General Mathematics SEE marking guide

External assessment 2021

SEE 1: Short response (60 marks)

SEE 2: Short response (95 marks)

Assessment objectives

This assessment instrument is used to determine student achievement in the following objectives:

1. select, recall and use facts, rules, definitions and procedures drawn from Unit 3 Topics 1, 2 and/or 3
2. comprehend mathematical concepts and techniques drawn from Unit 3 Topics 1, 2 and/or 3
3. communicate using mathematical, statistical and everyday language and conventions
4. evaluate the reasonableness of solutions
5. justify procedures and decisions by explaining mathematical reasoning
6. solve problems by applying mathematical concepts and techniques drawn from Unit 3 Topics 1, 2 and/or 3.

Queensland Government | Queensland Curriculum & Assessment Authority

For all Queensland schools

Purpose

This marking guide:

- provides a tool for calibrating external assessment markers to ensure reliability of results
- indicates the correlation, for each question, between mark allocation and qualities at each level of the mark range
- informs schools and students about how marks are matched to qualities in student responses.

Mark allocation

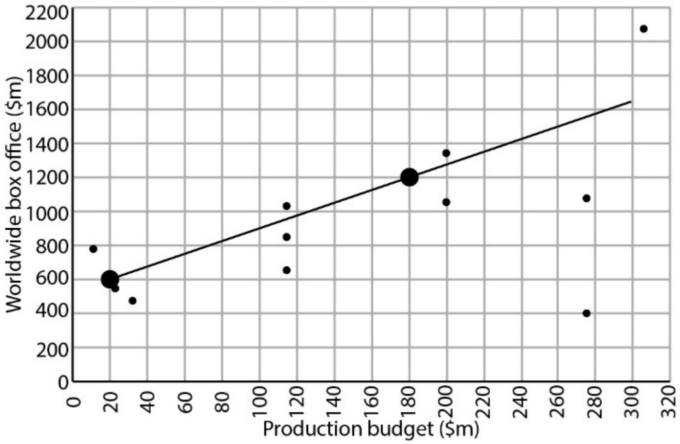
Where a response does not meet any of the descriptors for a question or a criterion, a mark of ‘0’ will be recorded.

Allowing for FT error — refers to ‘follow through’, where an error in the prior section of working is used later in the response, a mark (or marks) for the rest of the response can be awarded so long as it still demonstrates the correct conceptual understanding or skill in the rest of the response.

Allow FT mark/s — refers to ‘follow through’, where an error in the prior section of working is used later in the response, a mark (or marks) for the rest of the response can still be awarded so long as it still demonstrates the correct conceptual understanding or skill in the rest of the response.

This mark may be implied by subsequent working — the full mathematical reasoning and/or working, as outlined in the sample response and associated mark, is not explicitly stated in the student response, but by virtue of subsequent working there is sufficient evidence to award the mark/s.

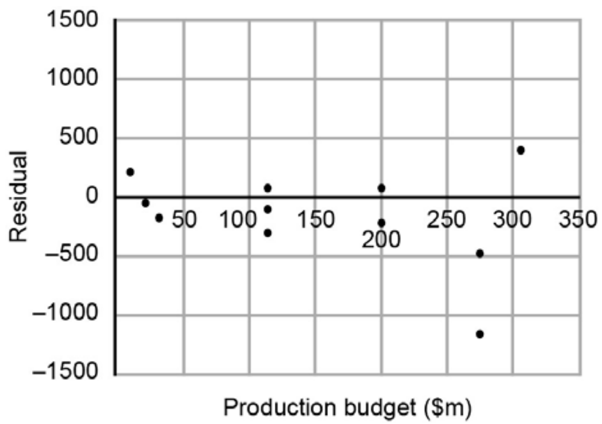
Marking guide SEE 1: Short response

Q	Sample response	The response:
1a)		• correctly labels the axes and scales for the scatterplot **[1 mark]** • accurately plots given data points **[1 mark]** • draws appropriate line of best fit **[1 mark]**
1b)	y-intercept = (0, 525) Points (20, 600) and (180,1200) are on the line. Gradient: $m = \frac{y_2 - y_1}{x_2 - x_1}$ $= \frac{1200-600}{180-20}$ $= \frac{600}{160}$ $m = 3.75$	• estimates y-intercept of the line **[1 mark]** • correctly substitutes into an appropriate rule **[1 mark]** • determines slope of the line **[1 mark]**
1c)	Model: $y = mx + c$ $y = 3.75x + 525$	• determines linear equation **[1 mark]**
1d)	Using the least-squares linear regression model from the calculator: $y = 2.5310x + 548.5617$	• determines model **[1 mark]**

Q	Sample response	The response:

1e) Residual analysis for line of best fit:

x	actual y (A)	predicted y (P)	residual ($A-P$)
11	775.4	566.25	209.15
23	548	611.25	-63.25
32.5	475.1	646.875	-171.775
115	1027	956.25	70.75
115	656.7	956.25	-299.55
115	849	956.25	-107.25
306	2068.2	1672.5	395.7
200	1056.1	1275	-218.9
200	1332.5	1275	57.50
275	393.2	1556.25	-1163.05
275	1073.5	1556.25	-482.75



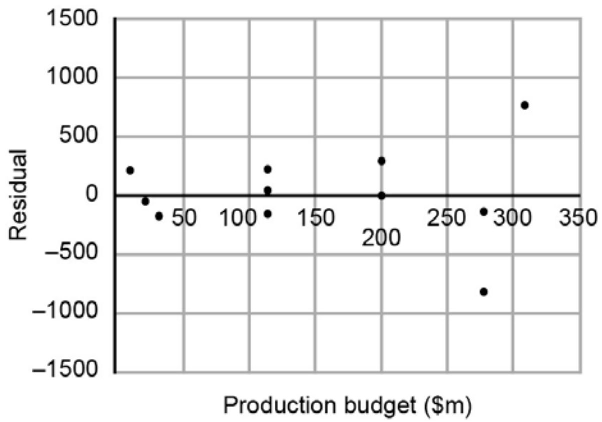
Residual analysis for least-squares line:

The response:

- provides relevant table showing actual, predicted and residual values for the line of best fit model **[1 mark]**
- correctly calculates the predicted values for each year using the line of best fit model from Question 1c) **[1 mark]**
- calculates residuals for all data values for the line of best fit model **[1 mark]**
- correctly chooses appropriate scales on residual plot/s **[1 mark]**
- accurately plots points on the residual plot for the line of best fit model **[1 mark]**

Q	Sample response	The response:

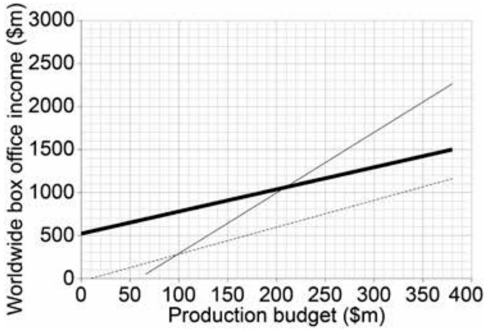
x	actual y (A)	predicted y (P)	residual ($A-P$)
11	775.4	576.403	198.9968
23	548	606.776	-58.7758
32.5	475.1	630.821	-155.721
115	1027	839.632	187.3679
115	656.7	839.632	-182.932
115	849	839.632	9.367865
306	2068.2	1323.062	745.1378
200	1056.1	1054.771	1.32885
200	1332.5	1054.771	277.7288
275	393.2	1244.600	-851.4
275	1073.5	1244.600	-171.1



The response:

- provides relevant table showing actual, predicted and residual values for the least-squares line model **[1 mark]**
- correctly calculates the predicted values for each year using the least-squares line model from Question 1d) **[1 mark]**
- calculates residuals for all data values for the least-squares line model **[1 mark]**
- accurately plots points on the residual plot for the least-squares line model **[1 mark]**
- shows logical organisation, communicating key steps **[1 mark]**

Q	Sample response	The response:
1f)	Both residual plots show a random pattern, so both linear models are reasonable. However, the more valid model is the least-squares line, because the residuals are generally smaller.	• evaluates reasonableness of each model by considering the results of the residual plots **[1 mark]** • determines more valid model **[1 mark]**

<table>
<tr><th>Q</th><th>Sample response</th><th>The response:</th></tr>
<tr><td>2a)</td><td>

Key
—— Star Wars
$y_{SW} = 2.5310x + 548.5617$</td><td>• sketches more valid model from Question 1 [1 mark]

• adds key [1 mark]</td></tr>
<tr><td>2b)</td><td>From the graph, Star Wars movies make the most box office income for lower budgets, and MCU movies make the most box office income for higher budgets.

Star Wars (SW):
$y_{SW} = 2.5310x + 548.5617$
Marvel Comic Universe (MCU):
$y_{MCU} = 7.0982x - 416.0061$

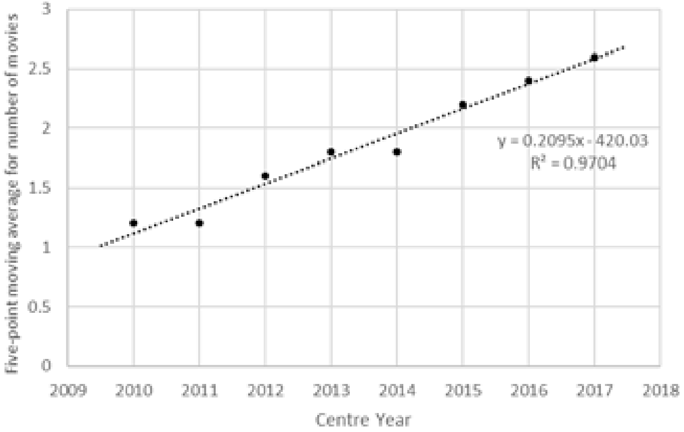
Using substitution, let $y_{SW} = y_{MCU}$
$2.5310x + 548.5617 = 7.0982x - 416.0061$
$964.5678 = 4.5672x$
$x = 211.1946$
$\therefore y$ = 1083.0952

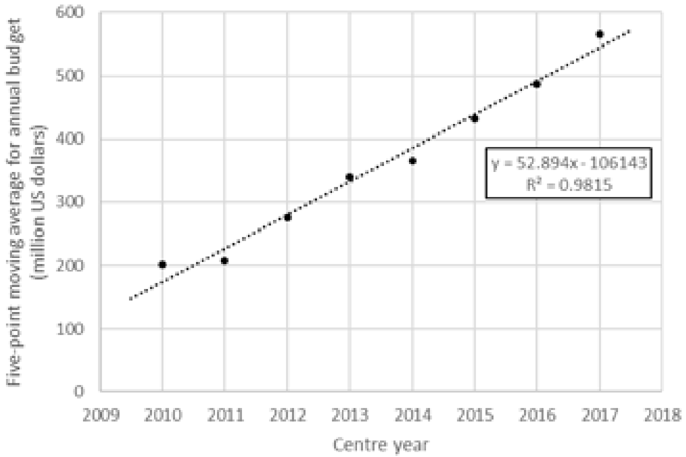
Therefore, MCU movies are more profitable than Star Wars movies when the production budget is greater than $211 million with a worldwide box office income of approximately $1.1 billion.</td><td>• uses linear equations for both companies [1 mark]

• uses simultaneous equations [1 mark]
• calculates production budget point (x) where the linear models for both movies intersect [1 mark]
• calculates worldwide box office point (y) [1 mark]

• determines production budget and worldwide box office income at which MCU movies are more profitable than Star Wars movies [1 mark]</td></tr>
</table>

<table>
<tr><th>Q</th><th>Sample response</th><th>The response:</th></tr>
<tr><td>2c)</td><td>From the graph, it can be seen that the intersection point was just over $200 million so the break-even point of $211 million seems mathematically reasonable.
But this is raw data and doesn’t account for inflation, so maybe the older movies are all cheaper and also earnt less at the box office (i.e. 6/10 Star Wars movies are last millennium) and the modern movies are more expensive and earnt more at the box office (all MCU movies are since 2008).
The R-squared values are all reasonably high so the linear models may be good predictors.</td><td>• identifies a strength of the solution [1 mark]
• identifies a limitation of the solution [1 mark]
• evaluates reasonableness of the solution [1 mark]</td></tr>
<tr><td>3a)</td><td>
<table>
<tr><th>Year</th><th>Number of movies</th><th>Five-point moving average</th></tr>
<tr><td>2008</td><td>2</td><td>—</td></tr>
<tr><td>2009</td><td>0</td><td>—</td></tr>
<tr><td>2010</td><td>1</td><td>1.2</td></tr>
<tr><td>2011</td><td>2</td><td>1.2</td></tr>
<tr><td>2012</td><td>1</td><td>1.6</td></tr>
<tr><td>2013</td><td>2</td><td>1.8</td></tr>
<tr><td>2014</td><td>2</td><td>1.8</td></tr>
<tr><td>2015</td><td>2</td><td>2.2</td></tr>
<tr><td>2016</td><td>2</td><td>2.4</td></tr>
<tr><td>2017</td><td>3</td><td>2.6</td></tr>
<tr><td>2018</td><td>3</td><td>—</td></tr>
<tr><td>2019</td><td>3</td><td>—</td></tr>
</table>
</td><td>• correctly constructs table with relevant headings [1 mark]
• correctly determines the number of movies released each year [1 mark]
• calculates five-point moving average values [1 mark]</td></tr>
</table>

Q	Sample response	The response:
3b)	Using the scientific calculator functionality: $y = 0.2095x - 420.0262$, where $x = \text{centre year}$  	• determines appropriate linear model **[1 mark]** • provides reasoning as to why a linear model is best **[1 mark]**
3c)	Using the centre year values for the five-point moving average model, the average number of MCU movies released from 2024 until 2028 inclusive can be calculated with $x = 2026$. $y = 0.2095(2026) - 420.0262$ $= 4.4208$ Therefore, the total number produced will be: $5 \times 4.4208 = 22.104$ Therefore, I would expect approximately 22 MCU movies will be released in this period.	• correctly determines the x value required for substitution **[1 mark]** • calculates corresponding five-point moving average **[1 mark]** • uses appropriate rule to connect average number of movies and number of years **[1 mark]** • predicts total number of movies released **[1 mark]**

<table>
<tr><th>Q</th><th>Sample response</th><th>The response:</th></tr>
<tr><td>3d)</td><td>
<table>
<tr><th>Year</th><th>Total production budget</th><th>Five-point moving average</th></tr>
<tr><td>2008</td><td>323.5</td><td>—</td></tr>
<tr><td>2009</td><td>0</td><td>—</td></tr>
<tr><td>2010</td><td>170</td><td>201.7</td></tr>
<tr><td>2011</td><td>290</td><td>207</td></tr>
<tr><td>2012</td><td>225</td><td>275</td></tr>
<tr><td>2013</td><td>350</td><td>340</td></tr>
<tr><td>2014</td><td>340</td><td>365</td></tr>
<tr><td>2015</td><td>495</td><td>431</td></tr>
<tr><td>2016</td><td>415</td><td>487</td></tr>
<tr><td>2017</td><td>555</td><td>566</td></tr>
<tr><td>2018</td><td>630</td><td>—</td></tr>
<tr><td>2019</td><td>735</td><td>—</td></tr>
</table>


</td><td>
• uses appropriate data from the stimulus [1 mark]
• uses appropriate method [1 mark]
• produces appropriate model [1 mark]
</td></tr>
</table>

Q	Sample response	The response:
	Let $x = 2026$ $y = 52.8940 \times 2026 - 106143.0774$ $= 1020.1666$ Therefore, the total amount spent on production budgets of MCU movies will be $5 \times 1020.1666 = 5100.833$. Therefore, I expect $5.1 billion to be spent on making MCU movies in this period.	• uses developed model to determine the total production budget **[1 mark]** • uses appropriate rule to connect average production budget and number of years **[1 mark]** • determines total production budget for the full five years, including units **[1 mark]**

Q	Sample response	The response:
4a)	Determining the opening weekend income: From Question 3, the total production budget of $5100.833 million was for 22.104 movies. Therefore, the average budget for each movie will be: $\text{average budget} = \frac{5100.833}{22.104}$ $= \$230.765$ Use the provided model to find the opening weekend income based on the production budget. Therefore, $230.765 = 0.8667x + 80.722$ $x = 173.12$ The opening weekend produced $173.12 million. Determining the price per ticket: From Stimulus 4, I found 2 points that were on the exponential curve: (Year, ticket price) (1960, 0.80) (2010, 8.20) This can be modelled using a geometric progression. If n = the number of years since 1959 and t_n = the ticket price then: $t_1 = 0.80$ and $t_{51} = 8.20$ $\therefore 8.20 = 0.80 \times r^{50}$ $\therefore 10.25 = r^{50}$ $\therefore r = 1.0476$	• selects appropriate values from Question 3 **[1 mark]** • determines average budget per movie **[1 mark]** • substitutes average budget as the y value of the given model **[1 mark]** • determines opening weekend income **[1 mark]** • identifies two points on the ticket price curve **[1 mark]** • defines variables (n and t_n) **[1 mark]** • substitutes into an appropriate rule **[1 mark]** • determines r **[1 mark]** • determines model for the ticket price **[1 mark]**

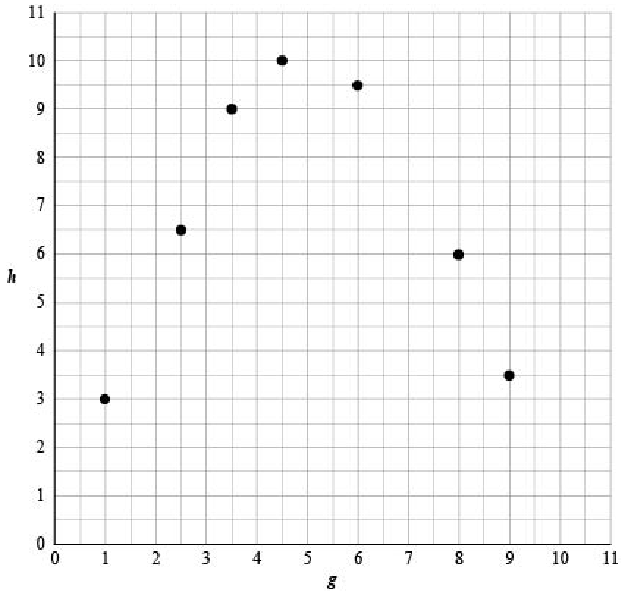
Q	Sample response	The response:
	$\therefore t_n = 0.80 \times 1.0476^{(n-1)}$ In 2026 (the average year in the range) $n = 67$ The movie ticket price will be: $t_n = 0.80 \times 1.0476^{(66)}$ $= \$17.27$ Determining the average number of people attending the opening weekend: $\text{Average number of people} = \frac{173.12}{17.27}$ $= 10.024$ million I would expect about 10 million people to attend the opening weekend of Film Company B movies from 2024 to 2028 inclusive.	• determines appropriate n value for the average movie **[1 mark]** • determines average ticket price **[1 mark]** • determines average number of people attending an opening weekend **[1 mark]**
4b)	Since $173.12 million ≥ $150 million, it is reasonable to say that it 'broke the box office' in terms of the amount of money MCU movies made. However, the attendance of 10.024 million < 12 million, which means that it is not completely reasonable to suggest MCU movies broke the box office in terms of the average number of people attending an opening weekend. Considering that only one of the two criteria had been successfully satisfied, it can be concluded that the entertainment critic would probably not say that MCU movies had broken the box office during the opening weekend between 2024 and 2028 inclusive.	• examines the first criterion **[1 mark]** • examines the second criterion **[1 mark]** • evaluates whether MCU movies have 'broken the box office' **[1 mark]**

Marking guide SEE 2: Short response

Paper 1: Multiple choice

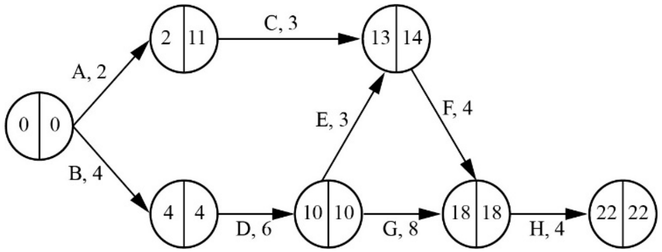
Question	Response
1	C
2	B
3	D
4	D
5	C
6	A
7	A
8	B
9	C
10	D
11	B
12	D
13	C
14	A
15	B

Paper 1: Short response

Q	Sample response	The response:
16a)		• correctly formats the Cartesian plane with *g* along the x-axis and *h* along the y-axis **[1 mark]** • correctly plots all the data points **[1 mark]**
16b)	non-linear and strong	• identifies form **[1 mark]** • identifies strength **[1 mark]**

Q	Sample response	The response:
17	$A = 720\,000$ $M = ?$ $i = \frac{0.048}{12} = 0.004$ $n = 25 \times 12 = 300$ $A = M\left(\frac{1-(1+i)^{-n}}{i}\right)$ $A = M\left(\frac{1-(1+0.004)^{-300}}{0.004}\right)$ $720\,000 = M \times 174.520\ldots$ $M = \frac{720\,000}{174.520\ldots}$ $M = 4125.578\ldots$ The monthly repayment will be $4126 each month for 25 years.	• correctly determines the i and n values **[1 mark]** • substitutes into appropriate annuity rule **[1 mark]** • determines monthly repayment **[1 mark]** • states solution to the nearest dollar **[1 mark]**

Q	Sample response	The response:
18a)	Let x = the number of years since 2013 Let y = the business's annual profit (in $'000s) $y = 4.286x + 34.267$	• correctly defines the variables **[1 mark]** • correctly determines the equation of the least-squares line **[1 mark]**
18b)	For 2021, $x = 8$ $\therefore y = 4.286 \times 8 + 34.267$ $= 68.55$ The business will make $68 600.	• correctly determines the x value **[1 mark]** • determines profit **[1 mark]**

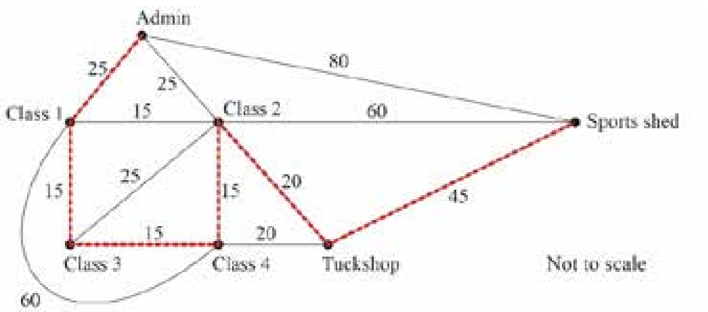
Q	Sample response	The response:
19a)		• correctly translates the information into a network diagram **[1 mark]** • correctly labels each activity letter and duration **[1 mark]** • provides evidence of forward and backward scanning **[1 mark]**
19b)	BDGH	• determines critical path **[1 mark]**
19c)	22 days	• determines shortest time **[1 mark]**
20	**Option 1: Arithmetic sequence** $t_1 = 45\,100$ $d = -2700$ $n = 10$ $t_n = ?$ $t_n = t_1 + (n-1)d$ $\therefore\ t_n = 45\,100 - 2700(10-1)$ $\therefore = 20\,800$ The tractor will be worth $20 800.	• correctly identifies the model **[1 mark]** • correctly identifies the parameters t_1, d and n **[1 mark]** • substitutes values into appropriate model **[1 mark]** • determines value of tractor, including units **[1 mark]**
	Option 2: Linear function $c = 45\,100$ $m = -2700$ $x = 9$ $y = mx + c$ $\therefore y = -2700 \times 9 + 45\,100$ $= 20\,800$ The tractor will be worth $20 800.	• correctly identifies the model **[1 mark]** • correctly identifies the parameters c, m and x **[1 mark]** • substitutes values into appropriate model **[1 mark]** • determines value of tractor, including units **[1 mark]**

Q	Sample response	The response:
21a)	Indi	• correctly identifies the federal electorate **[1 mark]**
21b)	Point A: $37.25°\ \mathrm{S}\ 141.75°\ \mathrm{E}$ Point B: $37.25°\ \mathrm{S}\ 148.5°\ \mathrm{E}$ $\text{angular distance} = 6.75°$ Distance is E–W $D = 111.2 \times cos\theta \times \text{angular distance}$ $= 111.2 \times \cos(37.25°) \times 6.75°$ $= 597.48$ The points are approximately 600 km apart.	• correctly identifies the coordinates for A **[1 mark]** • correctly identifies the coordinates for B **[1 mark]** • determines angular distance **[1 mark]** • substitutes values into appropriate rule **[1 mark]** • states answer rounded to the nearest 100 km **[1 mark]**
22	**Option 1: Recursion** $i = \frac{4.8}{1200}$ $= 0.004$ $\therefore r = 1.004$ $R = 278$ $A_0 = 32\ 000$ $A_{n+1} = rA_n - R$ $\therefore A_1 = 1.004 \times 32\ 000 - 278$ $= 31\ 850$ $\therefore A_2 = 1.004 \times 31\ 850 - 278$ $= 31\ 699.4$ After 2 months, Rosa owes \$31 699.40	• correctly determines the i value **[1 mark]** • correctly substitutes into an appropriate rule **[1 mark]** • substitutes for A_2 using result from A_1 **[1 mark]** • provides answer rounded to the nearest cent **[1 mark]**
	Option 2: Annuity $i = \frac{4.8}{1200}$ $= 0.004$ $\therefore r = 1.004$ $R = 278$ $P = 32\ 000$	• correctly determines the i value **[1 mark]**

Q	Sample response	The response:
	$A_n = P(1+i)^n - M\left(\frac{(1+i)^n - 1}{i}\right)$ $\therefore A_2 = 32\,000(1.004)^2 - 278\left(\frac{1.004^2 - 1}{0.004}\right)$ $= 31\,699.4$ After 2 months, Rosa owes $31 699.40	• correctly substitutes into an appropriate compound interest rule **[1 mark]** • correctly substitutes into an appropriate annuity rule **[1 mark]** • provides answer, including units rounded to the nearest cent **[1 mark]**

Q	Sample response	The response:
23a)	L_4 is not valid because the tank and the tap are on the same side of the line.	• correctly explains why L_4 is not a valid cut **[1 mark]**
23b)	L_1 capacity = 20 + 22 + 15 = 57 L_2 capacity = 18 + 19 + 22 + 15 = 74 L_3 capacity = 18 + 8 + 10 = 36	• correctly determines the L_1 capacity **[1 mark]** • correctly determines the L_2 capacity **[1 mark]** • correctly determines the L_3 capacity **[1 mark]**
24	1. Non-linear form 2. Seasonal cycle every 12 months 3. Positive long-term trend	• correctly identifies the non-linear form **[1 mark]** • correctly identifies a seasonal pattern **[1 mark]** • correctly identifies a positive long-term trend **[1 mark]**
25a)	Depart Brisbane 10:30 Mon 7/12 Flight: + 7:40 Arrive Singapore 18:10 UTC correction –2:00 = 16:10 4:10 pm in Singapore on Mon 7/12	• correctly adds the flight time **[1 mark]** • correctly determines the local time, day and date in Singapore **[1 mark]**
25b)	Arrive Singapore 17:00 Mon 7/12 Flight: – 8:25 Depart Dubai 8:35 UTC correction –4:00 = 4:35 4:35 am in Dubai on Mon 7/12	• correctly subtracts the flight time **[1 mark]** • correctly determines the local time, day and date in Dubai **[1 mark]**

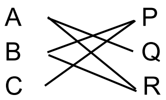
Paper 2: Short response

Q	Sample response	The response:
1	Home latitude = $14°52'$ S Change time difference to angular difference $\text{Angle} = 1\frac{13}{60} \times 15°$ $= 18.25°$ Home longitude $= 145°29' - 18°15'$ $= 127°14'$ Home coordinates are $14°52'$ S, $127°14'$ E	• correctly identifies the latitude **[1 mark]** • correctly determines the angle **[1 mark]** • subtracts angle from longitude in same format **[1 mark]** • determines longitude **[1 mark]**
2	 Minimum spanning tree $= A - C1 - C3 - C4 - C2 - T - SS$ Total length $= (15 \times 3) + 20 + 25 + 45 = 135$ m Total cost $= 135 \times 1200 = \$162\ 000$ Since $155 000 is less than $162 000, the school cannot afford the project.	• correctly identifies a minimum spanning tree **[1 mark]** • determines – total length of minimum spanning tree **[1 mark]** **OR** – cost of each arc of minimum spanning tree **[1 mark]** • determines total cost **[1 mark]** • determines if the school can afford the project **[1 mark]**

Q	Sample response	The response:
3	Value of regular contributions $M = 2500$ $i = \frac{3.6}{400}$ $= 0.009$ $n = 6 \times 4$ $= 24$ $A = M\left(\frac{(1+i)^n - 1}{i}\right)$ $= 2500\left(\frac{(1.009)^{24} - 1}{0.009}\right)$ $= 66\,639.94$	• correctly determines the i and n values **[1 mark]** • substitutes into appropriate annuity rule **[1 mark]**
	Value of extra payment $P = 10\,000$ $i = \frac{3.6}{400}$ $= 0.009$ $n = 2 \times 4$ $= 8$ $A = P(1+i)^n$ $= 10\,000(1.009)^8$ $= 10\,743.09$	• substitutes into appropriate rule **[1 mark]**
	Total value $= 66\,639.94 + 10\,743.09$ $= 77\,383.03$ $= \$77\,383$	• determines sum of two values **[1 mark]** • determines total value, rounded to the nearest dollar **[1 mark]**

Q	Sample response	The response:
4	Let $n =$ the number of years since 2019 Let $t_n =$ the amount of money In 2020, $n = 1$ and $t_1 = 250$ In 2038, $n = 19$ and $t_{19} = 2750$ Find r $t_n = t_1 r^{(n-1)}$ $\therefore 2750 = 250 \times r^{18}$ $\therefore 11 = r^{18}$ $\therefore r = 1.1425$ The geometric model for Model 1 $\therefore t_n = 250 \times 1.1425^{(n-1)}$ The arithmetic model for Model 2 $t_n = t_1 + (n-1)d$ $\therefore t_n = 126(n-1)$ Comparison of investments in 2030, $n = 11$ Model 1's amount in 2030, $t_{11} = 250 \times 1.1425^{10}$ $= 947.33$ Model 2's amount in 2030, $t_{11} = 126 \times 10$ $= 1260$ Difference $= 1260 - 947.33$ $= 312.67$ In 2030 Model 2 is $313 more than Model 1.	• correctly substitutes the values into a geometric rule **[1 mark]** • determines geometric model for Model 1 **[1 mark]** • correctly determines an arithmetic model for Model 2 **[1 mark]** • determines the amounts for both models in 2030 **[1 mark]** • determines difference to nearest dollar **[1 mark]** • shows logical organisation communicating key steps **[1 mark]**

Q	Sample response	The response:
5	Predicted data @ $x = 31$ $y_A - y_P = -0.75$ $119 - y_P = -0.75$ $\therefore y_P = 119.75$	• correctly determines the y_P value **[1 mark]**
	Find b $b = r\frac{s_y}{s_x}$ $= 0.875 \times \frac{6}{4}$ $= 1.3125$	• correctly determines the b value **[1 mark]**
	Find a $y = bx + a$ $119.75 = 1.3125 \times 31 + a$ $\therefore 79.0625 = a$	• determines a value **[1 mark]**
	Model: $y = 1.3125x + 79.0625$	
	Oldest patient @ $x = 40$ $y = 1.3125 \times 40 + 79.0625$ $= 131.5625$	• determines predicted y value for oldest person **[1 mark]**
	Residual = 1.4 $y = 131.5625 + 1.4$ $y = 132.9625$	
	The oldest person in the sample has a systolic blood pressure of 133.	• determines actual systolic blood pressure as a whole number **[1 mark]** • shows logical organisation communicating key steps **[1 mark]**

Q	Sample response	The response:
6	**Hungarian algorithm** Matrix form $\begin{array}{cccc} & P & Q & R \\ A & x+6 & 2x+3 & x+7 \\ B & x+3 & 2x+4 & x+5 \\ C & x & 2x+1 & x+7 \end{array}$	• correctly converts the network information into a matrix form **[1 mark]**
	Row reduction: $R_1 - (x+6), R_2 - (x+3), R_3 - x$ $\begin{array}{ccc} 0 & x-3 & 1 \\ 0 & x+1 & 2 \\ 0 & x+1 & 3 \end{array}$	• determines each matrix element by reducing each row **[1 mark]**
	Column reduction: $C_2 - (x-3), C_3 - 1$ $\begin{array}{ccc} 0 & 0 & 0 \\ 0 & 4 & 1 \\ 0 & 4 & 2 \end{array}$	• determines each matrix element by reducing each column **[1 mark]**
	Only 2 lines are needed to cover all the 0s; therefore, need to use Hungarian algorithm with minimum of 1. Add 1 to overlap, subtract 1 from uncovered. $\begin{array}{ccc} 1 & 0 & 0 \\ 0 & 3 & 0 \\ 0 & 3 & 1 \end{array}$	• correctly applies Hungarian algorithm **[1 mark]**
	Bipartite graph  AQ BR CP	• determines minimum allocation **[1 mark]**
	$\text{Total distance} = 2x + 3 + x + 5 + x$ $32 = 4x + 8$ $24 = 4x$ $x = 6$ It is 6 km from C to P.	• determines x **[1 mark]** • shows logical organisation communicating key steps **[1 mark]**

Q	Sample response	The response:
7	Let $n = \frac{\text{\# of days}}{5}$ Let $t_n =$ the total number of plays $\therefore\ t_1 = 8$ $r = \frac{12}{8}$ $= 1.5$ $\therefore t_n = 8 \times 1.5^{(n-1)}$ At 60 days $n = \frac{60}{5}$ $= 12$ Total number of plays (in 1000s) $\therefore t_{12} = 8 \times 1.5^{11}$ $= 691.98$ Total predicted income Income $= 0.175 \times 691\,980$ $= 121\,096.5$ cents $= \$1210.97$ At least $1000 is a reasonable prediction if plays continue as a geometric progression.	• correctly defines the variables **[1 mark]** • correctly determines the parameter r **[1 mark]** • correctly determines a geometric (exponential) model **[1 mark]** • determines total number of plays **[1 mark]** • determines income **[1 mark]** • evaluates reasonableness of solution **[1 mark]**