YOUR GUIDE TO BECOMING A TI-NSPIRE GURU.

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About the author.

Renata Galiamov, Senior Lecturer and Product Lead at Connect, is the author of this guide. Ren achieved a raw study score of 47 in Maths Methods when she was in Year 11. She now studies Biomedicine at The University of Melbourne, while simultaneously pursuing her passion for teaching at Connect.

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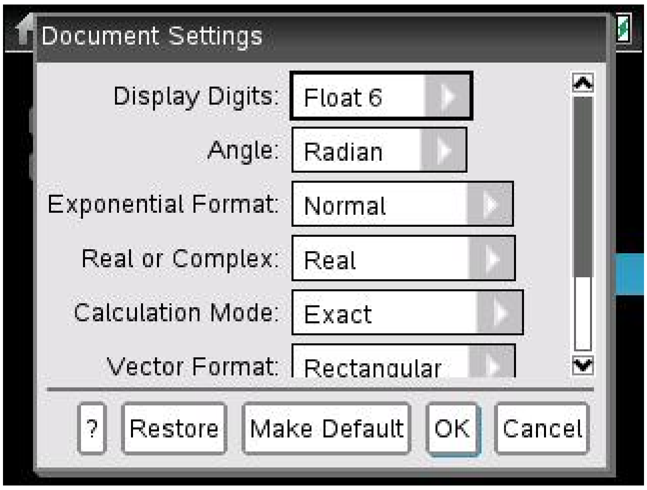
SETTING UP AND NAVIGATING WITHIN THE CALCULATOR

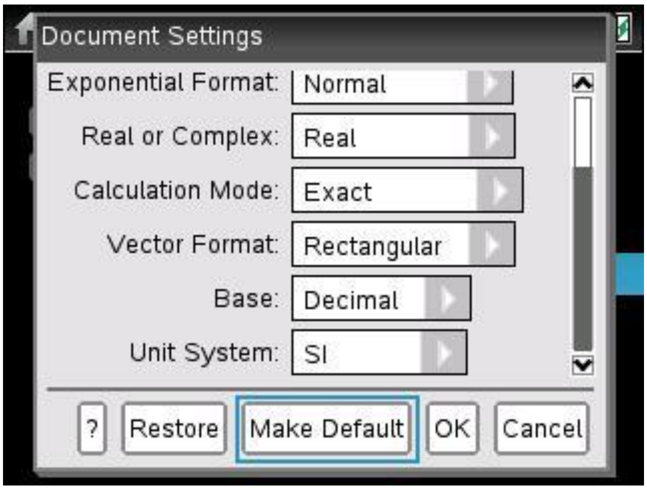
Before we begin exploring the various commands on the calculator, it's important we first ensure your calculator is set up properly and that you know how to navigate around it.

Settings

On the **homepage**, go to 5: Settings and select 2: Document settings.

In this pop-up box, you can adjust how your calculator processes equations and how it presents answers. Below are the settings that I recommend.





The following three settings are particularly important, so I've given them a special mention:

- **Display digits: Float 6**
  'Fix' means the calculator will always give you a certain number of decimal places. For example, 'Fix 5' will give 32.00000, whereas 'Float 5' gives just 32, but will provide up to 5 digits if needed. We recommend 'Float 6' because it's less messy than 'Fix', and provides enough digits to avoid rounding error.

- **Angle: Radian**
  Use Radian mode, or else your trig functions will look very weird.

- **Calculation mode: Exact**
  The calculator will spit out answers in their exact form, unless you press ctrl + enter.

NOTE You can easily go down to the next setting in the list by pressing the 'tab' button or the downward arrow on the touchpad.

Once you've adjusted your settings, press Make default so that the settings you chose are saved for the current document you're working on, as well as any new document you open between now and the end of the year.

Document navigation

Whenever you need to use your calculator, **always work in a document** and not in Scratchpad. The document page has the full suite of commands available, plus has a wider screen display.

On the **homepage**, press 1: New Document to open up a blank calculator or graph sheet. If you've already got one open and want to just continue using the same one, press 4: Current instead.

Inserting additional pages

Let's suppose that you open a new document and you select to add a calculator page. What if you now need to graph something? Do you have to open a new document? Thankfully, you don't! All you have to do is press:

- ctrl + I or
- ctrl + doc (page)

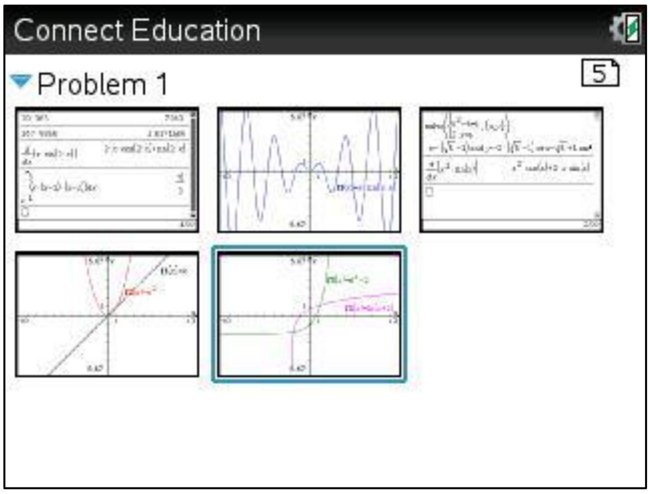
to insert a new page into the current document you're working on.

Navigating and organising pages

In SACs and the exam, you'll need to quickly switch between the calculator screen and graphs screen to both calculate and visualise. You can do this by pressing:

- ctrl + right arrow to move forwards through your pages
- ctrl + left arrow to move backwards through your pages

Opened up too many pages and need to remove some? No worries – the Page Sorter helps you see all your pages and allows you to remove the ones you don't need by pressing del.



The Page Sorter can also be used to navigate between pages. Just use the left/right arrows to choose the page you want, then press the enter button.

You can access Page Sorter by using ctrl + up arrow.

GENERAL CALCULATIONS

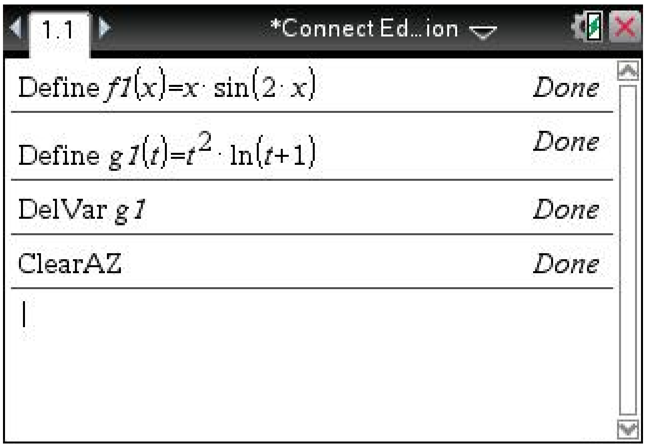
This section goes through a bunch of useful commands on the calculator that are applicable to many types of questions involving different kinds of functions.

Defining functions

Arguably one of the most time-saving commands on the calculator is Define. This lets you 'save' a function so that you don't have to repeatedly type it into the calculator or copy/paste equations and waste time modifying them using the arrows.

To define a function, go to menu, **1: Actions**, **1: Define**. In the entry line, choose a letter that you'd like to represent the function, followed by (x) or (t) or whatever variable your function has. Then, just type in the equation of the function!

TIP Your SACs and the exam will most likely have several functions called f because it is the letter conventionally used to denote functions. The problem is that you can't save all these equations to the same letter – each new equation you define as f will replace the previous equation. To get around this problem, you can include a number after the letter. For example, if there is a function f in Question 1, call it $f1$. If there's another in Question 3, call it $f3$. That way, you can keep all equations on the calculator at the same time, allowing you to go back and re-use them if need be.



Recalling defined functions

Forgotten what you had defined a letter as? Go to menu, **1: Actions**, **2: Recall Definition**. It'll give you a list of functions you've already defined – all you have to do is click on the letter you're interested in and it'll tell you what equation the letter represents.

Clearing definitions

If you've finished an exercise or SAC and you don't need the defined functions anymore, there are a few ways of clearing them from your calculator. Firstly, you can just open a new document from the homepage – this will delete everything you've defined. Similarly, by heading to menu, **1: Actions**, **4: Clear a-z**, you can also delete all the letters you've defined.

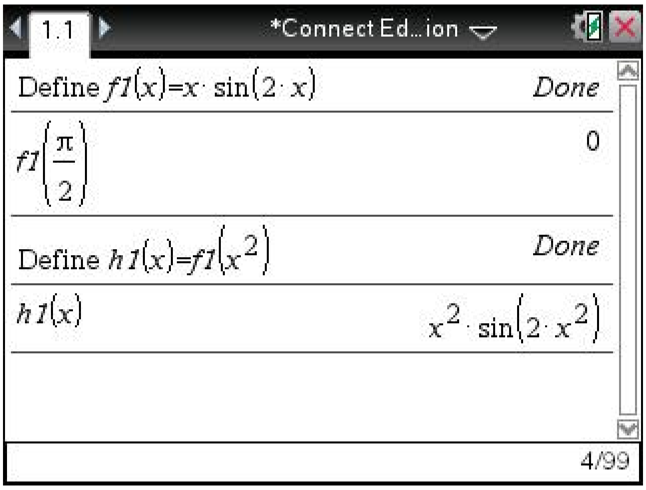
However, if you don't want to delete all definitions, you can also select which ones to delete by going to menu, **1: Actions**, **3: Delete Variable** instead.

Substituting values into equations

In Exam 2, there's no point wasting time trying to sub numbers into equations by hand and running the risk of getting your arithmetic incorrect. Instead, there are two ways you can efficiently sub values into equations on the calculator.

Subbing values into defined functions

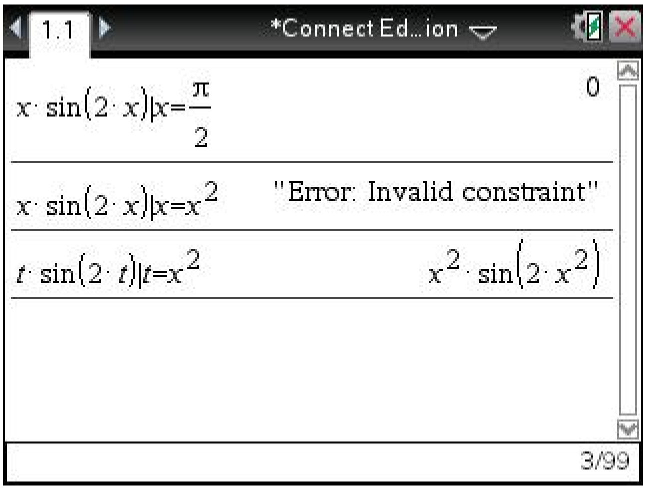
The beauty about defining a function is that you can just use function notation to sub values into it. That is, instead of writing x inside the brackets, replace it with the value you'd like to sub in, as seen in the example on the right.



This can also be applied to composite functions – rather than replacing the x with a number, you can replace it with a whole equation (such as x^2), as seen in the example on the right.

Subbing values into equations 'on the fly'

If you're dealing with a question where you won't need to re-use the same equation, then defining the equation isn't all that necessary. Instead, you can sub values in by typing out the equation, then using the 'given' symbol. You can access this symbol by pressing ctrl + =, then using the arrow keys to select |. After this 'given' symbol, type $x =$ followed by the value you'd like to sub in.



When it comes to finding the equation of a composite function, you have to change the variable in the first function, otherwise the calculator gets confused (as you can see in the example above!).

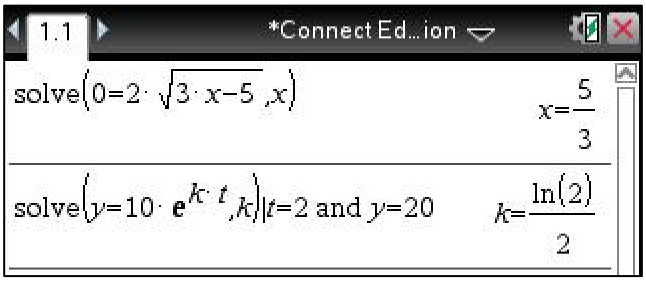
Algebraic commands

The following commands are all found under the Algebra section of the menu. They're useful when it comes to finding solutions or manipulating equations.

Solving equations

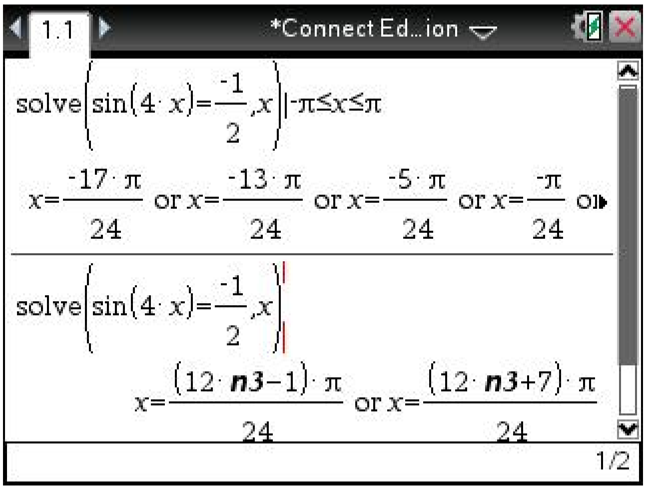
Going to menu, **3: Algebra**, **1: Solve** lets you type in an equation you'd like to solve. Simply type in the equation, followed by a comma and the variable you're trying to solve for (which is x in most cases). (See the first entry line below.)

NOTE If the equation has letters representing constants (e.g. the k in $y = 10e^{kt}$) then you must include a multiplication sign between the letter and the variable or else the calculator will treat them as one variable.



If you need to **sub a coordinate** into an equation and then **solve** for a constant, you can do this cool thing where you:

- Type in the equation, followed by a comma and the letter of the constant you're trying to solve for (k in the example on the right).
- Insert a 'given' sign by pressing ctrl + =, and selecting |.
- Then type what the x and y value equal (in this case, t and y).

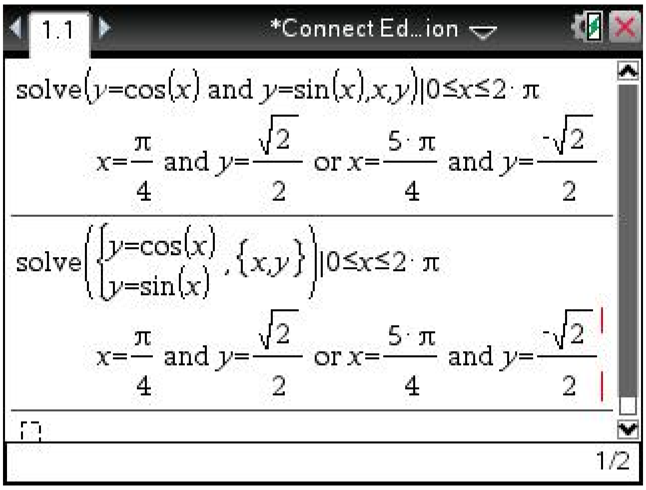


The 'given' symbol can also be used to restrict the domain of an equation – this is especially useful for finding specific solutions to trigonometric equations. In the example on the left, we restricted the domain to $[-\pi, \pi]$, which means the calculator only gives us solutions within this interval. You can insert the 'less than' or 'bigger than' arrows using ctrl + = by the way!

If you don't restrict the domain for a trigonometric equation, the calculator will give you a general solution. You'll see an n in the answer followed by a number (in this case $n3$) – the number will increase the more you solve trigonometric equations, but in all cases it just represents an integer. Remember, for general solutions to trigonometric equations, we always say $n \in \mathbb{Z}$, where $\mathbb{Z}$ represents integers.

Solving simultaneous equations

When you have two or more equations that you need to solve simultaneously, you *can* still use the menu, 3: Algebra, 1: Solve command to find solutions. As you can see in the example below, all you have to do is write each equation within the brackets, separating each equation with a space and the word ‘and’. At the end, list the variables you’re solving for, placing commas between them. If there is a domain restriction, include it after the bracket (don’t forget the ‘given’ sign).



However, the command I prefer using for simultaneous equations is actually menu, 3: Algebra, 7: Solve System of Equations, 1. This gives you a pop-up box where you can enter the number of equations you have (in this case, 2) and the variables you’re using (in this case, x and y). The calculator will then give you boxes where you can enter your equations. Once again, if there’s a domain restriction, just type it after the bracket (remembering the ‘given’ sign). This method is simpler in my opinion and involves less typing – still, try both out for yourself and decide which you prefer.

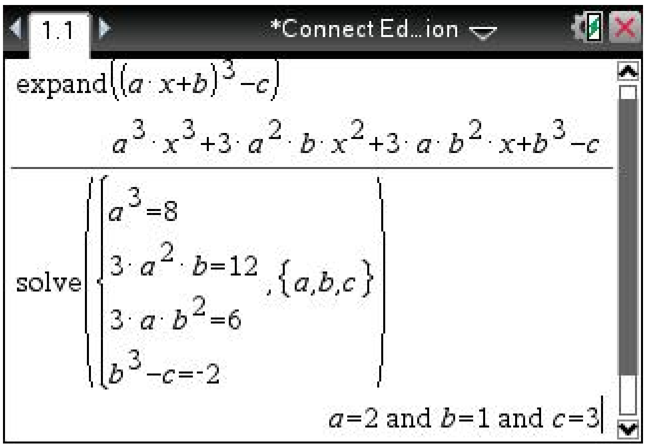
Expanding

The expand command is found under menu, 3: Algebra, 3: Expand, and as the name suggests, it allows you to expand a factorised function. This is handy in many situations – we’ll discuss two of these through examples below.

Equating coefficients

Consider the function, $f(x) = 8x^3 + 12x^2 + 6x - 2$. If $f(x)$ can be expressed in the form of $f(x) = (ax + b)^3 - c$, find the values of $a, b,$ and c where $a, b,$ and c are real, positive constants.

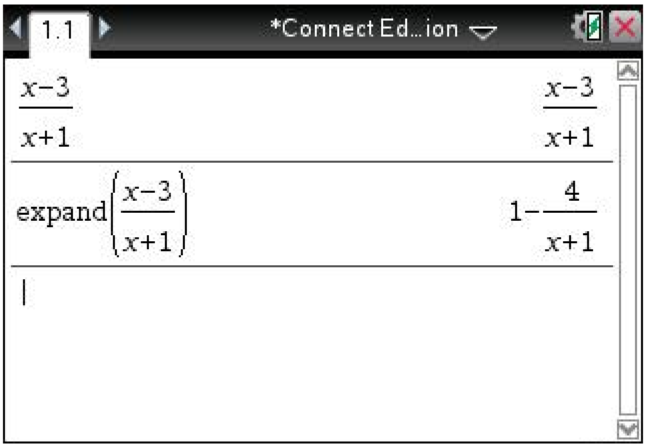
To find the value of these letters, we just have to expand the equation, then make the coefficients equal to the corresponding coefficients in the other equation.



Simplifying fractions

Consider the function $g(x) = \frac{x-3}{x+1}$. Express $g(x)$ in the form $g(x) = a - \frac{b}{x+1}$ and, hence, state the equation(s) of any asymptote(s).

When you get funny looking equations like the one above, where there's an expression containing x on the top and bottom of the fraction, what you want to do is divide the numerator by the denominator to simplify it. The problem is that when you just enter $x - 3$ divided by $x + 1$ on the calculator, it doesn't actually do the division… instead, you should use Expand to get the required form. As you can above, $g(x) = 1 - \frac{4}{x+1}$, which means the asymptotes are $y = 1$ and $x = -1$.



Factorising

The Factor command is not used all that much, but it does come in handy when you need to express an equation in a different form to meet what the question requires.

For example, the following question was asked in the **2002 VCAA paper**:

The equation of the normal to the curve with equation $y = x\sin(x)$ at the point on the curve with x coordinate π, is:

A. $y = -(x - \pi)\pi$

B. $y = (x - \pi)\pi$

C. $y = -\frac{1}{\pi}(x - \pi)$

D. $y = \frac{1}{\pi}(x - \pi)$

E. $y = \frac{-1}{x\sin(x)}$

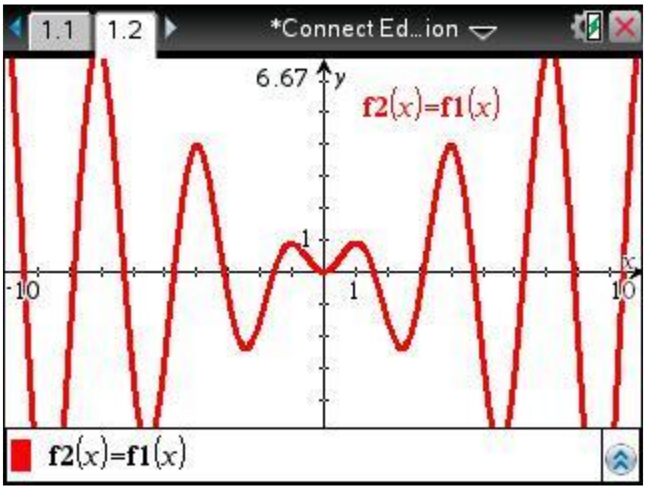
The problem here is that when you obtain the equation of the normal using the calculator (this is explained in the Differentiation section), the answer you get is $y = \frac{x}{\pi} - 1$, which isn't in the multiple choice options.

When this happens, try the Factor command – in this case, we get option D.

SKETCHING GRAPHS

Visualisation is key to understanding what's going on in a question and for checking your answers, so being able to efficiently sketch a graph is very powerful.

Entering equations



When you first open a Graph page, the Graph Entry bar appears automatically at the bottom of the screen. Here you can enter an equation, making sure you use the variable x.

Note that you can also enter defined equations here. Even if you initially defined an equation in terms of t or some other variable, you can still graph it by writing x now inside the bracket, as you can see in the example above.

Adding another equation

When you add one equation, the Graph Entry bar disappears. To get it back again, press the tab key.

Modifying equations

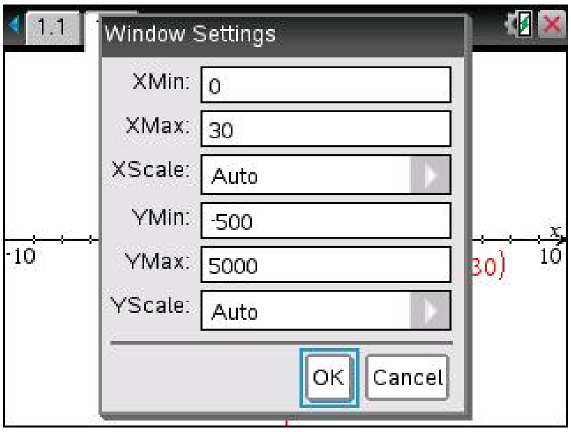
After you've entered an equation, if you need to change it you can do so by pressing the tab key as before, but this time using the cursor on the mousepad to select the equation you want to edit.

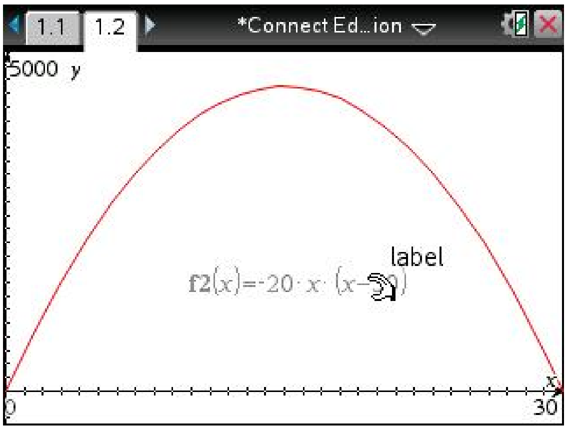
Window settings

Often, when you enter an equation, you can't 'see' it properly because the window zoom isn't suitable. You can fix this using:

- menu, 4: Window/Zoom, 3: Zoom – in or 4: Zoom – out. This just zooms in/out from the centre of the graph. You can use the mousepad to 'drag' the screen around and look at a different part of the graph.

- menu, 4: Window/Zoom, 1: Window Settings. This is the method I prefer because it gives you more control over exactly what you see. For example, if there's a domain restriction, you can specify that.





In the example above, since the equation is $y = -20x(x - 30)$, we know that the x-intercepts are going to be 0 and 30, so we can set the XMin to 0 and XMax to 30. With the YMin, I've set it to -500 so I can still see the x-axis. With the YMax, you sometimes have to play around until you find a number that gives you a good view of the graph. In this case, 5000 did the trick.

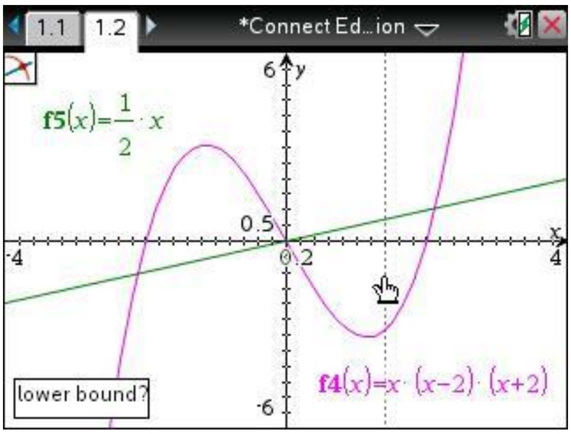
NOTE If the label of the equation is getting in the way of your graph, you can move it to a different location by moving your cursor over the label until you get the 'hand' symbol, then dragging it out of the way.

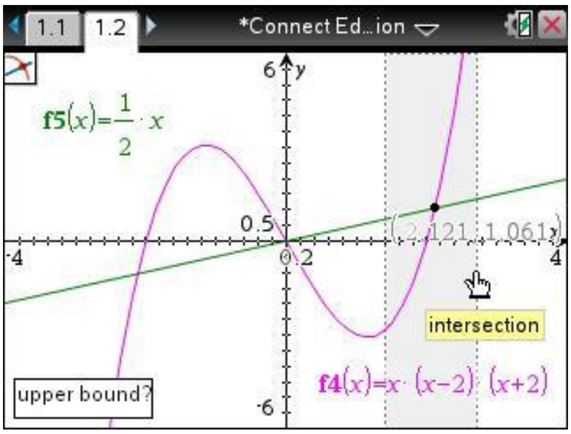
Analysing graphs

While you can find most features on graphs using a Calculator page, it is sometimes helpful to use the Graph page instead as it is easier to visualise what's going on.

Maximum/minimum/intersection of two graphs

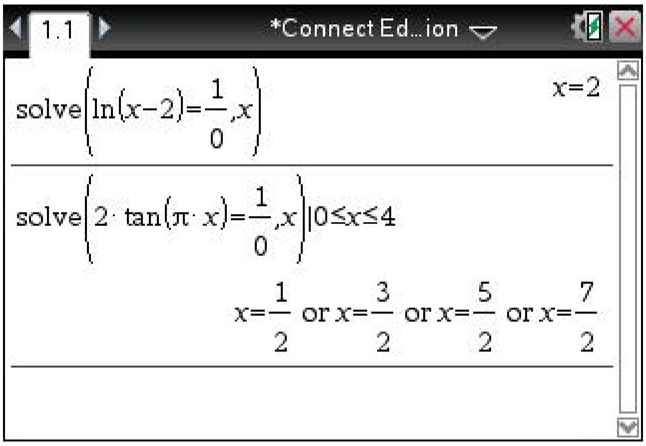
These features can be found by going to menu, 6: Analyze Graph. In each of these cases, the calculator will prompt you to select a 'lower bound' first, then an 'upper bound'. All you have to do is click somewhere to the left of the maximum/minimum/point of intersection, then somewhere to the right of it.





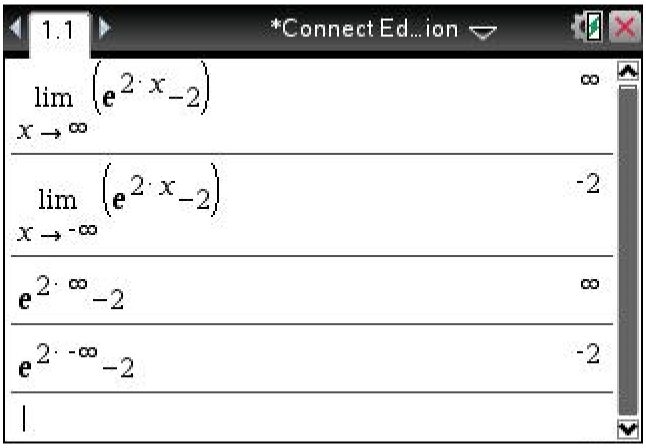
In simple situations, you can look at the Graph screen and ‘see’ what the equations of the asymptotes are. However, when you’re dealing with more complicated equations or trigonometric functions, it’s difficult to read the scale on the x- and y-axes correctly. This is where the Calculator page can help.

Vertical asymptote



Remember, these occur when an x-value is not allowed to exist. This crops up when you have a function where you’re dividing by something containing x, such as in hyperbolas, truncus graphs, and tan graphs (because tan is sin divided by cos). Because it is impossible to divide something by zero, these graphs have vertical asymptotes where the denominator equals zero. We can exploit this fact to find the equation(s) of the vertical asymptote(s). Simply go to $\boxed{\text{menu}}$, **3: Algebra**, **1: Solve**, and type in your equation, following by =1/0. It will return the equation(s) of the vertical asymptote(s).

Horizontal asymptote



In contrast, the horizontal asymptote represents a y-value that cannot exist. The graph will *approach* this y-value, but never reach it. Again, we can exploit this fact to find the equation(s) of the horizontal asymptote(s).

You can either go to $\boxed{\text{menu}}$, **4: Calculus**, **4: Limit**, and input $x \to \infty$ and $x \to -\infty$, or you can directly sub $\pm\infty$ into your equation. In the example, you can see that the horizontal asymptote of the exponential graph is $y = -2$.

NOTE Often the horizontal and vertical asymptotes can be quickly found just by looking at the equation of the function. That’s why I recommend trying this first, and using the above calculator commands if you get stuck or if you have time to go back and check your answers.

Graphing composite functions

SACs and the exams commonly ask for the domains and ranges of composite functions. Visualising the graphs is the best way to avoid silly errors.

Let's explore this through an example:

Let $g: [0, \infty) \to R,\ g(x) = \sqrt{x+4}$

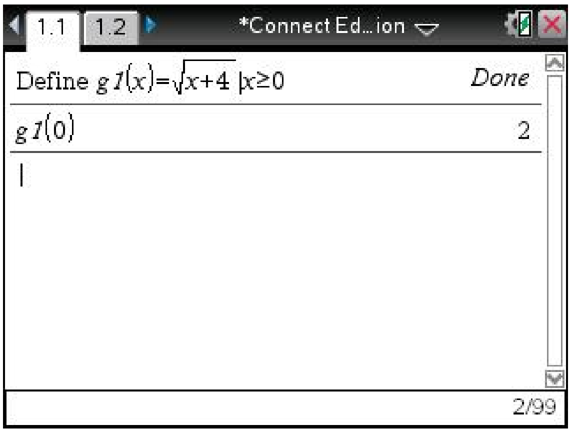
a) State the range of g.

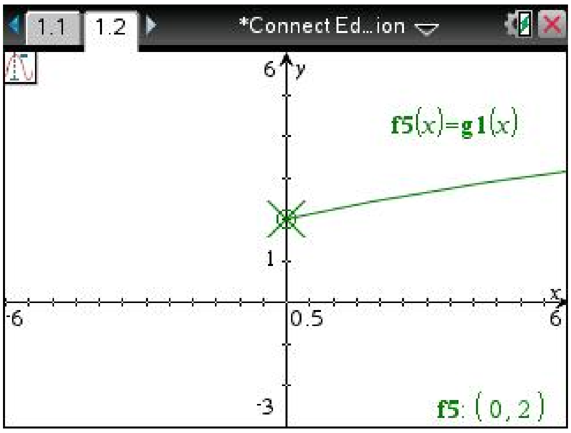
b) Let $f: (-\infty, p] \to R,\ f(x) = x^2 + x - 6$, where $p < 0$.

i. Find the largest possible value of p such that $g \circ f$ exists.
ii. State the domain of $g \circ f$.
iii. State the range of $g \circ f$.

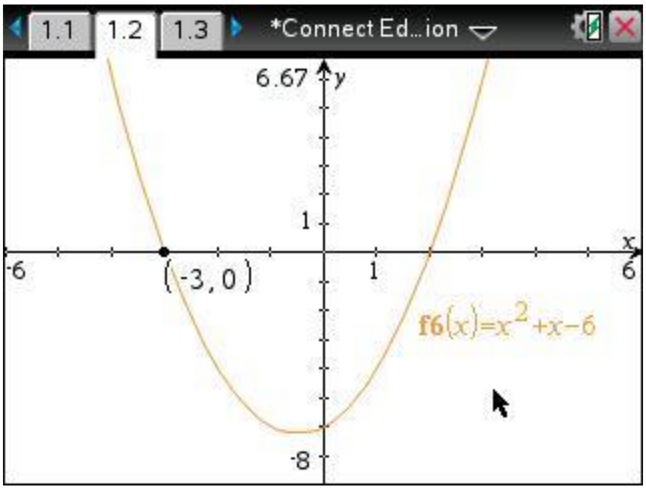
Firstly, since we have an equation we'll be using repeatedly, we should define it straight away and include the domain restriction.

When finding the range of g, students often only think about the shape of a root graph, but forget to consider the domain restriction. That's where graphing the function really helps! (Alternatively, you can sub in $x = 0$ to see at what y-value the root graph starts.) Hence, $\boldsymbol{ran\ g = [2, \infty)}$.





In Part (b), we have a parabola with a domain that starts from the left and stops at an x-value called p.

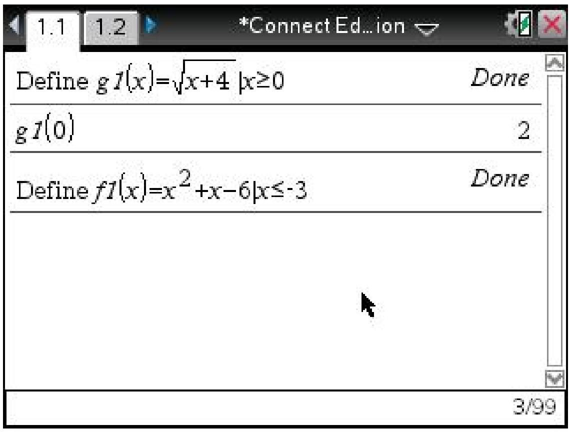


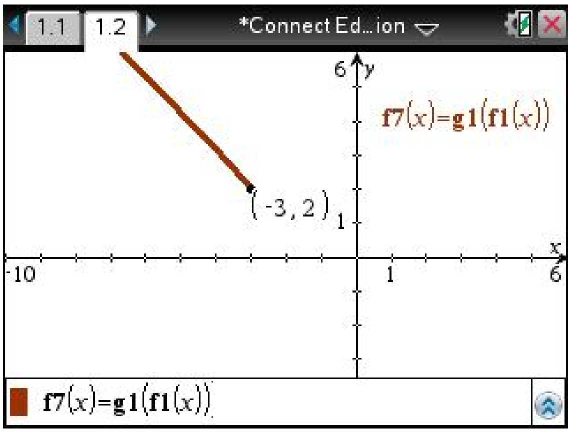
For $g(f(x))$ to exist, recall that the range of the 'inside' function (in this case, $f(x)$) has to fit inside the domain of the 'outside' function (which is $g(x)$). Since the domain of $g(x)$ is $[0, \infty)$, this means we need to restrict the domain of f so that it's range is $[0, \infty)$. Again, visualisation is key here!

As you can see from the graph above, the range of f will be $[0, \infty)$ if the domain is either $x \in (-\infty, -3]$ or $x \in [2, \infty)$. In this question, since the domain of f has already been defined as $(-\infty, p]$, this means $\boldsymbol{p}$ **is -3**.

To answer Part (b)ii, you just recall the rule that the domain of a composite function is the same as the domain of the 'inside' function. So, $dom\ g \circ f = (-\infty, -3]$.

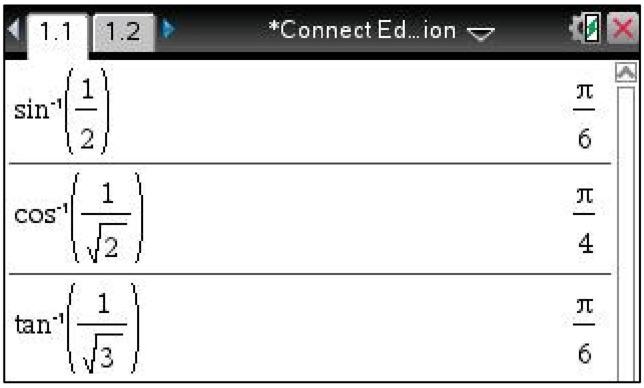
Part (b)iii is a little trickier though because the range depends on the equation of the composite function, as well as the domain restriction. The easiest way to answer it is… you guessed it, visualisation! Define $f(x)$ (including its domain restriction) in the Calculator page, then open a Graph page and enter $g1(f1(x))$. From the scale on the axes, you can see that the range of the composite function begins at 2 and continues upwards (if you're unsure, you can always use menu, **5: Trace**, **1: Graph Trace** to locate the endpoint of the graph. Hence, $ran\ g \circ f = [2, \infty)$.





TRIGONOMETRY

Past VCAA questions have often involved trigonometric functions and triangles, so it's a good idea to be able to confidently calculate various angles on the calculator.



Calculating angles

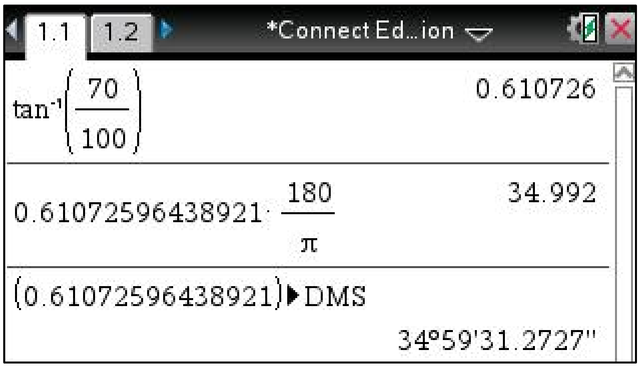
When you're trying to find the value of one angle in a triangle, the easiest way to do so is with the inverse sin, cos, and tan functions. The 'inverse' here means that we can use these functions to calculate an angle. (Normal sin, cos, and tan functions instead use angles to calculate the ratio of the opposite/hypotenuse or adjacent/hypotenuse or opposite/adjacent.) You can access the inverse functions by pressing the trig button and selecting the appropriate trigonometric function that has a -1 in it. Some examples using exact values are shown above, but below we will consider a more difficult question from VCAA.

Radians to degrees conversion

In the Settings section above, we said you should set your calculator to radians. This still holds here, but what if the question asks for the answer in degrees?

Rather than going back to the Settings menu and changing the Angle Mode to degrees, it's a lot easier to just perform the conversion on an ordinary Calculator page. There are two ways to do this, depending on what the question is after.

- If the question wants the angle in **degrees correct to a certain number of decimal places**, it's easiest to just multiply whatever radians you have by $\frac{180}{\pi}$. This is easy to remember because radians usually have the π on top, so to 'undo' this you need to multiply by $\frac{180}{\pi}$, where the π is on the bottom of the fraction.



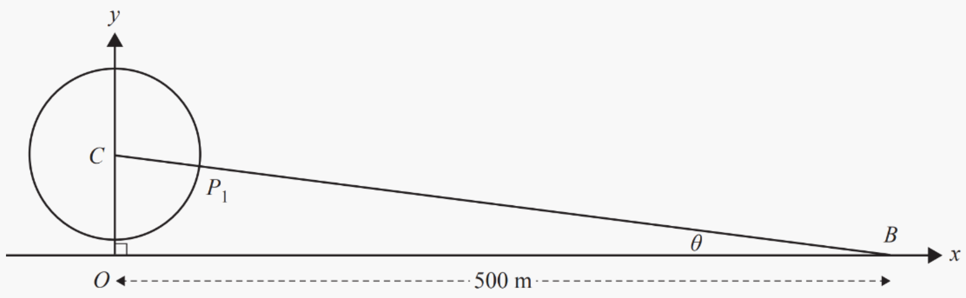
- If the question wants the **angle in degrees, minutes, and seconds**, you can first calculate the answer in radians, then press the 'book' symbol. Type D using the keyboard to get to the section of commands beginning with letter D. Scroll down using the mousepad until you reach >DMS. Press enter to select the command, then ctrl + enter to get the answer.

Let's apply all of the above to the following **2017 VCAA** question. (Note: I've picked out only the parts of this question that are relevant.)

Sammy enters a capsule on the Ferris wheel from a platform above the ground. The Ferris wheel is rotating anticlockwise. The capsule is attached to the Ferris wheel at a point P. The height of P above the ground, h metres, is modelled by $h(t) = 65 - 55\cos\left(\frac{\pi t}{15}\right)$, where t is the time in minutes after Sammy enters the capsule. Sammy exits the capsule after one complete rotation of the Ferris wheel.

b) For how much time is Sammy in the capsule?

As the Ferris wheel rotates, a stationary boat at B, on a nearby river, first becomes visible at point P_1. B is 500 m horizontally from the vertical axis through the centre C of the Ferris wheel.

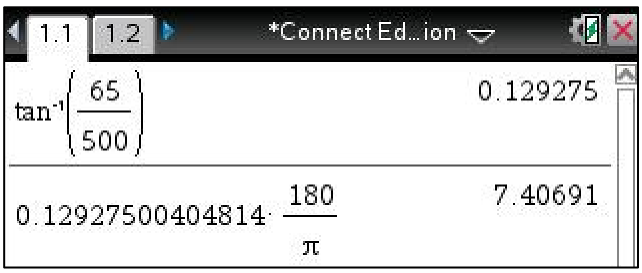


d) Find θ in degrees, correct to two decimal places.

For Part (b), students often get confused due to the wording of the question. It's basically asking how long it takes for Sammy to go around the Ferris wheel once. Since we're given a trigonometric equation, $h(t)$, which tells us the height of the capsule over *time*, we can use this equation to determine how long it takes for the capsule to go around and get back to where it started. In other words, we're after the period of the function. $Time\ (period) = \frac{2\pi}{n} = \frac{2\pi}{\frac{\pi}{15}} = 30\ minutes$

In Part (d), we're given a pretty confusing diagram and asked to find the value of θ. What you should take note of is that the θ is part of a triangle. Whenever you're asked to find the value of an angle in a triangle, you should always consider whether you can use the inverse sin, cos, or tan functions. Here, we know the adjacent side is 500 m, and we can figure out the opposite side – it's just the height of the centre of the Ferris wheel, 65 m, which we can get from $h(t)$. So, the angle in radians is given by $\tan^{-1}\left(\frac{65}{500}\right)$.

We can convert this to degrees by multiplying by $\frac{180}{\pi}$. Hence, the answer is 7.41° (two decimal places).



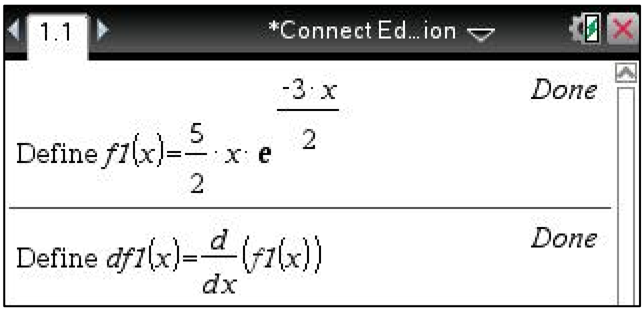
DIFFERENTIATION

Questions requiring differentiation appear multiple times in the calculator exam, so by mastering the following tips and commands, you can buy yourself a lot of precious time in the exam.

Defining derivative equations

Hopefully by now, having read through the previous pages, you can see how useful it is to define functions – the derivative function is no different.

Here's a piece of advice: instead of choosing another letter or number to define the derivative by, just chuck a d in front of whatever function you're differentiating. That way, you're not going to get confused about what derivative belongs to which function.



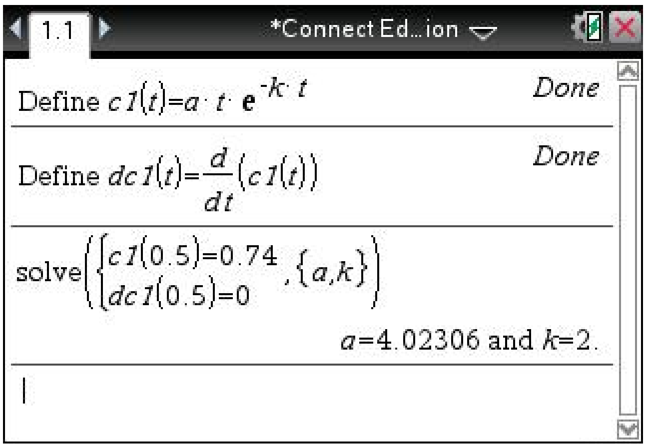
For example, in the screen on the right, we defined $df1(x)$ as being the derivate of $f1$ using menu, **1: Actions**, **1: Define** and menu, **4: Calculus**, **1: Derivative**. Now we can simply use $df1(x)$ in whatever calculations or substitutions we need.

Example (adapted from VCAA 2014, Exam 2)

The concentration, c, of medicine in a person's blood (in milligrams per litre) at time t hours after administration is given by $c(t) = Ate^{-kt}, t \geq 0$, where A and $k \in \mathbb{R}^{+}$.

If the maximum concentration of medicine in the blood was 0.74 mg/L at 0.5 hours after administration, find the value of A and k, correct to the nearest integer.

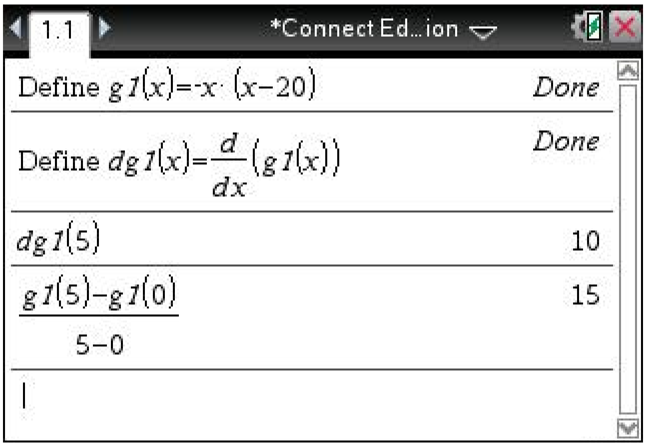
Firstly, as always, define the equation. Now, whenever you have two unknowns in a question (A and k), you should straight away think about setting up two simultaneous equations. We're told that (0.5, 0.74) is a coordinate on the graph, so that gives us one equation. To get the other equation, we can use the fact that this point is a maximum. This means the derivative equals zero when t is 0.5. Therefore, we can define the derivative equation, and using the point (0.5, 0) to get our other equation. Finally, we just solve them simultaneously!



Instantaneous vs average rate

This trips students up every year. The **instantaneous rate** is the rate at *one point* on a curve, so it's found by subbing the x-value into the **derivative**. The **average** rate of change, on the other hand, is just the **rise over run** between *two points* on a curve.

For example, say we were looking at a curve with the equation $g(x) = -x(x - 20)$. If we wanted to know the **instantaneous rate** at $x = 5$, we would just sub 5 into the derivative of g, which we've defined as being $dg1(x)$.



In contrast, if we wanted to find the **average** rate of change of g over the interval $x \in [0, 5]$, then we need to calculate rise over run instead, which is given by the formula $\frac{y_2-y_1}{x_2-x_1}$. Since we've defined g, we can easily get y_2 and y_1 by using $g1(5)$ and $g1(0)$.

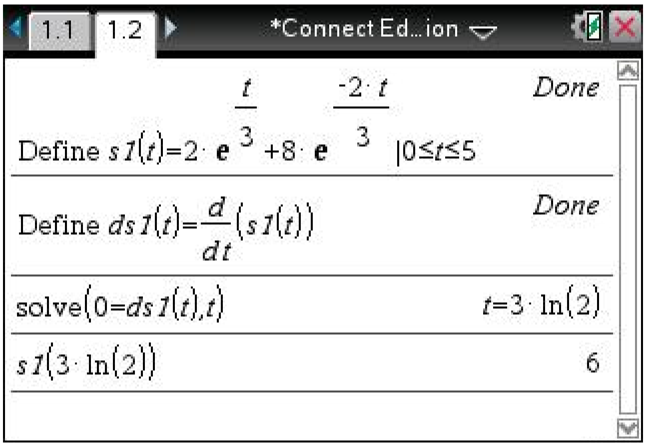
Maxima and minima

Finding the x-value of where the maximum or minimum of a graph occurs can be done two ways, depending on what the question's after.

Making the derivative equation equal zero

This is the traditional way of finding a graph's local maximum or minimum turning point, or stationary point of inflection. Since the gradient of the graph is zero at these points, we just make the derivative equation equal zero and solve for x.

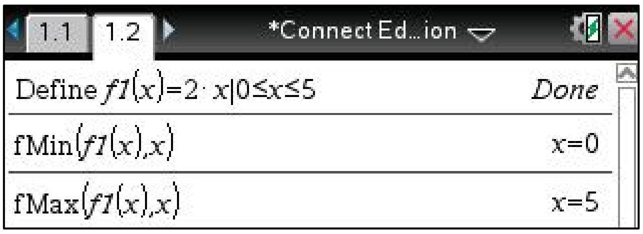
NOTE When you solve $\frac{d}{dx} = 0$, you get the x-value of the turning point or stationary point. To find the y-value, you need to sub the x-value back into the **original** equation – <u>not</u> the derivative! Students often make this mistake, so pay close attention to what equations you're using on your calculator.



Using fMin and fMax

An alternative to the above method is to use the in-built command for finding a function's minimum and maximum. All you do is go to $\boxed{\text{menu}}$, **4: Calculus**, **7: Function Minimum** or **8: Function Maximum**, then type in your equation, followed by a comma and the variable (e.g. x).

Try it on the equation we defined as $s1(t)$ *above!*



However, you need to practice some caution with this command. You see, it finds the minimum or maximum of the function in general, but not necessarily the minimum and maximum *turning point*. For example, if we consider the equation $f: [0,5] \to R, f(x) = 2x$, we know that because it's a straight line, it doesn't have a maximum or minimum turning point. However, when we use the fMin or fMax command on it, it does give us x-values because it's just telling us where the lowest and highest points on the graph occur.

… So when are fMin and fMax useful?

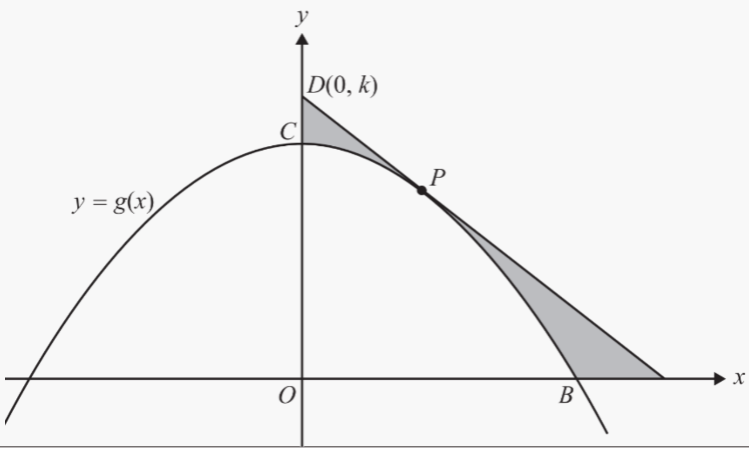
VCAA will sometimes ask questions where they get you to find the maximum and minimum of an equation, but the equation only has one turning point. This often stumps students because they forget that 'maximum' and 'minimum' don't necessarily have to be turning points, but could just be the endpoints. Let's look at an example:

Example (adapted from VCAA 2013, Exam 2)

The tangent to the graph of $g(x) = \frac{16-x^2}{4}$ at a point P intersects the y-axis at the point $D(0, k)$, where $5 \le k \le 8$. The area of the shaded region, in terms of k, is given by $A(k) = \frac{k^2}{2\sqrt{k-4}} - \frac{32}{3}$.

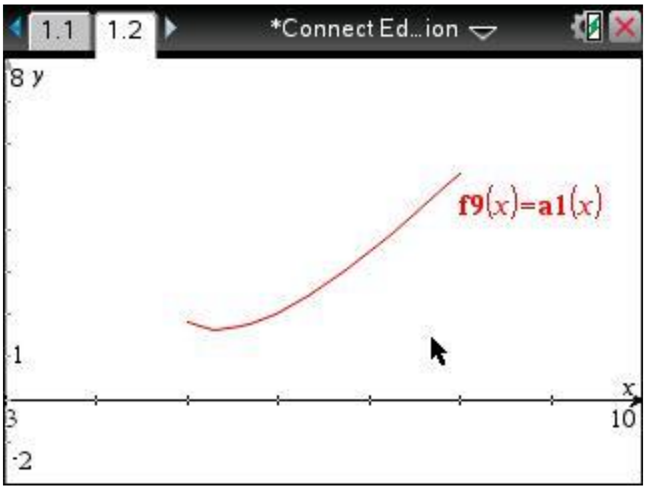
a) Find the **maximum** area of the shaded region and the value of k for which this occurs.

b) Find the **minimum** area of the shaded region and the value of k for which this occurs.

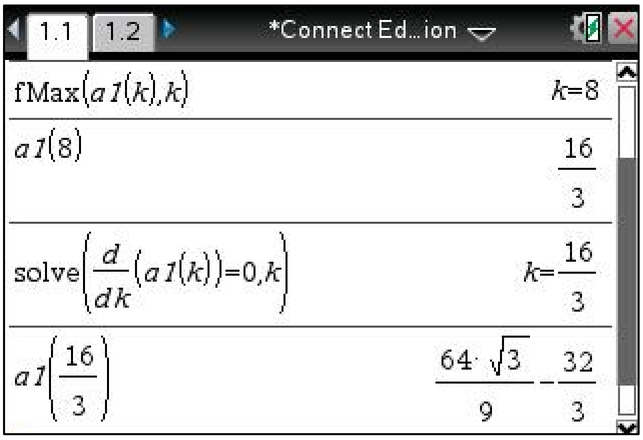


Since we're working with the area equation, let's define it on our calculator first. Take note of the domain restriction on k!

To understand what's going on, it's a good idea to first graph $A(k)$ to see whether the max/min is an endpoint or turning point. As you can see from the graph on the right, the maximum is an endpoint, while the minimum is a turning point – this will influence what method we use to calculate their coordinates:



- For the maximum (endpoint), use fMax because it will tell you the maximum regardless of whether it's a legitimate turning point or not.
- For the minimum (turning point), make the derivative of $A(k)$ equal zero.



In each case, sub the k value you get back into the original equation, $A(k)$, to get the y-coordinate of the point (which represents the area).

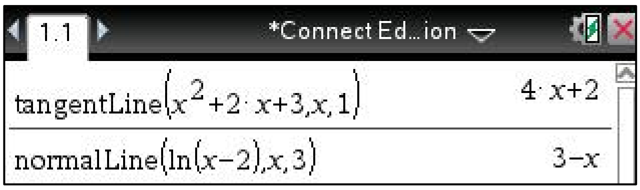
$\therefore Max: \left(8, \frac{16}{3}\right)$

$\therefore Min: \left(\frac{16}{3}, \frac{64\sqrt{3}}{9} - \frac{32}{3}\right)$

Tangent and normal equations

As you're probably aware, finding the equation of a tangent or normal can be quite a long process. Luckily, the calculator can do it for us in a flash!

If you go to menu, **4: Calculus**, **9: Tangent Line** or **A: Normal Line**, all you have to do is type in the equation of the curve, then a comma and your variable (x), followed by another comma and the x-value where you're trying to find the tangent or normal line. In the example below, we've found the equation of the tangent to the curve $y = x^2 + 2x + 3$ at $x = 1$, and the equation of the normal to the curve $y = \log_e(x - 2)$ at $x = 3$.



ANTIDIFFERENTIATION

In this section, we'll go through how to find the antiderivative equation, as well as the difference between setting up an integral for signed area and absolute area.

Finding the equation of the antiderivative

A typical exam question relating to antidifferentiation is when they give you the equation of a derivative, then ask you to find the equation of the antiderivative, given it goes through some point. You can tackle this two ways, which we'll look at through this example:

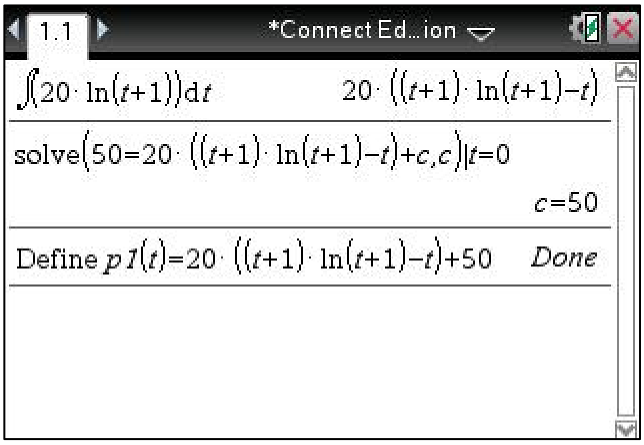
To save the quokkas from extinction, fifty of them are introduced to a remote island off the shore of WA at the start of 2000. The population increases steadily with a rate given by the function $R: [0, \infty) \to R,\ R(t) = 20\log_e(t+1)$, where R is the number of quokkas per t years after 1 Jan 2000.

Find an equation for quokka population, P, at time t years after 1 Jan 2000.

When approaching application questions, first always think carefully about the information you're provided and how it relates together. Here, we're given the **rate** of population growth of quokkas – that means $R(t)$ is a **derivative** function. Since we're trying to find the equation for the quokka population, we'll need to antidifferentiate $R(t)$.

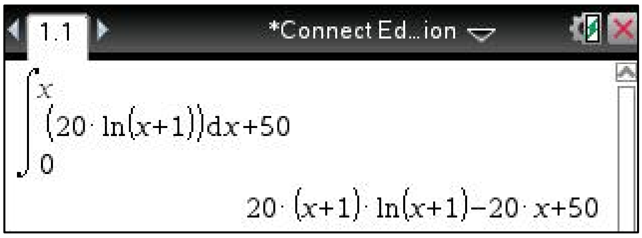
Method 1

Using $\boxed{\text{menu}}$, **4: Calculus**, **3: Integral**, we can antidifferentiate $R(t)$. Since the calculator doesn't show it, remember that you need to include a $+c$ at the end of the antiderivative. Now we can sub in a point to figure out what this $+c$ is. We know that initially there are fifty quokkas, so our point is (0, 50). As you can see from the screen-shot below, $c = 50$, so $P(t) = 20(t+1)\log_e(t+1) - 20t + 50$.



Method 2

By setting up the integral a bit differently, you can actually get the value of c in your answer straightaway. The format of the integral is as follows: $\int_{x_1}^{x} f(x)\,dx + y_1$. This tells the calculator to antidifferentiate $f(x)$ in terms of x as per usual, but then it subs in x and the point (x_1, y_1). The answer you'll get is an equation in terms of x, with the c value already figured out at the end.



If you're using this method, it's super important to put things in the right places. The x_1 is always the bottom terminal, while y_1 goes outside the integral.

For those who are curious to find out the mechanics behind this method, I've outlined where it comes from below:

Imagine we have a derivative represented by $f(x)$. The antiderivative, $F(x)$, would be given by:

$$F(x) = \int f(x)\,dx + c$$

To find the value of c, we would sub in a point (x_1, y_1) and solve for c.

$$\therefore F(x_1) = \int f(x_1)\,dx + c$$

$$y_1 = \int f(x_1)\,dx + c, \qquad as\ F(x_1) = y_1$$

$$c = -\int f(x_1)\,dx + y_1$$

We can then sub this c value back into $F(x)$ and modify the integrals:

$$F(x) = \int f(x)\,dx - \int f(x_1)\,dx + y_1$$

$$F(x) = [F(x)]_{x_1}^{x} + y_1$$

$$F(x) = \int_{x_1}^{x} f(x)\,dx + y_1$$

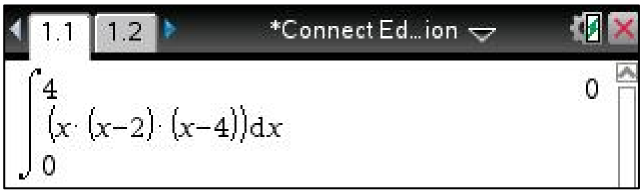
Using integrals to calculate area

There are two types of areas you can be asked to calculate – signed and absolute – and the method for doing each is different.

The **signed area** involves taking the area bounded by a graph and the x-axis, *regardless of whether that area is negative or positive*. On the other hand, when finding the **absolute area**, you do have to be aware of any ‘negative’ area and make it positive.

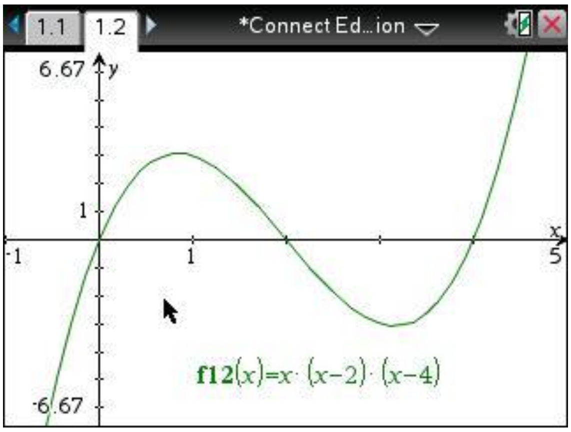
For example, let’s say we had the graph of $y = x(x-2)(x-4)$ and we were interested in the area bounded by the graph between $x = 0$ and $x = 4$.

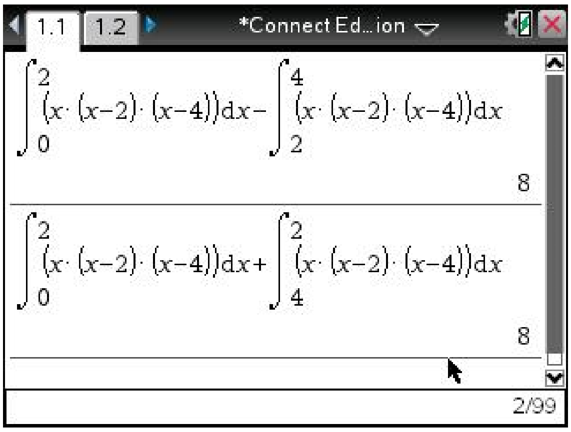
If we were calculating the **signed area**, we wouldn’t bother checking whether the area was above or below the x-axis – we would just integrate between $x = 0$ and $x = 4$.



However, if we were after the **absolute area**, we’d need to graph the equation first and calculate area above the x-axis and area below the x-axis separately. As you can see from the graph below, the area between $x \in [2,4]$ is negative. We can make it positive by either:

- Multiplying the integral by -1 (as multiplying two negatives creates a positive)
- Swapping the terminals





The moral to take away from the above is that the signed area does not represent the true area bounded by the graph and the x-axis – what happens is that the negative area actually subtracts from the positive area, resulting in a lower value than expected. In contrast, the absolute area gives you the actual area (as it involves making any negative area positive), so it is the one that crops up in the exam more often.

PROBABILITY

It's one of students' most despised/feared topics. That's why by making it your strength, you can lap up more marks in the exam that other students would avoid or struggle with.

Binomial distributions

When you have a situation where there are only two outcomes (typically either success or fail), but the attempts can be repeated any number of times without changing the probability of those outcomes, then the situation can be described by a **binomial distribution**. Below, we'll look at some common questions that get asked in relation to binomial distributions and how to calculate them.

Binomial pdf vs Binomial cdf

When you head to menu, **5: Probability**, **5: Distributions**, you'll notice that there are two types of binomial commands – **pdf** and **cdf**. These abbreviations stand for **Probability** Distribution Function and **Cumulative** Distribution Function, respectively. From the names, we can logically infer that the pdf command gives us the probability of obtaining *one* particular outcome (e.g. 4 successes out of 6 attempts), whereas the cdf command will *accumulate* or *add* probabilities together (e.g. 4 *or more* successes out of 6 attempts). It's crucial you pick the right one.

Example (VCAA 2008, Exam 2) [GA exam]

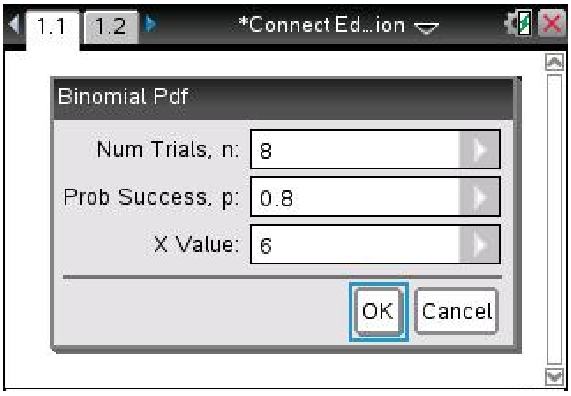
Sharelle is a goal shooter for her netball team. During her matches, she has many attempts at scoring a goal. Assume that each attempt at scoring a goal is independent of any other attempt. In the long term, her scoring rate has been shown to be 80% (that is, 8 out 10 attempts to score a goal are successful).

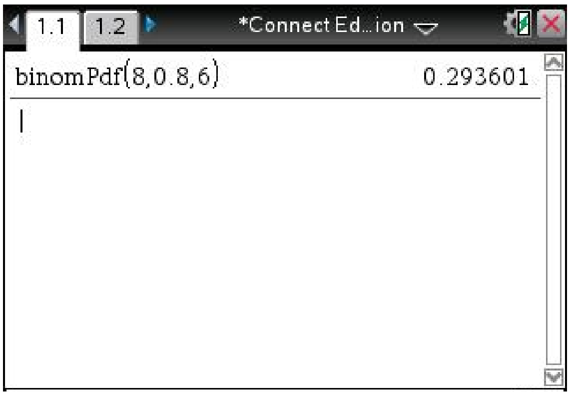
ii. What is the probability, correct to four decimal places, that exactly 6 of her first 8 attempts at scoring a goal in a match are successful?

iii. What is the probability, correct to three decimal places, that her first 4 attempts at scoring a goal are successful, given that exactly 6 of her first 8 attempts at scoring a goal in a match are successful?

First, in probability questions you must identify the type of distribution. Here there are many repeated attempts, and the outcomes are only success/fail, so this in a binomial distribution.

For Part (ii), we're asked for exactly 6 of 8 goals to be successful – the word 'exactly' here is a big hint that we need to use **D: Binomial Pdf**. When filling out the pop-up box for Binomial Pdf, make sure you input the probability as a decimal. The 'X Value' refers to the number of successes you want.

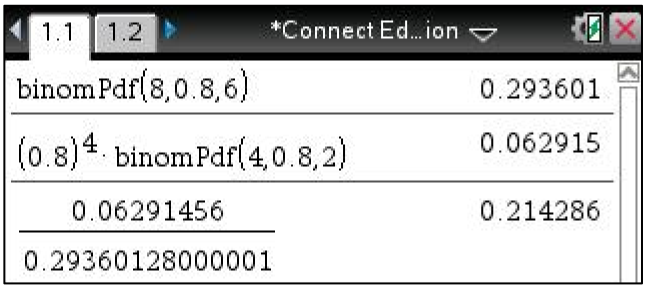




Part (iii) is challenging. The word 'given' is a dead giveaway that this question involves conditional probability. When you're dealing with conditional probability, always identify the outcome you *already know has happened*, and the outcome *you're finding the probability of*. In this case, *we know* that Sharelle has scored 6/8 goals, so that's what's given (it goes on the bottom of our fraction). What we want to know is the probability that the first four in a row are successful. Bear in mind that we still need Sharelle to score 6 goals overall, so we need the first four in a row to be successful, and then any 2 of the next 4 to be successful. The way we'd write this down on our exam paper is as follows:

$$\Pr(first\ 4, then\ 2\ out\ of\ 4) = (0.8)^4 + \binom{4}{2}(0.8)^2(0.2)^2 = 0.062915$$

Then we construct a fraction to find the conditional probability: $\frac{0.62915}{0.2936} = 0.214$



Finding sample size

Sometimes, we know there's a certain probability of an outcome, but we don't know how many attempts we should have to make sure we actually observe the outcome. This comes up in research a lot. For example, you might know from health records that 5% of people develop a certain disease in their lifetime; if you want to observe a group of people over their lifetime to see what factors could be contributing to developing the disease, you want to make sure you pick a sample size large enough such that the chance of at least one person developing the disease is greater than 95%. Otherwise, if your sample size is too small and no one develops the disease, then all your research has been for naught.

There are two ways to calculate the sample size for binomial distributions:

- **Solve an equation**

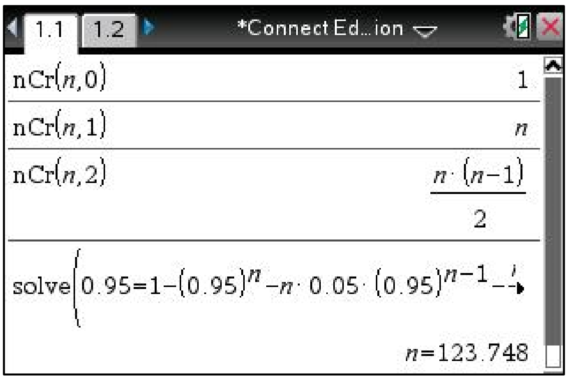
  Imagine we have the above situation (where 5% of people will develop a particular disease), and we want to find a sample size such that the probability of at least 3 people getting the disease is more than 95%.

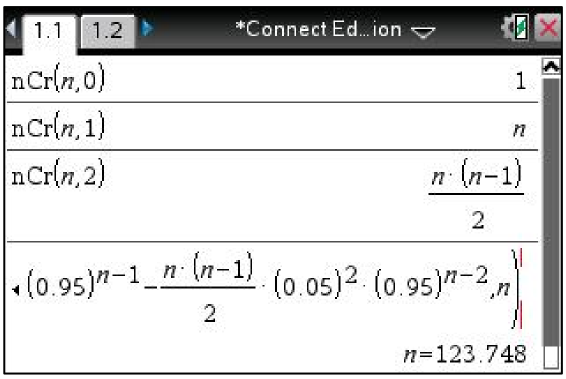
  That means we want $\Pr(X \geq 3) > 0.95$, where X is the number of people with the disease. Solving this is very hard because we wouldn't know when to stop adding our probabilities together! Using the complement law, we can write this equation another way, which is easier to solve:
  $1 - \Pr(x = 0) - \Pr(x = 1) - \Pr(x = 2) > 0.95$.

  Now we just enter the equation on our calculator, using the format $\Pr(X = x) = \binom{n}{x}(p)^x(1-p)^{n-x}$. To figure out what the value of $\binom{n}{x}$ is, you can use $\boxed{\text{menu}}$, **5: Probability**, **3: Combinations**, and enter the sample size (n), followed by the number of successes ($0, 1,$ and 2 in this case).

  NOTE The calculator doesn't solve equations well when there's an inequality. Instead, use an equals sign on the calculator, but write an inequality sign on your exam paper.

  The calculator gives us $n = 123.748$, meaning we need at least 124 people.

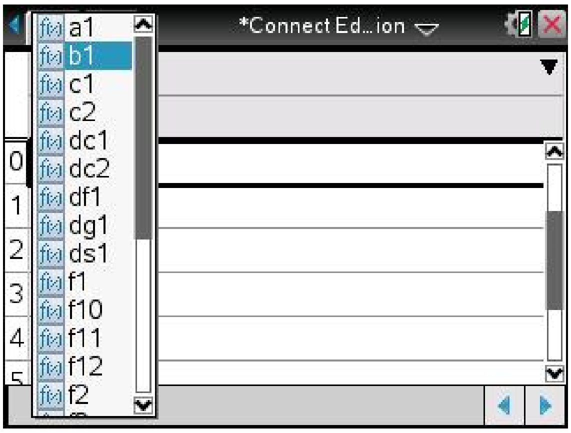


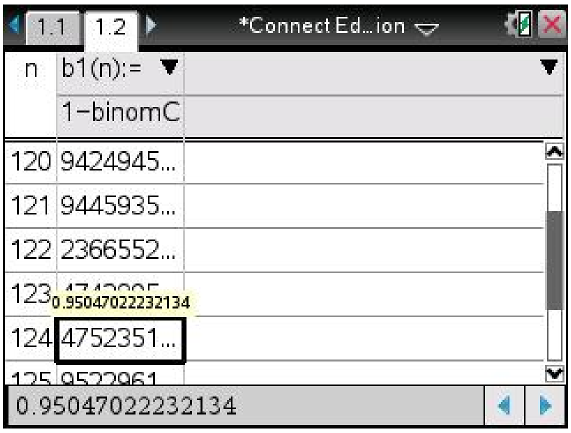


- **Use a table**

If the equation above freaks you out, try the following approach. Define the binomial equation as shown. This is similar to what we have above, but we're using Binomial Cdf to add up the probabilities of $X = 0, X = 1$, and $X = 2$.

Then, use ctrl + I to open up a new page, and press **4: Add Lists & Spreadsheets**. To input data, press ctrl + T which will show you a list of all the equations you've defined. Select your equation ($b1$ in this case). Now scroll down the table by holding the 'down' arrow on the mousepad – keep an eye on the probabilities and stop when as soon as it gets over 0.95. The corresponding 'n' value is your sample size!





Continuous distributions

Data that follows a continuous distribution can be easily identified because they're always presented as a hybrid function.

Setting up integrals

To find the probability of an outcome for a continuous variable, all you have to do is set up a definite integral – just as you would for finding the area under a graph. Something to be weary of is if the continuous distribution is defined by multiple equations – make sure you're using the right equation over the appropriate domain!

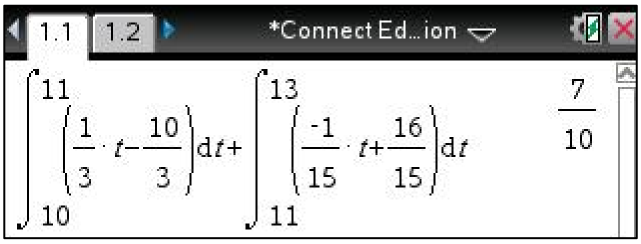
Example

The continuous random variable, T, the time taken for a driver to get to work, has a pdf with the rule:

$$T(x) = \begin{cases} \frac{1}{3}t - \frac{10}{3} & if\ 10 \le t \le 11 \\ \frac{-1}{15}t + \frac{16}{5} & if\ 11 \le t \le 16 \\ 0 & otherwise \end{cases}$$

Find the probability that the time taken to get to work is less than 13 minutes.

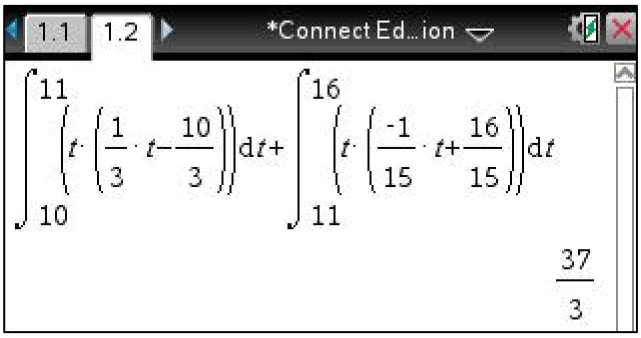
Since the pdf begins at $t = 10$, we'll need to integrate over the interval [10, 13). However, the first equation is only defined over [10, 11], so we'll need to use the second equation for the interval (11, 13). Hence, we need two integrals:



Note that for continuous variables, it doesn't matter whether or not the terminal values are inclusive or exclusive – that is, we'd construct the same integrals regardless of whether the question wanted the probability for 'less than 13' or 'less than or equal to 13'.

Mean

As defined on the formula sheet, the mean for a continuous distribution is found by integrating x times the function over the whole domain. For example, for the above distribution, the mean would be calculated as shown.



Median

The median is the ‘middle’ value of the data, so it’s essentially the data value that gives you a probability of 50% (0.5). Therefore, to find its value you have to integrate under the graph from the start of the domain to m (the median), and make this integral equal 0.5 to solve for m.

When the continuous random variable is defined by multiple equations, you have to integrate under the first equation first to see whether it’s below or above 0.5. If it’s above 0.5, you can just replace the top terminal with m and solve. If it’s below 0.5, this means the median is in the next equation, so you would put the m in the next integral, as shown below.

1.1 1.2 *Connect Ed...ion

$$\int_{10}^{11}\left(\frac{1}{3}\cdot t-\frac{10}{3}\right)dt \qquad 0.166667$$

Here, when we integrate under the first equation, the area is less than 0.5. This means the median is in the next equation. Therefore, we now integrate underneath the first equation and up to m in the second equation, and make the sum equal 0.5 so we can find m.

Since $m \in [10,16]$, the median is 12.13 minutes (two decimal places).

$$\text{solve}\left(0.5=\int_{10}^{11}\left(\frac{1}{3}\cdot t-\frac{10}{3}\right)dt+\int_{11}^{m}\left(\frac{-1}{15}\cdot t+\frac{16}{15}\right)dt,m\right)$$

$$m=12.127 \text{ or } m=19.873$$

Percentiles

Finding percentiles works in a very similar way to finding the median. The difference is that this time the area isn’t 0.5. Rather, if you’re trying to find the 10th percentile, you’d make the area equal 0.1. Or if you’re trying to find the 80th percentile, you’d make the area 0.8.

Just as before, we integrate our equation(s) from the lower boundary up to some value p which represents the data value that gives you the area you’re after. For example, the calculation you’d use to find the 25th percentile (also called the ‘lower quartile’) is given below.

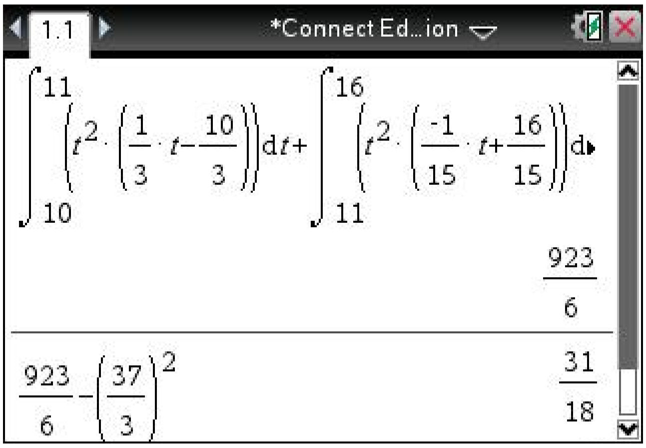
$$\text{solve}\left(0.25=\int_{10}^{11}\left(\frac{1}{3}\cdot t-\frac{10}{3}\right)dt+\int_{11}^{p}\left(\frac{-1}{15}\cdot t+\frac{16}{15}\right)dt,p\right)$$

$$p=11.2566 \text{ or } p=20.7434$$

Variance

The formula for variance is a tad confusing, so it's crucial you pay close attention to your formula sheet and enter it on the calculator correctly. Instead of entering it all in one go, it can help to evaluate each part of the variance separately. That is, since the variance formula is $Var(X) = E(X^2) - [E(X)]^2$, it may be easier to first find $E(X^2)$, and then subtract $[E(X)]^2$ from it.

TIP The $[E(X)]^2$ term is just the mean squared. Questions will often get you to find the mean in an earlier part before finding the variance, so you can just use your answer from before (just like we're doing here).



The standard deviation is just the square root of the variance, so if asked to find it you would just evaluate $\sqrt{Var(X)}$.

In this case, $SD = \sqrt{\frac{31}{18}} = \frac{\sqrt{62}}{6}$

CONNECT EDUCATION

Normal distribution

The normal distribution is a special type of continuous distribution. When data is normally distributed, this means it's perfectly symmetrical, with the mean, median, and mode all being the same value. Examples of this include the distribution of heights and ATAR scores – in each case, there is a central value that represents the most common height/ATAR, and as you go further away from the centre (either left or right), the probability of observing a very low or very large height/ATAR gets smaller.

Normal pdf vs Normal cdf

When you go to menu, **5: Probability**, **5: Distributions**, you'll notice that there's both **1: Normal Pdf** and **2: Normal Cdf**. The difference is subtle, but crucial.

- **Normal Pdf** lets you enter one x-value (one data value). The probability that the calculator spits out is all the area to the left of the x-value you enter (i.e. $\Pr(X < x)$). This can be annoying to remember, and can be costly if the question actually wants you to find the area to the right of the x-value (i.e. $\Pr(X > x)$).

- **Normal Cdf**, on the other hand, gets you to enter a lower and upper bound. If you need to find area to the left of a point, go from $-\infty$ up to the point, or if you need the area to the right of a point, go from the point up to ∞. Therefore, it does the same job as Normal Pdf, but gives you more control! That's why I recommend you **always use Normal Cdf**, and never Pdf.

Example (VCAA 2009, Exam 2)

The Bouncy Ball Company (BBC) makes tennis balls whose diameters are normally distributed with mean 67 mm and standard deviation 1 mm. The tennis balls are packed and sold in cylindrical tins that each hold four balls. A tennis ball fits into such a tin if the diameter of the ball is less than 68.5 mm.

a) What is the probability, correct to four decimal places, that a randomly selected tennis ball produced by BBC fits into a tin?

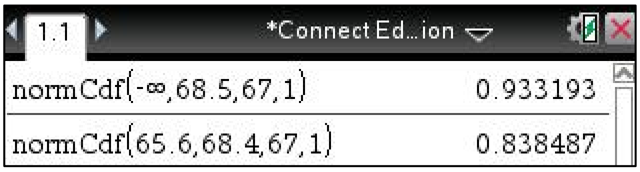
BBC management would like each ball produced to have a diameter between 65.6 and 68.4 mm.

b) What is the probability, correct to four decimal places, that the diameter of a randomly selected tennis ball made by BBC is in this range?

c) What is the probability, correct to four decimal places, that the diameter of a tennis ball which fits into a tin is between 65.6 and 68.4 mm?

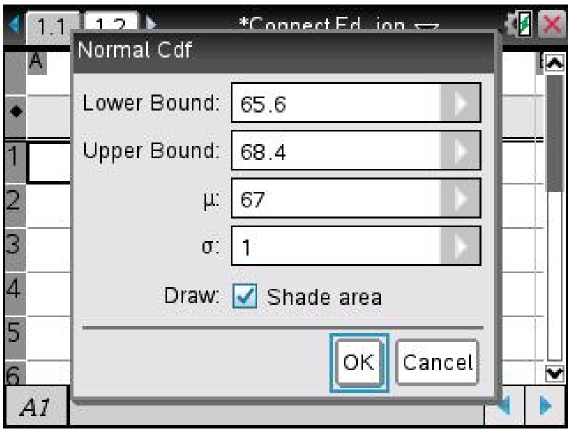
For Part (a), a tennis ball fits in a tin if it's less than 68.5 mm. In mathematical terms, we're finding $\Pr(X < 68.5)$. Therefore, our interval is $(-\infty, 68.5)$.

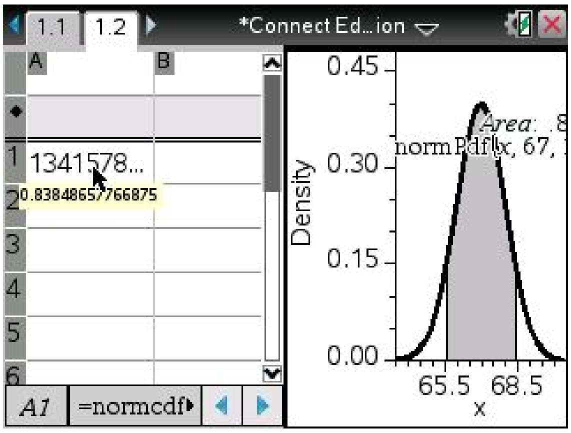
For Part (b), our interval is $(65.6, 68.4)$.



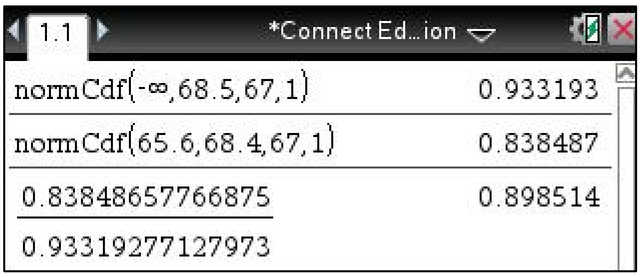
Both Part (a) and (b) can be done using Normal Cdf on a **Calculator page**, as shown. However, if you're more of a visual person and like to physically *see* the area you're finding, follow the steps below instead:

- Open a **Lists & Spreadsheets** page
- Go to $\boxed{\text{menu}}$, 4: Statistics, 2: Distributions, 2: Normal Cdf
- Enter in the appropriate values, and tick the 'shade area' box.
- And tada! The calculator shows you what area it has calculated, and if you hover your cursor over the value in the table, you can see what the value of this area is.





Part (c) is a tricky conditional probability question… a lot of students don't realise it's conditional probability because it's not stated explicitly. However, the fact that the question says that the ball fits in the cylinder, and *then* asks us to find the probability that its diameter is between 65.6 and 68.4 mm makes it conditional. All we do is divide $\Pr(65.6 < X < 68.4)$ by $\Pr(X < 68.5)$.



$\therefore \Pr(65.6 < X < 68.4 | X < 68.5)$ is 0.8985 (four decimal places).

CONNECT EDUCATION

Inverse normal

Found under menu, **5: Probability**, **5: Distributions**, **3: Inverse Normal**, this command lets you enter an area/probability and tells you what data value produces it.

What you have to be cautious of is that the area is **always** calculated as being to the **left** of the data value. Therefore, if a question wanted you to find the value of x such that $\Pr(X > x) = 0.3$, what you would have to enter into the calculator is the left area, which is 0.7.

This Inverse Normal command is particularly useful in questions involving the **standardisation formula**. Before we jump into that, it's important you remember that the **Standard Normal curve** is often represented by Z and is defined as having a mean of 0 and a standard deviation of 1. We can take any other Normal curve and *standardise* it to the Standard Normal curve by using this transformation:

$$z = \frac{x - \mu}{\sigma}$$

What this means is that you can convert an x-data value on a non-standard curve into a z-data value on the Standard curve by subtracting the mean from the x-value and dividing by the standard deviation.

TIP This is a good formula to have in your Summary book as it's not on the Formula Sheet!

So, why is this equation useful? Well, when the mean or standard deviation are unknown, we can rearrange the formula and solve for them. Let's look at this through the following example, which continues from the question above.

Example continued (VCAA 2009, Exam 2)

BBC management wants engineers to change the manufacturing process so that 99% of all balls produced have a diameter between 65.6 and 68.4 mm. The mean is to stay at 67 mm but the standard deviation is to be changed.

d) What should the new standard deviation be (correct to two decimal places)?

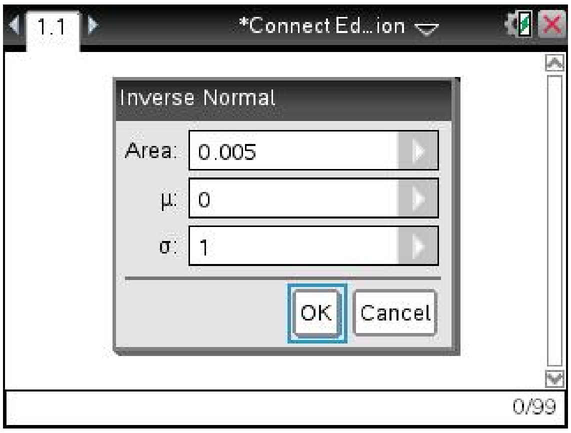
Translating this to mathematical notation, what this question is saying is that $\Pr(65.5 < X < 68.4) = 0.99$. What we've written down is too tricky because there are two x-values involved. To simplify it, we can just consider the area to the left of 65.5, which is equal to 0.005. (I got this by doing (1-0.99) divided by 2.)

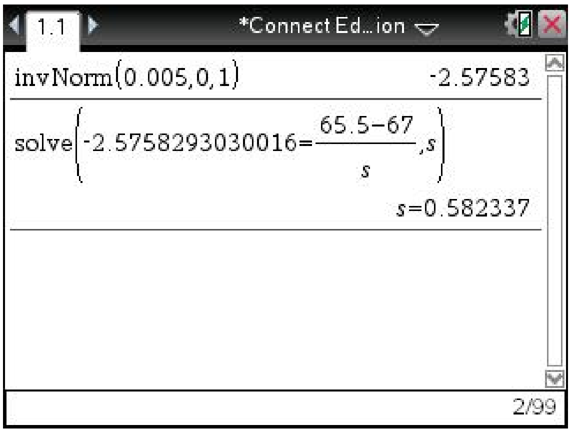
Therefore, $\Pr(X < 65.5) = 0.005$

In order to use the standardisation formula to solve for σ, we need to find the value of z. Remember, z just represents the value on the Standard Normal curve that gives you the equivalent area that an x-value gives you on another curve. In this case, we need to find the z-value that gives us an area of 0.005. We can use the Inverse Normal command for this!

The calculator tells us that $z = -2.5783$, so we can sub this into the standardisation formula and solve for σ.

Therefore, $\sigma = 0.58$.





STATISTICS

A lot of the commands used in Statistics are the same as those described above in Probability. In Statistics, the major difference is that we're dealing with **samples** that only serve to *represent* a population. That means the sample proportions and sample means we calculate are only **estimates** of what the true population proportions/means are. A classic example is the proportion of males and females in a sample. According to biology, theoretically the population proportion of males and females should each be 0.5. However, when you randomly select people from the population, you might not necessarily exactly have a 50:50 split of females to males.

Calculating confidence intervals

Because sample proportions/means are only estimates, we use confidence intervals to get a range of values that is likely to contain the *true* population proportion/mean.

The equation on the formula sheet for this looks quite scary…

$$Approximate\ confidence\ interval = \left(\hat{p} - z\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}, \hat{p} + z\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}\right)$$

However, all this is really saying is that the interval is given by your sample proportion or mean, plus and minus the degree of confidence (z), multiplied by the sample standard deviation. The reason why the p values have **hats** is to represent that these have been calculated from a **sample**, and are therefore only estimates.

When you're using the equation by hand, it's important to note that the z value changes depending on the degree of confidence. For 95% confidence, the z value is 1.96, which you can get by taking the Inverse Normal of 0.975 (it's 0.975 because remember, the Inverse Normal needs all the area on the left, so it's 0.95 + 0.025). For 98% confidence, z is 2.326 (found by doing Inverse Normal of 0.99).

If you're asked to find a confidence interval in a calculator-active exam, it's a lot easier to just use the in-built command rather than fiddling around with the above formula and z values. Go to $\boxed{\text{menu}}$, **6: Statistics**, **6: Confidence Intervals**, **5: 1-Prop z Interval**, and enter the number of 'successes', sample size, and degree of confidence. Let's see how this works in the following example.

Example

A chocolate factory needs to estimate the proportion of their chocolate bars that are underweight so that appropriate remedies can be made. In a random sample of 100 bars, 9 of them are underweight.

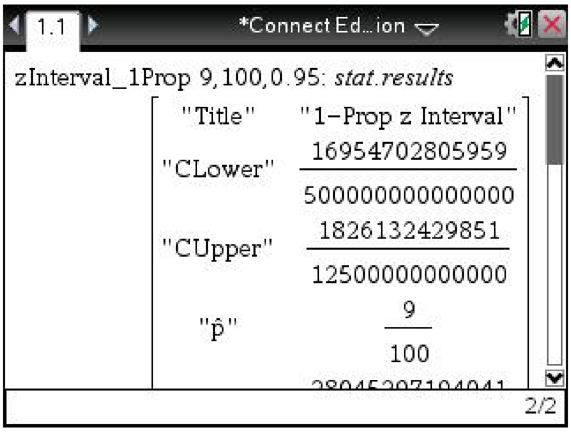
a) Find a point estimate for p, the proportion of bars that are underweight, correct to 2 decimal places.

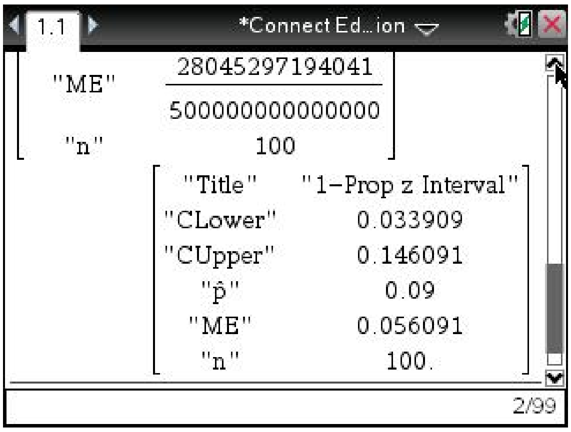
b) Calculate a 95% confidence interval for p (correct to 4 decimal places) and interpret it.

For Part (a), we're asked for an **estimate** of the proportion. Therefore, all we do is divide the number of underweight bars by the total number of bars in the sample, and ensure we write $\hat{p}$ because it is just an estimate of the true proportion.

$$\hat{p} = \frac{9}{100} = 0.09$$

For Part (b), we input the data using the **1-Prop z Interval** command. If you're using an older TI-Nspire calculator (like me), the answer will appear as large nasty fractions. To overcome this issue, just copy the matrix into the next entry line and press ctrl + enter.





The "CLower" and "CUpper" give you the values in the confidence interval. Note that it also gives you $\hat{p}$ and "ME" (the margin of error).

To finish answering the question, we'd write that our 95% confidence interval is (0.0339, 0.1461), which means that there is 95% certainty that the true proportion of underweight chocolate bars is within this interval.

That's a wrap!

It's clear that knowing what your calculator is capable of and being able to efficiently punch in commands will be the keys to saving precious time in your SACs and end-of-year exam. I hope this guide has alleviated any anxiety you previously had about your TI-Nspire, and helped you foster an alliance with your calculator instead. I urge you to keep playing around with it, practising your commands, and searching for new and perhaps more efficient ways of performing calculations.

Thank you for reading!

– Renata 'Rendawg' Galiamov

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