing functions and store the function as y1 using the LIST feature of the calculator.
[F3] :STYLE ... [F3] :STYLE [ENTER] [ENTER] [EXIT]		Set the graph style as a thin line.
[F3] :ZOOM [F4] :ZSTD		Choose the Standard option from the [ZOOM] menu.

> Occasionally you will see a vertical bar of moving dots in the upper right corner. This means the calculator is working. Wait until the dots have stopped before continuing.

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

[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.

[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 setting 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 ROOT 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 values.
2. Set zoom factors using [F1] :ZFACT on the [F3] :ZOOM menu on the [GRAPH] menu.
Then use the [F2] :ZIN option on the [F3] :ZOOM menu on the [GRAPH] menu.
3. Use the [F1] :BOX option on the [F3] :ZOOM menu on the [GRAPH] menu.

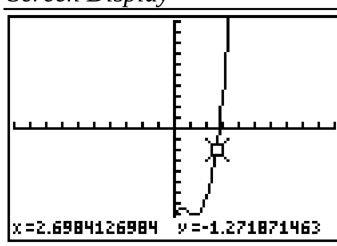
ZOUT means to zoom out. This allows you to see a "bigger picture." (See Section C-9 Example 1 of this document.)

ZIN means to zoom in. This will magnify a graph so the coordinates of a point can be approximated with greater accuracy.

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 values.
Enter the function in the y= list and graph the function using the Standard Graphing Screen (see Section D-7 of this document).

Keystrokes	*Screen Display*	*Explanation*
[GRAPH] [F4] :TRACE [▶] …[▶]		Press the right arrow repeatedly until the trace cursor gives a *y* value as close as possible to -1.58 which is about (2.6984…, -1.2718…).

[GRAPH] [F2] :WIND

[2] [ENTER] [3]

[ENTER] [.1] [ENTER]

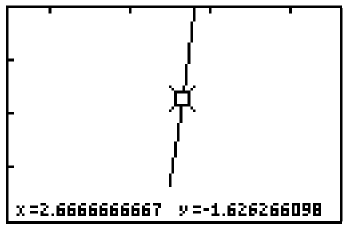
[(-)] [2] [ENTER]

[(-)] [1] [ENTER] [.1]

[ENTER] [1]

[F5] :GRAPH

```
WINDOW
 xMin=2
 xMax=3
 xScl=.1
 yMin=-2
 yMax=-1
¬yScl=.1
```



The *x* coordinate is between 2 and 3. So we set the RANGE at xMin=2, xMax=3, xScl=.1, yMin=-2, yMax= -1, and yScl=.1. This will be written as [2, 3].1 by [-2, -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.

[F4] :TRACE can be used again to estimate a new *x* value. Repeat using TRACE and changing the WINDOW until the approximation of (2.67, -1.58) has been found.

> 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 a moving bar in the upper right corner. This means the calculator is working. Wait until the bar disappears before continuing.

Method 2 Use the [F2] :ZIN option on the [ZOOM] menu.

Enter the function in the y= list and graph the function using the ZStandard Graphing Screen (see Section D-7 of this document).

Keystrokes	*Screen Display*	*Explanation*
[GRAPH] [F3] :ZOOM [MORE] [MORE]	y(x)= WIND ZOOM TRACE GRAPH ZRCL ZFACT ZOOMX ZOOMY ZINT	Get the ZOOM option from the GRAPH menu. There is a small right arrow on the screen at the right of the ZOOM menu options. This means there are more options. Press [MORE] twice until ZFACT option is visible.

[F2] :ZFACT

[5] [ENTER] [5]

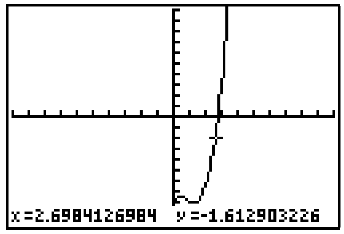
```
ZOOM FACTORS
 XFact=5
 YFact=5
```

Magnification factors need to be set. For this example let us set them at 5 for both horizontal and vertical directions.

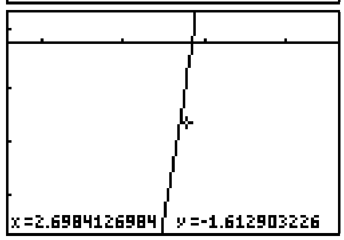
[GRAPH]

[F3] :ZOOM [F2] :ZIN

[▶] …[▼] …[ENTER]



A new cursor appears. Move it to (2.6984…, -1.6129…).

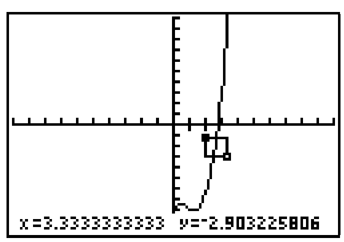
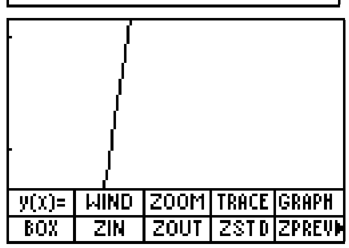


Now press ENTER to zoom in.

Use trace to get a new approximation for the coordinates of the point.
Repeat this procedure until you get a value for the *x* coordinate accurate to two decimal places. The point has coordinates (2.67, -1.58). Hence the desired value for *x* is approximately 2.67.

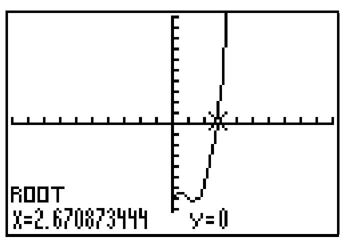
Method 3 Use the [F1] :BOX option on the ZOOM menu.

Graph the function using the ZStandard Graphing Screen (See Section D-7 of this document).

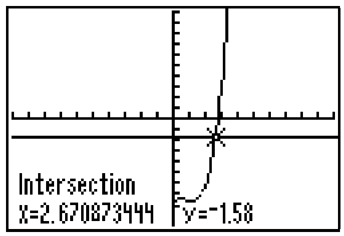
Keystrokes	*Screen Display*	*Explanation*
[ZOOM] [F4] :ZSTD [F1] :BOX [▶] …[▼] …[ENTER] [▼] …[▶] …[ENTER]	  	Use the arrow keys until the cursor is a little to the left and above the point we are trying to find, say at (2.222222222, -1.290322581) and press [ENTER] . This anchors the upper left corner of the box. Now use the arrow keys to locate the lower right corner of the box, say at (3.333333333, -2.903225806) and press [ENTER] to get the new display.

Repeat using trace and zoom box 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 ROOT feature of the calculator.

Keystrokes	*Screen Display*	*Explanation*
		Set the expression involving *x* equal to -1.58, the value of *y*. Now change the equation so it is equal to zero. $x^3 - 2x^2 + \sqrt{x} - 8 = -1.58$ $x^3 - 2x^2 + \sqrt{x} - 8 + 1.58 = 0.$ Enter the left side of the equation into the function list and graph.
[ZOOM] [F4] :ZSTD		Get the ROOT feature.
[EXIT] [GRAPH] [MORE] [F1] :MATH [F1] :ROOT [◀] or [▶] [ENTER]		Place the cursor at a point on the graph to the left of the *x* intercept, say at (2.53…, -1.34…).
[◀] or [▶] [ENTER]		Place the cursor at a point on the graph to the right of the *x* intercept, say at (2.85…, 2.26…).
[◀] or [▶] [ENTER]		Place the cursor at a point between the left and right bounds, near to the intercept, for the guess. In this case we can leave the cursor at (2.85…, 2.26…). Press ENTER to calculate the *x* intercept. The *x* intercept is approximately 2.67. Hence the desired value for *x* is approximately 2.67.

<u>Method 5</u> Use the Intersect feature of the calculator.

Keystrokes	*Screen Display*	*Explanation*
		Enter the original equation as y1 in the function list and enter -1.58 as y2 in the function list.
[ZOOM] [F4] :ZSTD		Graph the function using the standard graphing screen.
[EXIT] [GRAPH] [MORE]		Get the intersect feature.
[F1] :MATH [MORE]		
[F3] :ISECT		
[◀] or [▶] [ENTER]		Place the cursor at a point on the first graph near the point of intersection and press ENTER.
[◀] …[▶] [ENTER]		Place the cursor at a point on the second graph near the same intersection point and press ENTER.
[◀] or [▶] [ENTER]		Move the cursor near the point of intersection and press ENTER for the guess.
[◀] or [▶] [ENTER]		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] [SOLVER]		Enter the original equation as y1 in the function list.
[F1] :y1		Get the EQUATION SOLVER. Recall y1 from the function list.
[ALPHA] [=] [(-)] [1.58] [ENTER]	`eqn:y1=-1.58`	

[2] [F5] :SOLVE	`y1=-1.58`
	`▪ X=2.6708734439907`
	`bound={-1E99,1E99)`
	`▪ left-rt=0`
		Continue the Solver function. Type 2 as the guess.

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

D-9 Determining the WINDOW Dimensions and Scale Marks

There are several ways to determine the WINDOW values that should be used for the limits of the *x* and *y* axes for the screen display. Three are described below:

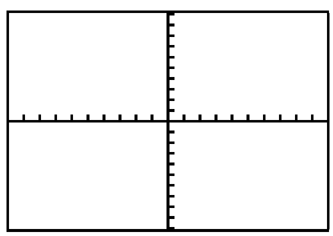
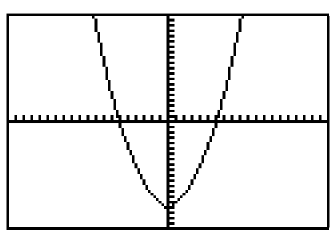
1. Graph using the ZSTD setting of the calculator and zoom out. The disadvantage of this method is that often the function cannot be seen at either the standard settings of [-10, 10]1 by [-10, 10]1 or the zoomed out settings of the WINDOW.
2. Evaluate the function for several values of *x*. Make a first estimate based on these values.
3. Analyze the leading coefficient and 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 the *x* axis a good scale value is (30-(-30))/20 or 3.

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

Solution:

<u>Method 1</u> Use the default setting and zoom out.

Keystrokes	*Screen Display*	*Explanation*
[GRAPH] [y(x)=] [CLEAR] ... [.2] [x-VAR] [^] [2] [+] [x-VAR] [^] [(] [1] [÷] [3] [)] [-] [32] [ENTER]	`\y1=.2 x^2+x^(1/3)-32`	Clear all functions. Then enter the function.
[EXIT] [F3] :ZOOM [F4] :ZSTD		Graph using the standard screen. Nothing is seen on the graph screen because no part of this curve is in this WINDOW.
[F3] :ZOOM [MORE] [MORE] [F2] :ZFACT [5] [ENTER] [5] [F3] :ZOOM [F3] :ZOUT [ENTER]		Set the zoom factors to 5 and 5. (See Section D-8 Example 1 Method 2 of this document.) Zooming out shows a parabolic shaped curve. Note the double axis. This indicates that the scale marks are very close together.

Method 2 Evaluate the function for several values of x to one decimal place accuracy. (See Section D-5 of this document 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

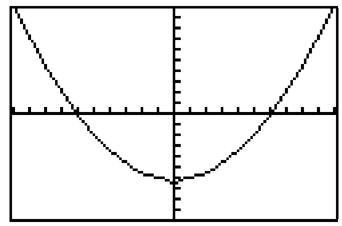
Analyzing this table indicates that a good WINDOW to start with is [-20,20]2 by [-50,50]5. Note the scale is chosen so that about 20 scale marks will be displayed along each of the axes.

[GRAPH] [F2] :WIND

[(-)] [20] [ENTER] [20] [ENTER] [2] [ENTER]

[(-)] [50] [ENTER] [50] [ENTER] [5] [ENTER]

[F5] :GRAPH



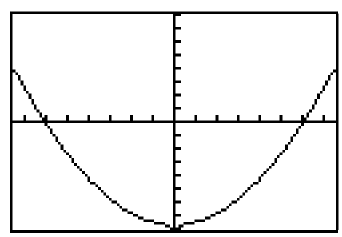
[-20, 20]2 by [-50, 50]5

Method 3 Analyze the leading coefficient and constant terms.   Since the leading coefficient is .2 the first term will increase 2 units for each 10 units x^2 increases. This is the same as about $\sqrt{10}$ (or about 3) units increase in x. Hence, a first choice for the x-axis limits can be found using:

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

A first choice for the scale on the x axis (having about 20 marks on the axis) can be found using $\frac{\text{Xmax-Xmin}}{20} = \frac{15-(-15)}{20}$ = 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 $\frac{\text{Ymax-Ymin}}{20} = \frac{32-(-32)}{20}$ = 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 the RANGE is [-15, 15]2 by [-32, 32]4.



[-15, 15]2 by [-32, 32]4

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

D-10 Piecewise-Defined Functions

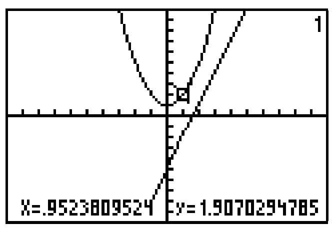
Two methods to graph piecewise-defined functions are:

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 an inequality statement following the expression which will set the WINDOW values on x for which the function should be graphed. Then graph all pieces on the same coordinate axes.

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

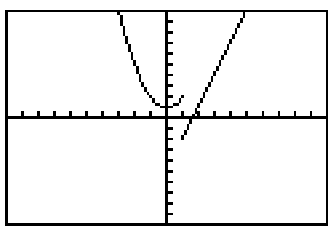
Solution:

Method 1

Keystrokes	*Screen Display*	*Explanation*
GRAPH y(x)= CLEAR		Clear all existing functions.
x-VAR ^ 2 + 1 ENTER 3 x-VAR - 5 EXIT	\y1=x^2+1 \y2=3 x-5	Enter the new functions in the function list
F3 :ZOOM F4 :ZSTD EXIT F4 :TRACE ▶ …▶		Graph. Both functions will be displayed. Use trace and zoom to find the point on the graphs where x is close to 1. The up and down arrow keys will move the cursor between the graphs. The endpoint of the parabolic piece of the graph is not included on the graph since x<1. The endpoint of the straight line piece of the graph is included. The graph shown to the left shows the curves with the cursor on the parabolic piece of the graph.

The number of the function being traced appears in the upper right corner of the screen.

Method 2

Keystrokes	*Screen Display*	*Explanation*
GRAPH y(x)= CLEAR (x-VAR ^ 2 + 1) ÷ (x-VAR 2nd TEST F2 :< 1) ENTER	\y1=(x^2+1)/(x<1)	Clear all existing functions. The logical statement $x<1$ will give a 1 when the value of x is less than 1 and a 0 when the value of x is greater than or equal to 1. Hence the first part of the function is divided by 1 when $x<1$ and 0 when $x\geq 1$. The function will not graph when it is divided by 0.
(3 x-VAR - 5) ÷ (x-VAR 2nd TEST F5 :≥ 1)	\y2=(3x-5)/(x≥1)	Similarly for the logical statement $x\geq 1$ for the second part of the function. The 1 and 0 are not shown on the screen but are used by the calculator when graphing the functions.
GRAPH F3 :ZOOM F4 :ZSTD		Graph.

D-11 Solving Equations in One Variable

Methods for approximating the solution of an equation using graphing are:

1. Write the equation as an expression equal to zero. Graph y=(the expression). Find where the curve crosses the x axis. The x values (x intercepts) are the solutions to the equation. This can be done using TRACE and ZOOM or using the Solver from the MATH menu. See Section D-8 of this document.

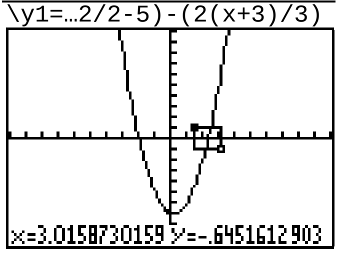
2. Graph y = (left side of the equation) and y=(right side of the equation) on the same coordinate axes. The x coordinate of the points of intersection are the solutions to the equation. This can be done using TRACE and ZOOM or using ISECT from the MATH menu from the GRAPH menu.

Example 1 Solve $\frac{3x^2}{2} - 5 = \frac{2(x+3)}{3}$.

Solution:

Method 1 Using TRACE and ZOOM

Write the equation as $\left(\frac{3x^2}{2} - 5\right) - \left(\frac{2(x+3)}{3}\right) = 0$. Graph $y = \left(\frac{3x^2}{2} - 5\right) - \left(\frac{2(x+3)}{3}\right)$ and find the x value where the graph crosses the x axis. This is the x intercept.

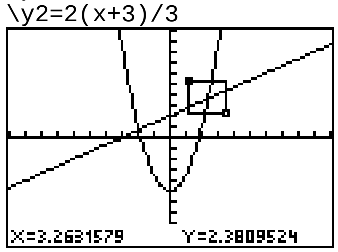
Keystrokes	*Screen Display*	*Explanation*
GRAPH F1 :y(x)= CLEAR (3 x-VAR ^ 2 ÷ 2 - 5) - (2 (x-VAR + 3) ÷ 3) EXIT F3 :ZOOM F4 :ZSTD	\y1=…2/2-5)-(2(x+3)/3) 	Store the expression as y1. The … means there is some of the expression not shown on the display. Use the arrow keys to see the rest of the expression. Use ZOOM BOX and TRACE to find the x intercepts. A typical zoom box is shown on the graph at the left. The solutions are: $x \approx -1.95$ and $x \approx 2.39$.

Method 1 Using Solver

Keystrokes	*Screen Display*	*Explanation*
2nd SOLVER 0 ALPHA = (3 x-VAR ^ 2 ÷ 2 - 5) - (2 (x-VAR + 3) ÷ 3) ENTER 2 F5 : SOLVE	eqn:0=(3X^2/2-5)-(2(X+3)/3) 0=(3X^2.2-5)-(2… ■ X=2.3938689206324 bound={-1E99,1E99) ■ left-rt=5E-13	The keystrokes given require the function to be entered directly in the Solver command. You could store the left and right side of the equation as y1 and y2 and put y1-y2=0 as the eqn in the Solver command. The approximate solutions to this equation are -1.95 and 2.39, rounded to two decimal places.

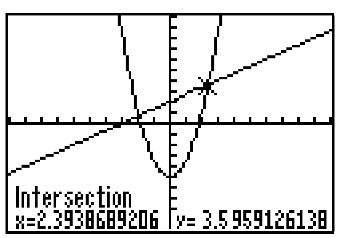
Method 2 Using TRACE and ZOOM

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	*Screen Display*	*Explanation*
[GRAPH] [F1] :y(x)= [CLEAR] [3] [x-VAR] [^] [2] [÷] [2] [-] [5] [ENTER] [2] [(] [x-VAR] [+] [3] [)] [÷] [3] [EXIT] [F3] : ZOOM [F4] :ZSTD [GRAPH] [F3] :ZOOM [F1] :BOX [▲] …[▶] [ENTER] [▼] …[▶] [ENTER]	\y1=3 x^2/2-5 \y2=2(x+3)/3 	Clear any existing functions. Store the two functions. Find the points of intersection. Use trace and zoom box to find the x values: $x \approx -1.95$ and $x \approx 2.39$. A typical zoom box is shown on the graph at the left. Hence the approximate solutions to this equation are -1.95 and 2.39.

Method 2 Using Intersect

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	*Screen Display*	*Explanation*
[GRAPH] [F3] : ZOOM [F4] :ZSTD [EXIT] [MORE] [F1] :MATH [MORE] [F3] :ISECT [ENTER] [ENTER] [2] [ENTER]		Store the two functions and graph using the standard window dimensions. Select ISECT from the MATH menu from the GRAPH menu. Enter the guess of 2 and press enter to find the coordinates of the point of intersection. The point of intersection is (2.39…, 3.59…) Hence the solution to the equation is approximately 2.39. Repeat for the other intersection point.

Hence the approximate solutions to this equation are -1.95 and 2.39.

D-12 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 and the expression on the other side. 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 TRACE and ZOOM or using the SOLVER feature of the calculator.

2. Graph *y*=(left side of the inequality) and *y*=(right side of the inequality) on the same coordinate axes. The *x* coordinate of each of the points of intersection is a solution 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 TRACE and ZOOM or using ISECT from the MATH menu from the GRAPH menu.

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

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* intercept(s). This was done in Method 1 of Example 1 in Section D-11 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. This was done in Method 2 of Example 1 in Section D-11. 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 0 which means the inequality is not true for this value of x. (See Section D-6 of this document.) Repeat the testing using 0 and 3. We see that the inequality is true for *x*=0 and not true for *x*=3. Hence the inequality is satisfied for $-1.95 \le x \le 2.39$.

D-13 Storing an Expression That Will Not Graph

Expressions can be stored as a variable. Variable names can be up to eight characters in length. The expressions can then be recalled and graphed using *y*(*x*)= on the graph menu.

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 this expression for A=3, B=2.58, and C=$\sqrt{3}$.

Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [QUIT] [CLEAR]		Return to the HOME screen and clear it.
[ALPHA] [ALPHA] [D] [I] [S] [C] [=] [B] [ALPHA] [^] [2] [-] [4] [ALPHA] [A] [×] [ALPHA] [C] [ENTER]	DISC=B^2-4A*C Done	Pressing [ALPHA] twice in succession locks the calculator in the ALPHA mode. Pressing [ALPHA] again releases the lock. Enter the variable name and the expression. DISC is the variable name. A multiplication sign is needed between A and C so that the calculator knows to multiply these variables instead of defining a new variable AC. DISC is automatically stored as a variable on the VARS list.
[3] [STO▶] [A] [ENTER]	3→A 3	
[2.58] [STO▶] [B] [ENTER]	2.58→B 2.58	
[2nd] [√] [3] [STO▶] [C] [ENTER]	√ 3→C 1.73205080757	Store the values for A, B, and C.
[ALPHA] [ALPHA] [D] [I] [S] [C] [ENTER]	DISC -14.1282096908	Enter the variable name DISC to get the value of the discriminant evaluated at the stored values of the variables.

D-14 Permutations and Combinations

<u>Example 1</u> Find (A) $P_{10,3}$ and (B) $C_{12,4}$

Solution (A):

Keystrokes	*Screen Display*	*Explanation*
[10] [2nd] [MATH]	10	Enter the first number. Get the math menu and choose PROB using the function keys. Choose `nPr`.
[F2] :PROB [F2] :nPr [3]	NUM | PROB | ANGLE | HYP | MISC ! | nPr | nCr | rand |	
[ENTER]	10 nPr 3 720	

Solution (B):

Keystrokes	*Screen Display*	*Explanation*
[12] [2nd] [MATH]	12	Enter the first number. Get the math menu and choose PROB using the arrow keys. Choose `nCr`.

[F2] :PROB [F3] :nCr [4]	`NUM PROB ANGLE HYP MISC`
	`! nPr nCr rand`
	`12 nCr 4`	

[ENTER]	`495`	

D-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] [MATRX] [F2] :EDIT	`MATRIX` `Name=B`	Enter the matrix mode. Choose EDIT. Name the matrix B. Note the calculator is already in ALPHA mode.

[B] [ENTER] [3] [ENTER]	`MATRIX:B 3 ×4`
	`[0 0 0 …`
	`[0 0 0 …`
	`[0 0 0 …`
		Set the dimensions of the matrix.

[3] [ENTER]		Enter the elements. The calculator moves across the rows identifying the position of the element to be entered. Enter all the elements row by row. Press [EXIT] to exit the matrix mode. (Note: To move to the next column, press [ENTER] .)
[2] [ENTER] [1] [ENTER]		
[5] [ENTER] [3] [ENTER]		
[2] [ENTER] [(-)] [1] [ENTER]		
[0] [ENTER] [8] [ENTER]		
[(-)] [3] [ENTER]		
[EXIT]		
[2nd] [MATRX] [F2] :EDIT		Repeat this procedure to enter the elements of matrix C.
[C] [ENTER] [3] [ENTER]		
[1] [ENTER] [1] [ENTER]		
[(-)] [5] [ENTER]		
[10] [ENTER] [EXIT]		

Keystrokes	Screen Display	Explanation
2nd MATRX F1 :NAMES (-) 3 F1 :B F2 :C ENTER	NAMES EDIT MATH OPS CPLX B C -3 B C [[-141] [51] [210]]	The matrices are selected from the menu at the bottom of the screen. The result is $\begin{bmatrix} -141 \\ 51 \\ 210 \end{bmatrix}$.

Solution (B):

Keystrokes	*Screen Display*	*Explanation*
2nd MATRX F1 :NAMES F1 :B 2nd x^{-1} ENTER	B^{-1} [[.015037593985 .323… [.067669172932 -.04… [.18045112782 -.12…	Use the arrow keys to see the rest of the matrix. The number of decimal places in the display can be set. See Section D-20 of this document.

Solution (C):

Keystrokes	*Screen Display*	*Explanation*
2nd MATRX F2 :EDIT A	MATRIX Name=A	
ENTER 3 ENTER 2 ENTER 1 ENTER (-) 2 ENTER 3 ENTER 0 ENTER 5 ENTER (-) 8 ENTER	MATRIX:A 3×2 1,1=1 2,1=3 3,1=5 MATRIX:A 3×2 1,2=-2 2,2=0 3,2=-8	Enter the elements of matrix A.
EXIT		Exit the matrix mode.
2nd MATRX F1 :NAMES F1 :A EXIT F3 :MATH F2 :T ENTER	A^T [[1 3 5] [-2 0 -8]]	Enter the matrix mode again. Get the A matrix from the matrix menu. Get the transpose operation from the MATH menu on the MATRX menu.

Solution (D):

Keystrokes	*Screen Display*	*Explanation*
[EXIT] [EXIT] [2nd] [MATRX]	`NAME EDIT MATH OPS CPLX` `det T norm dot LU`	Get the MATRX menu.

[F3] :MATH [F1] :det
[EXIT] [F1] :NAMES [F2] :B
[ENTER]
	`det B`
	`133`
	`NAME EDIT MATH OPS CPLX`
	`A B C`
		Get det from the MATRX menu and recall matrix B.

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

Two methods that can be used are:

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

Method 1 Using row operations

Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [MEM] [F2] :DELET [MORE] [F1] :MATRX [ENTER] [ENTER] [ENTER] [EXIT]		Delete the existing matrices.

[2nd] [MATRX] [F2] :EDIT
[A] [ENTER] [3] [ENTER]
[4] [ENTER] [2] [ENTER] [1]
[ENTER] [5] [ENTER] [1]
[ENTER]
[3] [ENTER] [2] [ENTER]
[(-)] [1] [ENTER] [(-)] [5]
[ENTER]
[0] [ENTER] [8] [ENTER]
[(-)] [3] [ENTER] [10] [ENTER]
	`MATRIX:A 3 ×4`
	`[0 0 0 …`
	`[0 0 0 …`
	`[0 0 0 …`
	
	`1,1 =0`
		Enter the matrix mode. Enter the dimensions and the elements.

[EXIT] [2nd] [MATRX]
[F4] :OPS [MORE]
[F4] :multR
[.5] [,] [ALPHA] [A] [,]
[1] [)] [ENTER]
	`multR(.5,A,1)`
	`[[1 .5 2.5 .5]`
	`[3 2 -1 -5]`
	`[0 8 -3 10]]`
		Multiply row 1 of matrix A by .5. The result is stored in the temporary memory ANS.

[STO►] [ALPHA] [A]
[ENTER]
	`Ans→A`
	`[[1 .5 2.5 .5]`
	`[3 2 -1 -5]`
	`[0 8 -3 10]]`
		Store the result in matrix A. Note Ans automatically appears on the screen when [STO►] is pressed.

[F5] :mRAdd [(-)] [3]
[,] [ALPHA]
[A] [,] [1] [,] [2] [)] [ENTER]
	`mRAdd(-3,A,1,2)`
	`[[1 .5 2.5 .5 ]`
	`[0 .5 -8.5 -6.5]`
	`[0 8 -3 10 ]]`
		Multiply -3 times matrix A row 1 and add the result to row 2.
		
		Store the result in matrix A.

[STO►] [A]
[ENTER]
	`Ans→A`
	`[[1 .5 2.5 .5 ]`
	`[0 .5 -8.5 -6.5]`
	`[0 8 -3 10 ]]`	

[F4] :multR [2] [,] [ALPHA]
[A] [,] [2] [)] [ENTER]
	`multR(2,A,2)`
	`[[1 .5 2.5 .5 ]`
	`[0 1 -17 -13]`
	`[0 8 -3 10 ]]`
		2 times matrix A row 2.

[STO►] [A]	`Ans→A`
	`[[1 .5 2.5 .5 ]`
	`[0 1 -17 -13]`
	`[0 8 -3 10 ]]`
		Store the result in matrix A.

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

<u>Method 2</u> Using rref from the MATRX OPS menu
Enter the elements in the matrix as done in Method 1.

Keystrokes	*Screen Display*	*Explanation*

[2nd] [MATRX] [F4] :OPS
[F5] :rref [EXIT] [F1] :NAMES
[F1] :A [ENTER]
	`rref A`
	`[[1 0 0 -2.428571428…`
	`[0 1 0 1.5714285714…`
	`[0 0 1 .85714285714…`
		Enter the matrix mode and choose MATH. Select the rref command and 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.

Hence if a system of equations is

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

with augmented coefficient matrix

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

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

$$\begin{aligned} x_1 &= -2.43 \\ x_2 &= 1.57 \\ x_3 &= .86 \end{aligned}$$

D-16 Graphing an Inequality

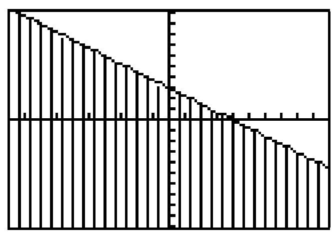
To graph an inequality:

- 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. If the result is a true statement, then the point is in the desired half-plane and we wish to shade this region. If the statement is not true, then the point is not in the desired half-plane and we wish to shade the other region.
- Graph the boundary curve using the lower shade option on the calculator to get a shaded graph.

<u>Example 1</u> Graph $3x + 4y \leq 12$.

Solution:

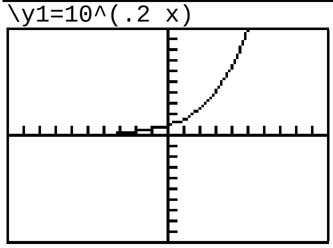
Changing the inequality sign to an equals sign yields $3x + 4y = 12$. Solving this equation for y yields $y = (12 - 3x)/4$. Determine the correct half-plane by substituting the point (0,0) into the original inequality. We have $3(0) + 4(0) \leq 12$, which is a true statement. Hence the point (0, 0) is in the solution set of the inequality.

Keystrokes	*Screen Display*	*Explanation*
GRAPH F1 :y(x)=		Clear all functions from the function list. Turn all plots off.
CLEAR (12 - 3 x-VAR) ÷ 4	`\y1=(12-3 x)/4`	Graph 3*x*+4*y*=12 by first writing as *y*=(12-3*x*)/4. Determine the half-plane by choosing the point (0, 0) and substituting into the inequality by hand. 3(0)+4(0)<12 is a true statement. The inequality is true for this point. Hence, we want the lower half-plane.
MORE F3 :STYLE … F3 :STYLE EXIT F3 :ZOOM F4 :ZSTD	`◣y1=(12-3 x)/4` 	Press F3 repeatedly until the symbol to the left of y1 is a lower triangle which indicates the graph will be shaded below the function.

D-17 Exponential and Hyperbolic Functions

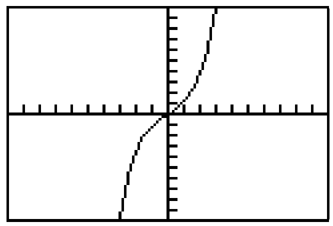
Example 1 Graph $y = 10^{0.2x}$

Solution:

Keystrokes	*Screen Display*	*Explanation*
GRAPH F1 :y(x)= CLEAR 10 ^ (.2 x-VAR) EXIT F3 :ZOOM F4 :ZSTD	`\y1=10^(.2 x)` 	Store the function and graph. Note the entire exponent needs to be in parentheses.

Example 2 Graph $y = \frac{e^{x} - e^{-x}}{2}$.

Solution:

Keystrokes	*Screen Display*	*Explanation*
[GRAPH] [F1] :y(x)= [CLEAR]	y1=sinh x	We observe that this is the hyperbolic sine function. So we can use the built-in function in the calculator.
[2nd] [MATH] [F4] :HYP		The function could also have been graphed by storing:
[F1] :sinh [x-VAR] [EXIT]		[(] [2nd] [e^x] [x-VAR] [-]
[EXIT] [F3] :ZOOM		[2nd] [e^x] [(-)] [x-VAR] [)] [÷] [2]
[F4] :ZSTD		as a function and graphing.

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

Numbers can be entered into the calculator in scientific notation.

Example 1 Calculate $(-8.513\times10^{-3})(1.58235\times10^{2})$. Enter numbers in scientific notation.

Solution:

Keystrokes	*Screen Display*	*Explanation*
[(-)] [8.513] [EE] [(-)]	¯8.513E¯3	Enter the first number.
[3] [ENTER]	¯.008513	The number displayed is not in scientific notation. (It is not necessary to press ENTER at this point. This is illustrated to show how the numbers are displayed on the screen.)
[×] [1.58235]		
[EE] [2] [ENTER]	Ans*1.58235E 2 ¯1.347054555	Multiply by the second number.

Example 2 Set the scientific notation mode with six significant digits and calculate

$(351.892)(5.32815\times10^{-8})$.

Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [MODE] [▶] [ENTER] [▼] [▶] [▶] [▶] [▶] [▶] [▶] [ENTER]	Normal Sci Eng Float 012345678901 Radian Degree RectC PolarC Func Pol Param DifEq Dec Bin Oct Hex RectV CylV SphereV dxDer1 dxNDer	Select Sci using the arrow keys and press ENTER. Select 5 decimal places using the arrow keys and press ENTER. Five decimal places will give six significant digits in scientific mode.
[2nd] [QUIT]		Return to the Home screen.
[351.892] [×] [5.32815] [EE] [(-)] [8] [ENTER]	351.892*5.32815E⁻8 1.87493E ⁻5	Enter the numbers. Note the result is displayed in scientific notation with six significant digits.

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] [MODE] [ENTER] [▼] [▶] [▶] [▶] [ENTER]	Normal Sci Eng Float 012345678901 Radian Degree RectC PolarC Func Pol Param DifEq Dec Bin Oct Hex RectV CylV SphereV dxDer1 dxNDer	Choose normal notation with 2 fixed decimal points.
[2nd] [QUIT]		Return to the Home Screen.
[53218] [×] [.0521] [×] [2] [ENTER]	53218*.0521*2 5545.32	Only two decimal places are shown in the answer. The interest is $5545.32.

Change the number of decimal places back to Float.

D-19 Angles and Trigonometric Functions

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

Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [MODE] [▼] [▼] [ENTER] [2nd] [QUIT]	Normal Sci Eng Float 012345678901 Radian Degree RectC PolarC Func Pol Param DifEq Dec Bin Oct Hex RectV CylV SphereV dxDer1 dxNDer	Change the mode to Float. Since the angle measure is given in radians, set the calculator for radian measure before starting calculations. Return to the Home screen using [2nd] [QUIT] .
[5] [2nd] [π] [÷] [8] [STO▶] [x-VAR] [ENTER]	5π/8→x 1.96349540849	Store $\frac{5\pi}{8}$ as x.
[SIN] [x-VAR] [ENTER]	sin x .923879532511	Enter $f(x)$ and evaluate.
[2nd] [TAN⁻¹] [x-VAR] [ENTER]	tan⁻¹ x 1.09973974852	Enter $g(x)$ and evaluate.

Example 2 Evaluate f(x) = csc x at x = 32° 5' 45".

Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [MODE] [▼] [▼] [▶] [ENTER] [2nd] [QUIT]	Normal Sci Eng Float 012345678901 Rad Deg RectC PolarC Func Pol Param DifEq Dec Bin Oct Hex RectV CylV dxDer1 dxNDer	Set the mode to Float. Since the angle measure is given in degrees, set the calculator for degree measure before starting calculations. Return to the Home screen using [2nd] [QUIT] .
[2nd] [MATH] [F3] :ANGLE [1] [÷] [SIN] [(] [32] [F3] :' [5] [F3] :' [45] [F3] :' [)] [ENTER]	1/sin (32'5'45') 1.88204482194	Get ANGLE mode from the MATH menu. Use 1/sin x as csc x. Degrees, minutes and seconds can be entered directly using the ['] from the MATH menu.

<u>Example 3</u> Graph f(x) = 1.5 sin 2x.

Solution:

Keystrokes

2nd MODE ▼ ▼ ENTER

GRAPH F1 :y(x)= CLEAR

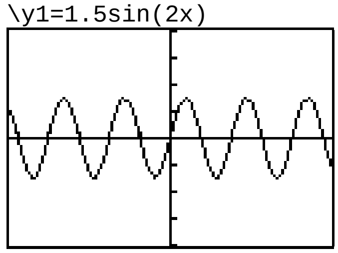
1.5 SIN (2

x-VAR) EXIT F3 :ZOOM

MORE F3 :ZTRIG

Screen Display

\y1=1.5sin(2x)



Explanation

Set MODE to radian measure. Store $f(x)$ as y1. 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 F2 :WIND to see the WINDOW settings are [-8.24…, 8.24…]1.57… by [-4, 4]1 on the calculator.

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

Solution:

Keystrokes

2nd MODE ▼ ▼ ENTER

GRAPH F1 :y(x)= CLEAR

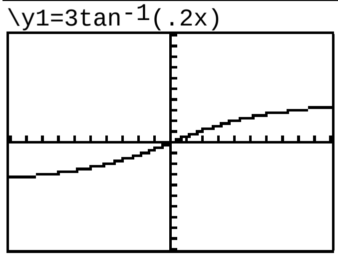
3 2nd TAN^{-1} (.2 x-VAR

) EXIT F3 :ZOOM F4

:ZSTD

Screen Display

\y1=3tan^{-1}(.2x)



Explanation

Set MODE to radian measure. Store $g(x)$ as y1. Graph using the standard WINDOW setting [-10, 10]1 by [-10, 10]1.

D-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] [MODE] [▼] [▼] [ENTER] [▼] [▶] [ENTER]	Normal Sci Eng Float 012345678901 Radian Degree RectC PolarC Func Pol Param DifEq Dec Bin Oct Hex RectV CylV SphereV dxDer1 dxNDer	Set the mode to Radian angle measure and to PolarC. Now when data is entered in rectangular coordinates, the result will be given in polar coordinates.
[2nd] [QUIT]		Return to the home screen.
[(] [(-)] [2nd] [√] [3] [,] [5] [)] [ENTER]	(¯√ 3,5) (5.29150262213∠1.904…	Enter the data. The result is in polar coordinates (r, θ). The angle symbol ∠ indicates an angle measure will follow. The calculator will interpret the angle measure to be in radians because we set the mode to radian measure.

Example 2 Change the polar coordinates $(5, \pi/7)$ to rectangular coordinates.
Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [MODE] [▼] [▼] [ENTER] [▼] [ENTER]	Normal Sci Eng Float 012345678901 Radian Degree RectC PolarC Func Pol Param DifEq Dec Bin Oct Hex RectV CylV dxDer1 dxNDer	Set the mode to Radian angle measure and to RectC. Now when data is entered in polar coordinates, the result will be given in rectangular coordinates.
[2nd] [QUIT] [(] [5] [2nd] [∠] [2nd] [π] [÷] [7] [)] [ENTER]	(5∠π/7) (4.50484433951,2.169…	Return to the home screen Enter the polar coordinates. The angle symbol must be used to designate an angle measure is being entered. The result is in rectangular coordinates (x, y).

Example 3 Evaluate $r = 5 - 5\sin\theta$ at $\theta = \frac{\pi}{7}$.

Solution:

Keystrokes	*Screen Display*	*Explanation*
[2nd] [π] [÷] [7] [STO▶] [2nd]	π/7→θ .448798950513	Store $\frac{\pi}{7}$ as θ .
[CHAR] [F2] :GREEK [MORE]		θ is on the CHAR menu.
[F2] :θ [ENTER]		
[5] [-] [5] [sin] [F2] :θ [ENTER]	5-5sin θ 2.83058130441	Enter 5-5sin θ and evaluate.

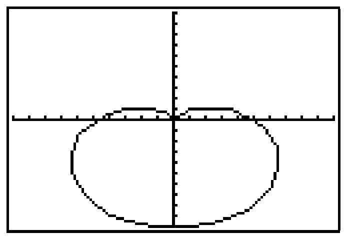
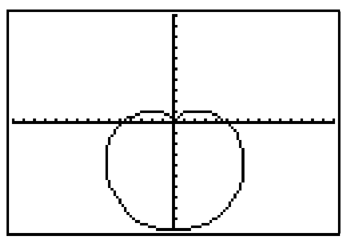
Example 4 Graph $r = 5 - 5\sin\theta$

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

In general the steps to graph a polar function are:

Step 1 Set the calculator in polar graph mode.
Step 2 Set the WINDOW FORMAT to PolarGC
Step 3 Enter the function in the y= list (This list now has r= as the function names.)
Step 4 Graph using the standard graph setting [ZOOM] [F4] :ZSTD and then the square setting of the calculator [F2] :ZSQR to get a graph with equal spacing between the scale marks.
Step 5 Zoom in to get a larger graph if you wish.

Solution:

Keystrokes	*Screen Display*	*Explanation*
2nd MODE ▼ ▼ ▼ ▼ ▶ ENTER EXIT GRAPH MORE F3 :FORMT ▶ ENTER EXIT		Set the MODE to polar. Set the FORMT to the PolarGC and the rest to default settings (in the leftmost positions). The coordinates shown at the bottom of the screen when using TRACE now will be in polar coordinates.
GRAPH F1 :r(θ) 5 - 5 sin F1 :θ EXIT F3 :ZOOM F4 :ZSTD	\r1=5-5sin θ 	Enter the function in polar form.
F3 :ZOOM MORE F2 :ZSQR CLEAR		ZSQR will square the screen by adjusting the horizontal scale to make the scale marks the same distance apart as on the y axis. Press F2:WIND to see how the window dimensions are changed. CLEAR will remove the menu from the bottom of the graph screen.

CLEAR will remove the menu from the bottom of the graph screen without removing the graph itself.