# Do you know all there is to know about using your graphics calculator in the SACE Mathematical Studies Examination?

Specifically the CASIO fx-9860G AU PLUS

2nd Edition

Written by Elena Zema
Edited by Anthony Harradine
and Alastair Lupton

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Specifically the CASIO fx-9860G AU PLUS.
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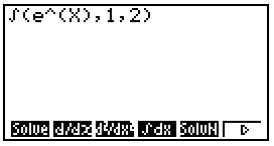
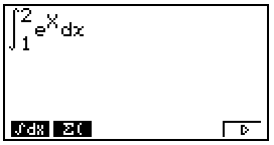
## LINEAR MODE VS MATH MODE

The 9860 has two operating modes: Linear Mode and Math Mode.

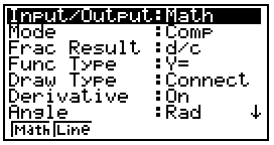
Linear Mode is the traditional mode of scientific calculators where calculations are entered in a line, as seen opposite.




Math Mode allows the user to work with calculation entry that looks 'natural'. This is often termed natural input. It can be seen opposite.




To set your 9860 to work in the mode you desire, enter the SET UP when in the RUN•MAT (RUN·MAT) application. To do this press SHIFT then MENU. You can then choose the option you want.




**Math Mode is the default setting for 9860's using OS version 2.0 and later.**

**In this book all instructions assume you have your 9860 set to work in Math Mode.**

# WORKING WITH STATISTICS

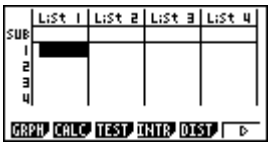
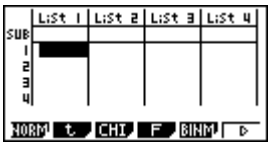
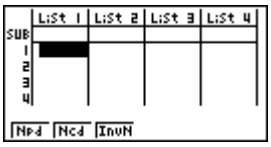
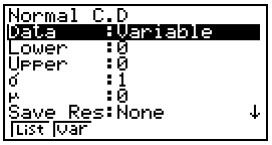
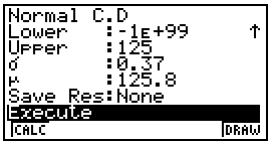
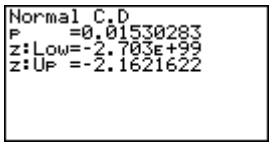
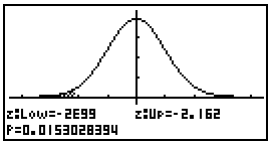
# NORMAL DISTRIBUTION

## How do I find probabilities from normal distributions?

Example:
A certain brand and flavour of chip is sold in bags stamped as containing 125 grams. The chips are delivered to each bag by a machine and the weight varies from packet to packet. Let W denote the weight of the chips in a packet. The distribution W can be modeled by a normal distribution with a mean of 125.8 grams and a standard deviation of 0.37 grams.

Determine the proportion of packets that will contain less than 125 grams of chips.

### PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the STAT application (STAT).<br><br>Press F5 to access the DISTribution menu. |  | |
| Press F1 to access the NORMal distribution menu. |  | |
| Press F2 to access NCD (normal cumulative distribution) function. |  | |
| Input the values. Press EXE after each entry. |  <br>  | In this example, we want to find P(W<125).<br><br>The lower limit of -1E99 is used to reflect the characteristics of the normal distribution.<br><br>To find P(120<W<125) set Lower to 120 and Upper to 125. |
| Once complete, press F1 (or EXE) to CALCulate the probability. The probability will be displayed along with the corresponding Z scores.<br><br>Alternatively, press F6 to DRAW the normal distribution and shade the region of interest, as well as display the probability along with the corresponding Z scores. |  <br>  | Therefore, P(W<125) = 0.0153 (or 1.53%) - correct to 3 significant figures. |

**⚠ Note that, when using some older operating systems, the use of -1 E 99 or 1 E 99 as the lower or upper limit may at times result in the calculator returning Ma Error. Should this occur, use -1 E 90 or 1 E 90 (or a similar suitably small or large number).**

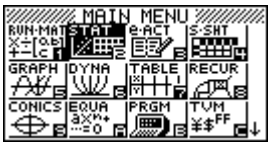
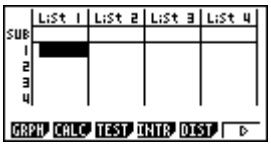
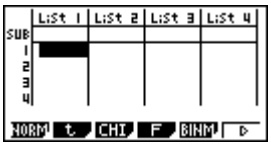
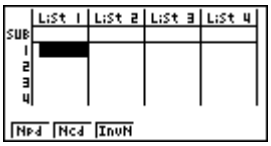
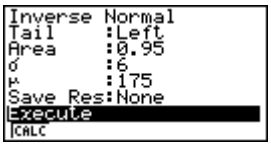
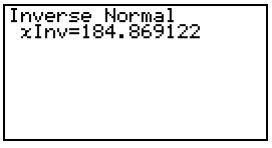
# INVERSE NORMAL

## How do I find a score, given a normal probability value?

Example:
The height of all year 12 female students is assumed to be normally distributed with a mean of 175 cm and a standard deviation of 6 cm.

Find how tall Elena is if she is taller than 95% of year 12 students?

### PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the STAT application (STAT). |  | |
| Press F5 to access the DISTribution menu. |  | |
| Press F1 to access the NORMal distribution menu. |  | |
| Press F3 to access InvN (inverse normal) function. |  | |
| Input the values. Press EXE after each entry.<br><br>Once complete, press F1 (or EXE) to calculate the value of the score. |  | In this example, we want to find x such that P(X<x) = 0.95. So the area we know is to the left of the unknown score. Hence we set the "Tail" setting to Left. Had we wanted to compute P(X>x) = 0.2, we would enter 0.2 for the area and set the "Tail" setting to Right. |
| The value of the score will be displayed. |  | Therefore, x = 185 cm correct to 3 significant figures. |

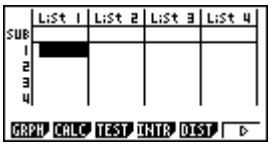
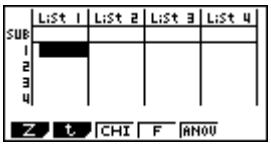
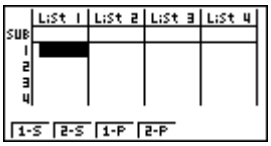
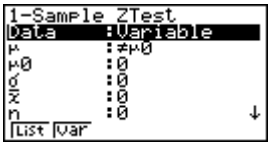
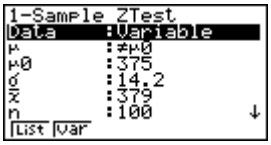
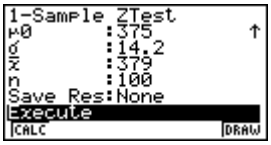
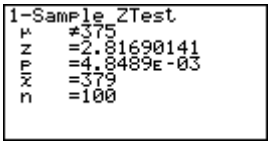
# Z-TEST

## How do I carry out the calculations for a Z-test?

Example:
A machine that delivers fruit to a can is known to deliver portions with mean 375 grams with a standard deviation of 14.2 grams. Changes are made to the machine. Following the changes, a random sample of 100 portions is taken and the average weight of this sample is found to be 379 grams.

Use a two-tailed Z-test, at the 5% level of significance, to determine whether or not the mean weight of the portions is now different to 375 grams. Assume the standard deviation has not changed.

### PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the STAT application (STAT) and then press F3 to access the TEST menu. |  | |
| Press F1 to access the Z menu. |  | |
| Press F1 to access the 1-S (one sample) function. |  | |
| Press F2 to select VARiable.<br><br>Input the values. Press EXE after each entry.<br><br>Once complete, press F1 (or EXE) to have the calculations carried out. |  <br>  <br>  | Note that a two-tailed test is required for the Mathematical Studies course, so set μ ≠ μ0.<br><br>Also note that the standard deviation of the population is entered, **not** the standard error.<br><br>If you press F6 DRAW, the distribution will be drawn and the Z score and p value given at the bottom of the view window. |
| The results are displayed. |  | In this case, since the p value is less than 0.05, sufficient evidence exists to reject the null hypothesis. |

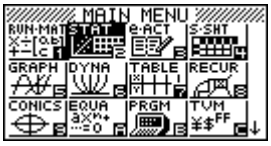
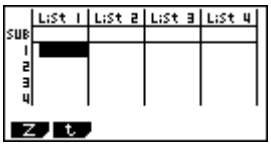
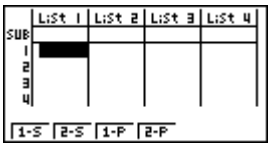
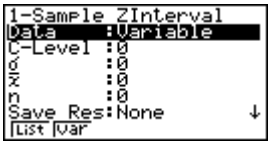
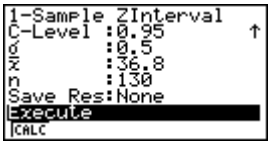
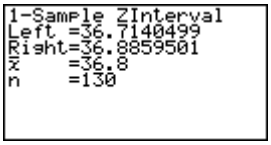
# CONFIDENCE INTERVALS

## How do I find a confidence interval for the population mean?

Example:
In 1990 a study was undertaken in which the body temperature of 130 healthy men from one nation were measured. The mean temperature of the sample was found to be 36.8°C. Let μ be the mean body temperature of all healthy men from this particular nation in 1990.

Assuming the population standard deviation is 0.5°C, find a 95% confidence interval for μ.

### PROCESS

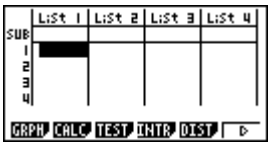
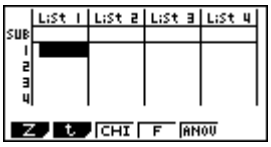
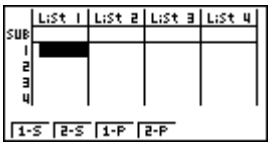
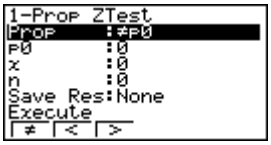
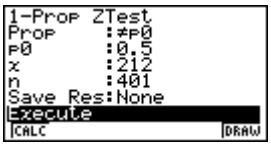
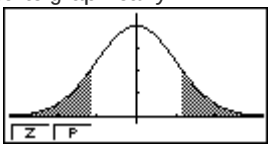
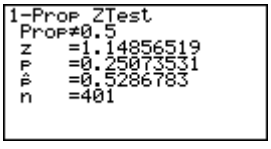
| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the STAT application ( ). |  | |
| Press F4 to access the INTRerval menu. |  | |
| Press F1 to access the Z menu. |  | |
| Press F1 to access the 1-S (one sample) function. |  | |
| Press F2 to select VARiable. |  | |
| Input the values. Press EXE after each entry.<br><br>Once complete, press F1 (or EXE) to calculate the interval. |  | Note that the standard deviation of the population is entered, **not** the standard error. |
| The confidence interval will be displayed. |  | |

## How do I test a claim about a population proportion?

Example:
The Gawler council decides to close Junction Road. A random sample of 401 residents from Gawler was asked whether they thought the road should stay open. 212 of the 401 surveyed said the road should stay open to traffic.

Is there sufficient evidence to suggest that the proportion of all Gawler residents who thought the road should stay open is different to 50%?

### PROCESS

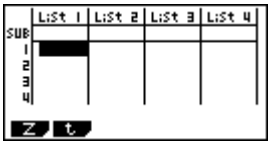
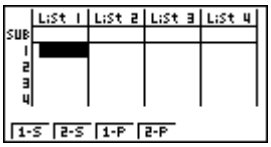
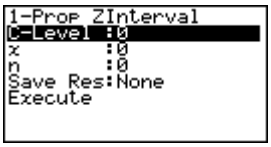
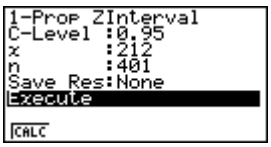
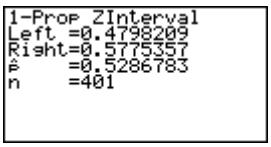
| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the STAT application (STAT) then press F3 to access the TEST option. |  | |
| Press F1 to access the Z menu. |  | |
| Press F3 to access the 1-P (one proportion) function. |  | |
| Input the values. Press EXE after each entry. |  | Prop is the sample proportion test conditions (≠p specifies two-tail test, which is required in Mathematical Studies).<br>p0 is the null proportion.<br>x is the number of 'successes' in the sample.<br>n is the size of the sample. |
| Once complete, press F1 (or EXE) to calculate the results. |  | Press F6 to display the results graphically.<br>  <br>Press F1 and F2 to display the Z and p value respectively. |
| The results will be displayed. |  | In this case, since the p value is greater than 0.05, we do not reject the null hypothesis. |

## How do I find a confidence interval for the population proportion?

Example:
The Gawler council decides to close Junction Road. A random sample of 401 residents from Gawler was asked whether they thought the road should stay open. 212 of the 401 surveyed said the road should stay open to traffic.

Calculate an approximate 95% confidence interval for the proportion of all Gawler residents who thought the road should stay open.

PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the STAT application ([STAT]) then press [F4] to access the INTRerval option. |  | |
| Press [F1] to access the Z menu. |  | |
| Press [F3] to access the 1-P (one proportion) function. |  | |
| Input the values. Press [EXE] after each entry. |  | |
| Once complete, press [F1] (or [EXE]) to calculate the interval. |  | Note that x is the number of "successes" in the sample (supporters in this case). |
| The confidence interval will be displayed. |  | |

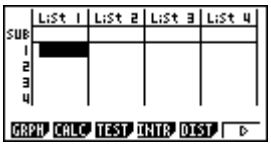
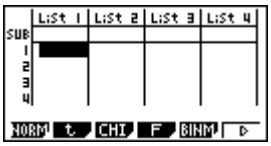
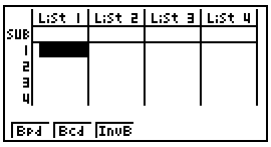
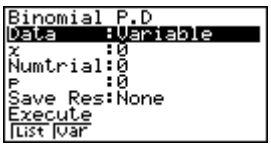
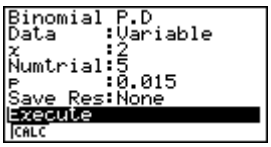
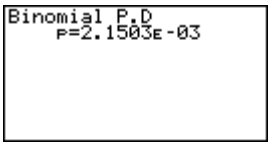
# BINOMIAL DISTRIBUTION

## How do I calculate probabilities (non-cumulative) from a binomial distribution?

Example:
The label on each packet of a certain brand and flavour of chip states each bag contains 125 grams of chips. Suppose that 1.5% of all bags produced contain less than 125 grams of chips. Let Y be the number of packets in the random sample that contain less than 125 grams of chips.

A random sample of 5 packets is selected. Use the binomial distribution to find the probability that 2 packets will contain less than 125 grams of chips?

### PROCESS

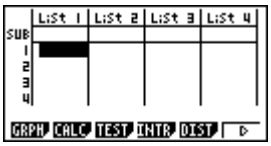
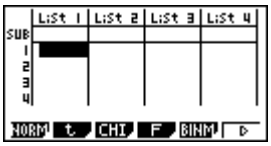
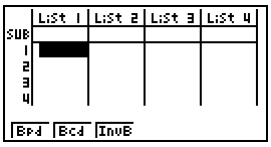
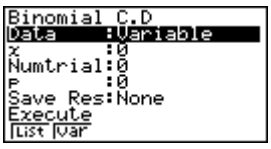
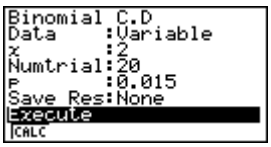
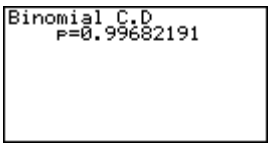
| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the STAT application (STAT) and then press [F5] to access the distribution menu. |  | |
| Press [F5] to access the BINMomial distribution. |  | |
| Press [F1] to access Bpd (binomial point distribution) function. |  | |
| Press [F2] to select VARiable. |  | |
| Input the values. Press [EXE] after each entry.<br><br>Once complete, press [F1] (or [EXE]) to calculate the probability. |  | In this example, we want to find P(Y=2), where Y can be modeled by B(5, 0.015). |
| The probability will be displayed. |  | Therefore, P(Y=2) = 0.00215 or 0.215% (3 significant figures). |

## How do I calculate probabilities (cumulative) from a binomial distribution?

Example:
The label on each packet of a certain brand and flavour of chip states each bag contains 125 grams of chips. Suppose that 1.5% of all bags produced contain less than 125 grams of chips. Let Y be the number of packets in the random sample that contain less than 125 grams of chips.

A random sample of 20 packets is selected. Use the binomial distribution to find the probability that **more than 2 packets** will contain less than 125 grams of chips?

### PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the STAT application (STAT) and then press [F5] to access the distribution menu. |  | |
| Press [F5] to access the BINMomial distribution. |  | |
| Press [F2] to access Bcd (binomial cumulative distribution) function. |  | |
| Press [F2] to select VARiable. |  | |
| Input the values. Press [EXE] after each entry.<br><br>Once complete, press [F1] (or [EXE]) to calculate the probability. |  <br>  | The Bcd function only calculates "less than or equal to" probabilities.<br><br>In this example, we want to find P(Y>2), where Y can be modeled by B(5, 0.015).<br><br>So first we must compute P(Y≤2) and then subtract from 1. |
| We can now compute 1- P(Y≤2). |  | |

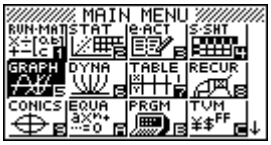
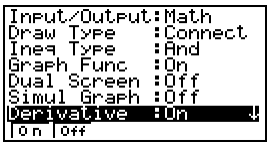
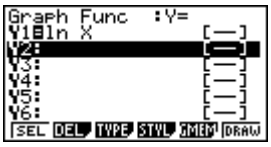
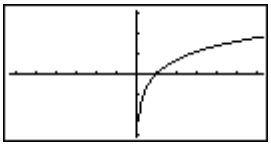
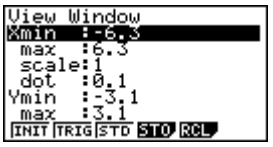
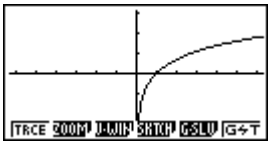
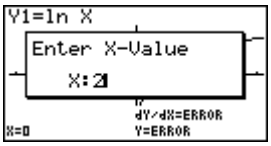
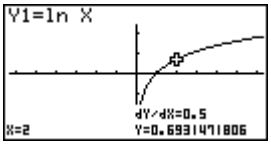
# WORKING WITH FUNCTIONS AND GRAPHS USING CALCULUS.

## How do I find an approximation for the derivative at a point using the trace function?

Example:

If $y = \ln x$, find $\frac{dy}{dx}$ at $x = 2$.

PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the GRAPH application (GRAPH). |  | |
| To use the trace function to find the derivative, you will need to check the SET UP.<br>Press SHIFT then MENU to access the SET UP options.<br><br>Turn the Derivative option On (F1).<br><br>Press EXE or EXIT to return to the graph editor window. |  | Note that when the Derivative option is turned On, some computations will take longer than when it is turned Off. |
| Define Y1 to be the function required and press EXE. Note the = sign is 'blackened' telling you this function will be graphed.<br><br>Before drawing the function, you should **always** check your view window. Press SHIFT then F3 to check/change your settings.<br><br>Press F6 to DRAW the function. |  <br>  | The INITial settings are often useful for 'text-book' functions. They also ensure that tracing occurs in units of 0.1 in the x direction.<br>  |
| To activate the Trace option, press SHIFT then F1.<br><br>Enter the X-value using the keypad and press EXE. The cursor will 'jump' to the required point.<br><br>The derivative is displayed. |  <br>  <br>  | **Note that the value computed is an approximation for the exact value. In this case, calculator displays 0.5 (which is the exact value), but in some cases it may display 0.499999999. This is why it is termed an approximation.**<br><br>**If a question requires you to find the 'exact' value, you should use the rules of algebraic differentiation to find your answer and give your answer in the appropriate form (e.g. fraction or surd)** |

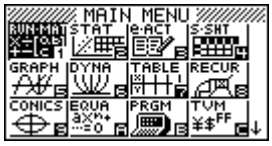
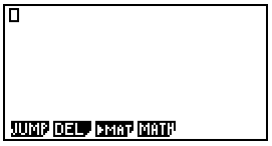
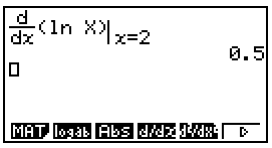
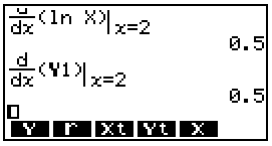
QUESTION

**How do I find an approximation for the derivative at a point in RUN the application?**

Example:

If $y = \ln x$, find $\frac{dy}{dx}$ at $x = 2$.

PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the RUN application ([RUN·MAT]). |   | |
| Press [F4] to access the MATH options. |   | |
| Press [F4] to select the d/dx function. |   | |
| Enter the function, then arrow across and enter the x-value for which you want to evaluate the derivative. Press [EXE]. |   | We suggest you graph the function first (see previous page). It is good practice to know what the function looks like before proceeding. This will give you a better understanding (visually) and give you a better chance at evaluating the validity of the result that is returned. |
| Note that if you have defined the function to be Y1 (in the Graph application) you can enter Y1 in place of the expression.<br><br>In Run application, once d/dx( is entered, press [VARS] then GRPH ([F4]) and then use Y ([F1]) and [1]. |   | |

**Note that the value computed using this process is an approximation of the exact value. In this case, calculator displays 0.5 (which is the exact value in this case), but in some cases it may display 0.499999999. This is why it is termed an approximation. Should the result have been the square root of 2, the calculator would return the approximation 1.414213562**

**If a question requires you to find the 'exact' value, you should use the rules of algebraic differentiation to find your answer and give your answer in the appropriate form (e.g. fraction or surd)**

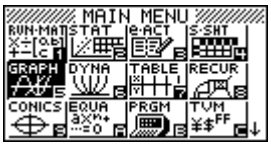
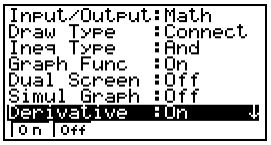
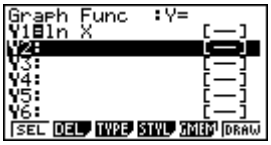
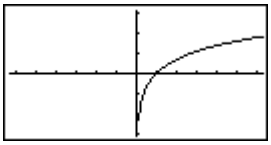
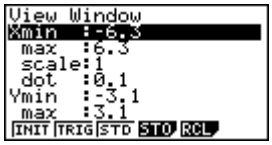
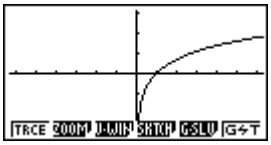
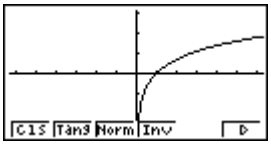
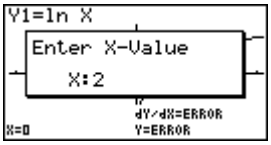
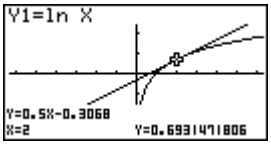
## QUESTION

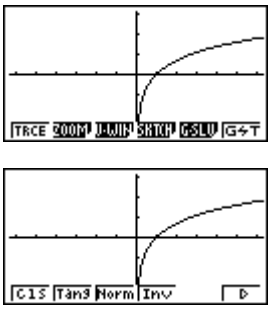
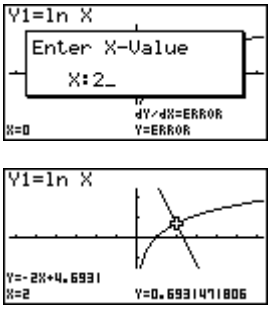
**How do I find the equation of the tangent and normal to a curve at a given point?**

Example:

Find the equation of the tangent and normal to the curve $y = \ln x$ at $x = 2$.

## PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the GRAPH application (GRAPH). |  | |
| To find the equation of a tangent, you will need to check the option settings in SET UP. Press SHIFT then MENU to access the SET UP options.<br><br>Turn the Derivative option On (F1).<br><br>Press EXE or EXIT to return to the graph editor window. |  | Note, if you do not turn the **Derivative option** on, the equation of the tangent/normal will not be displayed on the screen. |
| Define Y1 to be the function required and press EXE. Note the = sign is 'blackened' telling you this function will be graphed.<br><br>Before drawing the function, you should **always** check your view window. Press SHIFT then F3 to check/change your settings.<br><br>Press F6 to DRAW the function. |  <br>  <br>  | The INITial settings are often useful for 'text-book' functions. They also ensure that tracing occurs in units of 0.1 in the x direction. |
| Press SKTCH (SHIFT, F4) to view options. Select Tang (F2). |  <br>  | |
| Enter the x-value using the keypad. **You must press EXE <u>twice</u>** in order for the tangent to appear.<br><br>The tangent at that point will be drawn. The equation of the tangent, along with the coordinates of the function will be displayed at the bottom of the screen. |  <br>  | Note, if you do not turn the **Derivative option** on, the equation of the tangent will not appear on the screen.<br><br>**Note that these results are approximations for the exact values. If exact values are required, used algebraic methods.** |

| | | |
|---|---|---|
| To have the normal drawn and to see its equation:<br><br>Press SKTCH ( SHIFT , F4 ) to view options. Select Norm ( F3 ). |  | |
| Enter the x-value using the keypad. **You must press** EXE **twice** in order for the normal to appear.<br><br>The normal at that point will be sketched. The equation of the normal, along with the coordinates of the function will also be displayed at the bottom of the screen. |  | Note, if you do not turn the **Derivative option** on, the equation of the normal will not appear on the screen. |

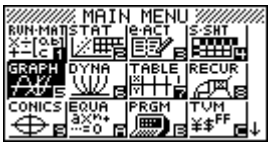
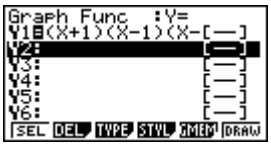
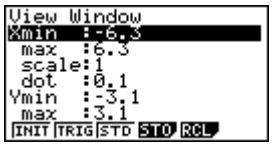
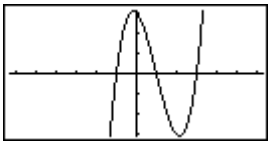
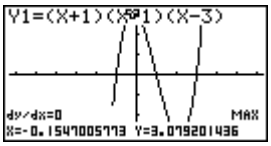
QUESTION

**How do I find a numerical approximation for coordinates of the local maximum (or local minimum) of a function?**

Example:

Find the coordinates of the local maximum and local minimum of $y = (x+1)(x-1)(x-3)$.

PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the GRAPH application (GRAPH) and define Y1 to be the function required and press EXE. |  <br>  | Before sketching the function, you should **always** check your view window. Press SHIFT then F3 to check/change your settings.<br>  <br>You can often use the zoom options (press SHIFT, F2) to help view the function. Often, Auto works well, especially if you set the domain sensibly. |
| Press F6 to draw the curve function. |  | It is important to note that the features you want to locate must be "in view" for the calculator to be able to locate them. |
| To find the coordinates of the **local maximum**:<br><br>Press G-SOLVE (SHIFT, F5) to view options. Select MAX (F2).<br><br>Use MIN (F3) to locate the local minimum. |  | |
| The calculator will display the coordinates of the local maximum (or local minimum). |  | If more than one local maximum (or local minimum) is in view, use the arrow keys (◀, ▶) to move to the next. |

**⚠ Note that this process will not necessarily locate all of the stationary points of a function, just the ones that are visible in the view window.**
**To find all stationary points, or be sure that what you are seeing is all there are, you need to use algebraic methods (set the derivative equal to zero).**
**Also, the values computed are approximations for the exact values of the coordinates being found.**
**If the question requires you to find the "exact value" you should use algebraic methods.**

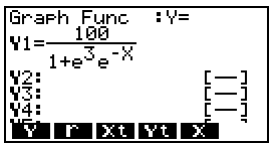
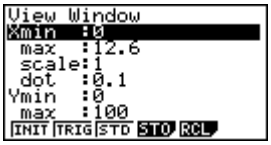
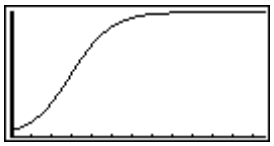
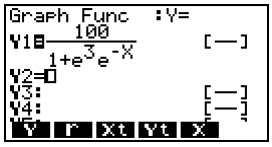
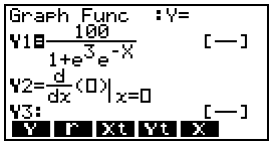
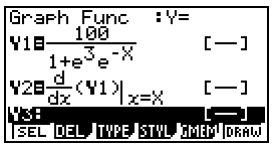
## QUESTION

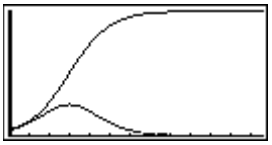
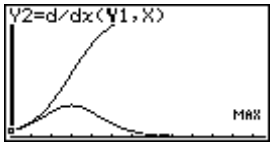
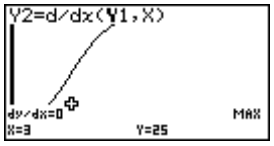
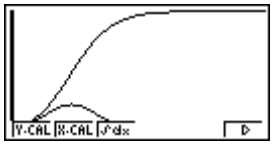
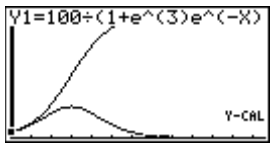
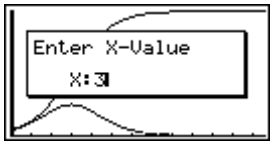
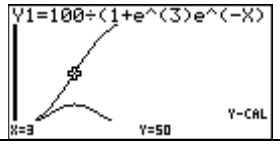
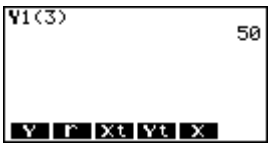
**How do I find a numerical approximation for the coordinates of a point of inflection?**

Example:

Find the coordinates of the point of inflection of $y = \dfrac{100}{1+e^3e^{-x}}$ for $0 \le x \le 10$.

## PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the GRAPH application (GRAPH) and then define Y1 to be the function required and press EXE. |  | Before sketching the function, you should **always** check your view window. Press SHIFT then F3 to check/change your settings.<br>  |
| Press F6 to draw the function. |  | You can also use the zoom options (press SHIFT, F2) to help achieve a good view of the function. Often Auto zoom works well, especially if you set the domain sensibly. |
| To find the point of inflection, we need to sketch the derivative function of Y1. We define Y2 to be the derivative function of Y1.<br><br>Press OPTN, select CALC (F2) and then press F1 to select d/dx. |  <br>  | |
| Select Y (F1) then enter 1. Arrow across and enter X (X,θ,T). Press EXE. |  | Continued on the next page. |

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Press [F6] to draw both functions. |  | Functions will be graphed in the order of entry.<br><br>You do not need Y1 to be graphed and so you could use SEL ([F1]) in the graph editor to deselect Y1. This will also speed up the process. |
| We need to find the turning point (local maximum in this case) of the derivative function, Y2.<br><br>Press G-SOLVE ([SHIFT], [F5]) to view options. Select MAX ([F2]).<br><br>Use the arrow keys ([▲], [▼]) to select the function for which the local maximum is required and press [EXE]. |  <br>  | The x coordinate of the maximum of the derivative function gives the x coordinate of the inflection point of the function. |
| The coordinates of the local maximum will be displayed.<br><br>This provides the x coordinate of the point of inflection of Y1. |  | |
| To find the y coordinate of the point of inflection:<br>Press G-SOLVE ([SHIFT], [F5]) to view options.<br><br>Then press ([F6]) view the rest of the menu.<br>Press Y-CAL ([F1]).<br><br>Use the arrow keys ([▲], [▼]) to select the function you would like to use (Y1) and press [EXE].<br><br>Enter the x-coordinate ([3] in this case) and press [EXE].<br><br>The calculator will display the coordinates of the required point. |  <br>  <br>  <br>  | You could also find the y-coordinate of the point of inflection in the RUN application.<br><br>Press [VARS] (variable menu).<br>Select GRPH ([F4]).<br>Enter Y1 (press [F1] [1]) then enter the x-coordinate in brackets([3] in this case).<br>Press [EXE].<br><br>  |

⚠ **Note that this process will not necessarily locate all of the points of inflection, just the ones that are visible in the view window. Algebraic processes are required to find all points of inflection.**
**Also, the values computed are approximations for the exact values of the coordinates being found.**

**If the question requires you to find the "exact value" you should use algebraic methods.**

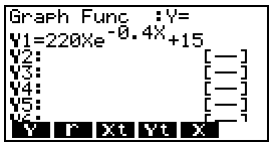
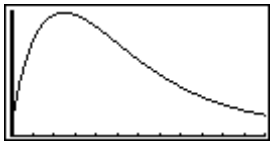
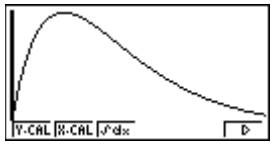
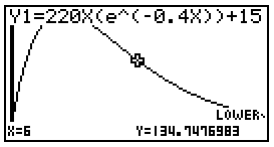
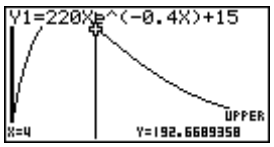
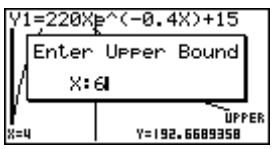
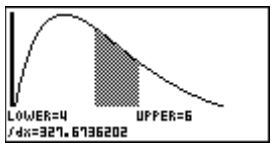
# INTEGRATION

## How do I find an approximation for a numerical integral using the GRAPH application?

Example:

Find $\int_4^6 (220xe^{-0.4x} + 15)\,dx$.

### PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the GRAPH application [GRAPH] and then define Y1 to be the function required; press [EXE]. |  | Before sketching the function, you should **always** check your view window. Press [SHIFT] then [F3] to check/change your settings.<br>  |
| Press [F6] to draw the curve function. |  | You can often use the zoom options (press [SHIFT], [F2]) to help view the function. Often, Auto works well, especially if you set the domain sensibly. |
| Press G-SOLVE ([SHIFT], [F5]) to view options. Press ([F6]) to see the rest of the options.<br><br>Press [F3] to select $\int dx$. |  | |
| The calculator will prompt you to select the lower value. Rather than using the arrow pad to move the cursor to the approximate lower value, enter the Lower Bound using the keypad ([4] in this case) and press [EXE].<br><br>It will then prompt you to select the upper value. Enter the Upper Bound ([6] in this case) and press [EXE]. |  <br>  <br>  | |
| The integral will be displayed. |  | |

**⚠ The value computed is an approximation for the exact value of the integral. If the question requires you to find the "exact value" you should use algebraic methods.**

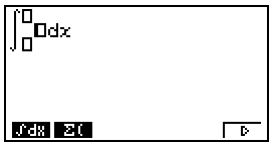
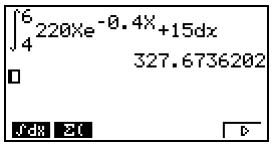
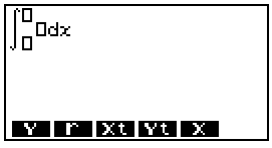
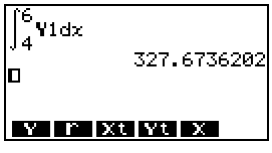
## QUESTION

**How do I find an approximation for a numerical integral using the RUN application?**

Example:

Find $\int_4^6 \left(220xe^{-0.4x} + 15\right)\mathrm{d}x$.

## PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter RUN application (MENU) and then press MATH( F4 ), then F6 to see more options. |  | |
| Press F1 to select $\int dx$. |  | |
| Enter the function, followed by the lower and upper bounds, using the arrow pad. Press EXE. |  | We suggest you graph the function first (see previous page). It is good practice to know what the function looks like before proceeding. This will give you a better understanding (visually) and give you a better chance at evaluating the validity of the result that is returned. |
| If Y1 is defined as the function you require (in the Graph application), you can proceed as follows:<br>When entering the function, press VARS (variable menu).<br>Select GRPH ( F4 ). |  | |
| Select Y ( F1 ) then enter 1, followed by the lower and upper limits using the arrow pad.<br><br>Press EXE. |  <br>  | |

**⚠ When using this process the value computed is an approximation for the exact value of the integral. If the question requires you to find the "exact value" you should use algebraic methods.**

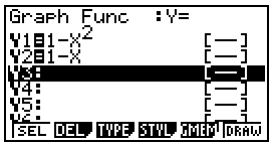
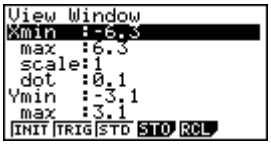
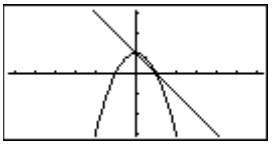
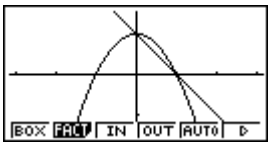
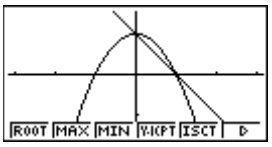
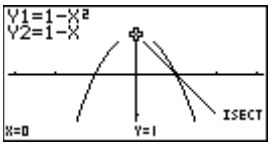
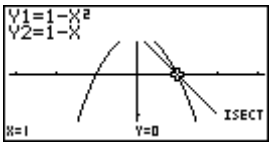
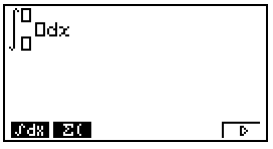
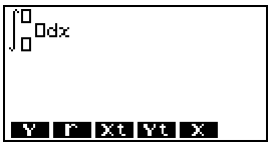
## QUESTION

**How do I find the area between two functions?**

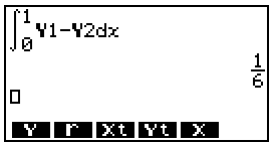
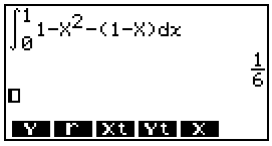
Example:

Find the area enclosed by the graphs of $y = 1 - x^2$ and $y = 1 - x$.

## PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the GRAPH application, (GRAPH) and then define Y1 and Y2 as the functions required. |  | Before sketching the function, you should **always** check your view window. Press SHIFT then F3 to check/change your settings.<br>  |
| Press F6 to draw the graphs. |  | You can also use the zoom options (press SHIFT, F2) to help view the function. BOX works well if you want to focus on a specific rejoin of the graph.<br>  |
| To find the points of intersection, press GSOLV (SHIFT, F5), then ISCT (F5).<br><br>The calculator will find the intersection point of the two functions and display the coordinates.<br><br>If more intersection points are visible, use the arrow keys to move onto them and have the coordinates displayed. |  <br>  <br>  | Note that the calculator will only find points of intersection that are visible on the screen. |
| Enter RUN application (RUN-MAT) and then press MATH(F4), then F6 to see more options.<br>Press F1 to select $\int dx$.<br><br>As Y1 and Y2 are defined to be the functions we are using, proceed as follows:<br>Press VARS (variable menu).<br>Select GRPH (F4). |  <br>  | Process continued on the next page. |

Area between two functions continued.

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Select Y (F1) 1 (−) Y(F1) 2, followed by the lower and upper limits using the arrow pad.<br><br>Press EXE. |  | |
| Alternatively you could enter the functions instead of using Y1 and Y2. |  | Note the careful use of brackets here. |

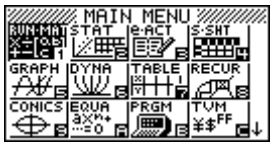
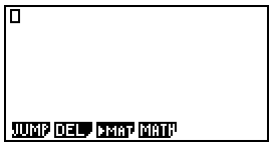
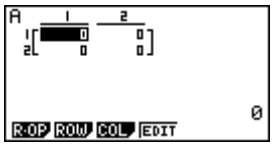
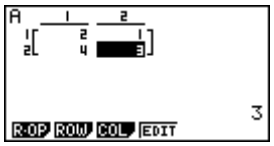
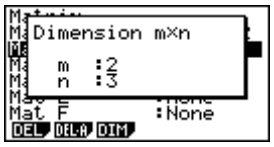
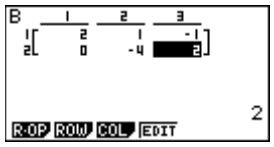
**When using this process the value computed is an approximation for the exact value of the area required.**
**If the question requires you to find the "exact value" you should use algebraic methods.**

# WORKING WITH LINEAR EQUATIONS AND MATRICES.

# MATRICES

## How do I define a matrix?

### PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the RUN·MAT application ( ). |  | |
| Press F3 to enter the MATrix mode. |  | |
| Select Mat A and define its size. To make it a "two by two" enter 2, press EXE then 2 and press EXE. Press EXE again to have the matrix appear. |  <br>  | |
| Enter the matrix elements. Press EXE after each entry. |  <br>  | If an error is made, simply highlight and overtype or press F4 to edit. |
| To define another matrix, press EXIT and define the size of the next matrix. |  <br>  | To begin performing matrix operations, you will need to press EXIT to return to the calculation area. |

QUESTION

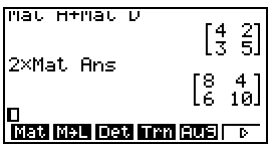
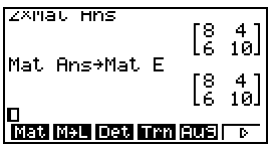
**How do I perform matrix operations?**

Example:

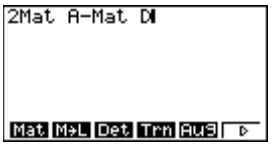
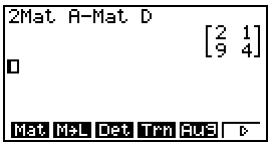
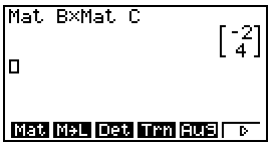
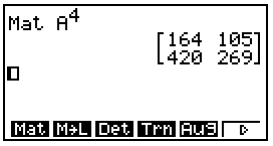
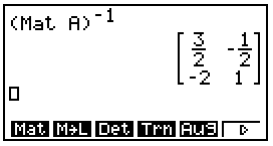
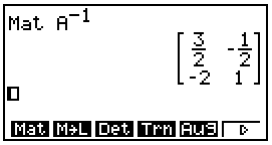
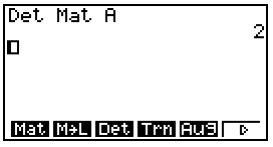
Let $A=\begin{bmatrix}2 & 1\\ 4 & 3\end{bmatrix}$, $B=\begin{bmatrix}2 & 1 & -1\\ 0 & -4 & 2\end{bmatrix}$, $C=\begin{bmatrix}-1\\ -2\\ -2\end{bmatrix}$ and $D=\begin{bmatrix}2 & 1\\ -1 & 2\end{bmatrix}$.

Find $A+D$, $BC$, $A^4$, $A^{-1}$ and $\det A$.

SOLUTION

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| The following assumes the above matrices have been defined. Enter the RUN·MAT application press OPTN and select MAT (F2). |  | |
| Various options are now available at the bottom of the screen. Use the function keys (F1 to F6) to select. |  | Note: the 'Mat' entry (that is so common in this topic) can also be found by pressing SHIFT then 2. |
| **Addition**<br>$A+D$<br>Press Mat (F1) then ALPHA (which allows entry of the red letters) then X,θ,T to enter A.<br>Then enter + and then Mat D in a similar way.<br>Press EXE to reveal the result matrix. |  <br>  | |
| **Using and storing a result.**<br>The result matrix can be used for another calculation by using the Mat Ans command.<br>To do so, press Mat (F1) then SHIFT then (−) (Ans).<br>The result matrix can also be stored for later use.<br>Press Mat (F1) then SHIFT then (−) (Ans) then → Mat (F1) then ALPHA followed by a letter not yet used for a matrix.<br>Press EXE.<br>Matrix E can now be used at will. |  <br>  <br>  | Note that the matrix that is recalled when Mat Ans is used is the most recently calculated result matrix. |

Matrix operations continued.

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| **Subtraction**<br>$2A-D$ |  <br>  | When multiplying a matrix by a number, the multiplication sign is not needed. |
| **Multiplication**<br>$BC$ |  | Note that the multiplication sign is not necessary in this calculation. |
| **Computing a power of a matrix.**<br>$A^4$ |  | |
| **Inverse**<br>$A^{-1}$<br>To enter the inverse, use the $x^{-1}$ command (SHIFT then ×⁻¹).<br>Press EXE to reveal the result. |  | Note that the brackets are not required here.<br>Also note you **can** use the power key (^) and -1.<br>  |
| **Determinant**<br>$\det A$<br>Press F3 (Det) then press F1 (Mat) then ALPHA and the appropriate letter.<br>Press EXE to reveal the result. |  | |

# SYSTEMS OF LINEAR EQUATIONS

## How do I solve systems of linear equations using EQUA?

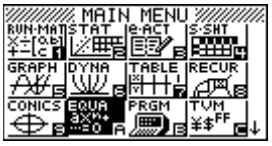
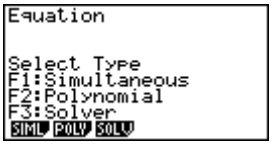
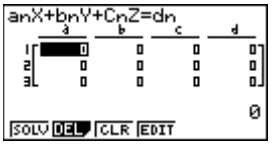
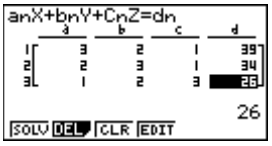
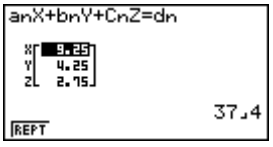
Example:

Suppose there are three different types of corn, of which there are three bundles of the first, two of the second, and one of the third making 39 *measures*. Two of the first, three of the second and one of the third makes 34 measures. And one of the first, two of the second and three of the third makes 26 measures. How many measures of corn are contained in one bundle of each type?
(This problem originally was printed in *The Nine Chapters on the Mathematical Art*, an ancient Chinese mathematics book.)
We can represent this problem as a system of linear equations, where the number of measures of each of the three types of corn can be represented by x, y and z respectively:

$$3x + 2y + z = 39$$
$$2x + 3y + z = 34$$
$$x + 2y + 3z = 26$$

To solve the system we can do the following.

### PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Press [MENU] and enter EQUA mode ([EQUA]) |  | |
| Press [F1] to select Simultaneous. |  | |
| Use the function keys, [F1] – [F5], to select the number of unknowns.<br>For this example, there are three unknowns. Press [F2]. |  | |
| Key in values. Press [EXE] after each entry.<br><br>Once complete, press [F1] to solve. |  <br>  | |
| The solution will be displayed. |  | Note that as each element is highlighted, if possible the fractional value of the number will be displayed in the bottom right of the screen. |

⚠ **Note that if the system of equations being solved has no solutions, or infinitely many solutions, the calculator will return Ma ERROR. It will not tell you which of the cases it is. Row operation will need to be used to determine this.**

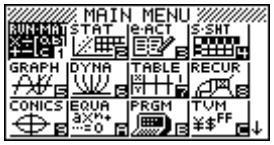
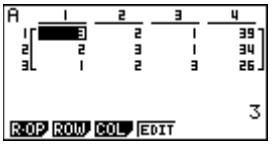
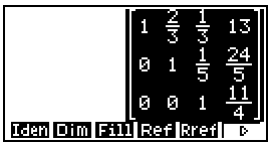
## QUESTION

**How do I solve systems of linear equations using row reduction?**

Solve the following system of equations:

$$3x + 2y + z = 39$$
$$2x + 3y + z = 34$$
$$x + 2y + 3z = 26$$

## SOLUTION

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the RUN·MAT application ( ). <br><br> Press F3 to enter the MATrix mode. |   | |
| Define Mat A to be a three by four matrix, of the coefficients and constants of the system |   | |
| Press EXIT. <br><br> Press OPTN, select MAT (F2) and then press F6 to see more options . |   | |
| Use the command: <br><br> Ref (F4) Mat A <br><br> to reduce Matrix A to row echelon form. |   <br>   | Note: when 'Mat' cannot be seen above one of the F keys, it can be found by pressing SHIFT then 2. |

## QUESTION

### How do I solve systems of linear equations using matrix operations?

Example:

Solve this system of linear equations:

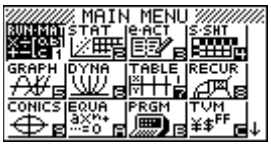
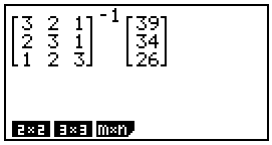
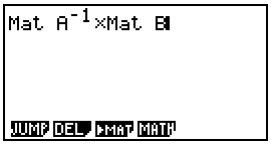
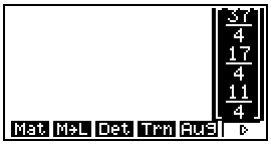
$$3x + 2y + z = 39$$
$$2x + 3y + z = 34$$
$$x + 2y + 3z = 26$$

This information can also be represented by a matrix equation in the form $Ax = B$ where

$A = \begin{bmatrix} 3 & 2 & 1 \\ 2 & 3 & 1 \\ 1 & 2 & 3 \end{bmatrix}$ and $B = \begin{bmatrix} 39 \\ 34 \\ 26 \end{bmatrix}$.

Hence we can find $x$ since $x = A^{-1}B$.

## PROCESS

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter the RUN·MAT application ( ). <br><br> Press F4 to enter the Math mode and then press F1 to bring up the MATrices options. |     | If you define the matrices as A and B first, then the same calculation can be made using Mat A and Mat B. This is shown below. |
| Press F2 to bring up a 3x3 template. <br><br> Use mxn (F3) and $x^{-1}$ to enter $A^{-1}B$ and press EXE |     |     |

**⚠ Note that if the system of equations being solved has no solutions, or infinitely many solutions, the calculator will return Ma ERROR when trying to compute the matrix product as the inverse of A will not exist. It will not tell you which of the cases it is. Row operation will need to be used to determine this.**

# POLYNOMIAL EQUATIONS.

# SOLVING POLYNOMIAL EQUATIONS

## QUESTION

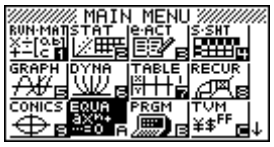
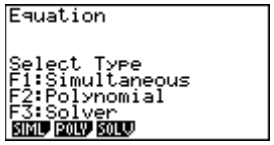
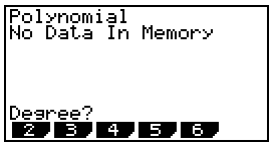
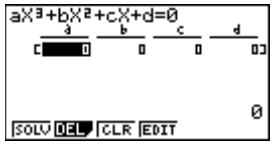
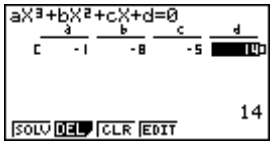
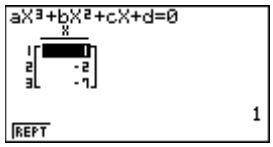
**How do I find the solutions to a polynomial equation?**

Example:

Solve of this equation:

$$-x^3-8x^2-5x+14=0$$

## SOLUTION

| ACTION | DIAGRAM | COMMENTS |
|---|---|---|
| Enter EQUA application ( ) |  | |
| Press F2 to select Polynomial. |  | |
| Use the function keys, F1 or F2, to select the degree of the polynomial, n this example, degree 3. |  | |
| Key in coefficients and constant of the equation. Press EXE after each entry.<br><br>Once complete, press F1 to solve. |  <br>  | Note the form that the equation must be expressed in to determine the values of a, b, c and d for correct entry is displayed at the top of the screen. |
| The solution will be displayed. |  | Note that all solutions of the polynomial equation are given.<br><br>We suggest that when solving polynomial equations it is wise to graph the polynomial first. You will then be able to see the x-intercepts (roots/solutions to the equation.) |

The End.
Good luck with your exam and your future.