Using a graphic display calculator

CHAPTER OBJECTIVES:

This chapter shows you how to use your graphic display calculator (GDC) to solve the different types of problems that you will meet in your course. You should not work through the whole of the chapter – it is simply here for reference purposes. When you are working on problems in the mathematical chapters, you can refer to this chapter for extra help with your GDC if you need it.

Instructions for the TI-84 Plus calculator

Use this list to help you to find the topic you need

Chapter contents

Before you start

You should be familiar with:

- Important keys on the keyboard: ON 2nd DEL CLEAR Y= X, T, Θ, n ENTER GRAPH
- The home screen
- Changing window settings in the graph screen
- Using zoom tools in the graph screen
- Using trace in the graph screen

For a reminder of how to perform the basic operations have a look at your GDC manual.

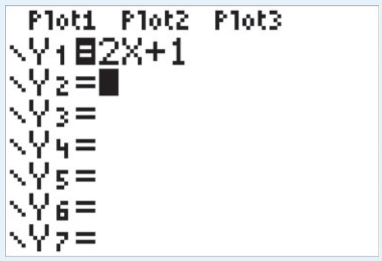
1 Functions

1.1 Graphing linear functions

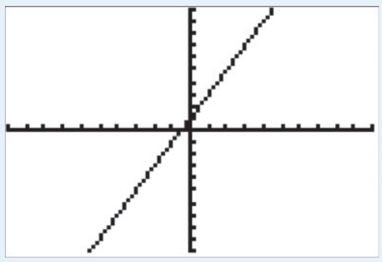
Example 1

Draw the graph of the function $y = 2x + 1$.

Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.
Type $2x + 1$ and press ENTER.
Press ZOOM | 6:ZStandard to use the default axes which are $-10 \le x \le 10$ and $-10 \le y \le 10$.



The graph of $y = 2x + 1$ is now displayed on the screen.



Finding information about the graph

The GDC can give you a lot of information about the graph of a function, such as the coordinates of points of interest and the gradient (slope).

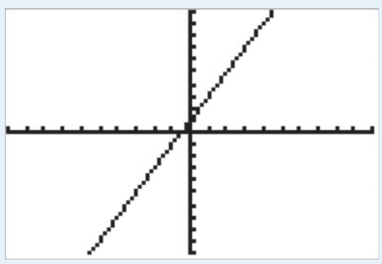
1.2 Finding a zero

The x-intercept is known as a *zero* of the function.

Example 2

Find the zero of $y = 2x + 1$.

Draw the graph of $y = 2x + 1$ as in Example 1.



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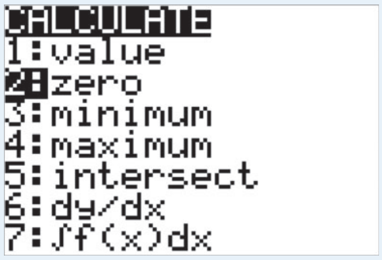
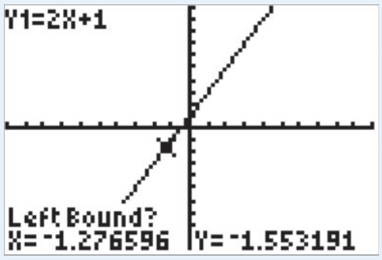
Press 2nd CALC | 2:Zero.
Press ENTER.



To find the zero you need to give the left and right bounds of a region that includes the zero.

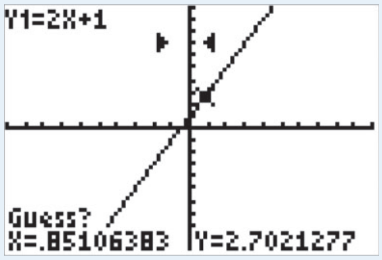
The calculator shows a point and asks you to set the left bound. Move the point using the ◀ and ▶ keys to choose a position to the left of the zero.
Press ENTER.



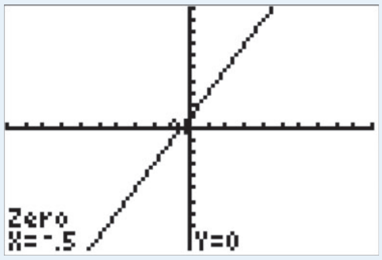
The calculator shows another point and asks you to set the right bound.

Move the point using the ◀ and ▶ keys so that the region between the left and right bounds contains the zero.

When the region contains the zero press ENTER.



Press ENTER again to supply a guess for the value of the zero.
The calculator displays the zero of the function $y = 2x + 1$ at the point $(-0.5, 0)$.



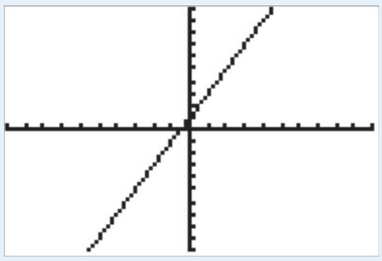
1.3 Finding the gradient (slope) of a line

The correct mathematical notation for gradient (slope) is $\frac{dy}{dx}$. You will find out more about this in the chapter on differential calculus. Here we just need to know this is the notation that will give us the gradient (slope) of the line.

Example 3

Find the gradient of $y = 2x + 1$.

First draw the graph of $y = 2x + 1$ as in Example 1.



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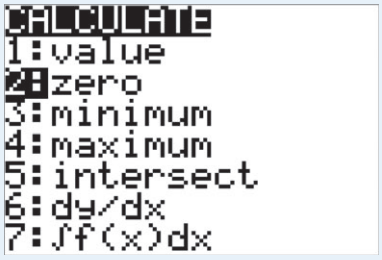
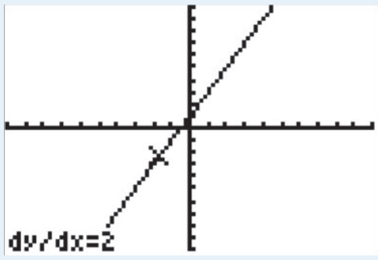
Press 2nd CALC | 6: dy/dx.

Press ENTER.



Select any point on the line using the ◄ and ► keys and press ENTER.

The gradient (slope) is 2.



1.4 Solving simultaneous equations graphically

To solve simultaneous equations graphically you draw the straight lines and then find their point of intersection. The coordinates of the point of intersection give you the solutions x and y.

Note: The calculator will only draw the graphs of functions that are expressed explicitly. By that we mean functions that begin with 'y =' and have a function that involves only x to the right of the equals sign. If the equations are written in a different form, you will need to rearrange them before using your calculator to solve them.

Solving simultaneous equations using a non-graphical method is covered in section 1.5.

Example 4

Solve the simultaneous equations $2x + y = 10$ and $x - y = 2$ graphically with your GDC.

First rearrange both equations in the form $y =$

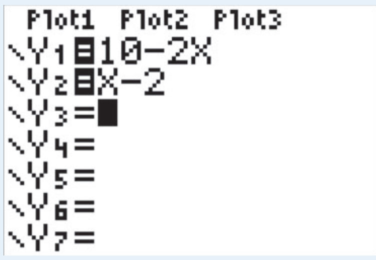
$2x + y = 10$	$x - y = 2$
$y = 10 - 2x$	$-y = 2 - x$
	$y = x - 2$

To draw graphs $y = 10 - 2x$ and $y = x - 2$.

Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.

Type $10 - 2x$ and press ENTER and $x - 2$ and press ENTER.

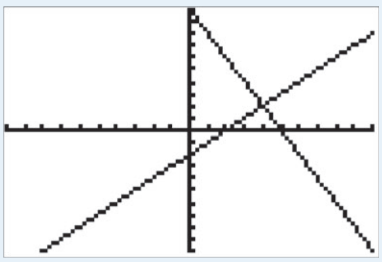
Press ZOOM | 6:Z Standard to use the default axes which are $-10 \le x \le 10$ and $-10 \le y \le 10$.



The calculator displays both straight line graphs

Y1 = $10 - 2x$ and

Y2 = $x - 2$



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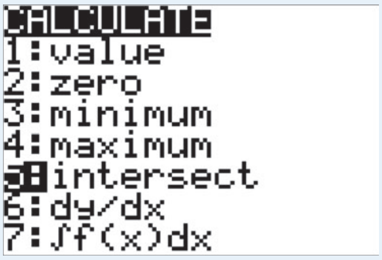
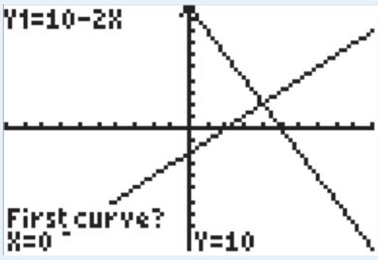
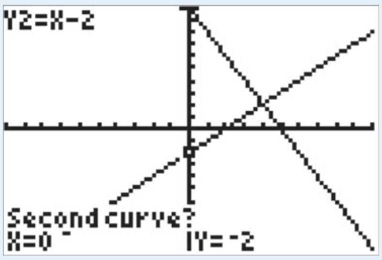
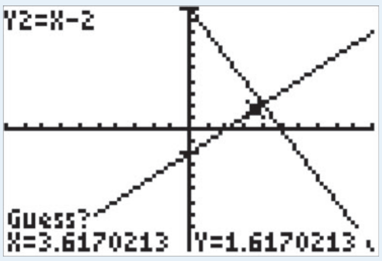
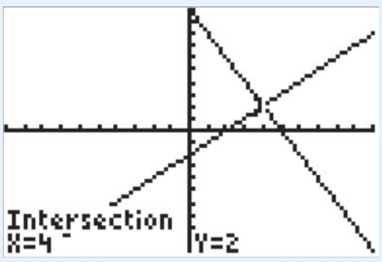
Press 2nd CALC | 5:intersect. Press ENTER.	
Press ENTER to select the first curve.	
Press ENTER to select the second curve.	
Select a point close to the intersection using the ◄ and ► keys and press ENTER.	
The calculator displays the intersection of the two straight lines at the point (4, 2). The solutions are $x = 4$, $y = 2$.	

Simultaneous and quadratic equations

1.5 Solving simultaneous linear equations in two unknowns

When solving simultaneous equations in an examination, you do not need to show any method of solution. You should simply write out the equations in the correct form and then give the solutions. The calculator will do all the working for you.

You will need to have the App PlySmlt2 installed on your GDC. This App is permitted by IBO in your examination.

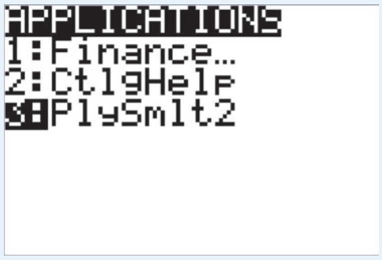
Example 5

Solve the equations:

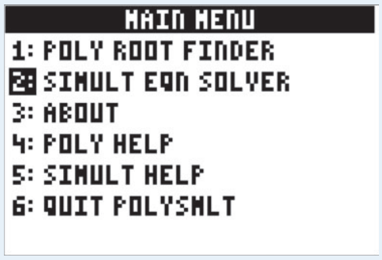
$2x + y = 10$

$x - y = 2$

Press APPS. You will see the dialog box as shown on the right. Choose the App PlySmlt2 and press ENTER.

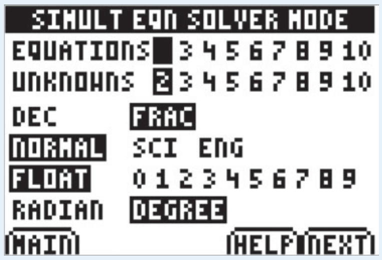


From the main menu, choose 2: SIMULT EQN SOLVER and press ENTER.



The defaults are to solve two equations in two unknowns.

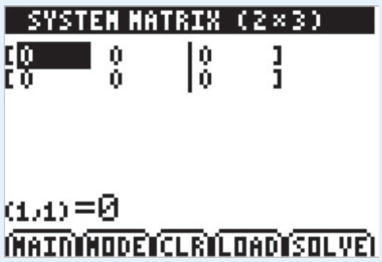
Note: This is how you will use the linear equation solver in your examinations. In your project, you might want to solve a more complicated system with more equations and more variables.



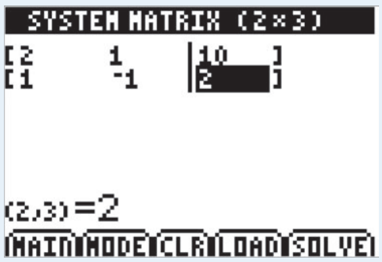
Press F5 and you will see the template on the right.

Type the coefficients from two equations into the template, pressing ENTER after each number.

The equations must be in the correct order.



Press F5 and the calculator will solve the equations, giving the solutions in the as x_1 and x_2.



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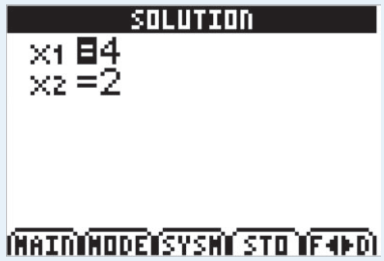
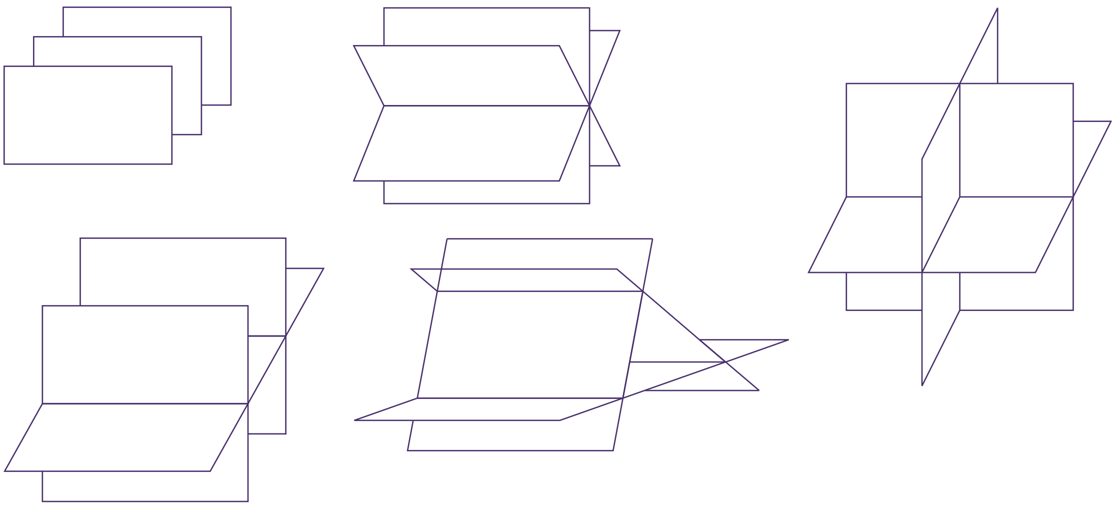
The solutions are $x = 4$, $y = 2$.



1.6 Solving simultaneous equations in three unknowns

When solving simultaneous equations in three unknowns there might be a unique solution, infinitely many solutions or no solutions at all. Geometrically, if the equations represent planes in three-dimensions, then their solutions would be intersection at a point, intersection on a line (or plane) or non-intersecting planes.



Example 6

Solve the equations

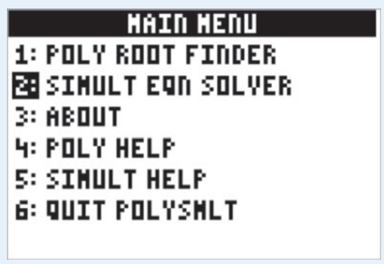
$2x - 3y + 4z = 1$

$x - y - z = -1$

$-x + 2y - z = 2$

Press APPS. You will see the dialog box as shown on the right.
Choose the App PlySmlt2 and press ENTER.

From the main menu, choose 2: SIMULT EQN SOLVER and press ENTER.



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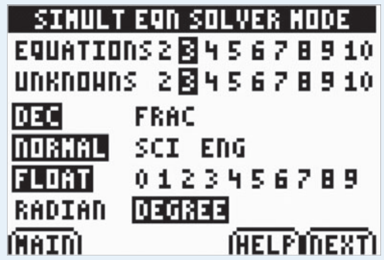
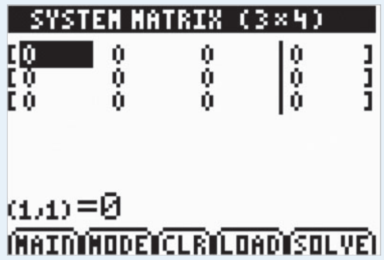
Change the defaults to three equations in three unknowns.

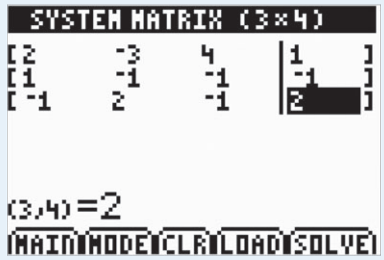


Press F5 and you will see the template on the right.
Type the coefficients from two equations into the template, pressing ENTER after each number.

The equations must be in the correct order.

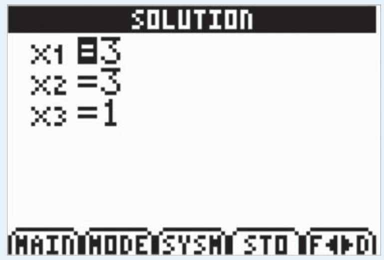


Press F5 and the calculator will solve the equations, giving the solutions as x_1, x_2 and x_3.



The solutions are $x = 3$, $y = 3$ and $z = 1$.

In this example, the solutions represent a point.



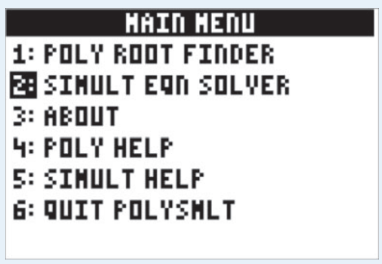
Example 7

Solve the equations

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

Press APPS. You will see the dialog box as shown on the right.
Choose the App PlySmlt2 and press ENTER.

From the main menu, choose 2: SIMULT EQN SOLVER and press ENTER.



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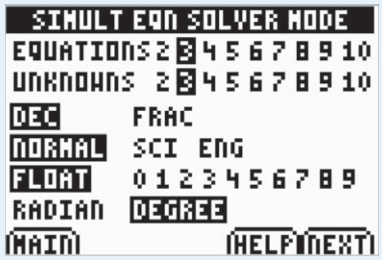
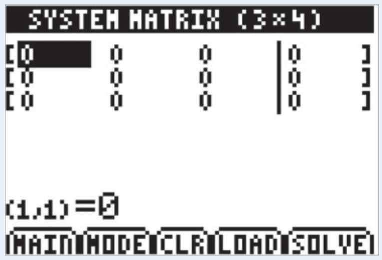
Change the defaults to three equations in three unknowns.



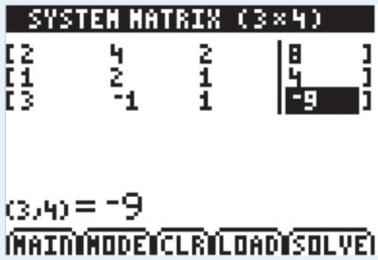
Press F5 and you will see the template on the right.

Type the coefficients from two equations into the template, pressing ENTER after each number.

The equations must be in the correct order.



Press F5 and the calculator will solve the equations, giving the solutions as x_1, x_2 and x_3.



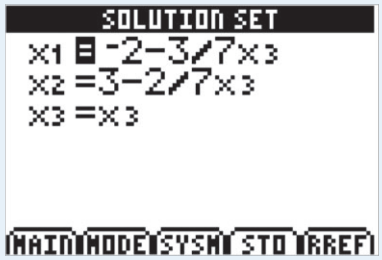
The solutions are $x = -2 - \frac{3x_3}{7}$, $y = 3 - \frac{2x_3}{7}$ and $z = x_3$

In this example, the solutions represent a straight line.

Since $z = x_3$ (an arbitrary constant) the equations of the line can be written

$$\frac{7(x+2)}{-3} = \frac{7(y-3)}{-2} = z$$

$$\frac{x+2}{3} = \frac{y-3}{2} = \frac{z}{-7}$$



Example 8

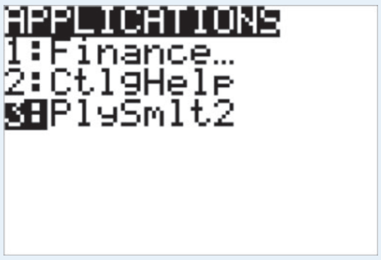
Solve the equations

$x + 2y - 3z = 13$

$2x - y + x = 4$

$x + 2y - 3z = 7$

Press APPS. You will see the dialog box as shown on the right.
Choose the App PlySmlt2 and press ENTER.



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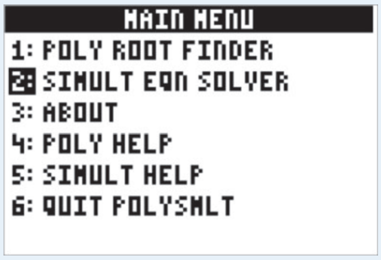
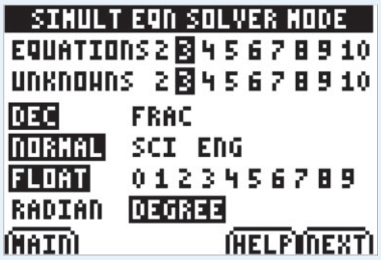
From the main menu, choose 2: SIMULT EQN SOLVER and press ENTER.

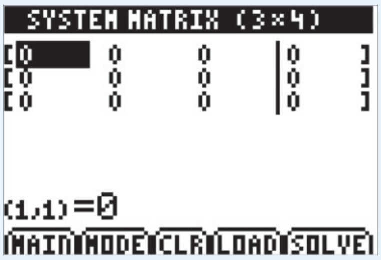


Change the defaults to three equations in three unknowns.

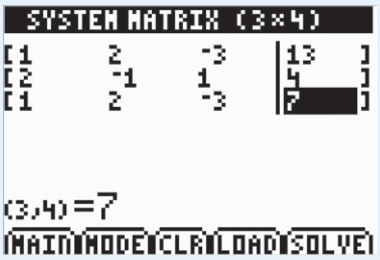


Press F5 and you will see the template on the right.
Type the coefficients from the three equations into the template, pressing ENTER after each number.

The equations must be in the correct order.

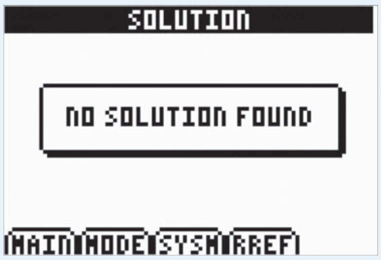


Press F5 and the calculator will solve the equations, giving the solutions as x_1, x_2 and x_3.



There are no solutions.

In this example the equations are inconsistent.



Quadratic functions

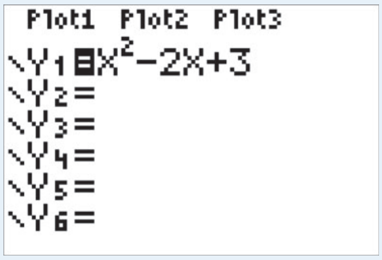
1.7 Drawing a quadratic graph

Example 9

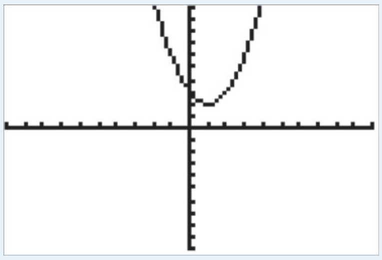
Draw the graph of $y = x^2 - 2x + 3$ and display it using suitable axes.

Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.
Type $x^2 - 2x + 3$ and press ENTER.

Press ZOOM | 6:Z Standard to use the default axes which are $-10 \le x \le 10$ and $-10 \le y \le 10$.

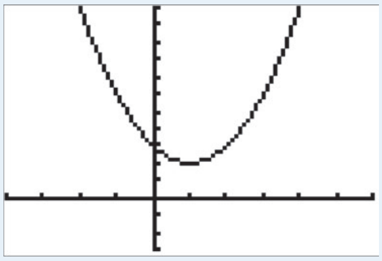


The calculator displays the curve with the default axes.



Adjust the window to make the quadratic curve fit the screen better.

For help with changing axes, see your GDC manual.



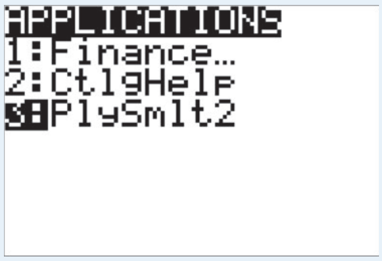
1.8 Solving quadratic equations

When solving quadratic equations in an examination, you do not need to show any method of solution. You should simply write out the equations in the correct form and then give the solutions. The GDC will do all the working for you.

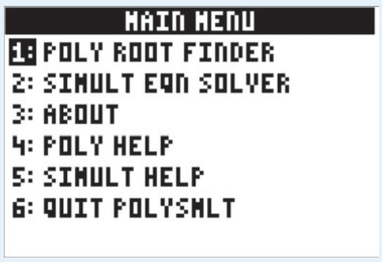
Example 10

Solve $3x^2 - 4x - 2 = 0$

Press APPS. You will see the dialog box as shown on the right. Choose the App PlySmlt2 and press ENTER.



From the main menu, choose 1: POLY ROOT FINDER and press ENTER.



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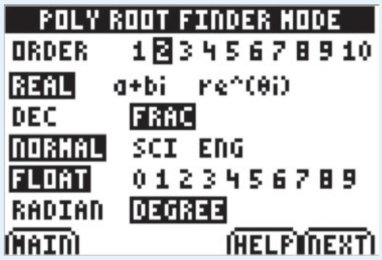
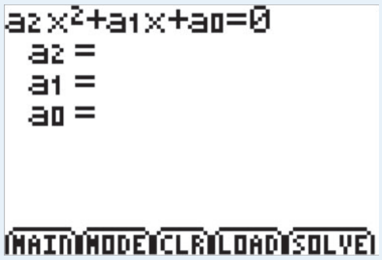
The defaults are to solve an equation of order 2 (a quadratic equation) with real roots. You do not need to change anything.



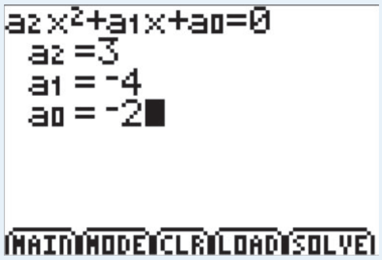
Another dialog box opens for you to enter the equation.

The general form of the quadratic equation is $a2x^2 + a1x + a0 = 0$, so we enter the coefficients in $a2$, $a1$ and $a0$.

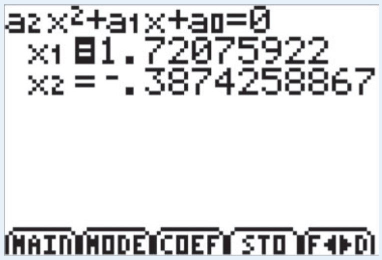


Here $a2 = 3$, $a1 = -4$ and $a0 = -2$. Be sure to use the (-) key to enter the negative values.
Press ENTER after each value.

Press F5 and the calculator will find the roots of the equation.



The solutions are $x = -0.387$ or $x = 1.72$ (3 sf).

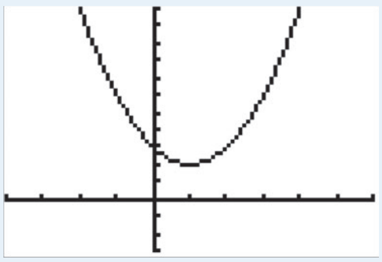


1.9 Finding a local minimum or maximum point

Example 11

Find the minimum point on the graph of $y = x^2 - 2x + 3$.

Draw the graph of $y = x^2 - 2x + 3$ (See Example 9).

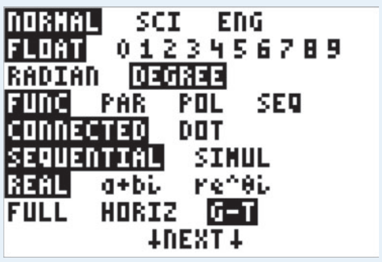


Method 1 - using a table

You can look at the graph and a table of the values on the graph by using a split screen.

Press MODE and select G-T.

Press GRAPH.



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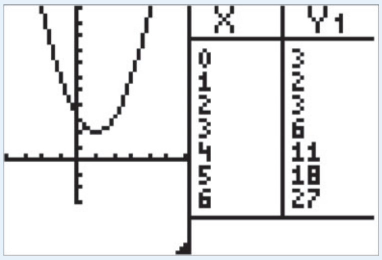
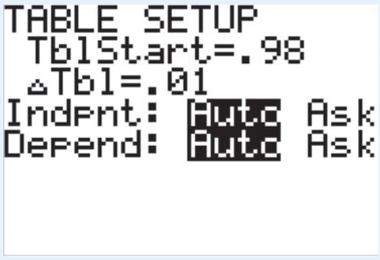
The minimum value shown in the table is 2 when $x = 1$.

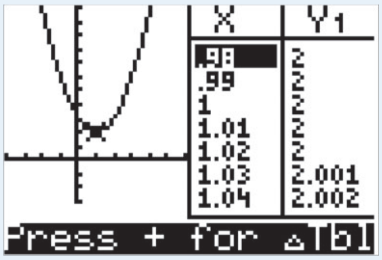


Look more closely at the values of the function around $x = 1$.

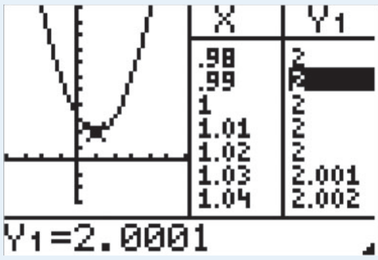
Change the settings in the table: Press 2nd TBLSET.
Set TblStart to 0.98
$\triangle$Tbl to 0.01
Press 2nd TABLE to return to the graph and table screen.



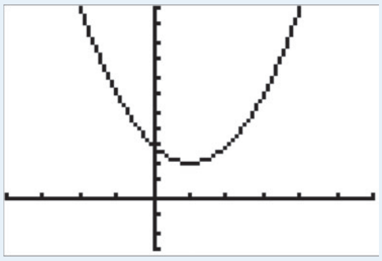
Press ▸ to move to the column containing y-values. This shows greater precision in the box below the table.



The table shows that the function has larger values at points around (1, 2). We can conclude that this is a local minimum on the curve.

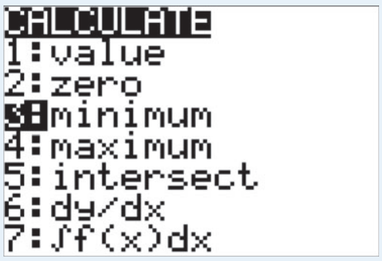


Method 2 – Using the minimum function



Press 2nd CALC | 3:minimum.

Press ENTER.

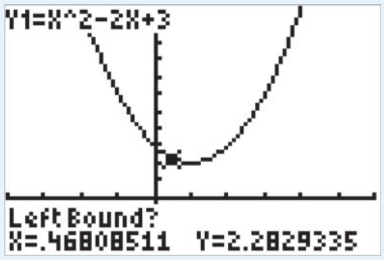


▶ Continued on next page

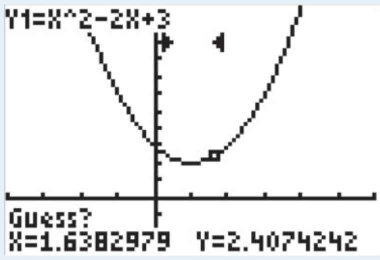
To find the minimum point you need to give the left and right bounds of a region that includes it.

The calculator shows a point and asks you to set the left bound. Move the point using the ◀ and ▶ keys to choose a position to the left of the minimum.

Press ENTER.



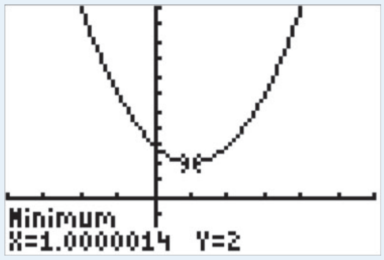
The calculator shows another point and asks you to set the right bound.
Move the point using the ◀ and ▶ keys so that the region between the left and right bounds contains the minimum.
When the region contains the minimum press ENTER.



Press ENTER again to supply a guess for the value of the minimum.

The calculator displays the minimum point on the curve at $(1, 2)$.

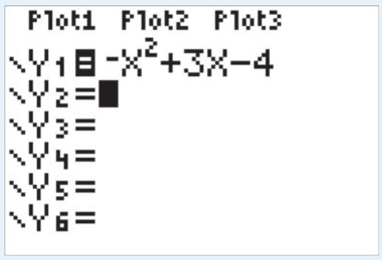
In this example the value of x is not exactly 1. This is due to the way the calculator finds the point. You should ignore small errors like this when you write down the coordinates of the point.



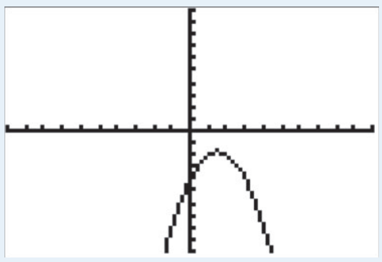
Example 12

Find the maximum point on the graph of $y = -x^2 + 3x - 4$.

Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.
Type $-x^2 + 3x - 4$ and press ENTER.
Press ZOOM | 6:Z Standard to use the default axes which are $-10 \le x \le 10$ and $-10 \le y \le 10$.

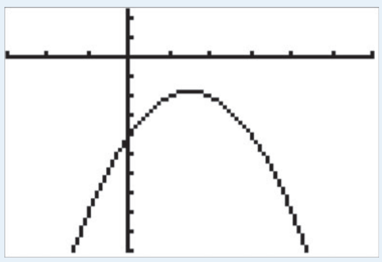


The calculator displays the curve with the default axes.



Adjust the window to make the quadratic curve fit the screen better.

For help with changing axes, see your GDC manual.



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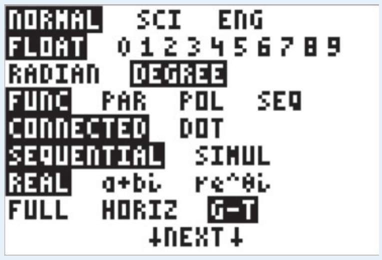
Method 1 - using a table

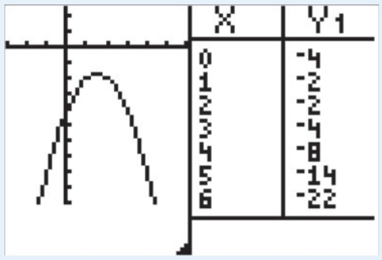
You can look at the graph and a table of the values on the graph by using a split screen.

Press MODE and select G-T.

Press GRAPH.



The maximum value shown in the table is –2 when $x = 1$ and $x = 2$.



Look more closely at the values of the function between $x = 1$ and $x = 2$.

Change the settings in the table: Press 2nd TBLSET.

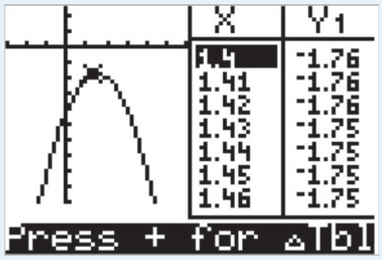
Set TblStart to1.4

$\triangle$Tbl to 0.01

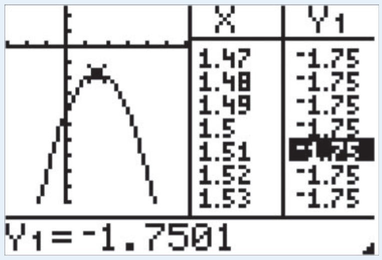
Press 2nd TABLE to return to the graph and table screen.

Press ▸ to move to the column containing y-values. This shows greater precision in the box below the table.

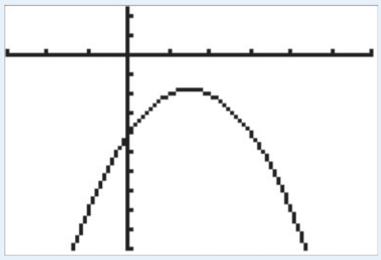
Press ▾ to scroll down until you find the maximum value of y.



The table shows that the function has smaller values at points around (1.5, –1.75). We can conclude that this is a local maximum on the curve.

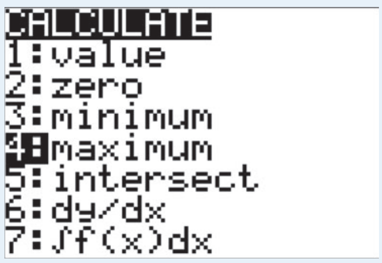


Method 2 - Using the maximum function



Press 2nd CALC | 4:maximum.

Press ENTER.

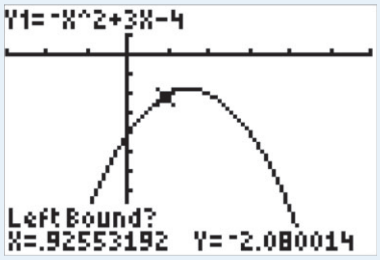


▶ Continued on next page

To find the maximum point you need to give the left and right bounds of a region that includes it.

The calculator shows a point and asks you to set the left bound. Move the point using the ◀ and ▶ keys to choose a position to the left of the maximum.

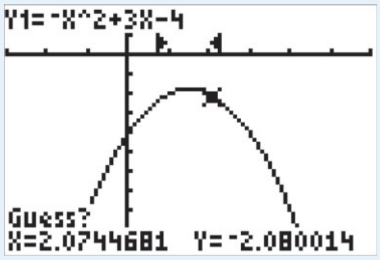
Press ENTER.



The calculator shows another point and asks you to set the right bound.

Move the point using the ◀ and ▶ keys so that the region between the left and right bounds contains the minimum.

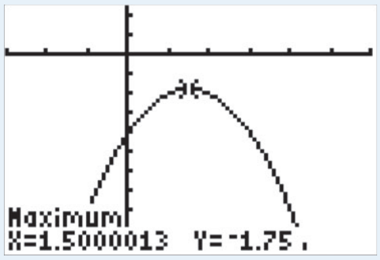
When the region contains the minimum press ENTER.



Press ENTER again to supply a guess for the value of the minimum.

The calculator displays the maximum point on the curve at (1.5, –1.75).

In this example the value of x is not exactly 1.5. This is due to the way the calculator finds the point. You should ignore small errors like this when you write down its coordinates.



Complex numbers

1.10 Operations with complex numbers

Example 13

Evaluate the following expressions

i $2(7+i)+\frac{1}{2}(4-2i)$

ii $(2+3i)\cdot(3-4i)$

iii $\sqrt{3+4i}$

iv $\frac{1-i}{3+i}$

v $(1-i)^3$

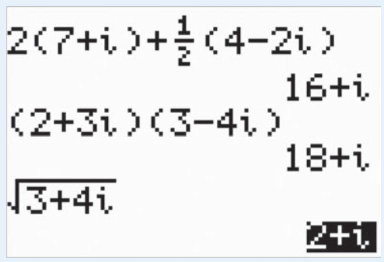
Complex calculations are entered in the same way as you would enter a real expression.

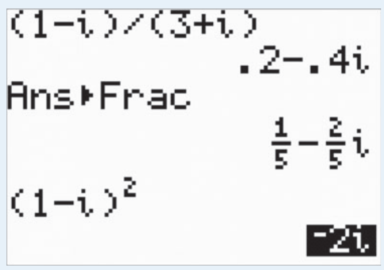
To enter the imaginary symbol i press number 2nd i

Enter the expressions and then press EXE

The results are as shown.

Note that the fraction template ALPHA F2 does not work with complex numbers.





1.11 Conjugate, modulus and argument

Example 14

Let $z = 1 + \sqrt{3}i$

Find **i** z^*

ii $|z|$

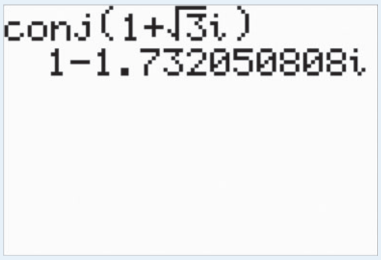
iii $\arg(z)$

i Press MODE | CPX | 1:conj(

Enter the complex number.

To enter the imaginary symbol i press number SHIFT i

Press ENTER

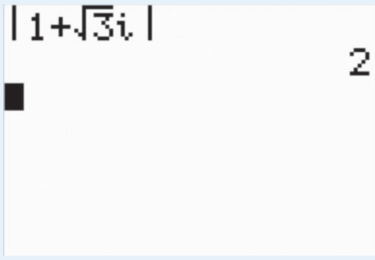


ii Press MODE | CPX | 5:abs(

Enter the complex number.

To enter the imaginary symbol i press number SHIFT i

Press ENTER

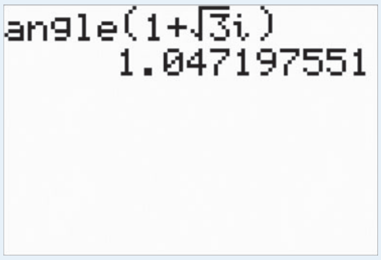


iii Press MODE | CPX | 4:angle(

Enter the complex number.

To enter the imaginary symbol i press number SHIFT i

Press ENTER



1.12 Solving equations with complex roots

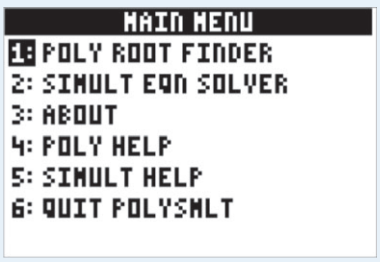
Example 15

Solve the equation:

$2x^3 - 15x^2 + 44x - 39 = 0$

Press APPS. You will see the dialog box as shown on the right.
Choose the App PlySmlt2 and press ENTER.

From the main menu, choose 1: POLY ROOT FINDER and press EXE.



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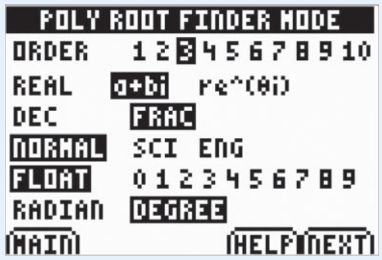
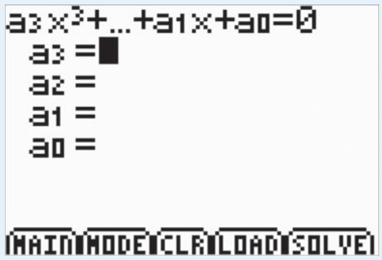
The defaults are to solve an equation of order 2 (a quadratic equation) with real roots. Change the order to 3 and the roots to $a + bi$.

Press F5 NEXT



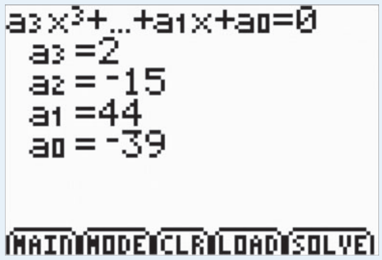
Another dialog box opens for you to enter the equation.

The general form of the cubic equation is $a3x^3 + a2x^2 + a1x + a0 = 0$ so we enter the coefficients in $a3$, $a2$, $a1$ and $a0$.



Here $a2 = 3$, $a1 = -4$ and $a0 = -2$. Be sure to use the (-) key to enter the negative values. Press e after each value.

Press F5 and the calculator will find the roots of the equation.



The solutions are,

$x = 3 + 2i$, $x = 3 - 2i$ and $x = 1.5$.

1.13 Polar form

The GDC displays complex numbers in either Cartesian form ($z = x + yi$) or in Euler's form ($z = re^{\theta i}$), but not in modulus, argument form – see 1.11 for how to find the modulus and argument of a complex number expressed in Cartesian form.

Example 16

i Change $2 + 2i$ to polar form.

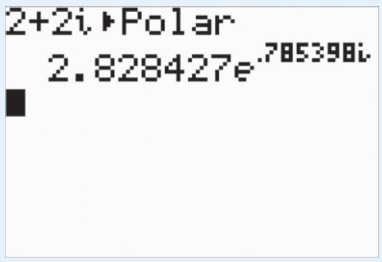
ii Change $3e^{\frac{2\pi}{3}i}$ to Cartesian form.

Complex calculations are entered in the same way as you would enter a real expression.

To enter the imaginary symbol i press number SHIFT i

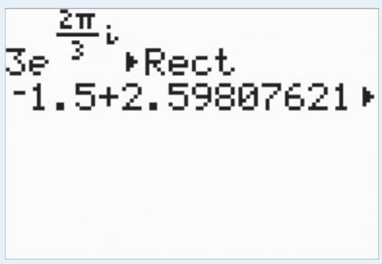
i Enter $2 + 2i$ and then press OPTN | CPX | F3 : ▸ Polar

Press ENTER



ii Enter $3e^{\frac{2\pi}{3}i}$ and then press OPTN | CPX | 6 : ▸ Rect

Press ENTER



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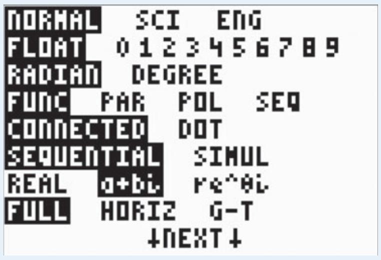
You can also change the mode that the calculator uses to display complex results in settings.

Press MODE

Select REAL, $a + bi$ for Rectangular or re^θi for Polar.

For example, in Polar mode, typing $2 + 2i$ ENTER would result in the number being displayed in polar form without entering ▸ Polar.



Exponential functions

1.14 Drawing an exponential graph

Example 17

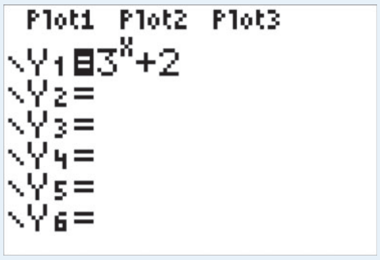
Draw the graph of $y = 3^x + 2$.

Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.

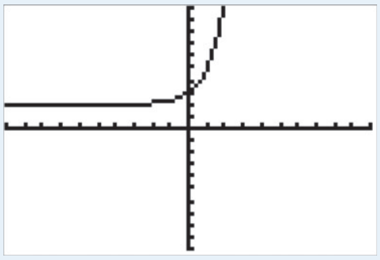
Type $3^x + 2$ and press ENTER.

Note: Type 3 ^ X,T,Θ,n ▸ to enter 3^x. The ▸ returns you to the baseline from the exponent.

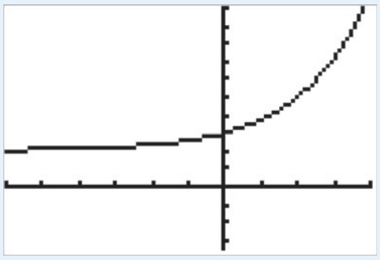
Press ZOOM | 6:ZStandard to use the default axes which are $-10 \le x \le 10$ and $-10 \le y \le 10$.



The calculator displays the curve with the default axes.



Adjust the window to make the exponential curve fit the screen better.

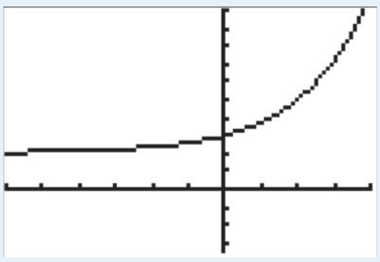


1.15 Finding a horizontal asymptote

Example 18

Find the horizontal asymptote to the graph of $y = 3^x + 2$.

Draw the graph of $y = 3^x + 2$ (see Example 17).



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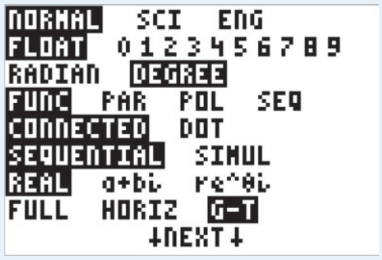
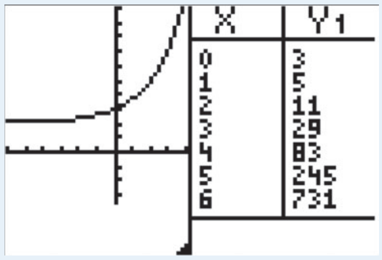
You can look at the graph and a table of the values on the graph by using a split screen.

Press MODE and select G-T.

Press GRAPH.



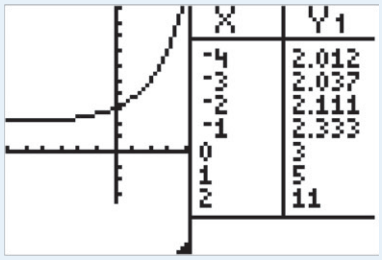
The values of the function are clearly decreasing as $x \to 0$.



Press 2nd TABLE to switch to the table.

Press ▲ to scroll up the table.

The table shows that as the values of x get smaller, Y_1 approaches 2.

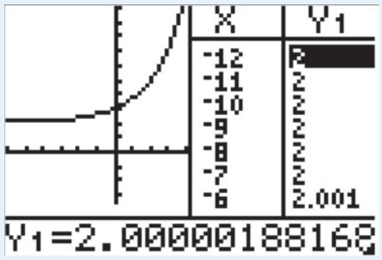


Eventually the value of Y_1 displayed in the table reaches 2.

Press ▶ to move to the column containing y-values. This shows greater precision in the box below the table. You can see, at the bottom of the screen, that the actual value of Y_1 is 2.00000188168...

We can say that $Y_1 \to 2$ as $x \to -\infty$.

The line $x = 2$ is a horizontal asymptote to the curve $y = 3^x + 2$.



Logarithmic functions

1.16 Evaluating logarithms

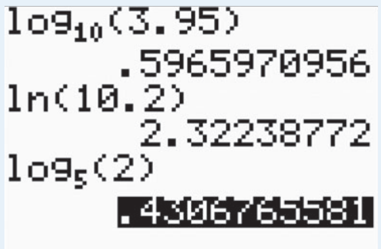
Example 19

Evaluate $\log_{10} 3.95$, ln10.2 and $\log_5 2$.

Press ALPHA F2 | 5:logBASE(to open the log template.
Enter the base and the argument then press ENTER.

For natural logarithms it is possible to use the same method, with the base equal to e, but it is quicker to press LN.

Note that the GDC will evaluate logarithms with any base without having to use the change of base formula.



1.17 Finding an inverse function

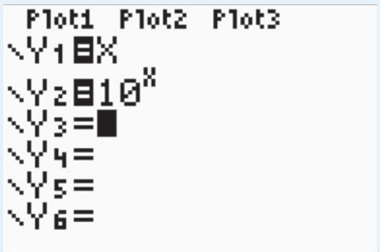
The inverse of a function can be found by interchanging the x and y values. Geometrically this can be done by reflecting points in the line $y = x$.

Example 20

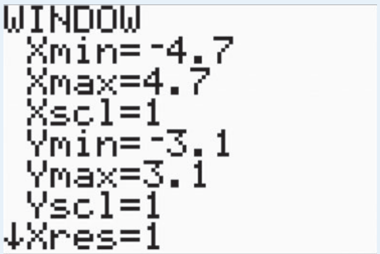
Show that the inverse of the function $y = 10^x$ is $y = \log_{10}x$ by reflecting $y = 10^x$ in the line $y = x$.

Draw the line $y = x$ so that it can be recognised as the axis of reflection.
Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.
Type x and press ENTER.
Type 10^x and press ENTER.

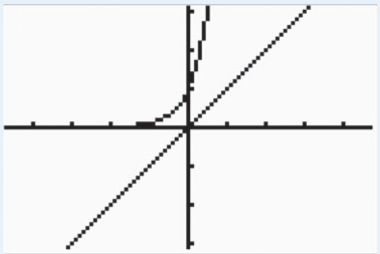
Note: Type 1 0 ^ X, T, Θ, n ▸ to enter 10^x. The ▸ returns you to the baseline from the exponent.



Press WINDOW and choose options as shown.
This will set up square axes $-4.7 \le x \le 4.7$ and $-3.1 \le y \le 3.1$. with the same horizontal and vertical scales.

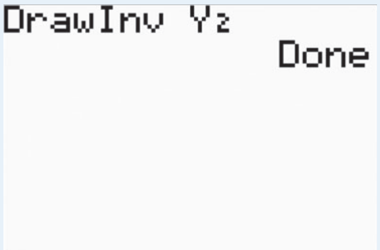


Press GRAPH.
The graphs of $y = x$ and $y = 10^x$ are displayed.

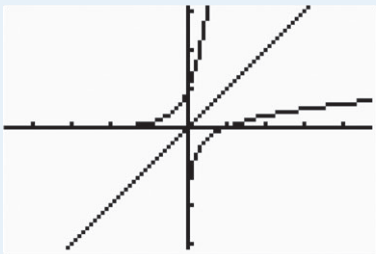


Press 2nd DRAW | 8:DrawInv.
Then press ALPHA F4 and choose Y_2.
Press ENTER.

Alternatively press LOG X, T, Θ, n to enter log(x). LOG is a shorter way to enter $\log_{10}$.

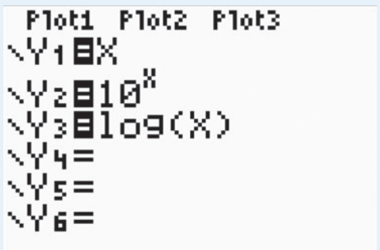


Press GRAPH.
The graphs are displayed.
The calculator will display the inverse of the function $y = 10^x$.



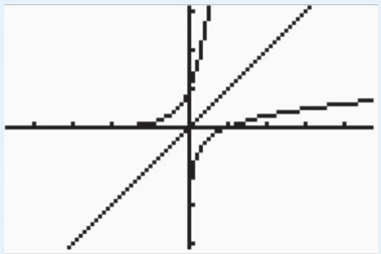
Press Y = to display the Y= editor.
Type log(x).

Press LOG X, T, Θ, n to enter log(x). LOG is a shorter way to enter $\log_{10}$.



▶ Continued on next page

Press GRAPH to display the graphs of $y = x$, $y = 10^x$ and $y = \log_{10}x$.
The inverse function and the logarithmic function coincide, showing that $y = \log_{10}x$ is inverse of the function $y = 10^x$.

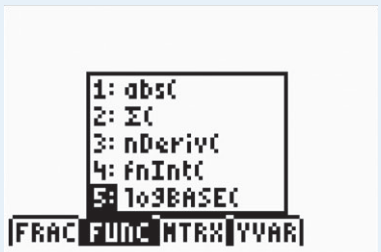


1.18 Drawing a logarithmic graph

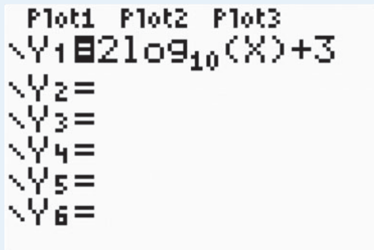
Example 21

Draw the graph of $y = 2\log_{10}x + 3$.

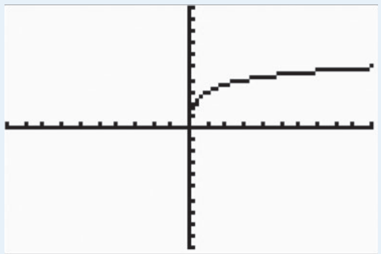
Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.
Press ALPHA F2 | 5:logBASE(to open the log template.
Enter the base and the argument then press ENTER.



Type $2\log_{10}(x) + 3$ and press ENTER.
Press ZOOM 6:XStandard so that the calculator displays the curve with the default axes.

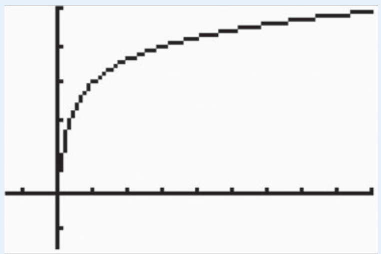


The calculator displays the curve with the default axes.



Change the axes to make the logarithmic curve fit the screen better.

For help with changing axes, see your GDC manual.



Trigonometric functions

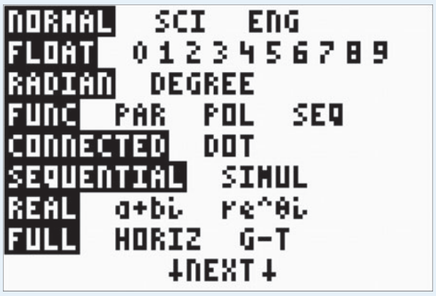
1.19 Degrees and radians

Work in trigonometry will be carried out either in degrees or radians. It is important, therefore, to be able to check which mode the calculator is in and to be able to switch back and forth

Example 22

Change angle settings from radians to degrees and from degrees to radians.

Press MODE.
Select either RADIAN or DEGREE using the ▶ ◀ ▲ ▼ keys.
Press ENTER.
Press 2nd QUIT.



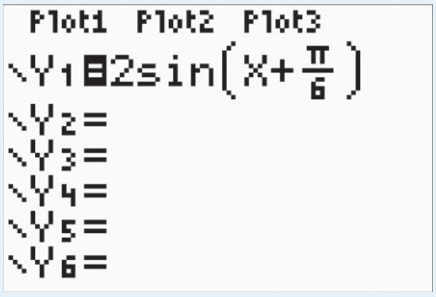
1.20 Drawing a trigonometric graph

Example 23

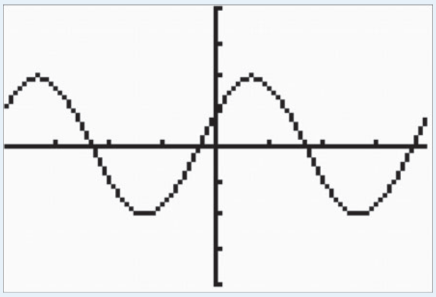
Draw the graph of $y = 2\sin\left(x + \frac{\pi}{6}\right) + 1$.

Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.

Type $y = 2\sin\left(x + \frac{\pi}{6}\right) + 1$ and press ENTER.



Press ZOOM 7:ZTrig.
The default axes are $-6.15 \le x \le 6.15$ and $-4 \le y \le 4$.



More complicated functions

1.21 Solving a combined quadratic and exponential equation

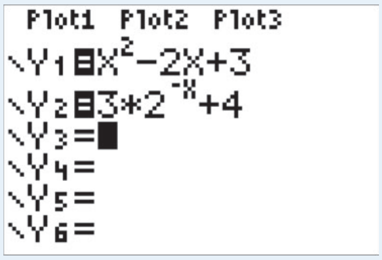
Example 24

Solve the equation $x^2 - 2x + 3 = 3 \cdot 2^{-x} + 4$

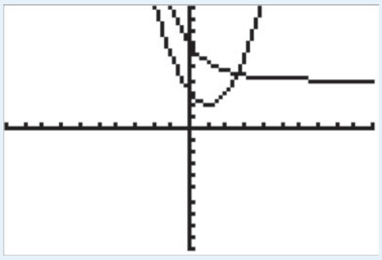
To solve the equation, find the point of intersection between the quadratic function $y_1 = x^2 - 2x + 3$ and the exponential function $y_2 = 3 \times 2^{-x} + 3$.

Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.
Type $x^2 - 2x + 3$ in Y_1 and press ENTER. Then type $3 \times 2^{-x} + 4$ in Y_2 and press ENTER.

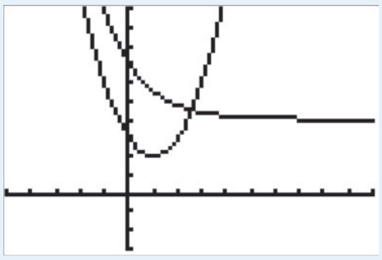
(**Note**: Type 2 ^ (–) X, T, Θ, n ▸ to enter 2^{-x}. The ▸ returns you to the baseline from the exponent.)



Press ZOOM | 6:Z Standard to use the default axes which are $-10 \leq x \leq 10$ and $-10 \leq y \leq 10$.
The calculator displays the curves with the default axes.

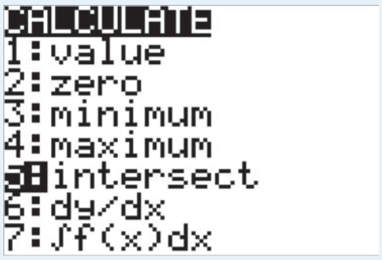


Adjust the window to make the quadratic curve fit the screen better.

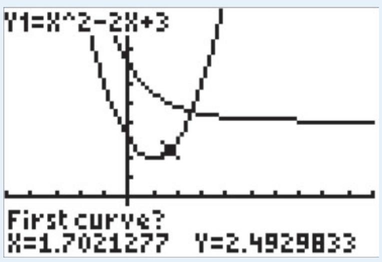


Press 2nd CALC | 5:intersect.

Press ENTER.

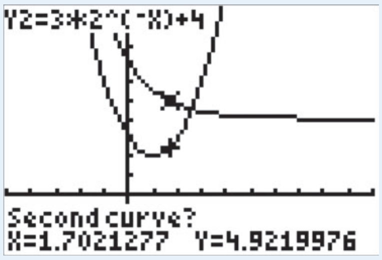


Press ENTER to select the first curve.

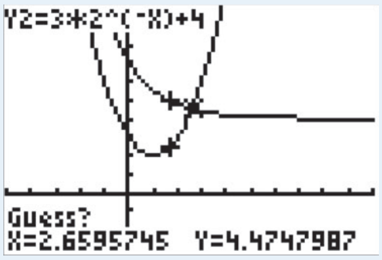


▶ Continued on next page

Press ENTER to select the second curve.

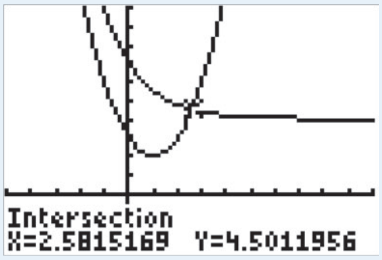


Select a point close to the intersection using the ◄ and ► keys and press ENTER.



The calculator displays the intersection of the two straight lines at the point (2.58, 4.50).

The solutions are $x = 2.58$ and $y = 4.50$.



Sequences and series

1.22 Summation of a series

Example 25

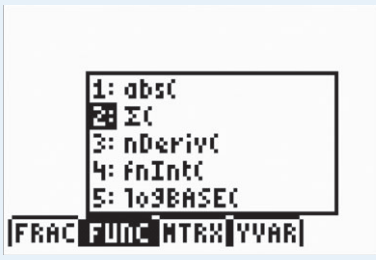
Find the sum of the first 20 terms of the arithmetic sequence 4, 7, 10, 13, …

The kth term of an arithmetic sequence is $u_k = u_1 + (k - 1)d$

In this example, $u_1 = 4$, $d = 3$ and $n = 20$.

$$s_n = \sum_{k=1}^{20} 4 + (k-1)3.$$

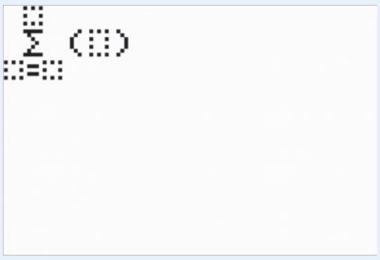
Press ALPHA F2 and select 2:Σ(



The template matches the written Sigma formula.

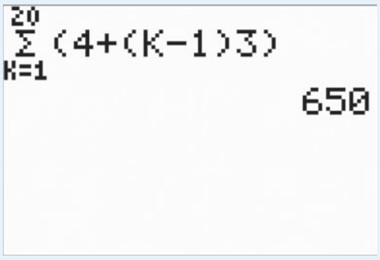
Enter the variables, values and the function as they are written.

Use the ► ◄ ▲ ▼ keys to move around the template.



Continued on next page

The sum of the terms of the sequence is 650.



Example 26

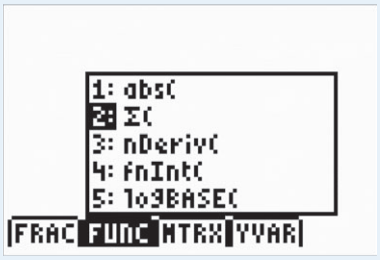
Find the sum of the first 12 terms of the geometric sequence $3, -1, \frac{1}{3}, -\frac{1}{9}, \ldots$

The kth term of a geometric sequence is $u_k = u_1 . r^{k-1}$

In the example $u_1 = 3$, $r = -\frac{1}{3}$ and $n = 12$.

$$s_n = \sum_{k=1}^{12} 3.\left(-\frac{1}{3}\right)^{k-1}.$$

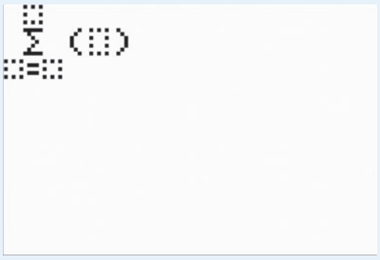
Press ALPHA F2 and select 2:Σ(



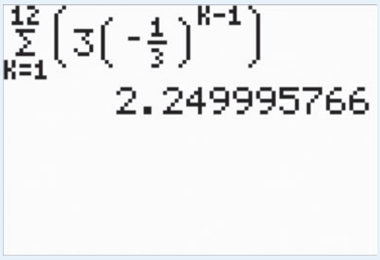
The template matches the written Sigma formula.

Enter the variables, values and the function as they are written.

Use the ▶ ◀ ▲ ▼ keys to move around the template.



The sum of the terms of the sequence is 2.25, to 3 significant figures.



Example 27

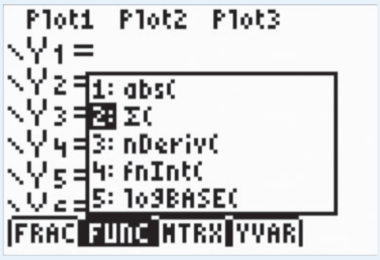
How many terms of the series $2 + 1\frac{1}{3} + \frac{8}{9} + \frac{16}{27} + \ldots$ are needed before their sum exceeds 5.5?

In the example $u_1 = 2$, $r = \frac{2}{3}$ and n is to be found.

$$s_n = \sum_{k=1}^{n} 2.\left(\frac{2}{3}\right)^{k-1}$$

Press !

Press ALPHA F2 and select 2:Σ(

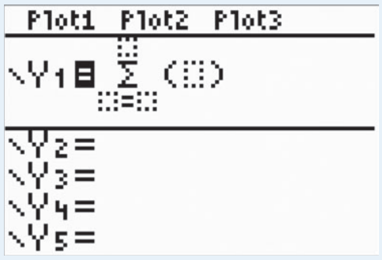


▶ Continued on next page

The template matches the written Sigma formula.

Enter the variables, values and the function as they are written.

Use the ▶ ◀ ▲ ▼ keys to move around the template.



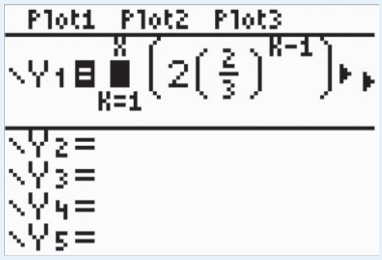
In place of the value for n type x.

Type the Sigma formula for the series.

Press ENTER

This stores the Sigma formula as the function, Y1.

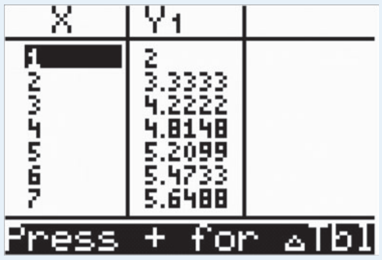
Instead of looking at the function as a graph, you will look at it in a table. The TI-84 Plus displays values in the table as exact, so in order to see the values of Y1 as decimal fractions press MODE | MATH | 2: ▶ Dec



Press 2nd TABLE

You will see a list of the sums of the series for different values of x.

The table shows that when n =7, S_n > 5.5 as required.



Modelling

1.23 Using sinusoidal regression

The notation $\sin^2 x$, $\cos^2 x$, $\tan^2 x$, … is a mathematical convention that has little algebraic meaning. To enter these functions on the GDC, you should enter $(\sin(x))^2$, etc. However, the calculator will conveniently interpret $\sin(x)^2$ as $(\sin(x))^2$.

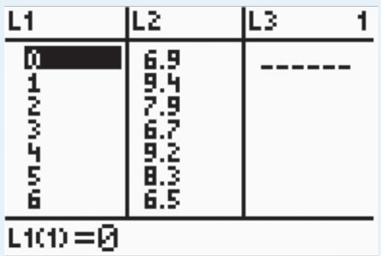
Example 28

It is known that the following data can be modelled using a sine curve:

x	0	1	2	3	4	5	6	7
y	6.9	9.4	7.9	6.7	9.2	8.3	6.5	8.9

Use sine regression to find a function to model this data.

Press STAT | 1:Edit and press F3.
Type the x-values in the first column (L1) and the y-values in the second column (L2).
Press ENTER or ▼ after each number to move down to the next cell.
Press ▶ to move to the next column.
You can use columns from L1 to L6 to enter the lists.



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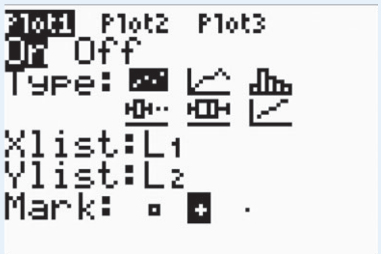
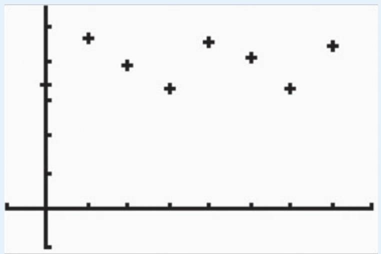
Press 2nd STAT PLOT and eto select Plot1.
Select On, choose the scatter diagram option, XList as L1 and Ylist as L2.
You can choose one of the three types of mark.

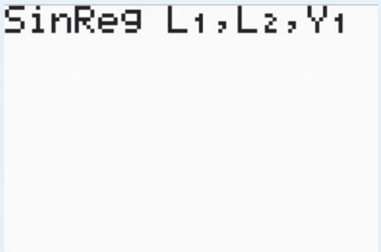


Press ZOOM 9:ZoomStat.
Adjust your window settings to show your data and the *x*- and *y*-axes.
You now have a scatter plot of *x* against *y*.

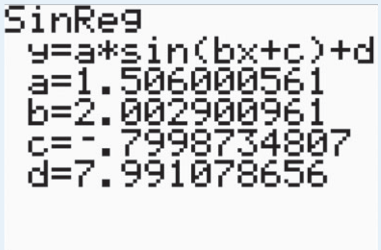


Press 2nd î to return to the Home screen.

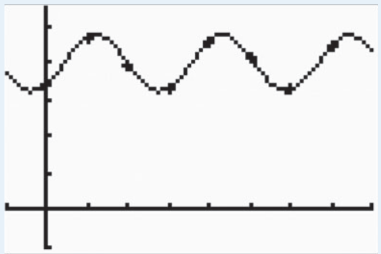
Press STAT CALC | C:SinReg.
Press 2nd L1 , 2nd æ, ALPHA F4 choose Y_1 and press F3.
Press F3 again.



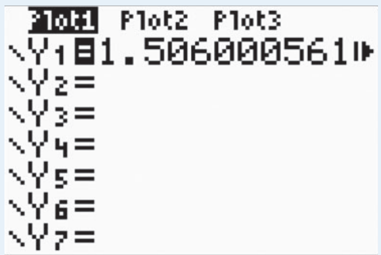
On screen, you will see the result of the sinusoidal regression.
The equation is in the form $y = a\sin(bx + c) + d$ and you will see the values of a, b, c and d displayed separately.
The equation of the sinusoidal regression line is
$y = 1.51\sin(2.00x - 0.80) + 7.99$



Press GRAPH to return to the Graphs page.



Press ▸.
The regression line is now shown in Y_1. You can see the full equation if you scroll to the right.



1.24 Drawing a piecewise function

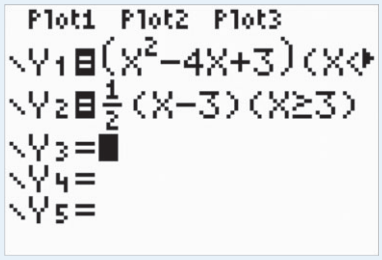
Example 29

Draw the function $f(x)=\begin{cases} x^2-4x+3, & x<3 \\ \frac{1}{2}(x-3), & x\ge 3 \end{cases}$

Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.

Type $(x^2 - 4x + 3)(x < 3)$ in Y_1 and press ENTER.

Type $\left(\frac{1}{2}(x-3)\right)$ in Y_2 and press ENTER.

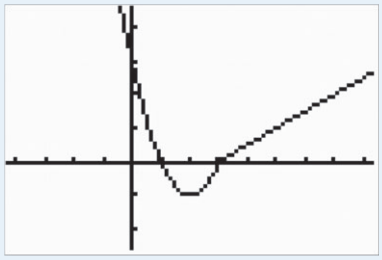


To enter the inequalities for the domain use 2nd TEST.

Press GRAPH

Choose suitable axes to display the curves.

The piecewise function is displayed.



2 Differential calculus

Finding gradients, tangents and maximum and minimum points

2.1 Finding the gradient at a point

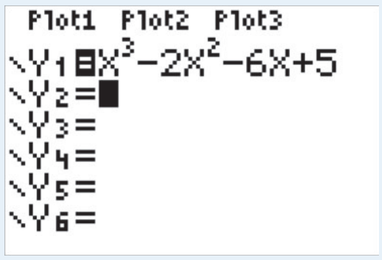
Example 30

Find the gradient of the cubic function $y = x^3 - 2x^2 - 6x + 5$ at the point where $x = 1.5$.

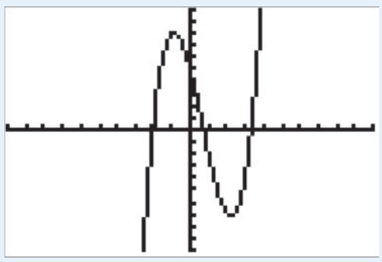
Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.

Type $y = x^3 - 2x^2 - 6x + 5$ and press ENTER.

> Note: Type X,T,Θ,n ^ 3 ▸ to enter x^3. The ▸ returns you to the baseline from the exponent.



Press ZOOM | 6:ZStandard to use the default axes which are $-10 \le x \le 10$ and $-10 \le y \le 10$.



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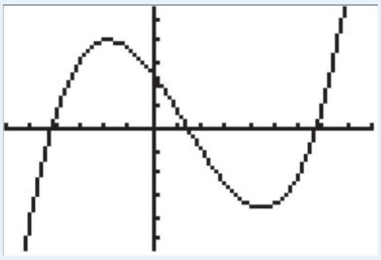
Adjust the window to make the cubic curve fit the screen better.

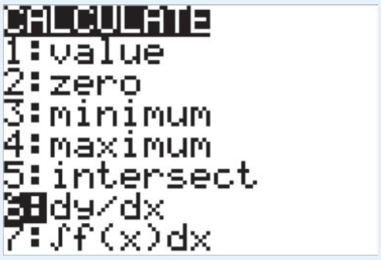
For help with changing axes, see your GDC manual.



Press 2nd CALC | 6: d*y*/d*x*.

Press ENTER.

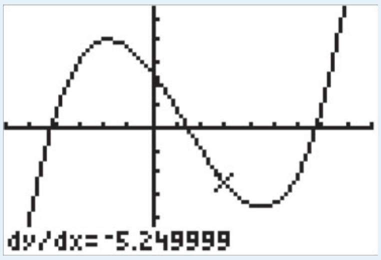
Press 1 . 5 ENTER.



The calculator displays the gradient of the curve at the point where $x = 1.5$.

The gradient is -5.25.

In this example the value of xdy/dx is not exactly –5.25. This is due to the way the calculator finds the point gradient. You should ignore small errors like this when you write down the coordinates of a gradient at a the point.

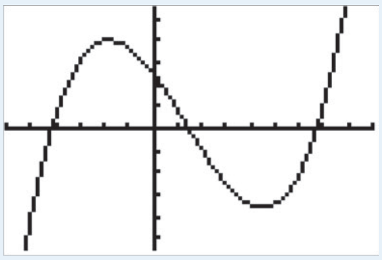


2.2 Drawing a tangent to a curve

Example 31

Draw a tangent to the curve $y = x^3 - 2x^2 - 6x + 5$ where $x = -0.5$.

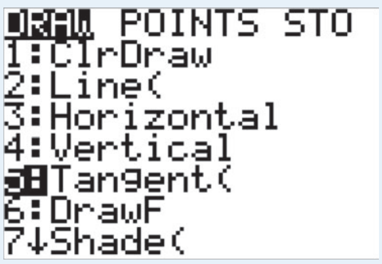
First draw the graph of $y = x^3 - 2x^2 - 6x + 5$ (see Example 30).



Press 2nd DRAW.

Choose 5:Tangent.

Press ENTER.



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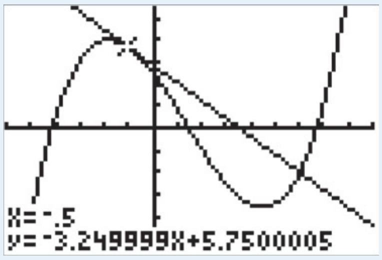
Press (-) 0 . 5 ENTER.

The equation of the tangent is

$y = -3.25x + 5.75$

In this example the values −3.25 and 5.75 are not shown as being exact. This is due to the way the calculator finds the values. You should ignore small errors like this when you write down the equation of a tangent.

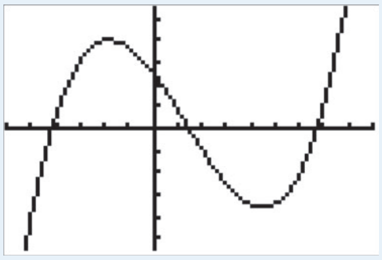


2.3 Finding maximum and minimum points

Example 32

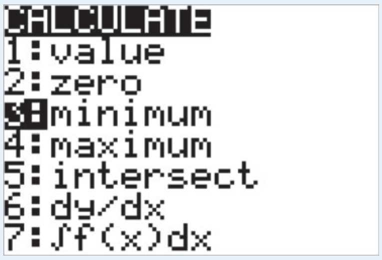
Find the local maximum and local minimum points on the cubic curve.

First draw the graph of $y = x^3 - 2x^2 - 6x + 5$ (see Example 30).



Press 2nd CALC | 3:minimum.

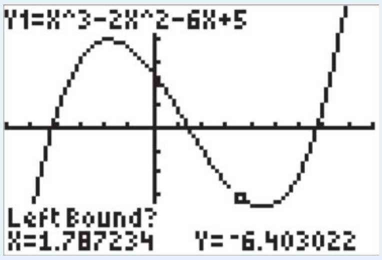
Press ENTER.



To find the minimum point you need to give the left and right bounds of a region that includes it.

The calculator shows a point and asks you to set the left bound. Move the point using the ◀ and ▶ keys to choose a position to the left of the minimum.

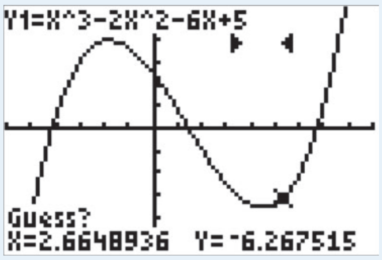
Press ENTER.



The calculator shows another point and asks you to set the right bound.

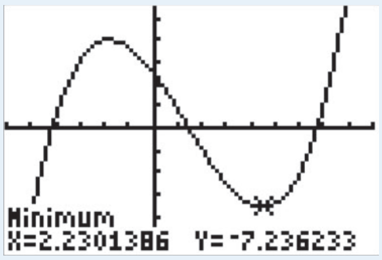
Move the point using the ◀ and ▶ keys so that the region between the left and right bounds contains the minimum.

When the region contains the minimum press ENTER.

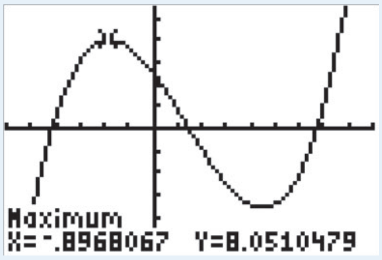


Press ENTER again to supply a guess for the value of the minimum.

The calculator displays the local minimum at the point (2.23, −7.24).



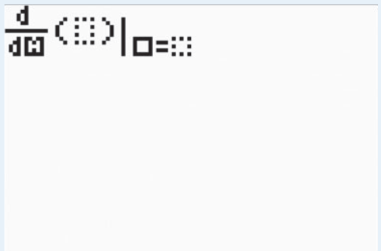
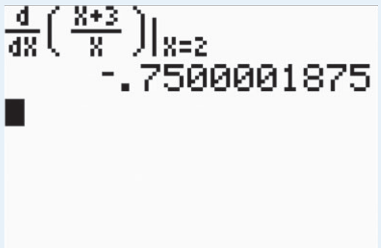
Continued on next page

Press 2nd CALC | 3:maximum ENTER. To find the local maximum point on the curve in exactly the same way. The maximum point is (−0.897, 8.05).	

2.4 Finding a numerical derivative

Using the calculator it is possible to find the numerical value of any derivative for any value of x. The calculator will not, however, differentiate a function algebraically. This is equivalent to finding the gradient at a point graphically (see Section 2.1 example 30).

Example 33

If $y=\frac{x+3}{x}$, evaluate $\left.\frac{dy}{dx}\right\|_{x=2}$	
Press ALPHA F2. Choose 3: nDeriv(to choose the derivative template.	
Enter x and the function in the template. Enter the value 2. Press ENTER.	
The calculator shows that the value of the first derivative of $y=\frac{x+3}{x}$ is −0.75 when $x = 2$.	

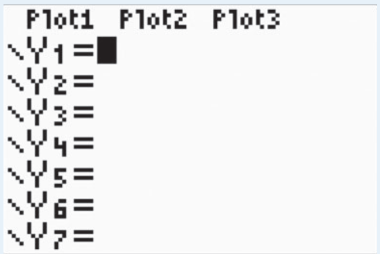
2.5 Graphing a numerical derivative

Although the calculator can only evaluate a numerical derivative at a point, it will graph the gradient function for all values of x.

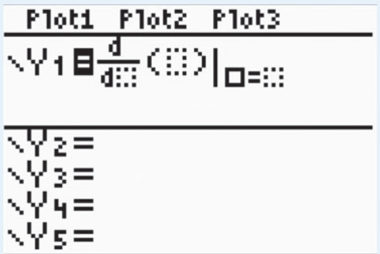
Example 34

If $y = \dfrac{x}{x+3}$, draw the graph of $\dfrac{\mathrm{d}y}{\mathrm{d}x}$.

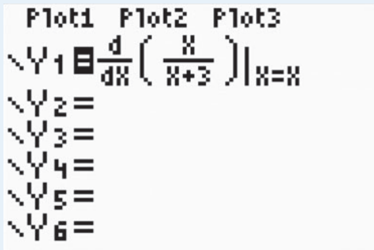
Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.



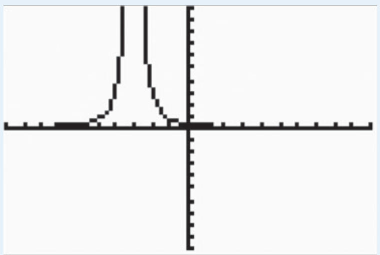
Press ALPHA F2.
Choose 3: nDeriv (to choose the derivative template.



In the template enter x, the function $\dfrac{x}{x+3}$ and the value x.
Press ENTER.



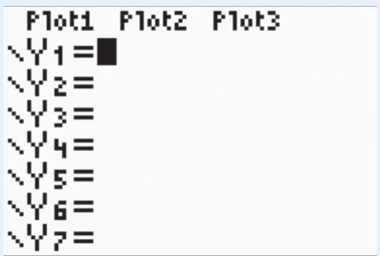
Press ZOOM 6:ZStandard.
The calculator displays the graph of the numerical derivative function of $y = \dfrac{x}{x+3}$.



Example 35

Find the values of x on the curve $y = \dfrac{x^3}{3} + x^2 - 5x + 1$ where the gradient is 3.

Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.



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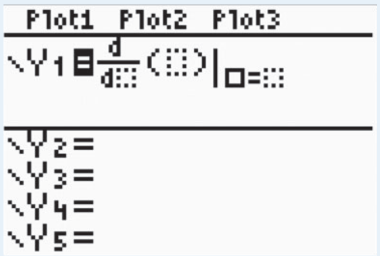
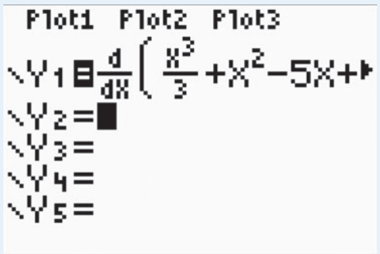
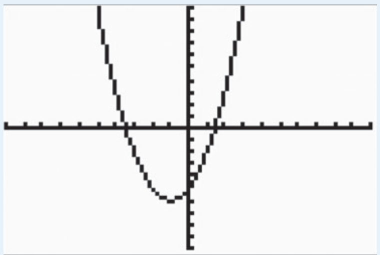
Press ALPHA F2.
Choose 3: nDeriv(to choose the derivative template.



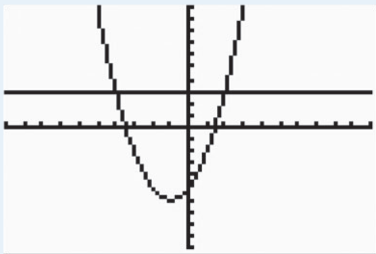
In the template enter *x*, the function $\frac{x^3}{3}+x^2-5x+1$ and the value *x*.
Press ENTER.



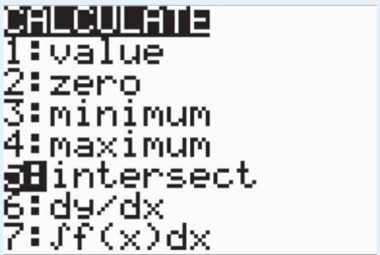
Press ZOOM 6:ZStandard.
The calculator displays the graph of the numerical derivative function of $y=\frac{x^3}{3}+x^2-5x+1$.



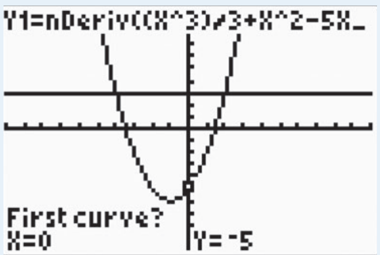
Press Y= to display the Y= editor.
Enter the function $Y_2 = 3$.
Press GRAPH.
The calculator now displays the curve and the line $y = 3$.



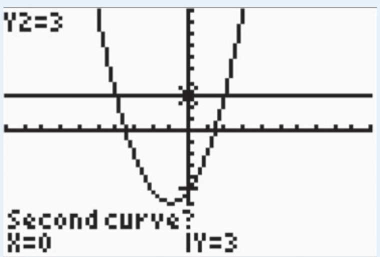
To find the points of intersection between the curve and the line.
Press 2nd CALC | 5:intersect.
Press ENTER.



Press ENTER to select the first curve.



Press ENTER to select the second curve.



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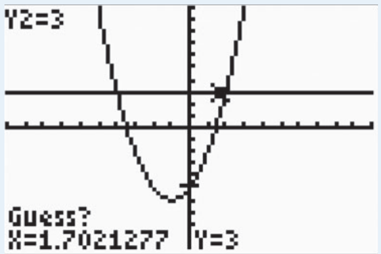
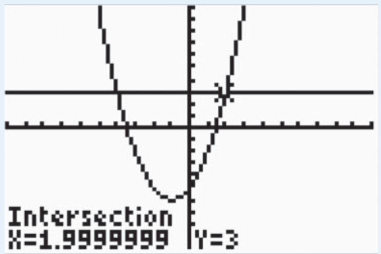
Select a point close to the intersection using the ◂ and ▸ keys and press ENTER.
Repeat for the second point of intersection.



The curve has gradient 3 when $x = -4$ and $x = 2$

In this example the value of x is not exactly 2. This is due to the way the calculator finds the point. You should ignore small errors like this when you write down the coordinates of a gradient at a point.



2.6 Using the second derivative

There is no second derivative function on the TI-84 Plus.

3 Integral calculus

The calculator can find the values of definite integrals either on a calculator page or graphically. The calculator method is quicker, but the graphical method is clearer and shows discontinuities, negative areas and other anomalies that can arise.

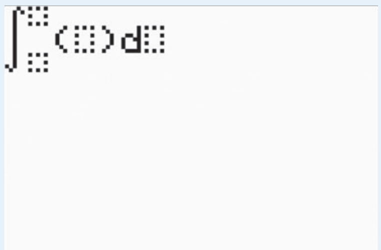
3.1 Finding the value of a definite integral

Example 36

Evaluate $\int_2^8 \left(x - \frac{3}{\sqrt{x}}\right) \mathrm{d}x$.

Press ALPHA F2.
Choose 4: fnlnt(to choose the integral template.
In this example you will also use templates to enter the rational function and the square root.

Enter the upper and lower limits, the function and x in the template.
Press ENTER.



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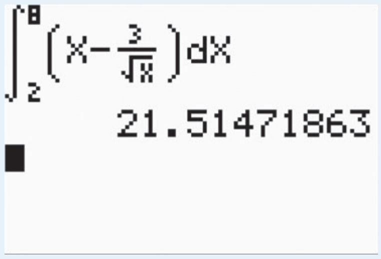
The value of the integral is 21.5 (to 3 sf).

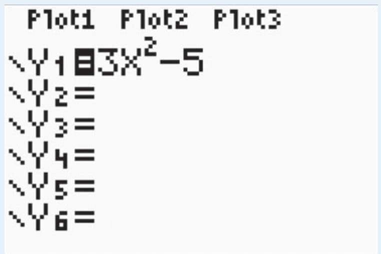


3.2 Finding the area under a curve

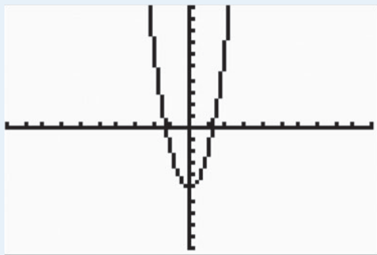
Example 37

Find the area bounded by the curve $y = 3x^2 - 5$, the x-axis and the lines $x = -1$ and $x = 1$.

Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.
Type $y = 3x^2 - 5$ and press ENTER.

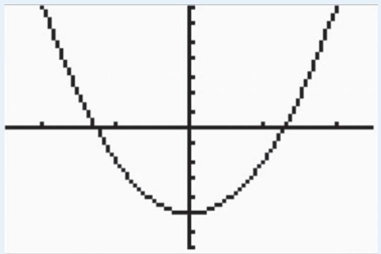


Press ZOOM 6:ZStandard.
The default axes are $-10 \le x \le 10$ and $-10 \le y \le 10$.



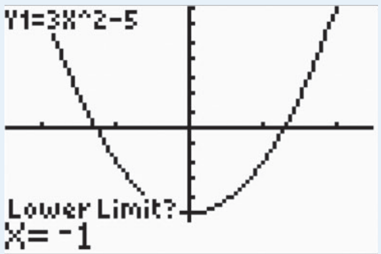
Adjust the window settings to view the curve better.

For help with changing axes, see your GDC manual.

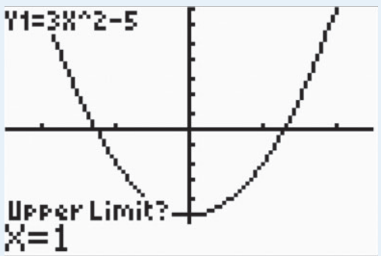


Press 2nd CALC 7:∫f(x)dx.

The calculator prompts you to enter the lower limit for the integral.
Type –1 and press ENTER.
Be sure to use the (-) key.



Type 1 and press ENTER.



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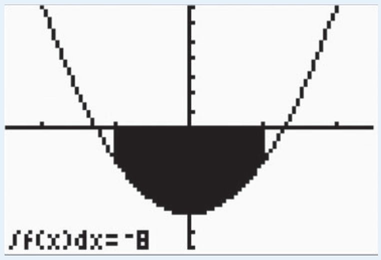
The area found is shaded and the value of the integral (–8) is shown on the screen.

The required area is 8.

Since the area lies below the x-axis in this case, the integral is negative.



4 Vectors

There is no scalar product function on the TI-84 Plus, but you can find the result by multiplying the vectors as lists and then finding the sum of the terms in the list.

Scalar product

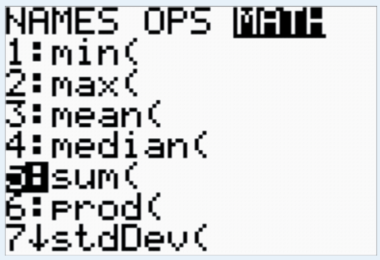
4.1 Calculating a scalar product

Example 38

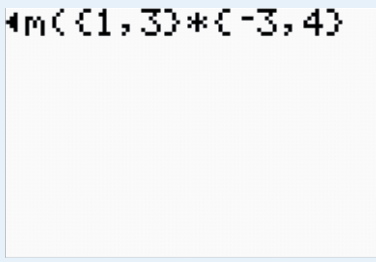
Evaluate the scalar products:

a $\begin{pmatrix}1\\3\end{pmatrix}\cdot\begin{pmatrix}-3\\4\end{pmatrix}$ **b** $\begin{pmatrix}1\\-1\\4\end{pmatrix}\cdot\begin{pmatrix}3\\2\\-1\end{pmatrix}$

a Press 2nd LIST | MATH | 5:sum(.

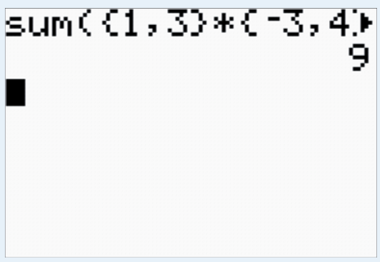


Enter the vectors as lists using curly brackets { }. Separate the terms of the vectors using commas.
Multiply the two vector lists together.

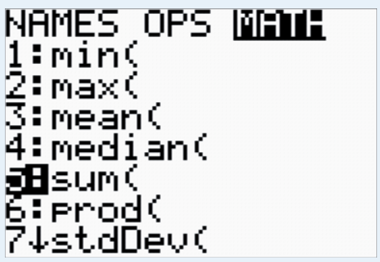


Close the bracket and press ENTER.

$\begin{pmatrix}1\\3\end{pmatrix}\cdot\begin{pmatrix}-3\\4\end{pmatrix}=9$



b Press 2nd LIST | MATH | 5:sum(.



Continued on next page

Enter the vectors as lists using curly brackets { }. Separate the terms of the vectors using commas. Multiply the two vector lists together.	`◂, -1,4}*{3,2,-1}▸`
Close the bracket and press ENTER. $\begin{pmatrix}1\\-1\\4\end{pmatrix}\cdot\begin{pmatrix}3\\2\\-1\end{pmatrix}=-3$	`sum({1,-1,4}*{3▸` `-3`

4.2 Calculating the angle between two vectors

The angle θ between two vectors $\vec{a}$ and $\vec{b}$, can be calculated using the formula

$$\theta = \arccos\left(\frac{\vec{a}\cdot\vec{b}}{|\vec{a}||\vec{b}|}\right)$$

Example 39

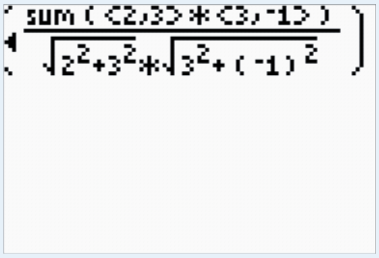
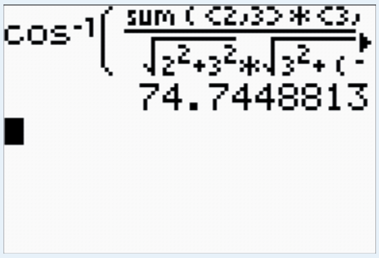
Calculate the angle between $2\vec{i}+3\vec{j}$ and $3\vec{i}-\vec{j}$	

Press MODE.
Select either RADIAN or DEGREE (according to the units you need your answer in) using the ▸ ◂ ▴ ▾ keys.
Press ENTER.
Press 2nd QUIT.
	`NORMAL SCI ENG`
	`FLOAT 0 1 2 3 4 5 6 7 8 9`
	`RADIAN DEGREE`
	`FUNC PAR POL SEQ`
	`CONNECTED DOT`
	`SEQUENTIAL SIMUL`
	`REAL a+bi re^θi`
	`FULL HORIZ G-T`
	`↓NEXT↓`

Press 2nd DISTR.	`cos⁻¹(`

Press ALPHA F1 and select the fraction template 1:n/d	`cos⁻¹(`
	`1: n/d`
	`2: Un/d`
	`3: ▸n/d◂▸Un/d`
	`4: ▸F◂▸D`
	`FRAC FUNC MTRX YVAR`

▶ Continued on next page

Press 2nd LIST | MATH | 5:sum(.	
Enter the vectors as lists using curly brackets { }. Separate the terms of the vectors using commas. Multiply the two vector lists together. To calculate the magnitudes of the vectors use the formula $\lvert a\vec{\mathbf{i}}+b\vec{\mathbf{j}}\rvert=\sqrt{a^2+b^2}$ Use the ▸ key to exit the templates before entering the final bracket.	
Press ENTER. The angle between $2\vec{\mathbf{i}}+3\vec{\mathbf{j}}$ and $3\vec{\mathbf{i}}-\vec{\mathbf{j}}$ is 74.7°.	

Vector product

4.3 Calculating a vector product

The TI-84 Plus does not have the ability to perform cross products of vectors.

5 Statistics and probability

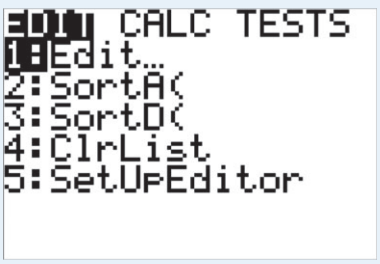
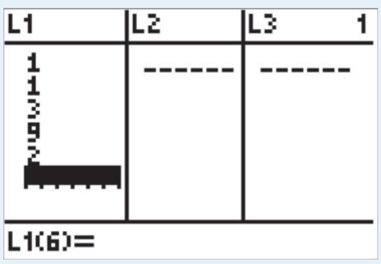
You can use your GDC to draw charts to represent data and to calculate basic statistics such as mean, median, etc. Before you do this you need to enter the data in a list.

Entering data

There are two ways of entering data: as a list or as a frequency table.

5.1 Entering lists of data

Example 40

Enter the data in the list: 1, 1, 3, 9, 2.	
Press STAT 1: Edit and press ENTER. Type the numbers in the first column (L1). Press ENTER or ▾ after each number to move down to the next cell. L1 will be used later when you want to make a chart or to do some calculations with this data. You can use columns from L1 to L6 to enter the list.	 

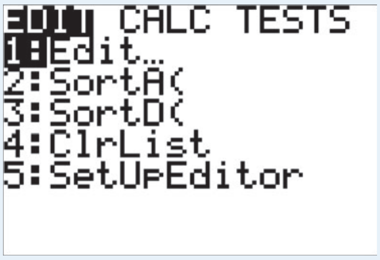
5.2 Entering data from a frequency table

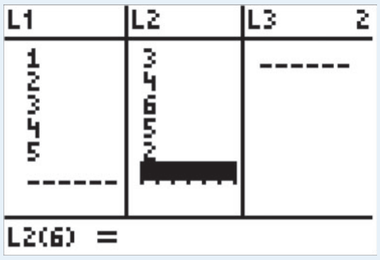
Example 41

Enter the data in the table:

Number	1	2	3	4	5
Frequency	3	4	6	5	2

Press STAT | 1:Edit and press ENTER.
Type the numbers in the first column (L1) and the frequencies in the second column (L2).
Press ENTER or ▼ after each number to move down to the next cell.
Press ▶ to move to the next column.
L1 and L2 will be used later when you want to make a chart or to do some calculations with this data. You can use columns from L1 to L6 to enter the lists.





Drawing charts

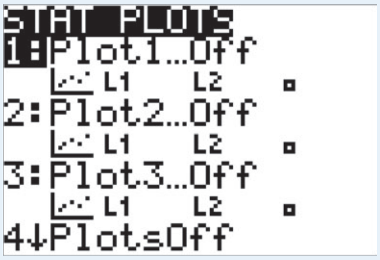
Charts can be drawn from a list or from a frequency table.

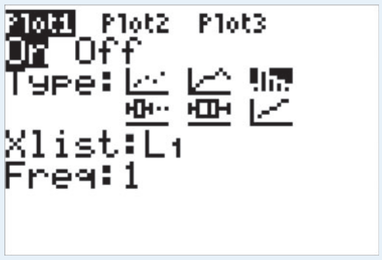
5.3 Drawing a frequency histogram from a list

Example 42

Draw a frequency histogram for this data: 1, 1, 3, 9, 2.

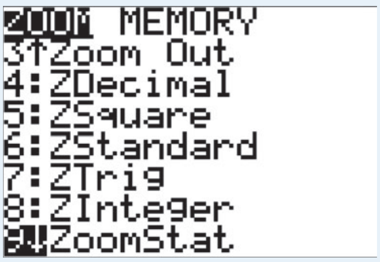
Enter the data in L1 (see Example 40).
Press 2nd STAT PLOT and ENTER to select Plot1.
Select On, choose the histogram option and leave XList as L1 and Freq as 1.

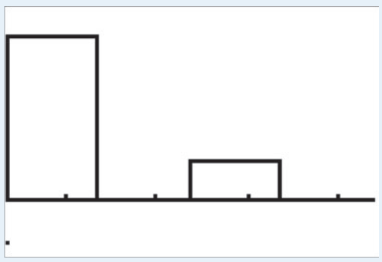




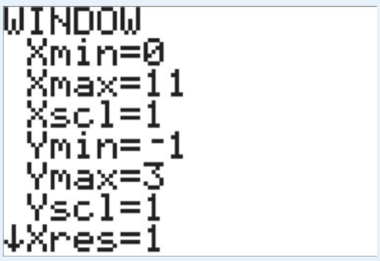
Press ZOOM | 9:Stat.
The automatic scales do not usually give the best display of the histogram. You will need to change the default values.

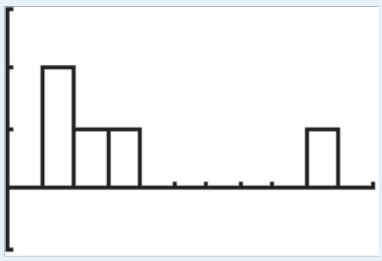
You may need to delete any function graphs. Y=





Press WINDOW and choose options as shown.
Xmin and Xmax should include the range of the data.
Ymin and Ymax should include the maximum frequency and should go below zero.
Xscl will define the width of the bars.





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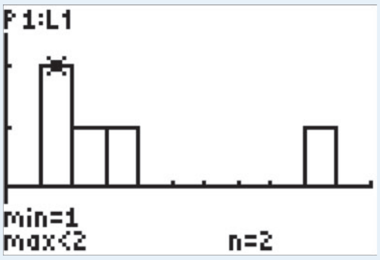
Press TRACE.

Use the ▸ key to move to each of the bars and display their value and frequency.

You should now see a frequency histogram for the data in the list 1, 1, 3, 9, 2.



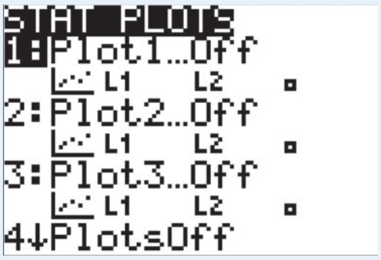
5.4 Drawing a frequency histogram from a frequency table

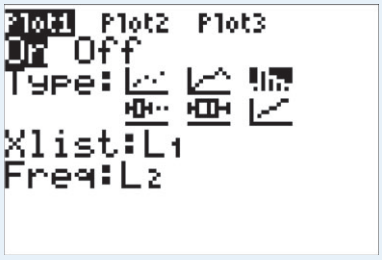
Example 43

Draw a frequency histogram for this data:

Number	1	2	3	4	5
Frequency	3	4	6	5	2

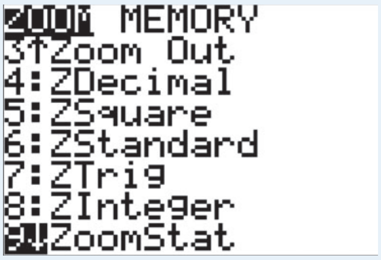
Enter the data in L1 and L2 (see Example 41).
Press 2nd STAT PLOT and ENTER to select Plot 1.
Select On, choose the histogram option and leave XList as L1 and Freq as L2.

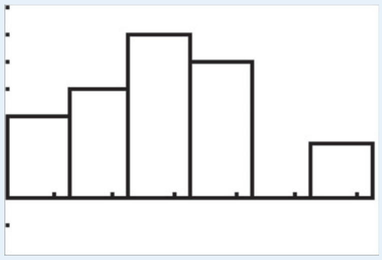




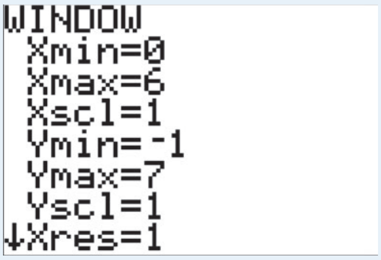
Press ZOOM | 9:Stat.
The automatic scales do not usually give the best display of the histogram. You will need to change the default values.

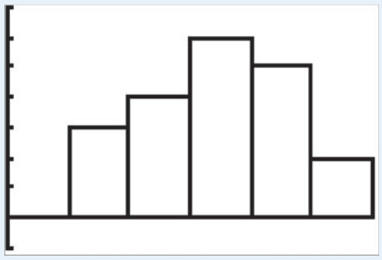
You may need to delete any function graphs. Y=





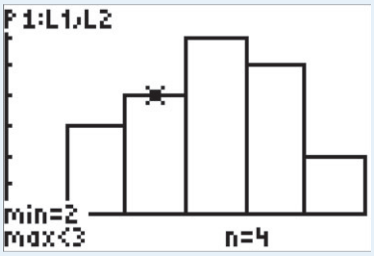
Press WINDOW and choose options as shown.
Xmin and Xmax should include the range of the data.
Ymin and Ymax should include the maximum frequency and should go below zero.
Xscl will define the width of the bars.





Press TRACE.
Use the ▸ key to move to each of the bars and display their value and frequency.

You should now see a frequency histogram for the data in the list 1, 1, 3, 9, 2.

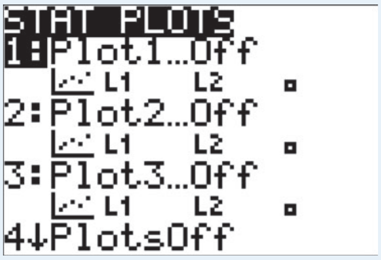


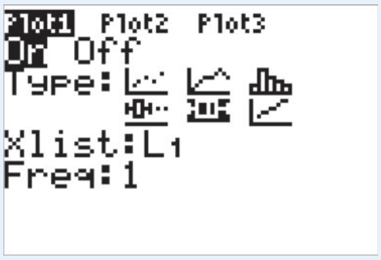
5.5 Drawing a box and whisker diagram from a list

Example 44

Draw a box and whisker diagram for this data:
1, 1, 3, 9, 2.

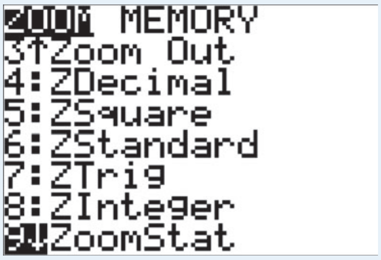
Enter the data in L1 (see Example 40).
Press 2nd STAT PLOT and ENTER to select Plot 1.
Select On, choose the box and whisker option and leave XList as L1 and Freq as 1.

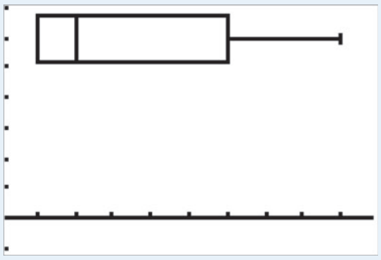




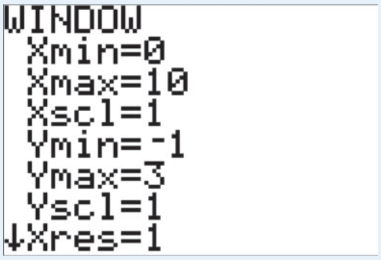
Press ZOOM | 9:Stat.
The automatic scales do not usually give the best display of the box and whisker diagram. You will need to change the default values.

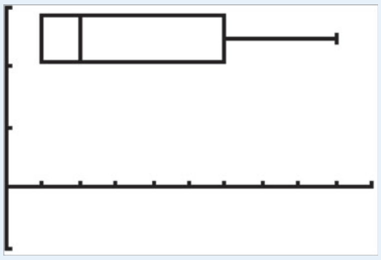
You may need to delete any function graphs. Y=



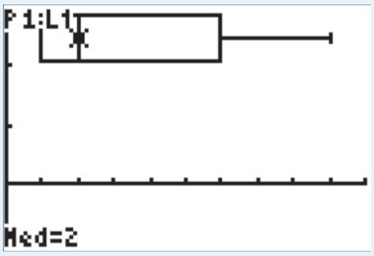


Press WINDOW and choose options as shown.
Xmin and Xmax should include the range of the data.
Ymin and Ymax do not affect the way in which the diagram is displayed.





Press TRACE.
Use the ▸ key to move the cursor over the plot to see the quartiles, Q1 and Q3, the median and the maximum and minimum values.



5.6 Drawing a box and whisker diagram from a frequency table

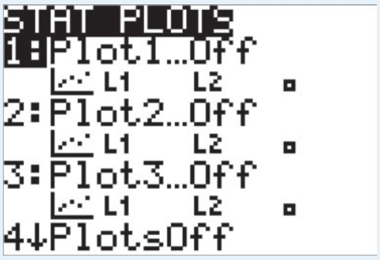
Example 45

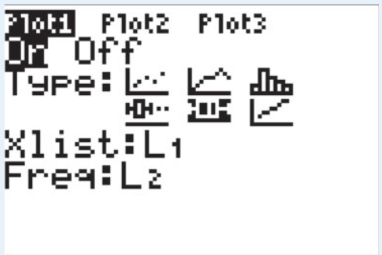
Draw a box and whisker diagram for this data:

Number	1	2	3	4	5
Frequency	3	4	6	5	2

▶ Continued on next page

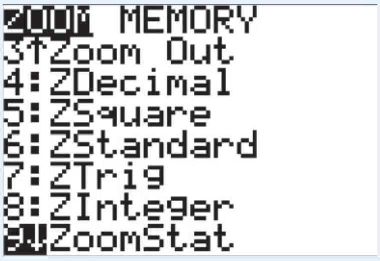
Enter the data in L1 and L2 (see Example 41).
Press 2nd STAT PLOT and ENTER to select Plot 1.
Select On, choose the box and whisker diagram option and leave XList as L1 and Freq as L2.

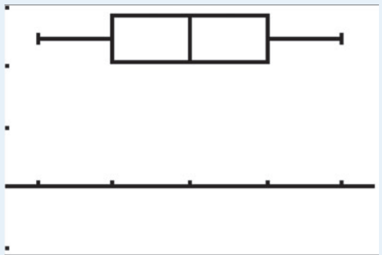




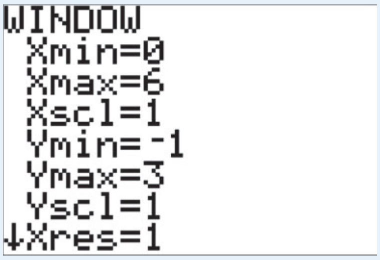
Press ZOOM | 9:Stat.
The automatic scales do not usually give the best display of the box and whisker diagram. You will need to change the default values.

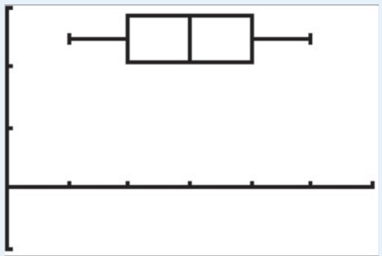
You may need to delete any function graphs. Y=



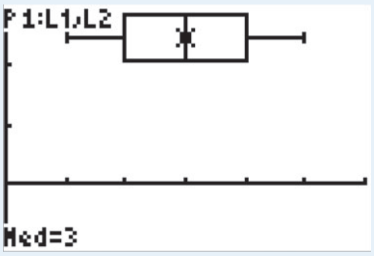


Press WINDOW and choose options as shown.
Xmin and Xmax should include the range of the data.
Ymin and Ymax do not affect the way in which the diagram is displayed.





Press TRACE.
Use the ▸ key to move the cursor over the plot to see the quartiles, Q1 and Q3, the median and the maximum and minimum values.



Calculating statistics

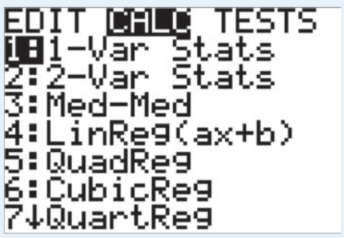
You can calculate statistics such as mean, median, etc. from a list, or from a frequency table.

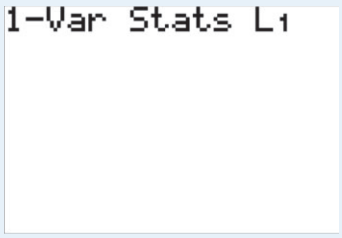
5.7 Calculating statistics from a list

Example 46

Calculate the summary statistics for this data: 1, 1, 3, 9, 2

Enter the data in L1 (see Example 40).
Press STAT | CALC | 1:1-Var Stats.
Type 2nd L1 and press ENTER.

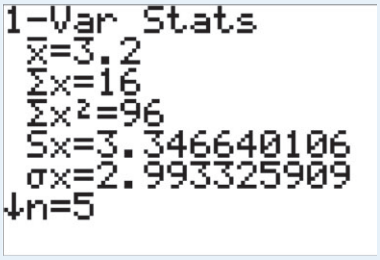


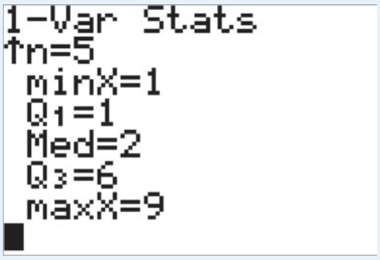


▶ Continued on next page

The information shown will not fit on a single screen. You can scroll up and down to see it all. The statistics calculated for the data are:

mean	$\bar{x}$
sum	Σx
sum of squares	Σx^2
sample standard deviation	s_x
population standard deviation	σ_x
number	n
minimum value	Min$X$
lower quartile	Q_1
median	Med
upper quartile	Q_3
maximum value	Max$X$





5.8 Calculating statistics from a frequency table

Example 47

Calculate the summary statistics for this data:

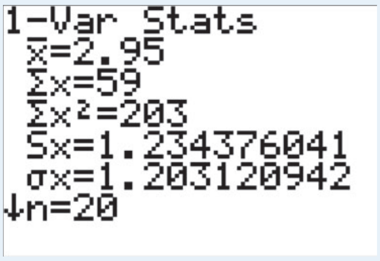
Number	1	2	3	4	5
Frequency	3	4	6	5	2

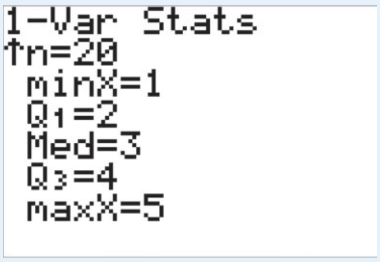
Enter the data in L1 and L2 (see Example 41).
Press STAT | CALC | 1:1-Var Stats.

Type 2nd L1 , 2nd L2 and press ENTER.

The information shown will not fit on a single screen. You can scroll up and down to see it all. The statistics calculated for the data are:

mean	$\bar{x}$
sum	Σx
sum of squares	Σx^2
sample standard deviation	s_x
population standard deviation	σ_x
number	n
minimum value	min$X$
lower quartile	Q_1
median	Med
upper quartile	Q_3
maximum value	Max$X$





5.9 Calculating the interquartile range

Example 48

Calculate interquartile range for this data:

Number	1	2	3	4	5
Frequency	3	4	6	5	2

The interquartile range is the difference between the upper and lower quartiles ($Q_3 - Q_1$).

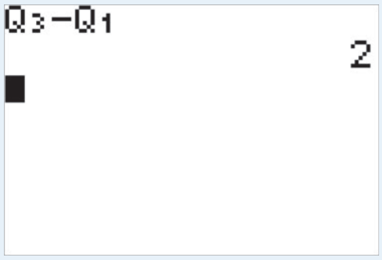
First calculate the summary statistics for this data (see Example 47).

(**Note**: The values of the summary statistics are stored after One-Variable Statistics have been calculated and remain stored until the next time they are calculated.)

Press VARS | 5:Statistics... | PTS | 9:Q3 ENTER – VARS | 5:Statistics... | PTS | 7:Q1 ENTER.

The calculator now displays the result:

Interquartile range = $Q_3 - Q_1 = 2$



5.10 Using statistics

The calculator stores the values you calculate in One-Variable Statistics so that you can access them in other calculations. These values are stored until you do another One-Variable Statistics calculation.

Example 49

Calculate the $\bar{x} + \sigma_x$ for this data:

Number	1	2	3	4	5
Frequency	3	4	6	5	2

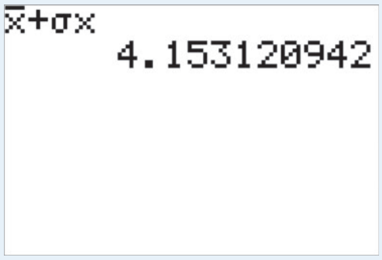
First calculate the summary statistics for this data (see Example 47).

(**Note**: The values of the summary statistics are stored after One-Variable Statistics have been calculated and remain stored until the next time they are calculated.)

Press VARS | 5:Statistics... | 2: $\bar{x}$ ENTER – VARS | 5:Statistics... 4:σx ENTER.

The calculator now displays the result:

$\bar{x} + \sigma_x = 4.15$ (to 3 sf)



Calculating binomial probabilities

5.11 The use of nCr

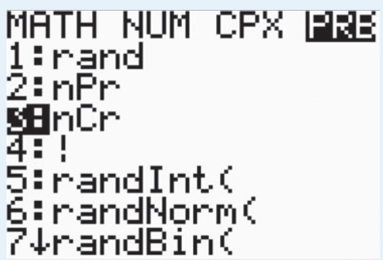
Example 50

Find the value of $\binom{8}{3}$ (or $_8C_3$).

Press 8.

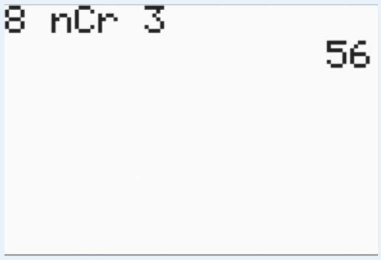
Press MATH 3:nCr.

Press 3 ENTER.



Continued on next page

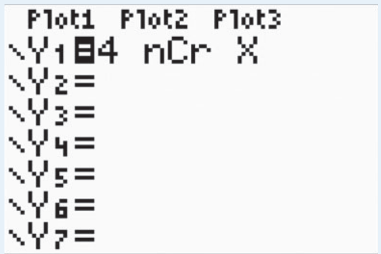
Press ENTER.



Example 51

List the values of $\binom{4}{r}$ for $r = 0, 1, 2, 3, 4$.

Press Y= to display the Y= editor. The default graph type is Function, so the form Y= is displayed.
Press 4.
Press m 3:nCr.
Press X,T,Θ,n ENTER.

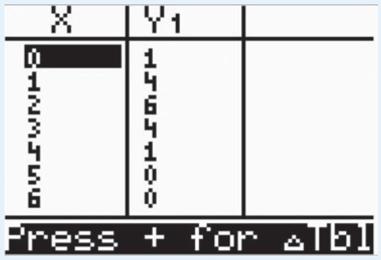


Press 2nd TABLE.
The table shows that

$$\binom{4}{0}=1, \binom{4}{1}=4, \binom{4}{2}=6, \binom{4}{3}=4$$

and $\binom{4}{4}=1$

You may need to reset the start value and incremental values for the table using 2nd TBLSET



5.12 Calculating binomial probabilities

Example 52

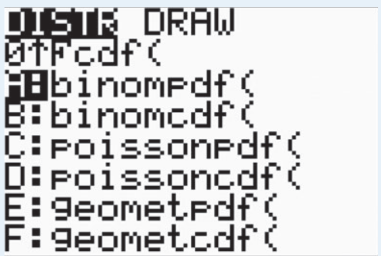
X is a discrete random variable and $X \sim \mathrm{Bin}(9, 0.75)$.
Calculate $\mathrm{P}(X = 5)$

$$P(X=5)=\binom{9}{5}0.75^5\ 0.25^4$$

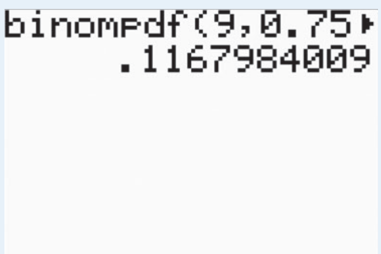
The calculator can find this value directly.

Press 2nd DISTR A:binompdf(.
Enter 9 as trials, 0.75 as p and 5 as x.
Select Paste and press ENTER
Press ENTER again

You should enter the values: n (numtrials), p and x, in order.



The calculator shows that P $(X = 5) = 0.117$ (to 3 sf).

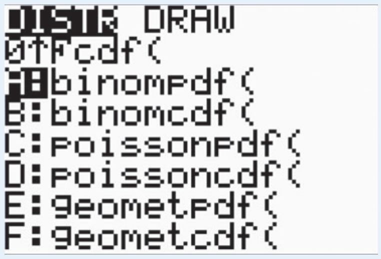


Example 53

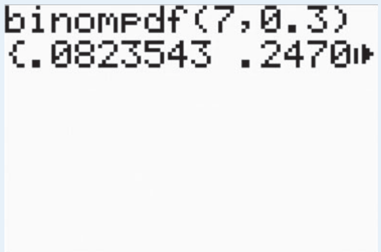
X is a discrete random variable and $X \sim \text{Bin}(7, 0.3)$.
Calculate the probabilities that X takes the values $\{0, 1, 2, 3, 4, 5, 6, 7\}$.

Press 2nd DISTR A:binompdf(.
Enter 7 as trials, 0.3 as p and leave x blank.
Select Paste and press ENTER
Press ENTER again

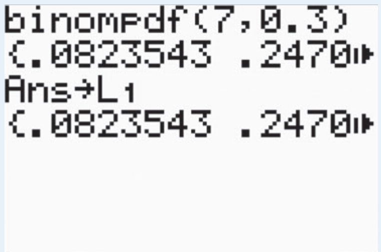
You should enter the values: n (numtrials), p and x, in order.



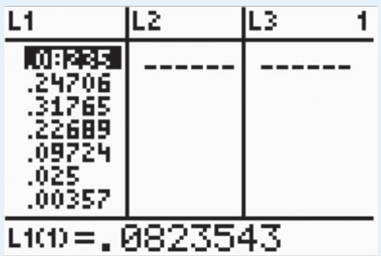
The calculator displays each of the probabilities.
To see the remaining values scroll the screen to the right.
The list can also be transferred as a list.



Press STO▸ 2nd L1.
Press ENTER.



Press STAT 1:Edit…
The binomial probabilities are now displayed in the first column.



Example 54

X is a discrete random variable and $X \sim \text{Bin}(20, 0.45)$.
Calculate

a the probability that X is less than or equal to 10.

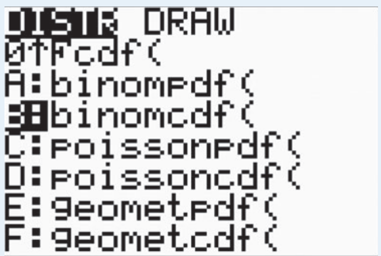
b the probability that X lies between 5 and 15 inclusive.

c the probability that X is greater than 11.

Press 2nd DISTR B:binomcdf(.

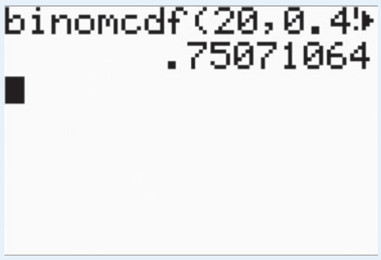
You are given the lower bound probability so you have to calculate other probabilities using this.

You should enter the values: n (numtrials), p and x, in order.

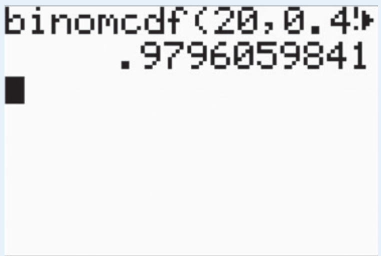


▶ Continued on next page

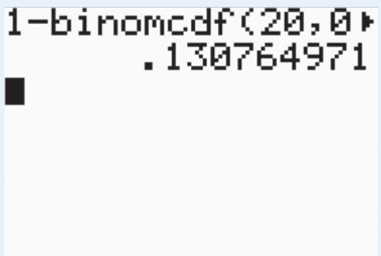
a Enter 30 as trials, 0.45 as p and 10 as x.
Select Paste and press ENTER
Press ENTER again
$P(X \le 10) = 0.751$ (to 3 sf).



b $P(5 \le X \le 15) = P(X \le 15) - P(X \le 4)$
Press 2nd DISTR B:binomcdf(
Enter 20 as trials, 0.45 as p and 10 as x.
Select Paste and press ENTER
Type (–) and then Press 2nd DISTR B:binomcdf(
Enter 20 as trials, 0.45 as p and 4 as x.
Select Paste and press ENTER
Press ENTER again
$P(5 \le X \le 15) = 0.980$ (to 3 sf).



c $P(X > 11) = 1 - P(X \le 11)$
Enter 1 – and then Press 2nd DISTR B:binomcdf(
Select Paste and press ENTER
Press ENTER again
$P(X > 11) = 0.131$ (to 3 sf).



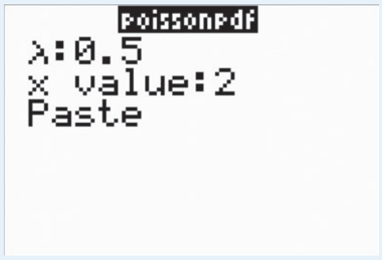
Calculating Poisson probabilities

5.13 Calculating Poisson probabilities

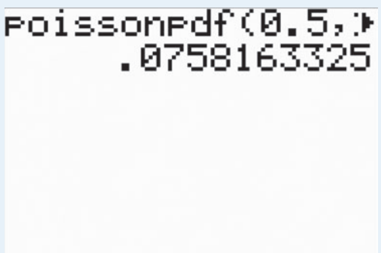
Example 55

X is a discrete random variable and $X \sim Po(0.5)$
Calculate
i $P(X = 2)$
ii $P(X \le 2)$
iii $P(X > 2)$

i $P(X = 2) = \dfrac{e^{-0.5} \times (0.5)^2}{2!}$
The calculator can find this value directly.
Press 2nd | DISTR | C:poissonpdf(
Enter the parameter and the X value.
Select Paste and press ENTER



Press ENTER again.
The calculator shows that
$P(X = 2) = 0.0758$ (to 3 sf)



Continued on next page

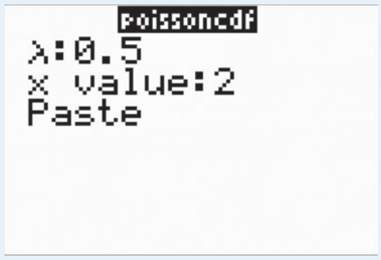
ii $P(X \le 2) = \dfrac{e^{-0.5} \times (0.5)^0}{0!} + \dfrac{e^{-0.5} \times (0.5)^1}{1!} + \dfrac{e^{-0.5} \times (0.5)^2}{2!}$

The calculator can find this value directly.

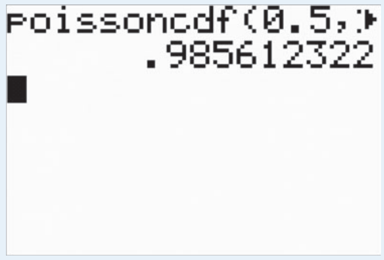
Press 2nd | DISTR | D:poissoncdf(

Enter the parameter and the upper bound 2.

Select Paste and press ENTER



Press ENTER again.
The calculator shows that
$P(X \le 2) = 0.986$ (to 3 sf)

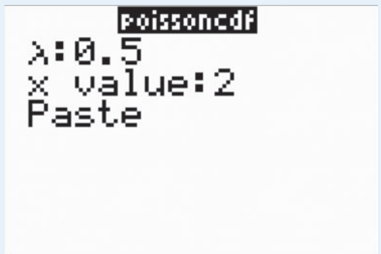


ii $P(X > 2) = \dfrac{e^{-0.5} \times (0.5)^3}{3!} + \dfrac{e^{-0.5} \times (0.5)^4}{4!} + \dfrac{e^{-0.5} \times (0.5)^5}{5!} + \ldots$

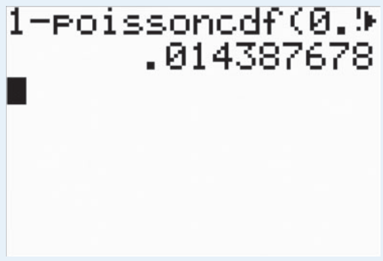
$= 1 - P(X \le 2)$

The calculator can find this value directly.

Type 1-
Press 2nd | DISTR | D:poissoncdf(
Enter the parameter and the upper bound 2.
Select Paste and press ENTER



Press ENTER again.
The calculator shows that
$P(X > 2) = 0.0144$ (to 3 sf)



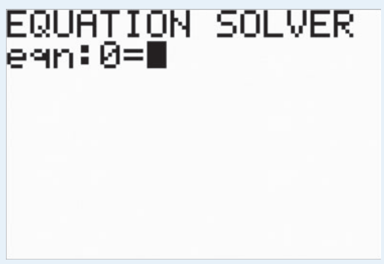
Example 56

If $X \sim \text{Po}(\lambda)$ find the value of λ, correct to 3 decimal places, given that $P(X = 2) = 0.035$.

There is no inverse Poisson function on the TI-84, so instead you could use the numerical solver function to find a value of λ when you are given a probability.

Press MATH | B: Solver…
If no equation is stored, the screen will display eqn: 0=, if not then press ▲ and CLEAR.

It is necessary to enter the variable x in the numerical solver and also an initial guess – 0 is close enough.



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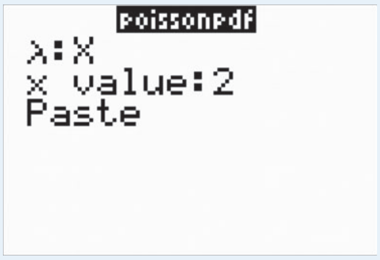
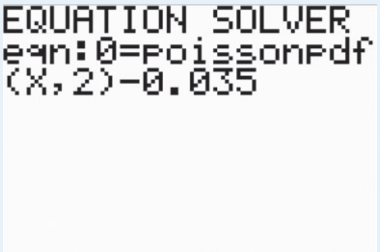
Press 2nd | DISTR | C:poissonpdf(
Enter the value of λ as X, the value of n as 2.
Select Paste and press ENTER

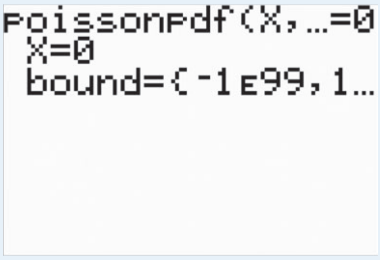


Type −0.035 and press ENTER
This makes the equation $0 = \mathrm{P}(X = 2) - 0.035$

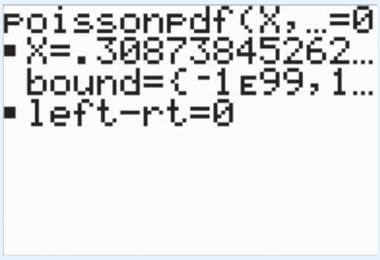


Enter an initial guess for x – 0 is close enough.

Then press ALPHA SOLVE



The required value of λ is 0.309 (to 3 sf).



Calculating normal probabilities

5.14 Calculating normal probabilities from *X*-values

Example 57

A random variable X is normally distributed with a mean of 195 and a standard deviation of 20 or $X \sim N(195, 20^2)$. Calculate

a the probability that X is less than 190.

b the probability that X is greater than 194.

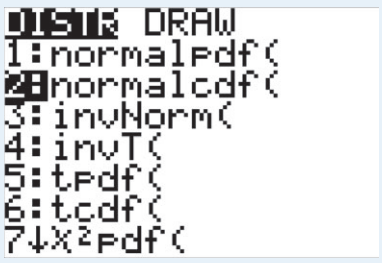
c the probability that X lies between 187 and 196.

Press 2nd DISTR | 2:normalcdf(.

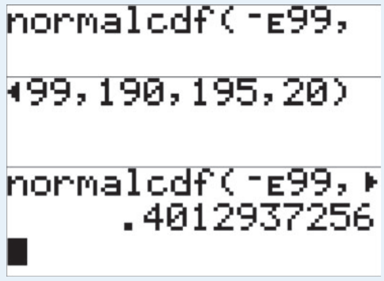
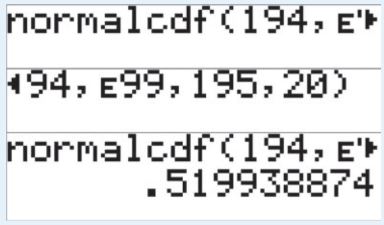
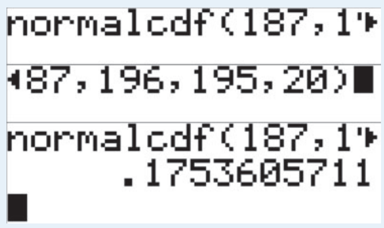
Press ENTER.

You should enter the values, Lower Bound, Upper Bound, μ and σ, in order.

The value E99 is the largest value that can be entered in the GDC and is used in the place of ∞. It stands for 1×10^{99} (–E99 is the smallest value and is used in the place of $-\infty$). To enter the E, you need to press 2nd EE.

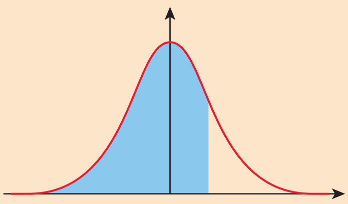


▶ Continued on next page

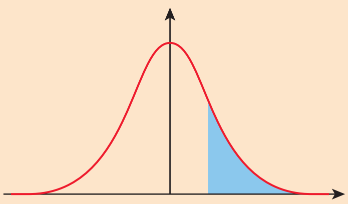
a $P(X < 190)$ Enter Lower Bound as −E99, Upper Bound as 190, μ to 195 and σ to 20. P(X < 190) = 0.401 (to 3 sf)	
b $P(X < 194)$ Enter Lower Bound as 194, Upper Bound as E99, μ as 195 and σ as 20. P(X > 194) = 0.520 (to 3 sf)	
c $P(187 < X < 196)$ Enter Lower Bound as 187, Upper Bound as 196, μ as 195 and σ as 20. P(187 < X < 196) = 0.175 (to 3 sf)	

5.15 Calculating *X*-values from normal probabilities

In some problems you are given probabilities and have to calculate the associated values of X. To do this, use the invNorm function.



When using the Inverse Normal function, make sure you find the probability on the correct side of the normal curve. The areas are always the lower tail, that is they are always in the form $P(X < x)$.



If you are given the upper tail $P(X < x)$, you must first subtract the probability from 1 before you can use invNorm.

Example 58

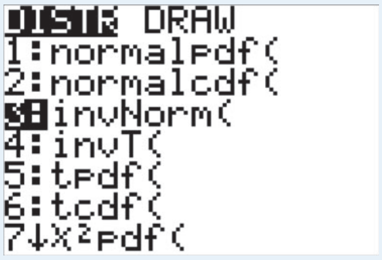
A random variable X is normally distributed with a mean of 75 and a standard deviation of 12 or $X \sim N(75, 12^2)$.
If $P(X < x) = 0.4$, find the value of x.

You are given a lower-tail probability so you can find $P(X < x)$ directly.

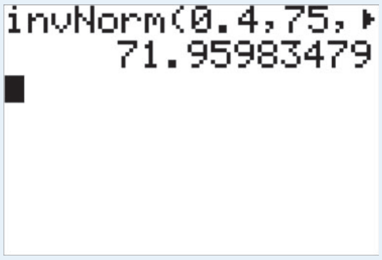
Press 2nd DISTR | 3:invNorm(.

Press ENTER.

You should enter the values: area (probability), μ and σ, in order.



Enter area (probability) as 0.4, μ as 75 and σ as 12.
So if $P(X < x) = 0.4$ then $x = 72.0$ (to 3 sf).



Example 59

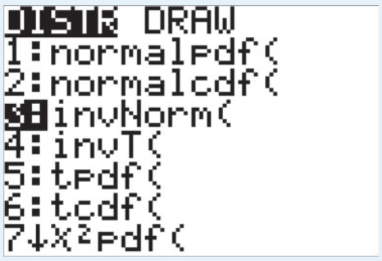
A random variable X is normally distributed with a mean of 75 and a standard deviation of 12 or $X \sim N(75, 12^2)$.
If $P(X > x) = 0.2$, find the value of x.

You are given an upper-tail probability so you must first find $P(X < x) = 1 - 0.2 = 0.8$. You can now use the invNorm function as before.

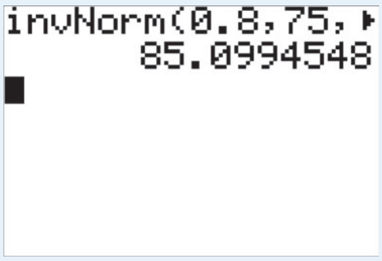
Press 2nd DISTR | 3:invNorm(.

Press ENTER.

You should enter the values: area (probability), μ and σ, in order.



Enter area (probability) as 0.8, μ as 75 and σ as 12.
So if $P(X > x) = 0.2$ then $x = 85.1$ (to 3 sf).



This sketch of a normal distribution curve shows this value and the probabilities from Example 59.