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

Specifically the CASIO fx-9860G AU PLUS 2<sup>nd</sup> Edition

Written by Elena Zema Edited by Anthony Harradine and Alastair Lupton Do you know all there is to know about using your graphics calculator in the SACE Mathematical Methods Exam? Specifically the CASIO fx-9860G AU PLUS. 2<sup>nd</sup> Edition.

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Potts-Baker Institute for School Mathematics Prince Alfred College PO Box 571 Kent Town SA 5071.

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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 (ﷺ) application. To do this press ∰ then ∰ 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 ( ).  Press F5 to access the DISTribution menu.	SUB LIST I LIST 2 LIST 3 LIST U  E B B B B B B B B B B B B B B B B B B	
Press [F1] to access the NORMal distribution menu.	LIST I LIST 2 LIST 3 LIST 4 SUB 1 2 3 4 NORM CHI F BINN D	
Press <b>F2</b> to access NCD (normal cumulative distribution) function.	LiSt   LiSt   LiSt   LiSt   U	
Input the values. Press EXE after each entry.	Normal C.D  Data :Variable Lower : 0  UPPer : 0  Save Res: None  List  var   Normal C.D  Lower : -1e+99 ↑  UPPer : 125  0 : 0.37  P : 125.8  Save Res: None  Execute  DRAW	In this example, we want to find P(W<125).  The lower limit of -1E99 is used to reflect the characteristics of the normal distribution.  To find P(120 <w<125) 120="" 125.<="" and="" lower="" set="" td="" to="" upper=""></w<125)>
Once complete, press <b>F1</b> (or <b>EXE</b> ) to CALCulate the probability. The probability will be displayed along with the corresponding Z scores.	Normal C.D P =0.01530283 Z:Low=-2.703e+99 Z:UP =-2.1621622	Therefore, P(W<125) = 0.0153 (or 1.53%) - correct to 3 significant figures.
Alternatively, press <b>F6</b> to DRAW the normal distribution and shade the region of interest, as well as display the probability along with the corresponding Z scores.	z:Low=-2E99 z:Up=-2.162 P=0.0153028394	

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?

ACTION	DIAGRAM	COMMENTS
Enter the STAT application ( ).	MAIN MENU ///  RUMMITS AT PACT S SHIT  AT COMMITS AT COMMITS AT PACT S SHIT  AT COMMITS AT CO	
Press <b>F5</b> to access the DISTribution menu.	LIST I LIST 2 LIST 3 LIST 4  SUB  2  3  4  MRPH CALC TEST UNITE DIST	
Press <b>F1</b> to access the NORMal distribution menu.	List I List 2 List 3 List 4  SUB  2  3  4  NORM t CHI F BINM D	
Press [F3] to access InvN (inverse normal) function.	SUB LIST I LIST Z LIST 3 LIST U Z 3 U NP4 NC4 INVN	
Input the values. Press  after each entry.  Once complete, press  (or EXE) to calculate the value of the score.	Inverse Normal Tail :Left Area :0.95 0 :6 H :175 Save Res:None	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.	Inverse Normal x=184.869122	Therefore, x = 185 cm correct to 3 significant figures.

#### CONFIDENCE INTERVALS FOR THE MEAN

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  $^{\circ}$ C. Let  $\mu$  be the mean body temperature of all healthy men from this particular nation in 1990.

Assuming the population standard deviation is 0.5  $^{\circ}$ C, find a 95% confidence interval for  $\mu$ . PROCESS

ACTION	DIAGRAM	COMMENTS
Enter the STAT application (THE).	MAIN MENU  BUNMATSTATE CACT SSHT  X=1000 MEEE EST BEEEE  GRAPH DYNA TABLE RECUR  AWA BUNMATSTATE  CONICSEQUA PROM TOM  BXAN BEEF BL  STATE  BEEF BL  BEEF BL	
Press F4 to access the INTRerval menu.	SUB   LiSt   LiSt   LiSt   LiSt   U	
Press [F1] to access the Z menu.	LiSt	
Press <b>F1</b> to access the 1-S (one sample) function.	LiSt   LiSt 2 LiSt 3 LiSt 4	
Press <b>F2</b> to select VARiable.	1-Sample ZInterval  Data :Variable  C-Level :0 0 :0 0 :0 0 :0 0 :0 Save Res:None ↓  [List   Var	
Input the values. Press EXE after each entry.  Once complete, press F1 (or EXE) to calculate the interval.	1-Sample ZInterval C-Level :0.95 ↑ 6 :0.5 \$\overline{2}\$ :36.8 n :130 Save Res:None	Note that the standard deviation of the population is entered, <b>not</b> the standard error.
The confidence interval will be displayed.	1-Sample ZInterval Left =36.7140499 Risht=36.8859501 \(\overline{z}\) =36.8 n =130	

#### 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?

ACTION	DIAGRAM	COMMENTS
Enter the STAT application ( ) and then press F5 to access the distribution menu.	SUB LIST I LIST 2 LIST 3 LIST U  2  3  4  MRPH CALC TEST UNITE DIST	
Press <b>F5</b> to access the BINMomial distribution.	LIST   LIST 2 LIST 3 LIST 4 SUB LIST 4 LIST	
Press <b>[F1]</b> to access Bpd (binomial point distribution) function.	LiSt   LiSt 2 LiSt 3 LiSt 4	
Press [F2] to select VARiable.	Binomial P.D  Data :Variable x X Numtrial:0 P :0 Save Res:None Execute [List  Var	
Input the values. Press EXE after each entry.  Once complete, press F1 (or EXE) to calculate the probability.	Binomial P.D Data :Uariable x:2 Numtrial:5 P:0.015 Save Res:None	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.	Binomial P.D P=2.1503E-03	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?

ACTION	DIAGRAM	COMMENTS
Enter the STAT application  ( ) and then press F5 to access the distribution menu.	SUB   L:St   L:St   L:St   L:St	
Press <b>F5</b> to access the BINMomial distribution.	LIST I LIST 2 LIST 3 LIST 4 SUB 1 2 3 4 NORM t CHI F BIHM D	
Press <b>F2</b> to access Bcd (binomial cumulative distribution) function.	SUB I SUB I BPd Bcd InvB	
Press [F2] to select VARiable.	Binomial C.D  Data :Variable  X  Numtrial:0 P Save Res:None Execute [List   Var	
Input the values. Press EXE after each entry.  Once complete, press F1 (or EXE) to calculate the probability.	Binomial C.D Data :Variable x :2 Numtrial:20 P: :0.015 Save Res:None   xecute	The Bcd function only calculates "less than or equal to" probabilities.  In this example, we want to find P(Y>2), where Y can be modeled by B(5, 0.015).  So first we must compute P(Y≤2) and then subtract from 1.0
We can now compute 1- P(Y≤2).	1-0.99682191 0.00317809 0	

#### CONFIDENCE INTERVALS FOR THE PROPORTION

# 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.

ACTION	DIAGRAM	COMMENTS
Enter the STAT application ( ) then press F4 to access the INTRerval option.	SUB   LiSt   LiSt   LiSt   LiSt	
Press <b>F1</b> to access the Z menu.	List   List   List   List   List	
Press [F3] to access the 1-P (one proportion) function.	LiSt   LiSt   LiSt   LiSt	
Input the values. Press EXE after each entry.	i-Prop ZInterval  B-Level 18  x : 0  n : 0  Save Res:None Execute	
Once complete, press <b>F1</b> (or <b>EXE</b> ) to calculate the interval.	1-Prop ZInterval C-Level :0.95 x :212 n :401 Save Res:None Execute	Note that x is the number of "successes" in the sample (supporters in this case).
The confidence interval will be displayed.	1-Prop ZInterval Left =0.4798209 Risht=0.5775357 £ =0.5286783 n =401	

# ALGEBRAIC MODELS FOM DATA - WORKING FROM OBSERVATION

#### ALGEBRAIC GENERATION OF LINEAR MODELS

#### How do I obtain, assess and use a linear model?

#### Example:

Basil's height has been recorded at particular points in time. The data is presented in the table below:

Age (months)	36	48	51	54	57	60
Height (centimetres)	86	90	91	93	94	95

- a) Make a scatterplot of these data.
- b) Determine the equation of the linear model that best fits these data.
- c) Make a residual plot to help assess the appropriateness of the model.
- d) Predict Basil's height at the age of 65 months.
- e) According to the model, how old will Basil be when he is 89 cm tall?

ACTION DIAGRAM COMMENTS						
Enter the STAT application	DIAGRAIN	COMMENTS				
(THE).	MAIN MENU MENU MENU MENU MENU MENU MENU MEN					
Enter the SET UP screen of the STAT application by pressing SHIFT then WENU.  Scroll down to the Resid List setting and press LIST (F2) and	Stat Wind : Auto     Resid	Set the Stat Wind option to Auto. This will see the 9860 automatically choose the best view window setting for the data entered.				
then enter 3 to set the residual list to be List3.  When computed, the residuals will be placed in List3.	Stat Wind : Auto  Resid List : Lists  List File : File!  Sub Name : On  Frac Result : d/c  Func Type : Y=  Graph Func : On   None Man	Also note that the List File is set to File1. The 9860 has six files (a file is a set of twenty six lists) to choose from.				
Enter the age data into List and the height data into List 2.  Press EXE after each entry.	List   List	You can name the lists to suit the data. Type in the variable name into the SUB line.  When entering data, it is a good idea to place the independent variable's data (x) into List 1 and the dependent variable's data (y) into List 2.				
Select GRPH (press F1).  Press F6 to select SET.  Scroll down to adjust the StatGraph1 options.  For a scatterplot, scroll down to Graph Type and press F1 for Scat.  Check the correct lists are set for the x and y axes.	List   List a List a List u  SUB A90 Heisht  51 93 51 94 6 50 95 7 GPHI GPH2 GPH3 SEL SAP  StatterAph Type   Scatter  XList   List1 YList   List2 Frequency   1 Mark Type   10 GPH1 GPH2 GPH3	The process is continued on the next page.				
Press EXE or EXIT to return to the stat list window.						

DD00500 (+)		
PROCESS (cont.)	DIAODAM	COMMENTS
ACTION  From the stat list window, use GPH1 (F1) to make the scatterplot.  The scatterplot is displayed.	List   List	COMMENTS  You can also use the arrow keys, (♠,♠) to move the view window.)
To determine the equation of the linear model of best fit press CALC (F1), then select the linear option, X (F2), then choose the form for your linear model, ax+b (F1) or a+bx (F2).	TO EAST SAST DAM X RAUS	In the work below, the form ax+b (F1) has been selected.
The output screen displays the slope and intercept of the equation of the linear model of best fit, as well as Pearson's product-moment correlation coefficient, r, and the coefficient of determination, r².  The COPY option (F5) allows you to copy the equation of the linear model to both the Graph and Table applications. This is very useful for further analysis. In this case we have selected Y1 and then pressed [XE].	LinearRes a = 0.38333333 b = 71.95 r = 0.99437671 r = 0.98878504 MS = 0.15 y = ax + b  COPY DRAW  Graph Func V3: V4: V5: V6: U-1 V6: LinearRes a = 0.38333333 b = 71.95 r = 0.99437671 r = 0.99437671 r = 0.99878504 MS = 0.15 y = ax + b  COPY DRAW	Note that you can choose to copy the model into any of the Y positions, particularly if you have other functions defined.
Now press EXIT twice to return to stat list window and you will see that List3 has been populated with the residual	List   List 2 List 3 List 4   SUB	
You can now SET (F6) StatGraph2 to be a scatterplot of List3 vs List1 to make a residual plot.	StatGraph2 Graph Type :Scatter XList	This process is continued on the next page.

PROCESS (cont.)						
ACTION	DIAGRAM	COMMENTS				
To predict values using the linear model: Enter the GRAPH application	MAIN MENU  RIPHMANSTAT   e-ACT   S-SAT  Y-[-O-B] LEER   E-BCUR  GRAPH DYNA TTABLE RECUR  GRAPH DYNA TTABLE RECUR  CONICS EQUA   PRGM TVM  AXM-   B   B   Y S F   C    B   CONICS   E-CONICS   E-CONICS	You could also use the Table application ( ) for this step.				
The linear model of best fit was copied into Y1 earlier.  Note that is will be unselected and so you will have to press SEL (F1) to select it for graphing.	Graph Func :Y=  VIEW NO. SECTION SECTI					
Before drawing the equation, you should always check your view window settings. Press [SHF] then [F3] to check/change your settings. The setting will currently be those used for the residual plot. Change them to those shown opposite.  Press [EXIT] and then DRAW (F6) the function.	View Window  Xmin : 10  max : 100  scale: 1  dot : 0.79365079  Ymin : 0  max : 100  INNIT TRIG STO STO RCL					
To find a predicted y-value for a given x-value do the following.  Press G-SOLVE (SHFT, F5) to view options.  Then press (F6) view the rest of the menu.  Use Y-CAL (F1).  Enter the x-value and press EXE.  Both the x and y values will be displayed.	TRCE (000) MANU (54T)  V.CAL (X.CAL (74x)   D  Enter X-Value   X:65  V1=0.3833333338833333X	You could also find the predicted value in the RUN application.  Press WARS. Select GRPH (F4). Select Y (F1) then enter the x-value. Close bracket and press EXE.  Y1(65) 96.86666667				
To predict an x-value for a given y-value press G-SOLVE (SHFT), F5) to view options.  Then press (F6) view the rest of the menu, use X-CAL (F2).  Enter the y-value and press EXE.	Y1=0.3833333333333X 					

# ALGEBRAIC GENERATION OF EXPONENTIAL MODELS

How do I obtain, assess and use an exponential model? Example:

The table below gives the average daily flow rate from a gas site for the months shown.

	Relative time, t (months)	1	3	5	7	9	11
l	Rate of Gas Flow, f (MMscf/d)	51.717	36.717	28.066	22.199	16.377	13.403

- a) Graphically display theses data.
- b) Find an exponential model that best fits these data.

<u>Please complete the linear model task before starting this task. Knowledge of the processes involved in that task is assumed here.</u>

ACTION	DIAGRAM	COMMENTS
Enter the STAT application ( ).	BIRONAINI  MAIN MENU  RUHMATSTATI PACT SSHT  X-10 EEF BETT  GRAPH DYNA TABLE RECUR  AUT BUT BETT  CONICS EQUA PROM TVM  CONICS EQUA PROM TVM  B 45FF  B 250° B B 45FF	COMMULIATO
Enter the SET UP (SHIFT then MENU) and set the options as seen opposite. Set the residual list to List4 and make File2 active. This way the data in File1 will not be lost.	Stat Wind : Auto Resid List : List4 List File : File2 Sub Name : On Frac Result : O/c Func Type : Y= Graph Func : On  FILE	
Enter the time data into List  l and the flow data into List  2.	List 1 List 2 List 3 List 4  SUB time flow   1 22.199  5 9 16.377  6 11 13.403 7 1888 GREE TEST TENTS DEST	
Press <b>EXE</b> after each entry.		
Now select GRPH (F1).  Press F6 to select SET.	SUB time flow  4 2.199 5 9 16.377 6 11 13.403 7 GPHI GPH2 GPH3 SQL	
Scroll down to adjust the StatGraph1 options as shown opposite.	StatGraph: Graph Type :Scatter XList :List1 YList :List2 Frequency :1 Mark Type :•	
Press EXE or EXIT to return to the stat list window.	EHQD SHQD THQD	
From the stat list window, you can now make the scatterplot by pressing [F1].  The scatterplot is displayed.	LiSt   LiSt 2 LiSt 3 LiSt 4	From this plot it appears that an exponential model might be an appropriate model for these data.
	CALC DATE	This process is continued on the next page.

PROCESS (cont.)		
ACTION	DIAGRAM	COMMENTS
To obtain an exponential model we can now try to 'straighten' the data out by finding the natural logarithm of the flow data.  Put the cursor in the very top of List3. Enter In then press OPTN, then LIST (F1) and then List (F2) followed by 2.	List   List 2   St 2   List 4    SUB time   flow   In flow	
Press EXE. This will result in List3 being populated with the natural logarithms of each value in List2.		
We can then make a scatterplot of the natural logarithm of flow by time. To do this we have SET up StatGraph2.	Stationaph2 Graph Type :Scatter XList :List1 YList :List3 Frequency :1 Mark Type :•  [GPHI   GPHI   GPHI	
	CALC DefG	
We can then find the linear model of best fit for these data.	EUNAR   X   Med   X \ Z   X \ 3   D	You can now use the laws of natural logarithms to convert the following equation to the more common exponential form: $\ln f = -0.134t + 4.036 \ .$
	T EVX SAX DOM X ARUS	
Pressing EXIT twice returns us to the stat list window and we find the residual values have filled List4.	List   List 2 List 3 List 4 Sub time   flow   In flow   1 Sining   0.0446   2 3 36.717   3.5032 - 0.029   3 5 28.066 3.3345 - 0.029   4   7 22.199   3.945.786548   GPH1   GPH2   GPH3   SQL	This process is continued on the next page.

PROCESS (cont.)		
ACTION	DIAGRAM	COMMENTS
To help assess this model, we can make a scatterplot of the residual values vs time.  We have SET up StatGraph3 to be this plot. See the settings opposite.	StatGraph3 Graph Type :Scatter XList :List1 VISU :List4 Frequency :I Mark Type :•	
Drawing GPH3 reveals the residual plot.		

#### ALGEBRAIC GENERATION OF POWER MODELS

How do I obtain, assess and use a power model?

Example:

Consider the data in the table below.

Х	1	3	5	7	9	11
У	1.3	8.6	27	47.1	84	116.3

a) Determine whether or not a power model is an appropriate model for these data.

<u>Please complete the linear model and exponential model task before starting this task.</u> Knowledge of the processes involved in those tasks is assumed here.

#### PROCESS

To complete this task we will try to 'straighten' the data out by finding the natural logarithm of both the x and y data.

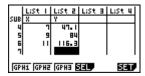
The following summarises the process. Specific detail is not provided as we have assumed you have completed the linear and exponential model task.

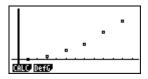
Firstly, we set the Stat application to use File3 (this is not necessary if you are happy to delete the data from previous tasks. We also set the residual list to List5 as we will use List3 and List 4 to compute the natural logarithm of the x and y data respectively.





After entering the data, we look at a scatterplot of y vs. x and note it is certainly non-linear.



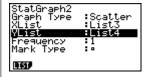


We can now proceed to try and 'straighten out' these data by computing the natural logarithms of both the x and y data.



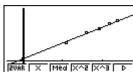


Now, we produce a graph of ln y vs. In x and find the linear model of best fit.





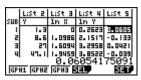


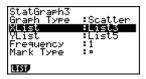


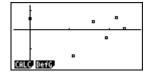
Now, using the laws of natural logarithms you can transform the following into the more traditional form of a power model:

$$\ln y = 1.90 \ln x + 0.202$$

Finally, we can produce a residual plot to assist us in assessing the goodness of fit of this power model.







<u>CALCI</u>	ULUS -	DESC	CRIBIN	NG CH	<u>ANGE.</u>

#### DERIVATIVES AND RELATED THINGS

How do I find the average rate of change? Example:

If  $f(x) = \ln x$ , find the average rate of change of f(x) for the interval  $3 \le x \le 6$ .

ACTION	DIAGRAM	COMMENTS
Enter the GRAPH application	MAIN MENU SHI	
Define Y1 to be the function required and press [X]. Note the = sign is 'blackened' telling you this function will be graphed.  Before drawing the function, you should always check your view window. Press [SHFT] then [F3] to check/change your settings.  Press [F6] to DRAW the function.	Graph Func : Y= Y181n X [—] Y3: [—] Y4: [—] Y5: [—] Y6: [—] Y6: [—] [SEL 035 W35 SW5 AMB   DRAW	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.  View Window Wmin :-6.3 max :6.3 scale:1 dot :0.1 Ymin :-3.1 max :3.1 INITIREGISTO SIO CCL
Enter the RUN application	MAIN MENU /// STAT leact   S.SHT  MAIN STAT Leact Leact   S.SHT  MAIN STAT Leact Leact Leact   S.SHT  MAIN STAT Leact	
Press (MRS) then GRPH (F4) and then use Y (F1) and 11 to enter Y1 (which is the function we are interested in). Complete the calculation as shown opposite.	(V1(6)-V1(3))÷(6-3) 0.2310490602 V r xt Vt x	

# How do I find an approximation for the instantaneous rate of change using the trace function?

(Note that this process is equivalent to finding the derivative of the function at the stated point and finding the gradient of the tangent to the function at the stated point.

#### Example

Find the instantaneous rate of change at x=2 if  $y = \ln x$ .

ACTION	DIAGRAM	COMMENTS
Enter the GRAPH application (ARAPH).	MAIN MENU SING SING SING SING SING SING SING SING	
To use the trace function to find the derivative, you will need to check the SET UP.  Press SHIFT then WENU to access the SET UP options.  Turn the Derivative option On	Draw Type :Connect Graph Func :On Dual Screen :Off Simul Graph :Off Derivative :On Background :None Sketch Line :Norm ↓	Note that when the Derivative option is turned On, some computations will take longer than when it is turned Off.
(F1).  Press EXE or EXIT to return to the graph editor window.		
Define Y1 to be the function required and press [XE]. Note the = sign is 'blackened' telling you this function will be graphed.  Before drawing the function, you should always check your view window. Press [SHFT] then [F3] to check/change your settings.  Press [F6] to DRAW the function.	Graph Func :Y= V1Bln X [-] V3: V4: V5: V6: V6: V6: V6: V6: V6: V6: V6: V6: V6	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.  View Window Mini - 6.3 max
To activate the Trace option, press SHFT then F1.  Enter the x-value using the keypad (2 in this case) and press EXE.  The derivative is displayed.	Yi=ln X Enter X-Value X:21  Yi=ln X  Yi=ln X  Yi=ln X  Yi=ln X  Yi=ln X	Note that the value computed is an approximation for 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.  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).
	X=Z Y=0.6931471806	

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	MAIN MENU /// MA	
Press <b>F4</b> to access the MATH options.	SUMP DELY PHAT MAIP	
Press F4 to select the d/dx function.	MATE TOTAL FIRS SAME SAME:	
Enter the function, then arrow across and enter the x-value for which you want to evaluate the derivative. Press EXE.	d	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.  In Run application, once d/dx( is entered, press (F1) and then use Y (F1) and 1.	$\frac{\frac{d}{dx}(\ln X) _{x=2}}{\frac{d}{dx}(Y^{1}) _{x=2}} = 0.5$	

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)

How do I display the tangent to a curve at a given point and find its gradient?

#### Example:

Find the gradient of the tangent to the curve  $y = \ln x$  at x = 2.

ACTION	DIAGRAM	COMMENTS
Enter the GRAPH application	MAIN MENU SHIT SHIT SHIT SHIT SHIT SHIT SHIT SHIT	
To find the equation of a tangent, you will need to check the SET UP. Press SHIFT then MENU to access the SET UP options.  Turn the Derivative option On (F1).	Draw Type :Connect Graph Func :On Dual Screen :Off Simul Graph :Off Derivative :On Background :None Sketch Line :Norm ↓  On  Off	Note, if you do not turn the Derivative option on, the equation of the tangent/normal will not be displayed on the screen.
Press EXE or EXIT to return to the graph editor window.		
Define Y1 to be the function required and press [XE]. Note the = sign is 'blackened' telling you this function will be graphed.  Before drawing the function, you should always check your view window. Press [SHIF] then [F3] to check/change your settings.  Press [F6] to DRAW the function.	Graph Func : Y= Y181n X	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.  Uiew Window Main 16.3  max 16.3  scale:1 dot 10.1 Ymin 1-3.1 max 3.1  INIT TRIG STO STO RCL
Press SKTCH (SHIFT), [F4]) to view options. Select Tang (F2).	TRCE 2000 ILANS SHICP (SSID) GFT	
Enter the X-value using the keypad. You must press EXE twice in order for the tangent to appear.  The tangent at that point will be displayed along with its equation (and therefore gradient and y-intercept).	V1=ln X Enter X-Value	Note, if you do not turn the Derivative option on, the equation of the tangent will not appear on the screen.  Note that these results are approximations for the exact values. If exact values are required, used algebraic methods.

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  $y = xe^{-x}$ .

#### **PROCESS**

ACTION	DIAGRAM	COMMENTS
Enter the GRAPH application ( ) and define Y1 to be the function required and press EXE.	MAIN MENU WHAT SHIT EST SHIT SHIT SHIT SHIT SHIT SHIT SHIT SH	Before sketching the function, you should always check your view window.  Press SHFT then F3 to check/change your settings.  View Window  Max 16.3  Scale:1  dot  Ymin :-3.1  INITITIESTO STO COL  You can often use the zoom options (press SHFT, F2) to help view the function.  Often, Auto works well, especially if you set the domain sensibly.
Press <b>F6</b> 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:  Press G-SOLVE (SHFT, F5) to view options. Select MAX (F2).  Use MIN (F3) to locate a local minimum (should there be one).	ROOT MAX MIN WICHT ISCT D	
The calculator will display the coordinates of the local maximum (or local minimum).	V1=Xe^-X 	If more than one local maximum (or local minimum) is in view, use the arrow keys ( , ) to move to the next one.

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.

<u>To find all stationary points</u>, 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.

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

Example:

Find the coordinates of the point of inflection of  $y = \frac{100}{1 + 5e^{-2x}}$  .

ACTION	DIAGRAM	COMMENTS
Enter the GRAPH application ( Are) and then define Y1 to be the function required and press E.	Graph Func :Y= VIB-100 1+5e <sup>-2X</sup> [] V3: V4: [] SEC 035 WAS SWD 3MED DRAW	Before sketching the function, you should always check your view window. Press SHFT then F3 to check/change your settings.  View Window Mini :- 18  Max : 18  Scale: 1  dot: 0.15873015  Ymin : 0  Max : 100  [INIT   TRIG   STO   ROL
Press F6 to draw the function.		You can also use the zoom options (press SHFT, 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.  Press OPTN, select CALC (F2) and then press F1 to select d/dx.	Graph Func :Y=  V18	
Select Y (F1) then enter 1.  Arrow across and enter X (X.A.T). Press EXE.	Graph Func : Y= $\frac{100}{1+5e^{-2X}}$ [-] $\frac{d}{dx}$ [Y1] $\frac{d}{dx}$ [-] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y1] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y1] $\frac{d}{dx}$ [Y1] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y1] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y1] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y3] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y3] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y3] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y3] $\frac{d}{dx}$ [Y2] $\frac{d}{dx}$ [Y3] $\frac{d}$	Continued on the next page.

#### Inflection (continued) ACTION COMMENTS DIAGRAM Press **F6** to draw both Functions will be graphed in functions. order of being entered. You do not need Y1 to be graphed and so you could use the SEL (F1) function in the graph editor to deselect Y1. This will also speed up the process. We need to find the turning The x coordinate of the maximum of the derivative point (local maximum in this case) of the derivative function gives the x coordinate function, Y2. of the inflection point of the function. Press G-SOLVE (SHIFT, F5) to ROOT MAX MIN VIORT ISCT | D view options. Select MAX Y2=d/dx(**Y**1<sub>2</sub>X) (**F2**). Use the arrow keys ( , ) to select the function for MAX which the local maximum is required and press [EXE]. The coordinates of the local Note that the calculator maximum will be displayed. Y2=d/dx(**Y**1, returns an approximation for the exact value of x at which This provides the x coordinate the local maximum occurs. of the point of inflection of MAX X=0.804715 To find the y coordinate of the You could also find the y point of inflection: coordinate of the point of Press G-SOLVE (SHIFT, F5) to inflection in the RUN view options. application. Then press (F6) view the rest Press (VARS) (variable menu). V-CAL X-CAL JAdx Select GRPH (F4). of the menu. Press Y-CAL (F1). Y1=100÷(1+5e^(-2X)) Select Y (press F1) then enter the x-coordinate (0.0804715). Use the arrow keys ( , ) Close brackets and press [EXE]. to select the function you Y-CAL would like to use (Y1) and press **EXE**. **V**1(0.804715) 49.99980219 Enter X-Value Enter the x-coordinate (0.804715 in this case) and X:0.804715 press **EXE**. Y r Xt Yt X The calculator will display the Y1=100÷(1+5e ^(-2X)) coordinates of the required point. | \ Y-CAL Y=49.99980219 X=0.804715

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.

# WORKING WITH MATRICES.

#### MATRICES

#### How do I define a matrix?

ACTION	DIAGRAM	COMMENTS
Enter the RUN-MAT application ( ).  Press F3 to enter the MATrix mode.	MAIN MENU  MAIN MENU  STAT LEACT S-SHT  LEB EST SETTING  GRAPH DYNA TABLE RECUR  WHITE AND	
	JUMP DELP PMAT MATH	
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.	Matrix Wal H None Mat B None Mat C None Mat C None Mat E None Mat E None Mat E None Mat E None	
	Matrice Matric	
Enter the matrix elements.  Press EXE after each entry.		If an error is made, simply highlight and overtype or press [F4] to edit.
	ROP ROW COL FEDET	
To define another matrix, press [EXIT] and define the size of the next matrix.	Material	To begin performing matrix operations, you will need to press EXIT to return to the calculation area.
	B _ 1 _ 2 _ 3 _ 11 _ 2 _ 2 _ 2 _ 2 _ 2 _ 2 _ 2 _ 2 _ 2 _	
	ı	

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 and  $A^4$  .

#### SOLUTION

ACTION	DIAGRAM	COMMENTS
The following assumes the above matrices have been defined. Enter the application press OPTN and select MAT (F2).	CISI MAT CRES CALC STATE -	
Various options are now available at the bottom of the screen. Use the function keys (F1 to F6) to select.	Mat Mal Det Trn Aus o	Note: the 'Mat' entry (that is so common in this topic) can also be found by pressing SHIFT then 2.
$\begin{array}{c} {\sf Addition} \\ {\it A+D} \end{array}$	Mat A+Mat Di	
Press Mat (F1) then ALPHA (which allows entry of the red letters) then KAT to enter A.  Then enter  and then Mat D in a similar way.	Mat Mat Det Trn Gus D  Mat A+Mat D  [4 2]  [3 5]	
Press EXE to reveal the result matrix.	Mat Mal Det Trn Gus D	
Using and storing a result.  The result matrix can be used for another calculation by	Mat A+Mat D Done 2×Mat Ans	Note that the matrix that is recalled when Mat Ans is used is the most recently calculated result matrix.
using the Mat Ans command.  To do so, press Mat (F1) then  (Ans).	Mat Mat Det Trn Aus D  Mat Harmat D  [4 2] 2×Mat Ans [8 4]	
The result matrix can also be stored for later use.  Press Mat (F1) then SHIFT then  (→) (Ans) then → Mat (F1)  then ALPHA followed by a letter not yet used for a matrix.  Press EXE.	8   4   6   10   10   10   10   10   10   10	
Matrix E can now be used at will.		

Matrix operations	continued.	
ACTION	DIAGRAM	COMMENTS
Subtraction $2A-D$	2Mat A-Mat D	When multiplying a matrix by a number, the multiplication sign is not needed.
	Mat Mal Oat Trn Aus D  2Mat A-Mat D  [2 1] [9 4]  Mat Mal Oat Trn Aus D	
Multiplication  BC	Mat B×Mat C [-2]    Mat M*L Det Trm Aus   D	Note that the multiplication sign is not necessary in this calculation.
Computing a power of a matrix. $A^4$	Mat A <sup>4</sup> [164 105] [420 269]  Mat Mat Oat Trn Aus D	

# LINEAR PROGRAMMING.

How do I graph an inequality?

Example:

Sketch  $y \le 2x + 1$ .

Enter the GRAPH application    Press   F6   to view other options.	
Press F6 to view other options.  Select the appropriate inequality form.  In this example, select Y≤  (F3).  Enter the rest of the inequation and press □E.  Enter the rest of the inequation and press □E.  Enter the rest of the inequation and press □E.	
Press F6 to view other options.  Select the appropriate inequality form.  In this example, select Y≤  (F3).   Enter the rest of the inequation and press 図.  Enter the rest of the inequation and press 図.  Enter the rest of the inequation and press 図.  Enter the rest of the inequation and press 図.  Before sketching the funcyou should always check	
Select the appropriate inequality form.  In this example, select Y≤ (F3).    Graph Func : Y=   Y=   Y=   Y=   Y=   Y=   Y=   Y=	
Select the appropriate inequality form.  In this example, select Y≤ (F3).  Enter the rest of the inequation and press EXE.    Craph Func : Y=   Y =	
Enter the rest of the inequation and press EXE.    Graph Func   Y=   Y4:	
inequation and press EXE.    Graph Func : Y≤   Y=   Y=   Y=   Y=   Y=   Y=   Y=	
View window. Press SHIFT  F3 to check/change you settings.  View Window Window Window 1-6-3 max :6-3 scale:1 dot:0.1 Ymin :-3.1 Ymin :-3.1 max :3.1 INIT TRIG STO STO RCL	ar at ulator nction, c your then
Press F6 to DRAW the inequality.	

# How do I graph a feasible region and determine the optimal solution?

Example:

a) Sketch the region bounded by the following constraints and shade the feasible region:

$$y \le 10 - x$$

$$y \ge x - 4$$

$$y \le 2x + 1$$

$$x \ge 0$$
 and  $y \ge 0$ 

- b) Determine the coordinates that are potential optimal solutions.
- c) If the objective function is P = 2x y, determine the optimal solution that maximises the value of

ACTION	DIAGRAM	COMMENTS
Enter the GRAPH application (FARE).	MAIN MENU WHITE SHIP SHIP SHIP SHIP SHIP SHIP SHIP SHIP	
Select TYPE (F3).	Graph Func :Y=  V2:  V3:  V3:  V4:  V5:  V6:  V6:  V6:  V6:  V6:  V6:  V6	
Press <b>F6</b> to view other options.  Select the appropriate inequality form.	Graph Func : Y=  V2:  V3:  V4:  V4:  V5:  V6:  []  V6:  [Y= r=   Parm   X=C   MONUM   D	
Enter each constraint.	Graph Func : Y=	
	Graph Func : Y≥  V16[0-X  V26X-4	
Select <b>F6</b> to DRAW the feasible region.		Before sketching the function, you should always check your view window. Press SHFT then F3 to check/change your settings.  View Window State 10 Scale: 1 dot: 0.15873015 Vmin: 10 max: 10 INIT TRIGISTO STO ROL

To determine the coordinates of the points that are potential optimal solutions (vertices of the feasible region) press G-SOLVE (SHIFT then F5) to view options.	TREE SOUND BANKS BANKS (GAT	
Select ISCT (F5).	ROOT MAX MIN PHOP ISCT D	
Use the arrow keys ( ,  ) to select the first of the pair of lines that intersect at the point you wish to find, press and then select the second line and press	V1≤10-X V2≥X-4 N=7 V≤3 ISECT	You may also need to find the x-intercept.  Press G-SOLVE (SHFT, F5) to view options. Select ROOT (F1).  Use the arrow keys ( , ) to select the line for which the
The coordinates of the point of intersection will be displayed at the bottom of the screen.  Repeat this process until all vertices are found.	V1410-X V342X+1 ♣ X=B Y41 ISECT	x-intercept is to be found and press EXE.
To find the optimal solution,		N=W YED ROOT
enter the RUN application	MAIN MENU  SSHT  S	
Substitute each of the coordinates into the objective function and compute its value.	2(7)-3 2(4)-0 2(3)-7 -1	

# SOLVING EQUATIONS.

How do I solve an equation graphically?

Example:

Solve the equation:

 $20(0.8)^{x} = 14$ 

#### SOLUTION

ACTION	DIAGRAM	COMMENTS
Enter the GRAPH application ( ).	MAIN MENU WWW.  RUNHMISTAT PACT SSHI  FICAL BEEF BETT BETT BETT BETT BETT BETT BETT	
Define Y1 to be the left hand side of the equation and press [XE].  Define Y2 to be the right hand side of the equation and press [XE].	Graph Func :Y= V1820(0.8) <sup>X</sup> [—] V2814 [—] V4: [—] V5: [—] ISEL 035 NWS NWS NWW NAME   DRAW	Before sketching the functions, you should always check your view window. Press SHFT then F3 to check/change your settings.
Press F6 (or EXE) to graph.		
To determine the solution of the equation, find the intersection point(/s) of the two functions.		The calculator will find one intersection point even if it is not displayed in the graph view window.
Press G-SOLVE (SHFT, F5) to view options. Select ISCT (F5).	ROOT MAX MIN WICHT ISCT D	However, if there is more than one intersection point, it will not locate both unless BOTH are visible. The move from one intersection point to the other press the left or right arrow keys ( , ).
The solution will be displayed (x-coordinate).	V1=20(0.8)^% V2=14 V2=14 ISECT	

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.

How do I solve an equation using Solver in EQUA?

Example:

Solve the equation:

 $20(0.8)^x = 14$ 

#### SOLUTION

ACTION	DIAGRAM	COMMENTS
Enter EQUA application.	MAIN MENU WHEN SHIP SHIP SHIP SHIP SHIP SHIP SHIP SHIP	
Press <b>F3</b> to select Solver.	Equation  Select Type F1:Simultaneous F2:Polynomial F3:Solver MMU 2014 MOLU	
Enter the equation to be solved.  Press EXE.  The value of x shown is NOT the solution, but the last value of x used by the 9860.  Make certain the cursor is placed on the second line and the press Solv (F6).	Eq: 20(0, 8) <sup>X</sup> =14 X=2 Lower=-9E+99 Upper=9E+99 RES DES	The lower and upper bounds form the domain in which the calculator will search for a solution. You can change them as desired.
The solution will be displayed.  To solve another equation, press REPT (F1).	Eq:20(0.8) <sup>X</sup> =14 X=1.598410269 Lft=14 Rgt=14	We suggest that when solving equations it is wise to graph first. You will then be able to see the intersection point (solutions to the equation).  The Lft and Rgt values are the values of the left and right side of the equation for the value of x found. If they are equal, then you know the solution is correct.

This process will only return one solution to the equation. There may be other solutions. You can change the first value of x that appears to a different value and another solution may be found.

Also, the values computed are approximations for the exact value of solution being found.

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

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 (	MAIN MENU MAIN MENU MENU MENU MENU MENU MENU MENU MEN	
Press <b>F2</b> to select Polynomial.	Equation  Select Type F1:Simultaneous F2:Polynomial F3:Solver MMD 200 MUD	
Use the function keys, <b>[F1]</b> or <b>[F2]</b> , to select the degree of the polynomial, n this example, degree 3.	Polynomial No Data In Memory Degree? 2 3 4 5 6	
Key in coefficients and constant of the equation. Press EXE after each entry.  Once complete, press F1 to solve.	aX³+bX²+cX+d=0 c	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.
	SOLV DEL CLR EDIT	
The solution will be displayed.	aX3+bX2+cX+d=0 [2[-2]-1] [REPT]  1	Note that all solutions of the polynomial equation are given.  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.