South Australian Certificate of Education

General Mathematics 2025

Question booklet

- Questions 1 to 9 (90 marks)
- Answer ***all*** questions
- Write your answers in this question booklet
- You may write on pages 9 and 26 if you need more space

Suggested Solutions in purple

Additional detail and notes (not part of the solution) in pink

Examination information

Materials
- Question booklet
- SACE registration number label

Instructions
- Show appropriate working and steps of logic in this question booklet
- Use black or blue pen
- You may use a sharp dark pencil for diagrams and graphical representations
- Approved calculators may be used — complete the box below

Notes on use of the CASIO fx-1AU GRAPH in green

Total time: 130 minutes
Total marks: 90

Note: not the SACE Board Solutions - may contain errors.

The SACE Board of South Australia acknowledges that this examination was created on Kaurna Land. We acknowledge First Nations Elders, parents, families, and communities as the first educators of their children, and we recognise and value the cultures and strengths that First Nations students bring to the classroom. We respect the unique connection and relationship that First Nations peoples have to Country, and their ever-enduring cultural heritage.

Attach your SACE registration number label here	**Graphics calculator** 1. Brand _____ Model _____ 2. Brand _____ Model _____

Government of South Australia

Question 1 (5 marks)

Table 1 below describes the steps involved in producing an online advertising video.

Table 1

Task	*Description*	*Time to complete (days)*	*EST (days)*	*LST (days)*	*Prerequisite task(s)*
A	Decide on a theme	2	0	0	None
B	Prepare storyboard and write script	10	2	2	A
C	Obtain equipment and props	5	2	7	A
D	Cast and hire actors	7	12	13	B
E	Hire production workers	3	12	12	B, C
F	Prepare scenes and wardrobe	5	15	15	E
G	Record scenes	12	20	20	D, F
H	Edit recorded scenes	8	32	32	G
J	Combine scenes and finalise video	2	40	40	H
K	Prepare website and upload video	1	42	42	J

(a) State the critical path for producing the online advertising video.

A B E F G H J K

as B > C

as E + F > D

* It may be easier to start with part (c) on the next page, then answer (a) and (b) *

(1 mark)

(b) State the minimum completion time for producing the online advertising video.

43 days (= 2 + 10 + 3 + 5 + 12 + 8 + 2 + 1)

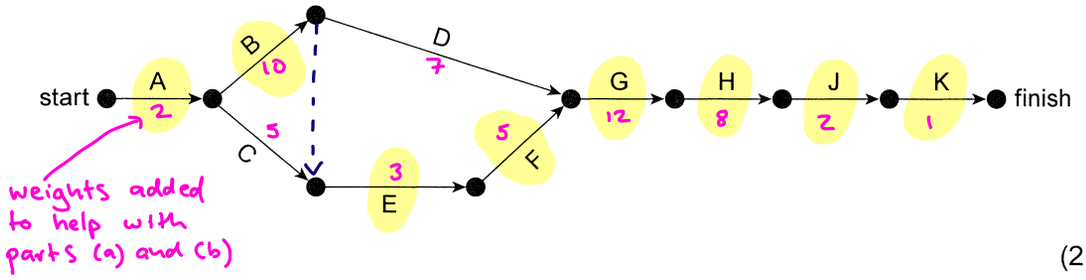
(1 mark)

The network diagram below shows the steps involved in producing an online advertising video.

The network diagram is missing a dummy link.

One way to start this qu. is to compare the task info with this diag. From there, it may be easiest to answer part c first!

(c) Using information from Table 1, *draw* the missing dummy link on the network diagram.



weights added to help with parts (a) and (b)

(2 marks)

It now takes an extra 6 days to hire the production workers.

(d) State why this will increase the minimum completion time of the online advertising video by 6 days.

Task E is on the critical path

(1 mark)

Question 2 (8 marks)

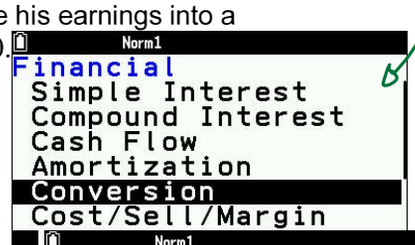
Hamish worked as a lifeguard over the summer holidays. He wants to place his earnings into a high-interest savings account to save up for a Jet Ski currently worth $9000.

He considers two options offered by his current bank.

- Account A: interest rate of 4.20% per annum, compounded weekly
- Account B: interest rate of 4.28% per annum, compounded quarterly

The effective annual interest rate of Account A is 4.29%.

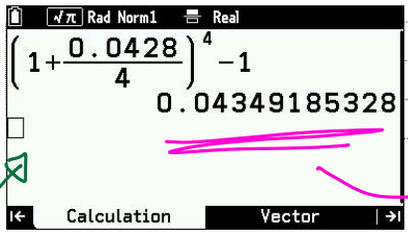
Open the Financial app and choose Conversion



n=4

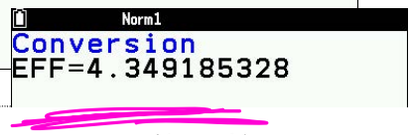
If you know this formula, evaluate it in the Calculate app.

(a) Calculate the effective annual interest rate of Account B.



4.35 %

answer as a decimal



ans. as %

(1 mark)

Hamish then sees a third option, Account C, which has an interest rate of 4.40% per annum.

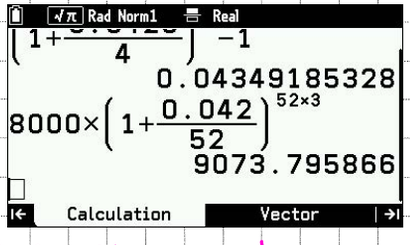
(b) Under what conditions will the effective rate for Account C be equal to the advertised rate of 4.40% per annum?

Tick the appropriate box to indicate your answer.

- ☐ The advertised rate compounds daily.
- ☐ The advertised rate compounds fortnightly.
- ☐ The advertised rate compounds monthly.
- ☑ The advertised rate compounds annually. (1 mark)

Hamish places a sum of $8000 into Account A for 4 years.

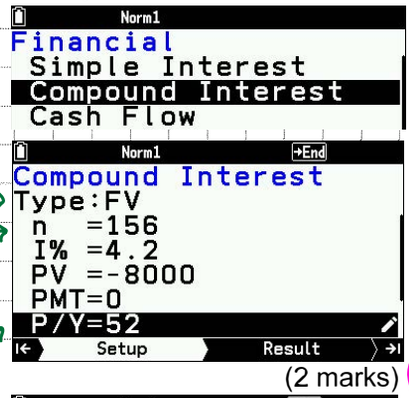
(c) (i) Calculate the balance in his savings account at the end of the third year.



$8000\times\left(1+\frac{0.042}{52}\right)^{52\times3}$
$= \$9073.80$

or

n = 52×3 = 156
i = 4.2%
PV = −$8000
PMT = 0
P/Y = C/Y = 52
⇒ FV = $9073.80

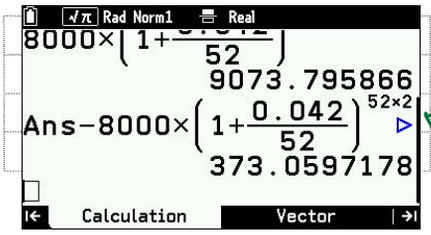


(2 marks)

As this question is worth 2 marks, working (either) should be shown

- choose Future Value (FV) as 'Type'
- you can enter n as 52×3
- change P/Y to 52, this sets C/Y = 52

(ii) Calculate the interest Hamish earns during the third year of his savings account.

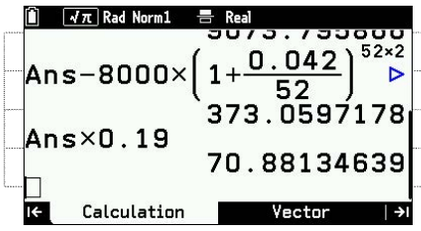


$373.06

If you know how to "copy + paste" on your fx-1 it is a good time-saver (duplicate above line, change the 3 to a 2)

(1 mark)

(iii) Hence, calculate the tax he must pay on the interest earned in part (c)(ii), if his marginal tax rate is 19%.



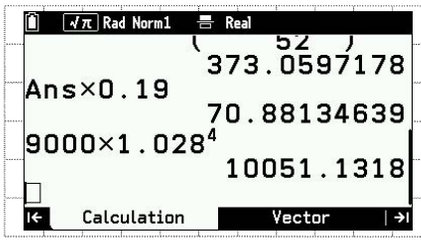
$70.88

The handy "Ans" (answer) is inserted by starting a line with an operator like "−" or "×" (or use ALPHA + FORMAT keys)

(1 mark)

The value of a Jet Ski is assumed to rise in line with inflation at a rate of 2.8% per annum.

(d) If the balance on the account after 4 years is $9462.85, use appropriate mathematical calculations and reasoning to determine if Hamish can afford to buy the Jet Ski.



The jet ski will cost $10,051.13 in four years if its price rises with inflation of 2.8%. As this is more than the value of Hamish's account of $9462.85 in four years, he cannot afford to buy the jet ski without additional funds

(2 marks)

Additionally, the tax payable on the interest earned further decreases the funds that Hamish could spend on a jet ski.

Question 3 (9 marks)

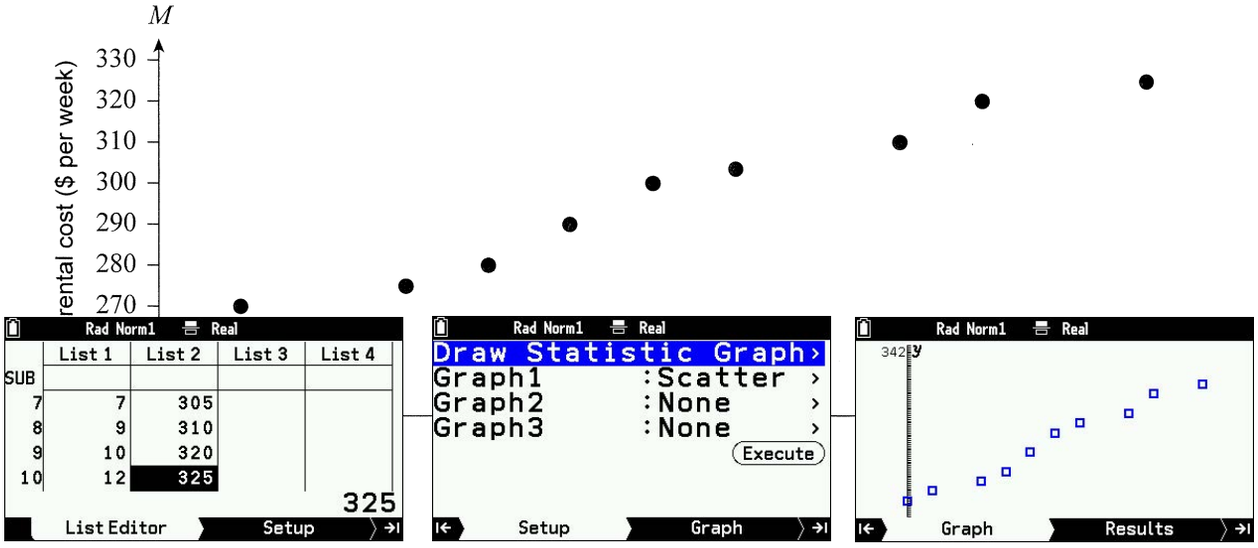
The median rental costs in metropolitan Adelaide have been steadily increasing. Table 2 below shows the median weekly rental cost *(M)* of private rental properties in metropolitan Adelaide from 2005 to 2017, where t is the time in years since 2005.

Table 2

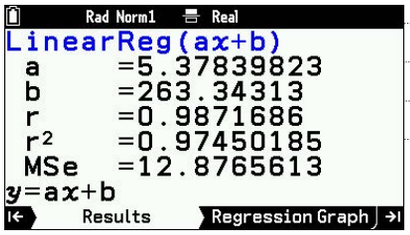
Years since 2005 (t)	0	1	3	4	5	6	7	9	10	12
Median rental cost (M) ($ per week)	265	270	275	280	290	300	305	310	320	325

Scatter plot 1 below displays this data.

Scatter plot 1: Metropolitan Adelaide median weekly rental costs 2005–2017



(a) By applying a linear model, calculate the value of Pearson's Correlation coefficient (r).



$r = 0.987$

- enter data
- choose Draw Statistics Graph (default is a scatterplot of list 1 vs list 2)
- choose Linear Reg from Results

(1 mark)

The data from Table 2 can be modelled using the linear model, $M = 5.38t + 263$.

(b) Interpret the meaning of 5.38 in the context of this question.

5.38 is the average annual increase in median weekly rental cost in Adelaide between 2005 and 2017, according to this data set.

(2 marks)

Using the linear model, $M = 5.38t + 263$, it can be predicted that the median weekly rental cost in 2013 is approximately \$306.

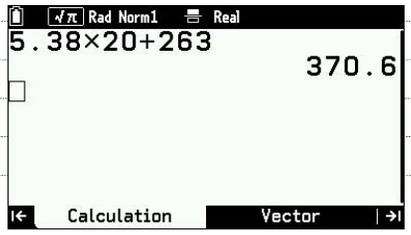
(c) (i) State *two* reasons why the predicted median weekly rental cost of \$306 in 2013 could be considered reasonable.

The linear model seems like an appropriate one for this data set as it has a linear appearance and a 'r' close to 1.

2013 corresponds to $t=8$, which lies within the range of the data, making the prediction an interpolation of the observed trend captured by the linear model.

(2 marks)

(ii) Predict the median weekly rental cost in 2025.

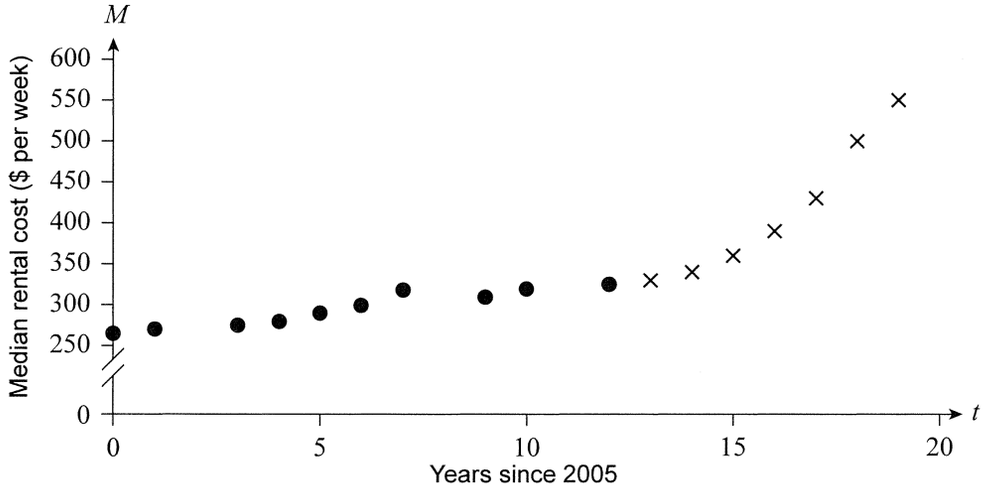


\$ 370.60

(1 mark)

Additional data from 2018 through to 2024 has since been collected and added to the original Scatter plot 1 to create Scatter plot 2 below.

Scatter plot 2: Metropolitan Adelaide median weekly rental costs 2005–2024



(d) State why it is **not** appropriate to apply a linear model to the data from 2005 to 2024.

The dataset from 2005 to 2024 does have a linear shape, with a clear curve or change in direction happening around 2020

(1 mark)

The data for the median weekly rental costs for 2018 through to 2024 is displayed in Table 3 below.

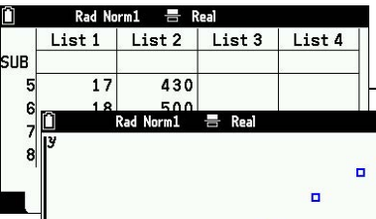
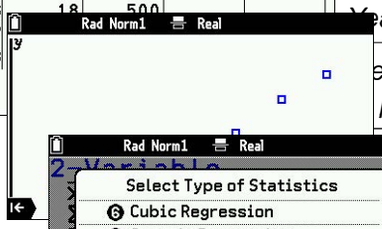
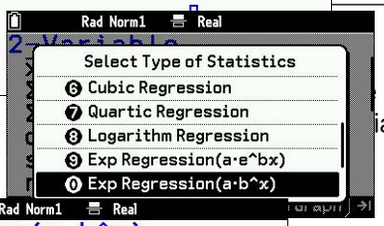


Table 3

Years since 2005 (t)	13	14	15	16	17	18	19
Median Rental Cost (M) ($ per week)	330	340	360	390	430	500	550

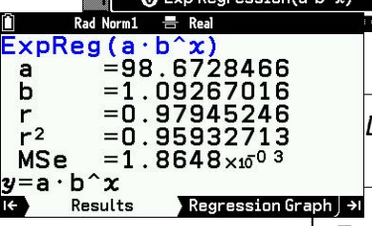




data from Table 3 **only**, complete Table 4 below by stating the equation of the ial regression model.

Arrow down for required model or use the numbered short cut "0"

Table 4

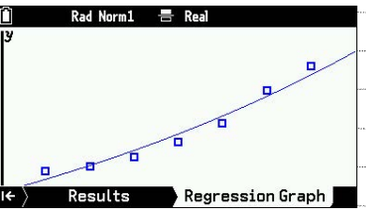


	r^2 value	Equation
Linear regression model $(y = ax + b)$	0.934	$M = 37.5t - 186$
Exponential regression model $(y = ab^x)$	0.959	$M = 98.7 \times 1.09^t$

Make sure you use "M" and "t" not x and y

(1 mark)

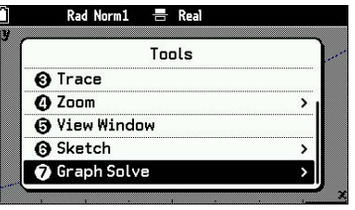
(ii) Hence, calculate the predicted median weekly rental cost for 2025, using your exponential regression model.



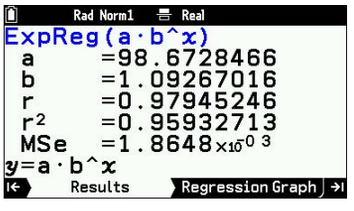
$580.74

IF you want access to more graphical tools:

- From your regression graph, press Tools ⋯
- Arrow back ◀ to Results

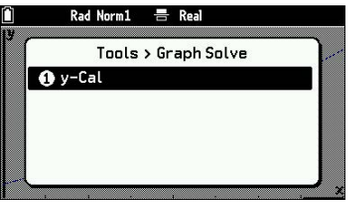


- Arrow down or press 7 for Graph Solve

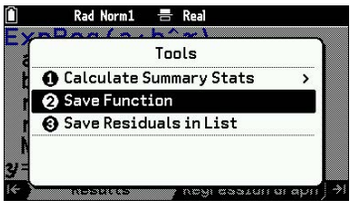


(1 mark)

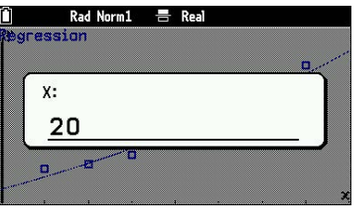
- Press Tools ⋯



- Press OK or EXE for y-Cal

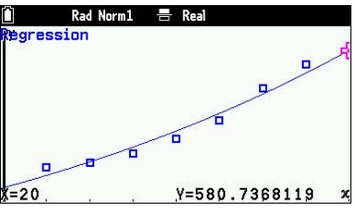


- Choose Save Function

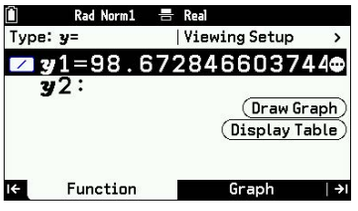


- Enter x-value
- Note: point does not need to be visible on graph

- Arrow to a free row (if necessary) and press OK



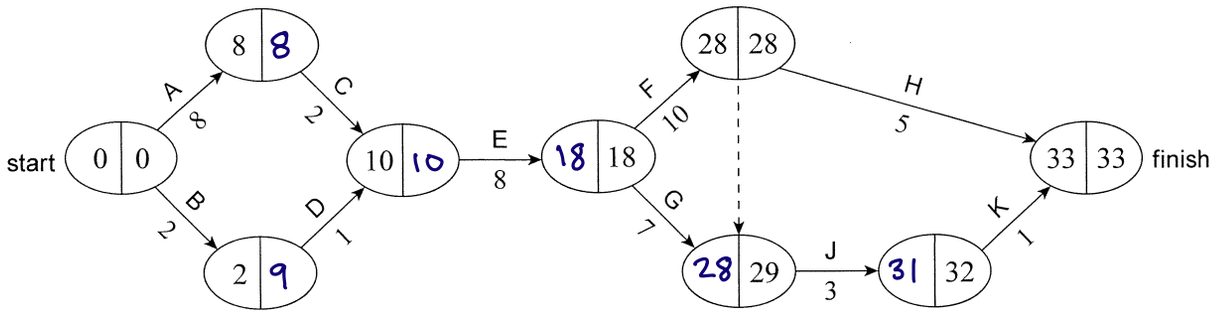
- result shown numerically and on the screen (if its in the view window)



- Go to the Graph & Table app and graph the model there.

Question 4 (11 marks)

A committee is set up to organise a school formal. The tasks to be completed are summarised in the network diagram below. The time taken for each task is given in days.



(a) Explain why the dummy link is required in the network diagram above.

Task J requires the completion of Tasks F and G and Task H only requires the completion of Task F.

(2 marks)

(b) *On the network diagram above*, complete the forward **and** backward scan. (2 marks)

(c) State the critical path for the network above.

A C E F H

(1 mark)

(d) State why task E must always lie on all critical path(s) of this network.

There are no alternate paths through the network (No other way to get from C&D to F&G)

(1 mark)

(e) (i) Calculate the slack time for task D.

7 days (= 9 - 2)

(1 mark)

(ii) What assumption has been made in your answer to part (e)(i) above?

There is no changes to the completion time of Task B (or A or C)

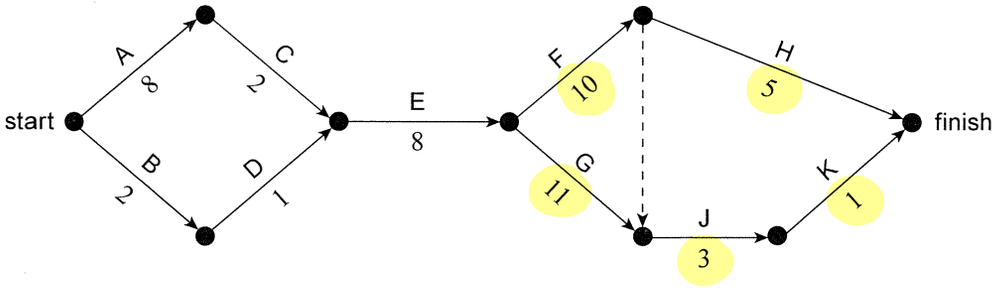
(1 mark)

(f) State the latest start time (LST) for task G.

22 days into the project (= 33 - 1 - 3 - 7)

(1 mark)

There has been a delay in completing task G and it now takes 11 days. The network diagram below has been updated to show this.



(g) **Without doing another forward and backward scan**, discuss the implications of this delay for the minimum completion time and the critical path.

This change means that F+H = G+J+K (= 15)
This does not change the minimum completion time but does mean that there are now two critical paths

(2 marks)

and ACEFH
ACEGJK

PLEASE TURN OVER

Question 5 (9 marks)

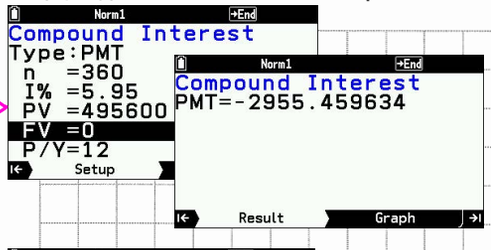
Gala wants to borrow $495 000 for a term of 30 years to buy her first home.

She considers two loan options being offered by her current bank:

Option A	An interest rate of 6% per annum, compounded monthly, with no establishment fee and no service fee
Option B	An interest rate of 5.95% per annum, compounded monthly, with a $600 establishment fee and a service fee of $20 per month

(a) (i) Calculate the comparison rate for Option B.

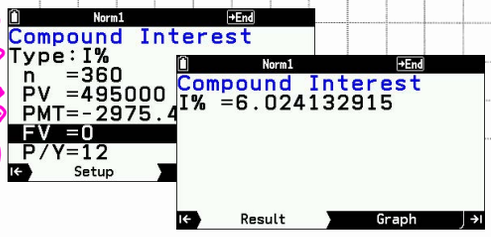
include the $600 est. fee



change Type

remove est. fee

include $20 fee in the payment



Calculating the payments to include $600 est. fee

$n = 12 \times 30 = 360$

$I\% = 5.95$

$PV = 495000 + 600 = \$495600$

$FV = 0 \qquad P/Y = C/Y = 12$

$\Rightarrow PMT = \$2955.46$

Calculating the rate to include $20 p/m service fee

$n = 360$

$PV = 495000$

$PMT = 2955.46 + 20 = \$2975.46$

$FV = 0 \qquad P/Y = C/Y = 12$

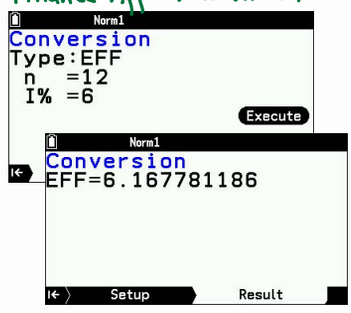
$\Rightarrow I\% = 6.024 =$ comparison rate for loan B

(3 marks)

(ii) Which statement below most accurately describes the best loan option for Gala?

Tick the appropriate box to indicate your answer.

Finance App → Conversion

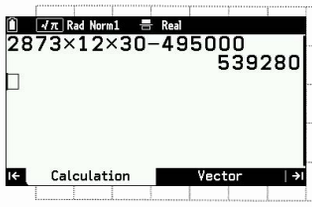


- ☐ Option A is the best because it has a higher comparison rate.
- ☐ Option A is the best because it has a lower comparison rate.
- ☐ Option B is the best because it has the lower nominal rate.
- ☐ Option B is the best because it has a higher comparison rate.
- ☑ Option B is the best because it has a lower comparison rate.

To be sure of this result a quick calculation of the Option A comparison rate is required. (1 mark)

Gala chose a different home loan option with an interest rate of 5.70% per annum, compounded monthly. Her monthly repayment for this loan will be $2873 for 30 years.

(b) Calculate the total interest that Gala would be expected to pay for the 30-year loan.



$539 280

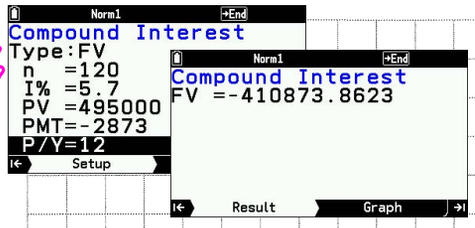
Total monthly payments for 30 years — Amount borrowed

(1 mark)

change Type to FV

n = 12×10

(c) Calculate the outstanding balance of the loan after 10 years.



$410 873.86

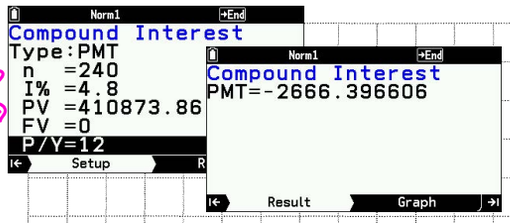
(1 mark)

At this time, Gala decides to change to a bank with a lower interest rate of 4.80% per annum, compounded monthly.

20 years of "new" loan at 4.8%

new PV is the FV from part (c)

(d) Show that the new monthly repayment is approximately $2665 for the remaining 20 years.



n = 12 × 20 = 240

I% = 4.8

PV = 410873.86

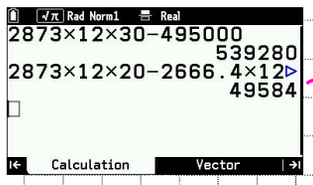
FV = 0

P/Y = C/Y = 12

⇒ PMT = $2666.40 which is approx. $2665

(2 marks)

(e) Calculate the interest Gala saved by changing to a new bank after 10 years.



$49 584

20 years worth of "old" loan payments (saved)
− 20 years of "new" loan payments (paid)

(1 mark)

Question 6 (10 marks)

Prisha runs a 'Splash and Swim' water park in a popular holiday destination. She wants to investigate the relationship between the daily temperature (T), in degrees Celsius, and the number of visitors (N), that come to the park.

After recording the data, Prisha modelled the data using a linear regression. She found a strong positive correlation between daily temperature (T) and the number of visitors (N).

(a) Tick *one* option that best represents the possible r and r^2 values for the data.

- ☐ $r = -0.945$ and $r^2 = 0.893$
- ☐ $r = 0.723$ and $r^2 = 0.523$
- ☑ $r = 0.931$ and $r^2 = 0.867$
- ☐ $r = 0.923$ and $r^2 = -0.852$

(1 mark)

The linear regression model for the two variables was found to be

$$N = 19.2T - 181.$$

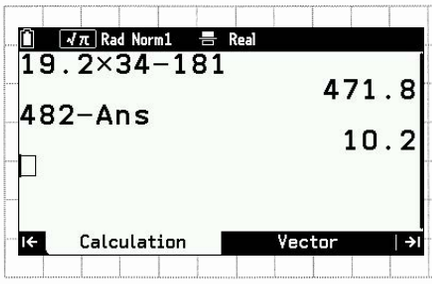
(b) In the context of the question, state why the linear model would not be considered reasonable in predicting the number of visitors to the water park when the daily temperature is below 9°C.

If the temperature is below 9°C then the linear model will predict a negative number of visitors, which is not reasonable.

(1 mark)

On one particular day, the daily temperature was 34°C and Prisha had 482 visitors at the water park.

(c) (i) Calculate the residual value, from the model, for this data.



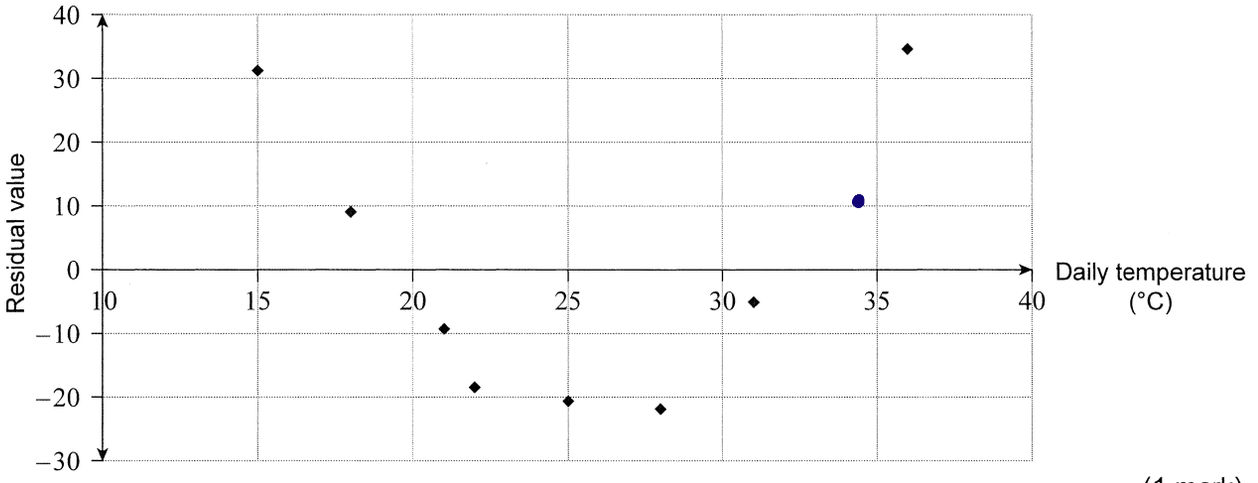
Predicted value is 471.8

Residual = observed − predicted
= 482 − 471.8
= 10.2

(2 marks)

(ii) Add the residual value that you found in part (c)(i) to the residual plot below.

Residual plot for linear model



(1 mark)

(d) With reference to the residual plot above, give *two* reasons why a linear model is not considered appropriate for this data.

The residuals shown in the plot are large.

and

The residuals appear systematic, rather than random.

or

They show a clear pattern, with the model underpredicting for all values below 20°C and above 32°C, and overpredicting between these temperatures

less detail

more detail

(2 marks)

Prisha then calculated the exponential regression model for this data to be $N = 52.2 \times 1.065^T$.

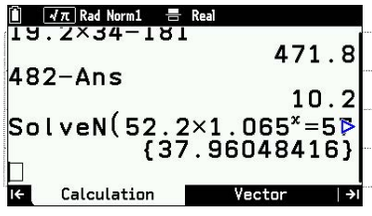
(e) (i) Explain, in the context of the question, the meaning of 1.065 in the exponential regression model.

For every one degree increase in temperature, the model predicts an increase in visitors by a factor of 1.065 i.e. a 6.5% increase in visitors.

(2 marks)

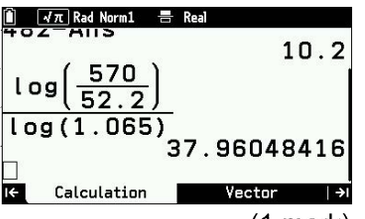
CATALOG
- Press (M) + (2) (Function Analysis)
- Choose (5)
- Enter equation
  - = is SHIFT + (.)
  - x is (x, σ, T)
- Press (OK) (OK)

(ii) Use the exponential regression model to predict the daily temperature when the park would have 570 visitors.



37.96°

A graphical method is shown on the next page

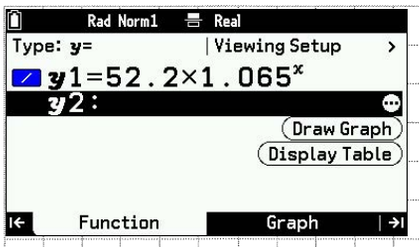


(1 mark)

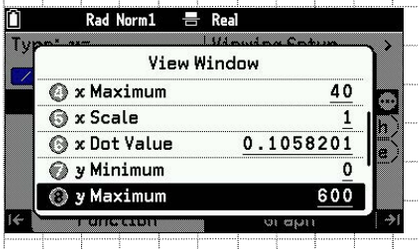
The 'SolveN' command is an efficient way to solve equations like $52.2 \times 1.065^x = 570$ which can also be solved algebraically

PLEASE TURN OVER

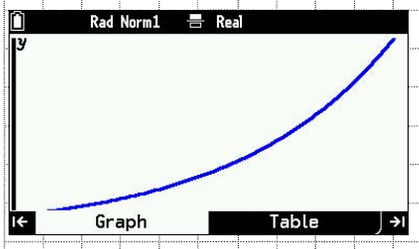
You may write on this page if you need more space to finish your answers. Make sure to label each answer carefully (e.g. 8(f) continued).

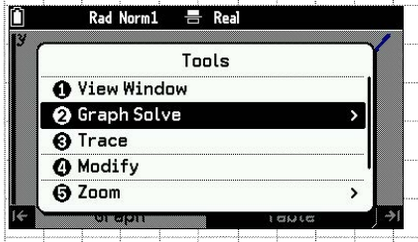


- Open the Graph and Table app
- Enter the model's equation using y and x.
- Press → (next)

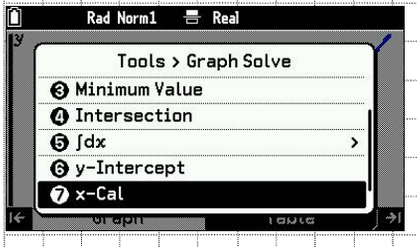


- Enter a sensible View Window (use x-values up to at least 40°C based on the residual plot)
- ↑ back up to Draw

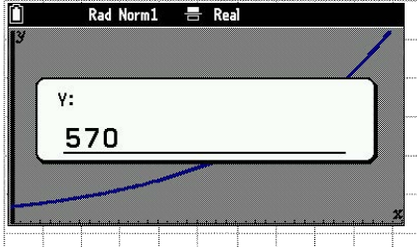




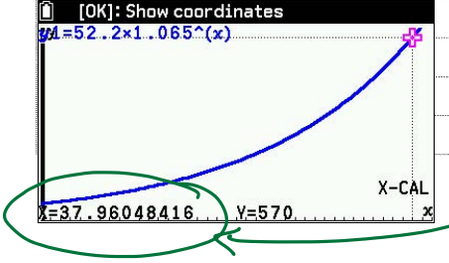
- With graph drawn, press Tools (menu)
- Choose (2) Graph Solve



- Arrow down (▼) and choose x-Cal (or use shortcut (7))



- enter y-value (N = 570 visitors) and press EXE or OK

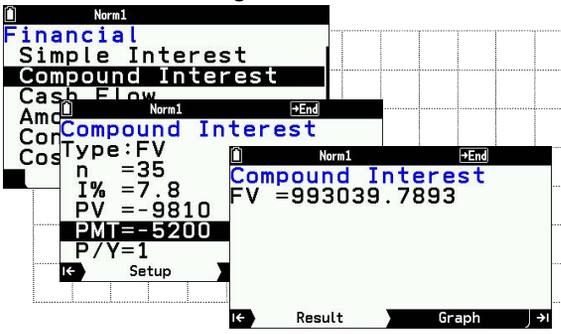


- required x-value is shown to 10 significant figures in bottom left of screen

Question 7 (14 marks)

Mei is a 30-year-old self-employed Pilates instructor who owns her own studio. She has just transferred her current superannuation balance of $9810 to a new superannuation provider, to which she will make annual payments of $5200. Her new superannuation account earns interest of 7.8% per annum, compounded annually.

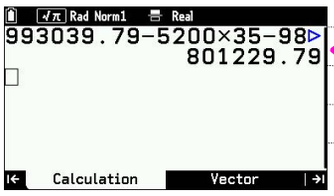
(a) Show that there would be approximately $993 000 in the fund when Mei reaches her planned retirement age of 65.



n = 65 − 30 = 35 years
I% = 7.8
PV = −9810
PMT = −5200
P/Y = C/Y = 1
⇒ FV = $993 039.79 when Mei is 65

(2 marks)

(b) (i) Calculate the amount of interest Mei's new superannuation account will have earned when she retires.



$ 801 229.79

Final balance − total contributions

(1 mark)

(ii) State *one* reason why the interest earned could be lower than the amount calculated in part (b)(i).

- Fees are likely to be charged on the account
- Account may not continue to earn 7.8% p.a.

or

- Mei may not be able to maintain $5200 p.a. contributions

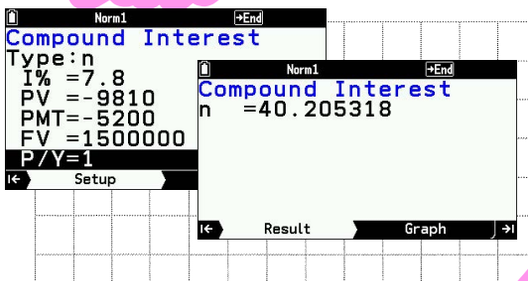
(1 mark)

Mei would like to retire with $1 500 000 in her superannuation account.

(c) What age would Mei be when she could retire with a balance of $1 500 000?

Change Type to n

Change FV to 1500000



I% = 7.8
PV = −9810
PMT = −5200
FV = 1500 000 P/Y = C/Y = 1
⇒ n = 40.2 years

make sure you answer the question

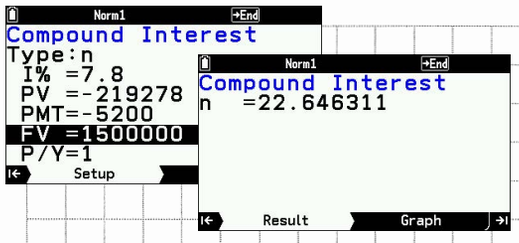
So, Mei would be 70.2 years old

(2 marks)

When Mei turns 45 years of age her superannuation balance is $169 278. At this time she receives an inheritance of $50 000, which she places as a lump sum into her superannuation account.

(d) Can she now retire at 65 years of age with a balance of at least $1 500 000?

Support your answer with relevant calculations, assuming all other account conditions remain the same.



* Method - Find how long til FV = 1500 000

I% = 7.8

PV = −169278 − 50000 = −219278

PMT = −5200

P/Y = C/Y = 1

⇒ n = 22.6 years

So, Mei will be 45 + 22.6 = 67.6 years old when her balance reaches $1500000

So, NO she can't retire with this balance at 65

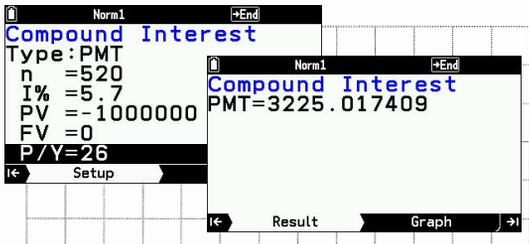
* Alt. method - Set n = 20 and show that Mei's FV at that time is less than $1500000

(3 marks)

answer the question

At 65 years of age, Mei deposits $1 000 000 of her superannuation savings into a retirement annuity, which generates interest of 5.7% per annum, compounded fortnightly.

(e) Calculate the amount Mei can withdraw each fortnight if she would like her retirement fund to last for 20 years.



n = 26 × 20 = 520 fortnights

I% = 5.7

PV = −1 000 000

FV = 0

P/Y = C/Y = 26

⇒ PMT = $3225.02

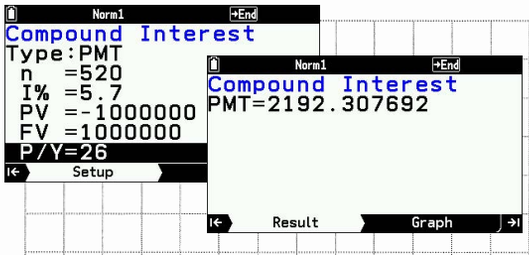
(2 marks)

Rather than reduce her balance, Mei would prefer to live off only the interest earned in her annuity account.

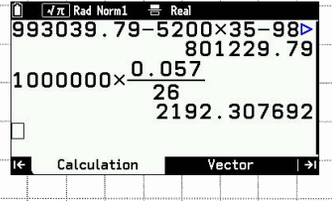
Use Finance App to find PMT if FV=1000000

(f) (i) How much can she withdraw each fortnight if she wants to live off interest alone?

In Calculate App the fortnightly interest on $1000000 can be calculated



$2192.31



(1 mark)

PLEASE TURN OVER

(ii) State *one* reason why Mei might choose the strategy outlined in part (f)(i) rather than the strategy outlined in part (e).

- She might want to leave money in her will

or

- She might live longer than 20 years

or

- She might not need the money to live on

(1 mark)

(iii) State *one* reason why Mei might choose the strategy outlined in part (e) rather than the strategy outlined in part (f)(i).

- $2193.31 might not be enough to live on.

or

- She might not want to leave money in her will.

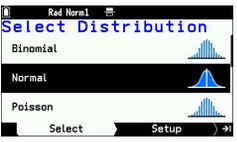
or

- She might want to maximise her standard of living

(1 mark)

Question 8 (11 marks)

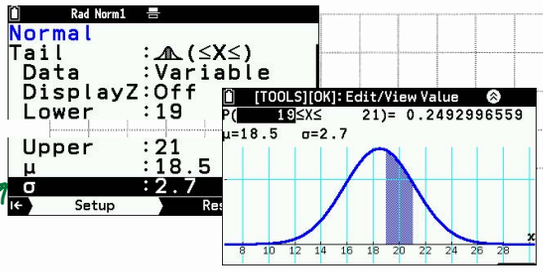
Using the Distribution app: Travellers who check in at Adelaide Airport for domestic flights have weights of luggage that are normally distributed with a mean weight of 18.5 kg and a standard deviation of 2.7 kg.



Choose Normal

(a) Calculate the proportion of domestic luggage that would be expected to weigh between 19 kg and 21 kg.

Choose Tail as "centre"



Note: order of μ and σ

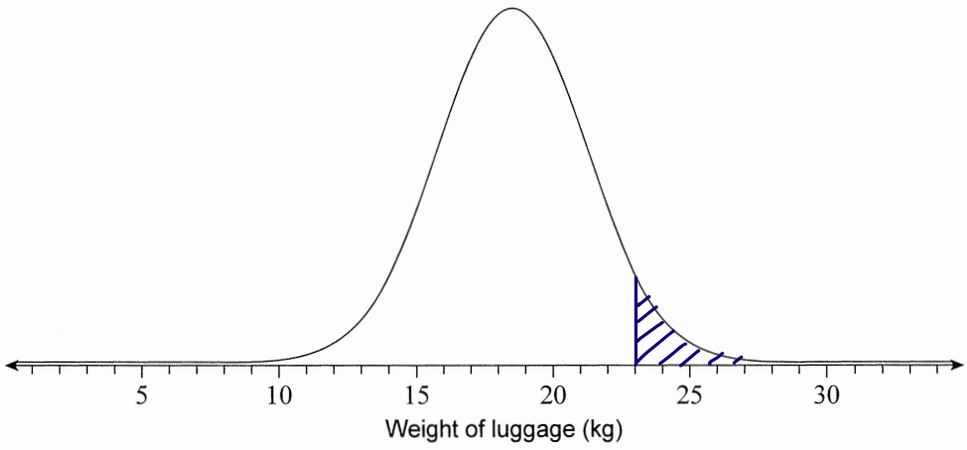
Proportion of luggage between 19 kg and 21 kg is 0.249.

(1 mark)

Bags for any flight that have a weight of 23 kg or more are required to be labelled with a Heavy Bag tag.

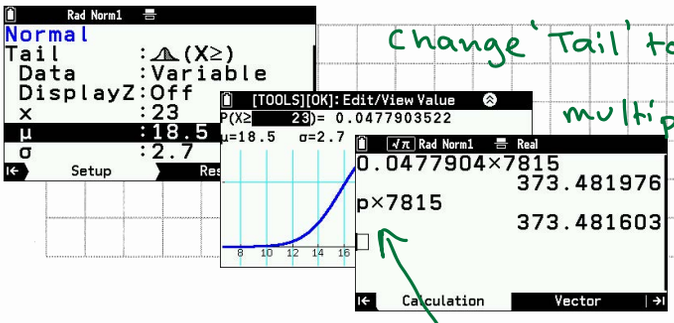
(b) (i) *On the diagram below,* ***shade*** the probability distribution to show the proportion of bags that would require a Heavy Bag tag.

Adelaide Airport domestic flight luggage weights



(1 mark)

(ii) On a certain day, 7815 pieces of luggage are checked in for domestic flights at Adelaide Airport. How many of these pieces of luggage are expected to require a Heavy Bag tag?



Change 'Tail' to 'right'

multiply proportion by total by direct entry

or

by calling up "p" in Calculate app

- Catalog (M)
- Variable Data (^^ or C)
- Distribution (2)
- p (1)

0.0477904 × 7815 = 373 pieces of luggage

integer answer required

(2 marks)

PLEASE TURN OVER

International travellers often fly on airlines that allow a heavier luggage allowance.

The weights of luggage that people check in for their international flights at Adelaide Airport are normally distributed with a mean weight of 18.5 kg and standard deviation of 4.3 kg.

(c) Which of the following best describes the international check-in luggage weight distribution?

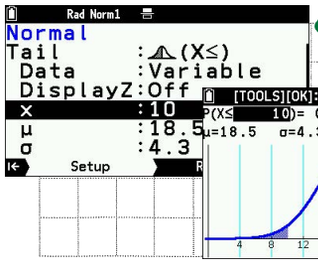
Tick *one* box to complete the statement below.

People flying internationally have:

- ☐ less variation in their luggage weight than those flying domestically
- ☐ a higher mean luggage weight than those flying domestically
- ☑ greater variation in their luggage weight than those flying domestically
- ☐ the same variation in luggage weight as those flying domestically. (1 mark)

On fully booked international flights departing Adelaide Airport, the lightest 2% of bags checked in were originally intended to be carried on board by passengers.

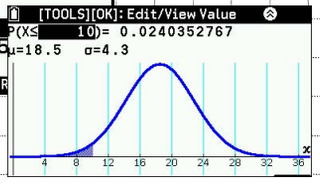
(d) What is the weight of the heaviest carry-on bag that has been checked in?



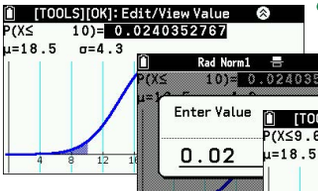
• perform a left tail calculation with a "dummy" bound

$Pr(\text{weight} \le w^*) = 0.02$

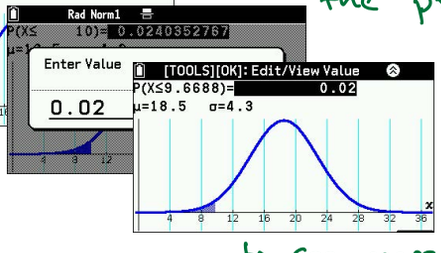
$w^* = 9.67$ kg



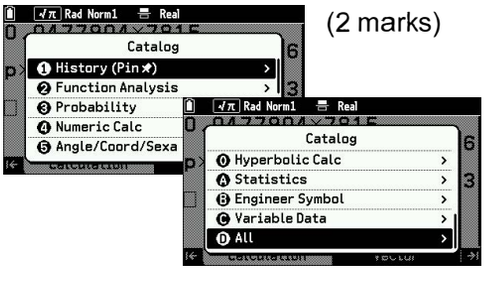
Alt. method - in Calculate: (2 marks)



• arrow right (>) to the proportion

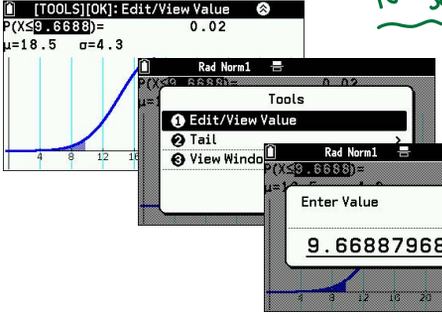


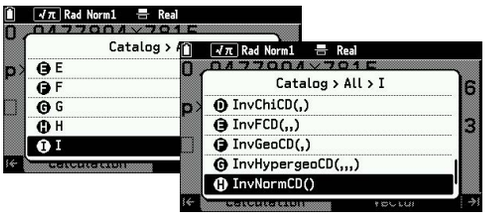
• enter the desired proportion

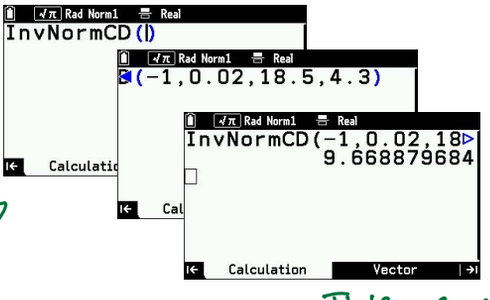


to see more sig. figs:

- arrow left (<)
- Press Tools (ooo)
- Choose (1)







In Catalog navigate to
• All • I • Inv Norm CD

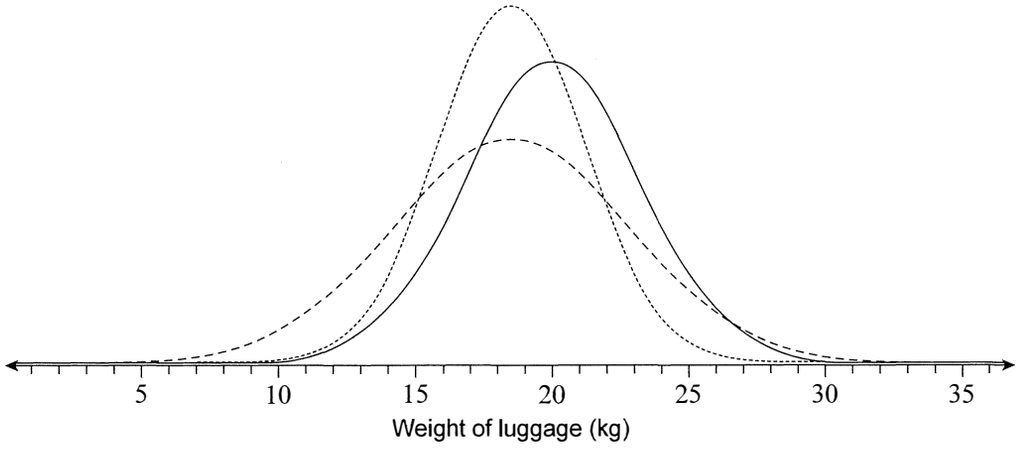
Enter (Tail, proportion, μ, σ)

Tail: −1 → left
0 → centre
1 → right

This command can be "pinned" in History.

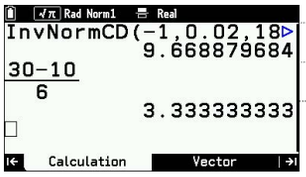
The weight of check-in luggage for domestic flights departing Sydney Airport is normally distributed.

The diagram below shows the probability distributions for the weight of check-in luggage from domestic flights departing Sydney Airport, along with domestic and international flights departing Adelaide Airport.



The mean weight of domestic check-in luggage at Sydney Airport is 20 kg.

(e) Using the appropriate probability distribution, estimate the standard deviation for domestic check-in luggage weight at Sydney Airport.



$\sigma \approx 3.33$ (or $3\frac{1}{3}$)

σ = width (from graph) / 6

(1 mark)

The weight of check-in luggage for international flights departing Sydney Airport is normally distributed with a mean weight of 22 kg and standard deviation of 3.8 kg.

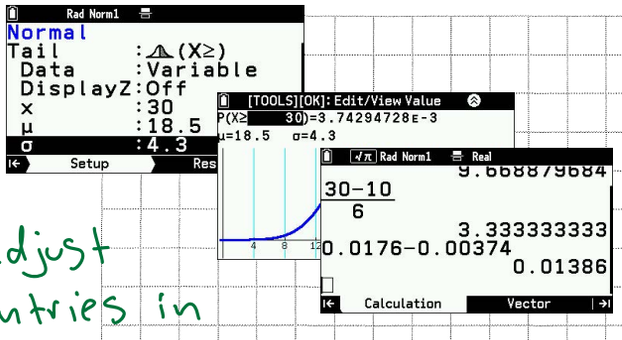
Cassowary Airlines is an international airline that flies from all states in Australia. They will charge customers for excess luggage when passengers have luggage weighing over 30 kg.

It is known that 1.76% of passengers departing Sydney will be charged for excess luggage.

(f) It is claimed that on a fully booked flight of 375 passengers:

'1.4% more Cassowary Airlines passengers will pay for excess luggage charges for Sydney international flights than pay for excess luggage charges for Adelaide international flights'.

Disprove this claim using appropriate mathematical calculations.



adjust entries in Distribution

using $N(18.5, 4.3)$

$Pr(\text{weight} \geq 30) = 0.00374$

$\therefore 0.374\%$ of Adelaide passengers pay for excess luggage

$0.0176 - 0.00374 = 0.01386$

This is 1.386% less than Sydney passengers.

(3 marks)

Question 9 (13 marks)

A theme park has four ride operators - Emma, James, Mia, and Oliver - assigned to four rides: Roller coaster, Ferris wheel, Bumper cars, and Carousel. The park's management wants to assign each operator to a ride in a way that minimises the time taken to perform safety checks.

Table 5 below shows the time (in minutes) each operator takes to perform the safety checks.

Table 5

	Roller coaster	*Ferris wheel*	*Bumper cars*	*Carousel*
Emma	12	18	14	20
James	22	15	19	17
Mia	16	14	20	21
Oliver	19	17	15	17

(a) Interpret the meaning of the number '18', shaded in Table 5 above.

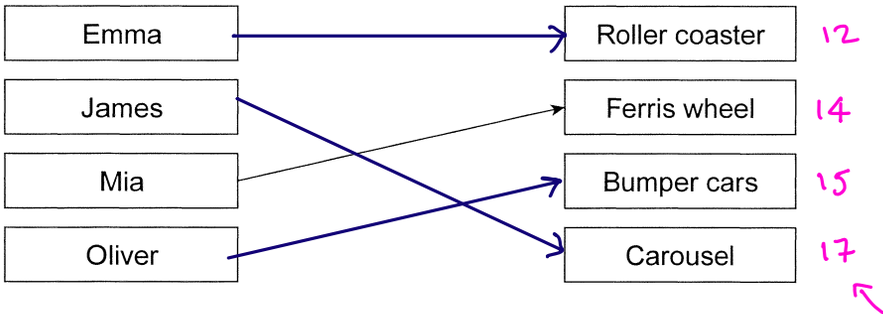
Emma takes 18 minutes to complete the safety checks on the Ferris wheel.

(1 mark)

The Hungarian algorithm has been applied to the information from Table 5 above to produce the following reduced array.

0	6	2	6
7	0	4	0
2	0	6	5
4	2	0	0

(b) (i) Using the reduced array, complete the diagram below by adding arrows to show the allocation of the three remaining operators to complete the safety checks for each ride in the shortest possible time.



(1 mark)

this might help answer part (ii)

(ii) If all staff must start their safety checks at the same time, which staff member will finish their safety check last, based on your solution to part (b)(i)?

James (his completion time for his assigned task is greatest)

(1 mark)

(iii) At what time must staff start the safety checks if they are all required to be completed at least 15 minutes prior to the scheduled opening of the theme park at 9 am?

8:28 am (9:00 am − 15 mins − 17)

buffer time before 9:00 opening

James' completion time

(1 mark)

(c) In the context of this question, state why it is not reasonable to add the time of each ride's safety check together to establish a total minimum completion time.

The safety checks all happen at the same time (not one after another)

(1 mark)

(d) State *one* limitation of using the Hungarian algorithm to determine when the daily safety checks for the rides must start.

- Doesn't allow for people to help each other (i.e. Emma help James with the carousel once she is done with the roller coaster)

or

- Assumes there are not delays, injuries, illness etc

(1 mark)

Question 9 continues on page 24.

A new ride operator, Sully, has joined the team. Table 6 below shows the time (in minutes) each operator takes to perform the safety checks.

Table 7 below shows the partially complete final array after all the steps of the Hungarian algorithm have been completed.

Table 6

	Roller coaster	*Ferris wheel*	*Bumper cars*	*Carousel*	
Emma	12	18	14	20	0
James	22	15	19	17	0
Mia	16	14	20	21	0
Oliver	19	17	15	17	0
Sully	14	14	19	17	0

Table 7

0	x	0	y	z
9	1	4	0	0
3	0	5	4	0
6	3	0	0	0
1	0	4	0	0

(e) (i) In the space below, show all the steps of the Hungarian algorithm required to achieve the final reduced array, and hence, state the values of x, y, and z.

Subtracting the column minimums from Table 6 (with the extra column of zeros added) gives:

−12	−14	−14	−17	−0
0	4	0	3	0
10	1	5	0	0
4	0	6	4	0
7	3	1	0	0
2	0	5	0	0

zeros can be covered by 4 lines (4<5) so not optimised

The minimum uncovered element is 1. Subtract it from the uncovered elements, and add it to the "double covered" elements, and we get

0	5	0	4	1
9	1	4	0	0
3	0	5	4	0
6	3	0	0	0
1	0	4	0	0

5 lines required ∴ optimised!

∴ $x = 5$ $y = 4$ $z = 1$

To complete part (ii), start the allocation. Emma must do RC, then Oli must do BC which leaves James or Sully to do the carousel

(4 marks)

(ii) Using *the final reduced array* from part (e)(i), tick the operator(s) that should be allocated to complete the safety check for the:

See page back for allocation

(1) Roller coaster

Emma ☑ James ☐ Mia ☐ Oliver ☐ Sully ☐

(1 mark)

(2) Carousel

Emma ☐ James ☑ Mia ☐ Oliver ☐ Sully ☑

(1 mark)

(f) State why the addition of Sully to the team has **not** changed the time at which safety checks for the rides must start.

Sully does not perform any task faster than any person currently assigned to a task

(1 mark)

(and the tasks that Sully does equally quickly do not free up others to improve the overall shortest completion time)