General Mathematics subject report

2024 cohort

January 2025

Queensland Government | QCAA Queensland Curriculum & Assessment Authority

250029

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Contents

Introduction

The annual subject reports seek to identify strengths and opportunities for improvement of internal and external assessment processes for all Queensland schools. The 2024 subject report is the culmination of the partnership between schools and the QCAA. It addresses school-based assessment design and judgments, and student responses to external assessment for General and General (Extension) subjects. In acknowledging effective practices and areas for refinement, it offers schools timely and evidence-based guidance to further develop student learning and assessment experiences for 2025.

The report also includes information about:

- how schools have applied syllabus objectives in the design and marking of internal assessments
- how syllabus objectives have been applied in the marking of external assessments
- patterns of student achievement.

The report promotes continuous improvement by:

- identifying effective practices in the design and marking of valid, accessible and reliable assessments
- recommending where and how to enhance the design and marking of valid, accessible and reliable assessment instruments
- providing examples that demonstrate best practice.

Schools are encouraged to reflect on the effective practices identified for each assessment, consider the recommendations to strengthen assessment design and explore the authentic student work samples provided.

Audience and use

This report should be read by school leaders, subject leaders, and teachers to:

- inform teaching and learning and assessment preparation
- assist in assessment design practice
- assist in making assessment decisions
- help prepare students for internal and external assessment.

The report is publicly available to promote transparency and accountability. Students, parents, community members and other education stakeholders can use it to learn about the assessment practices and outcomes for senior subjects.

Subject highlights

460
schools offered General Mathematics

76.74%
agreement with provisional marks for IA1

96.11%
of students received a C or higher

Subject data summary

Subject completion

The following data includes students who completed the General subject.

Note: All data is correct as at January 2025. Where percentages are provided, these are rounded to two decimal places and, therefore, may not add up to 100%.

Number of schools that offered General Mathematics: 460.

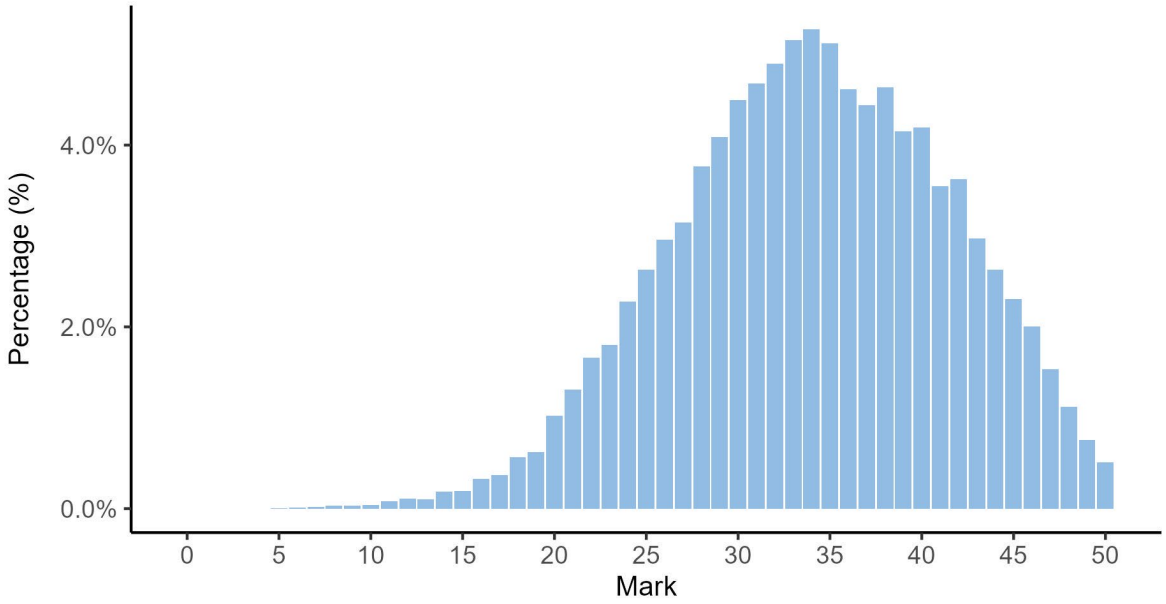
Completion of units	Unit 1	Unit 2	Units 3 and 4
Number of students completed	23,152	22,188	20,414

Units 1 and 2 results

Number of students	Satisfactory	Unsatisfactory
Unit 1	20,173	2,979
Unit 2	19,385	2,803

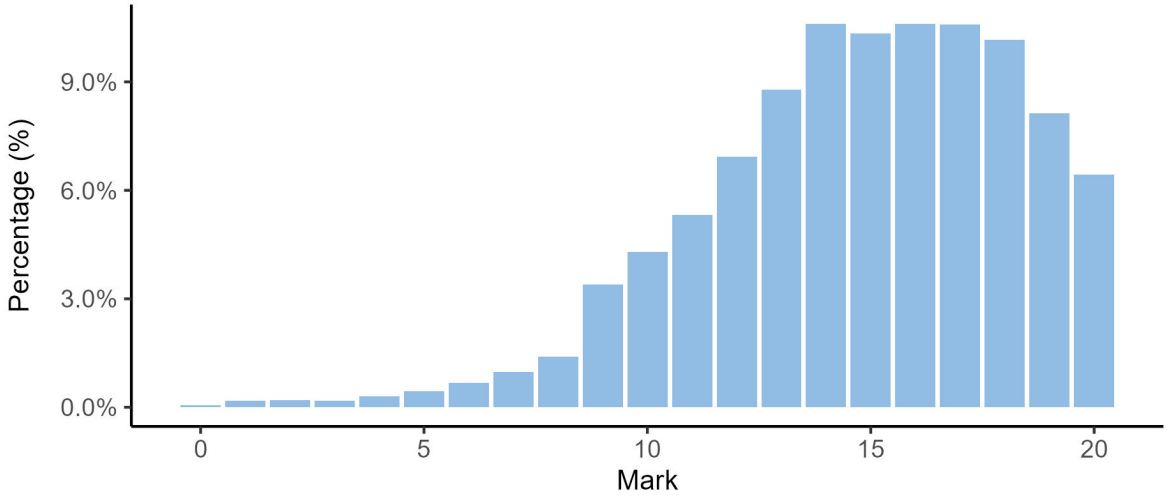
Units 3 and 4 internal assessment (IA) results

Total marks for IA

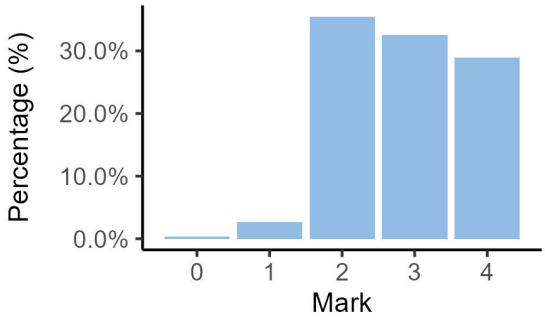


IA1 marks

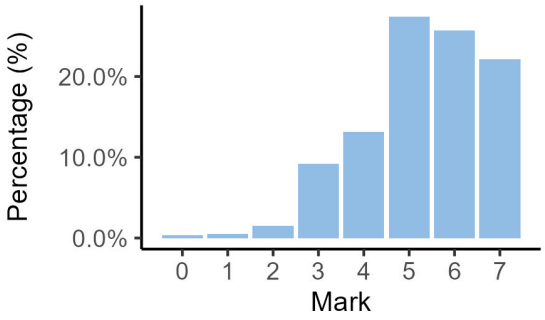
IA1 total



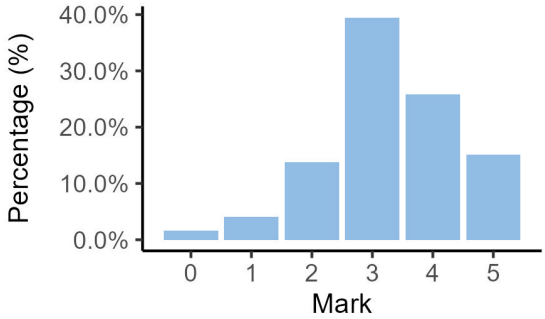
IA1 Criterion: Formulate



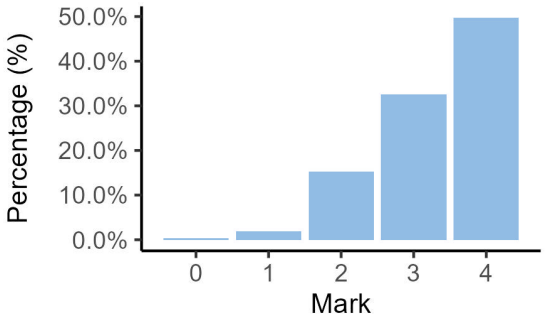
IA1 Criterion: Solve



IA1 Criterion: Evaluate and verify

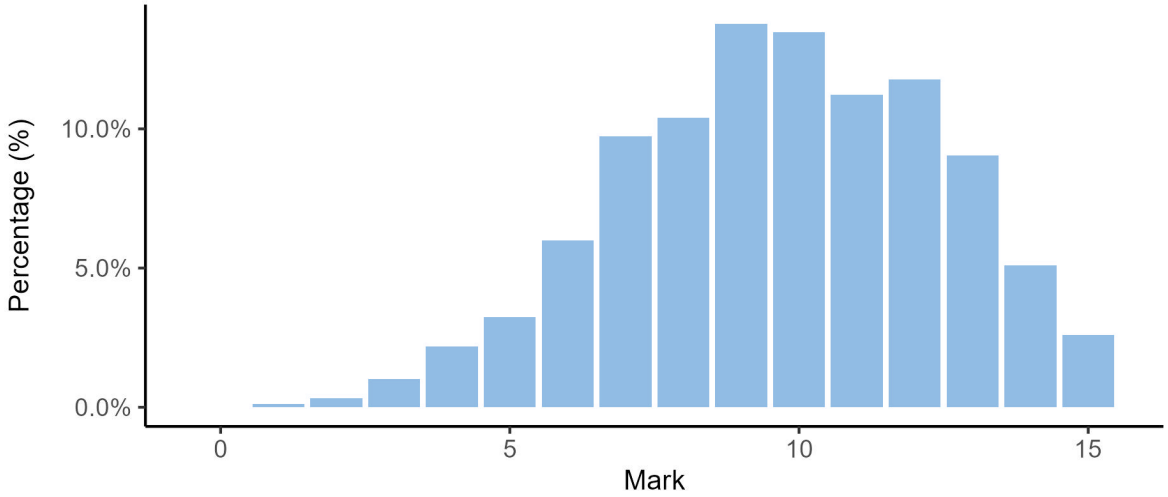


IA1 Criterion: Communicate

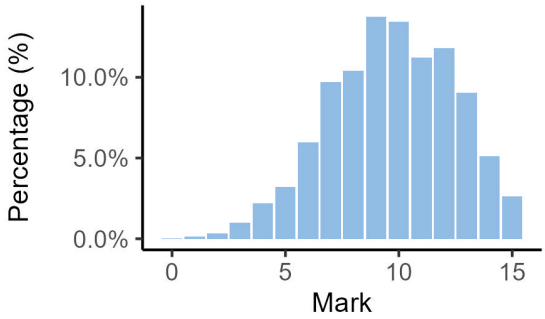


IA2 marks

IA2 total

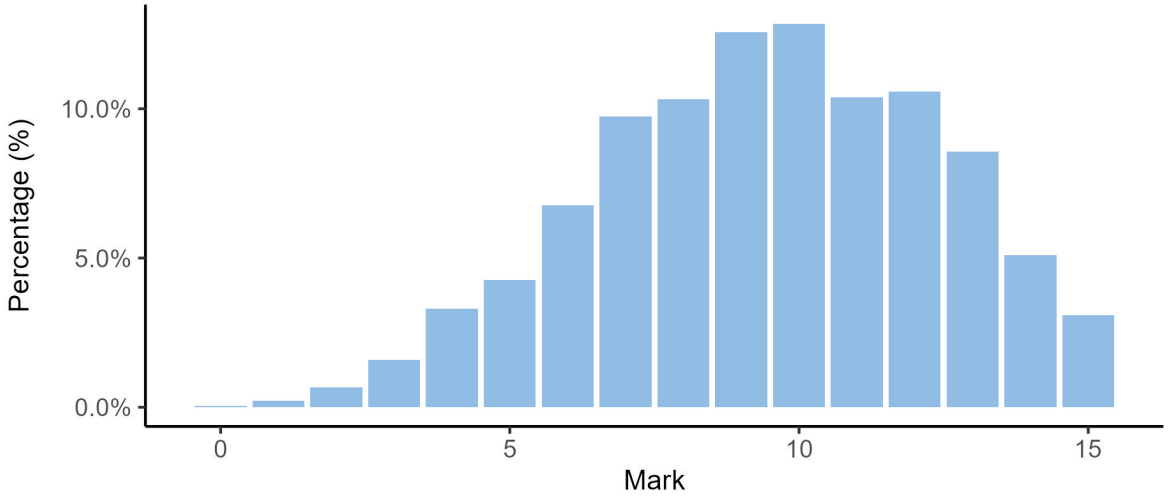


IA2 Criterion: Foundational knowledge and problem-solving

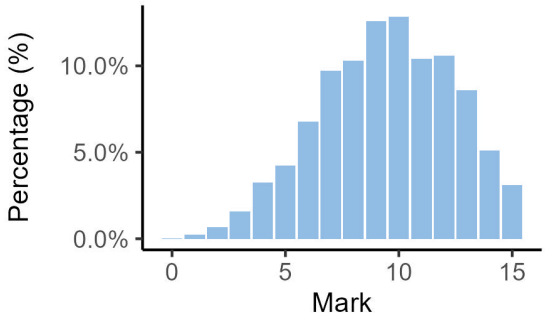


IA3 marks

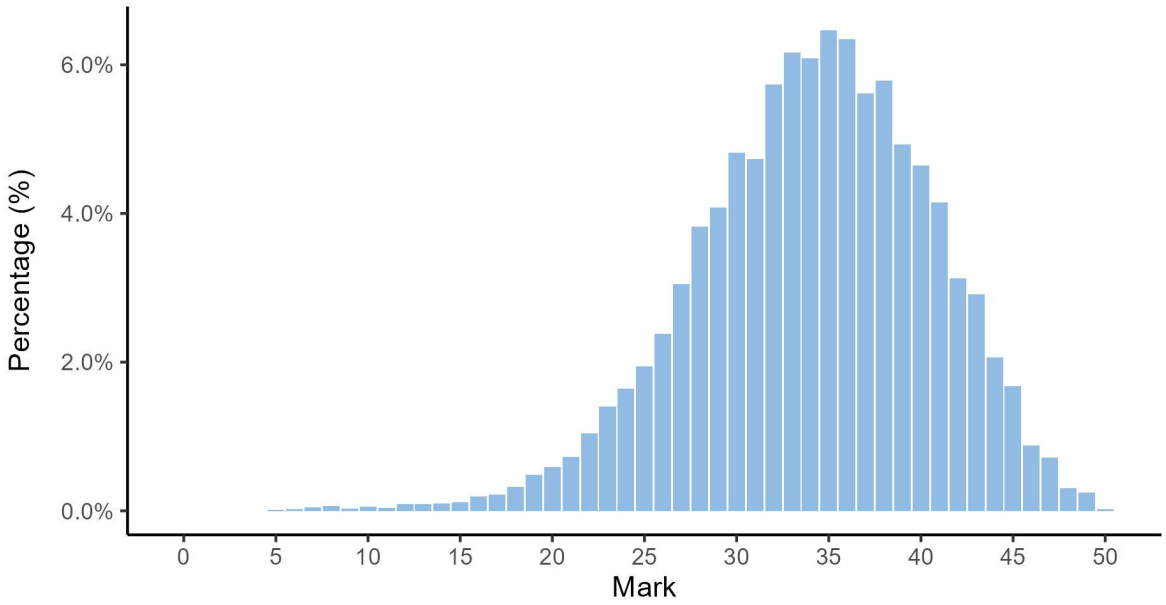
IA3 total



IA3 Criterion: Foundational knowledge and problem-solving

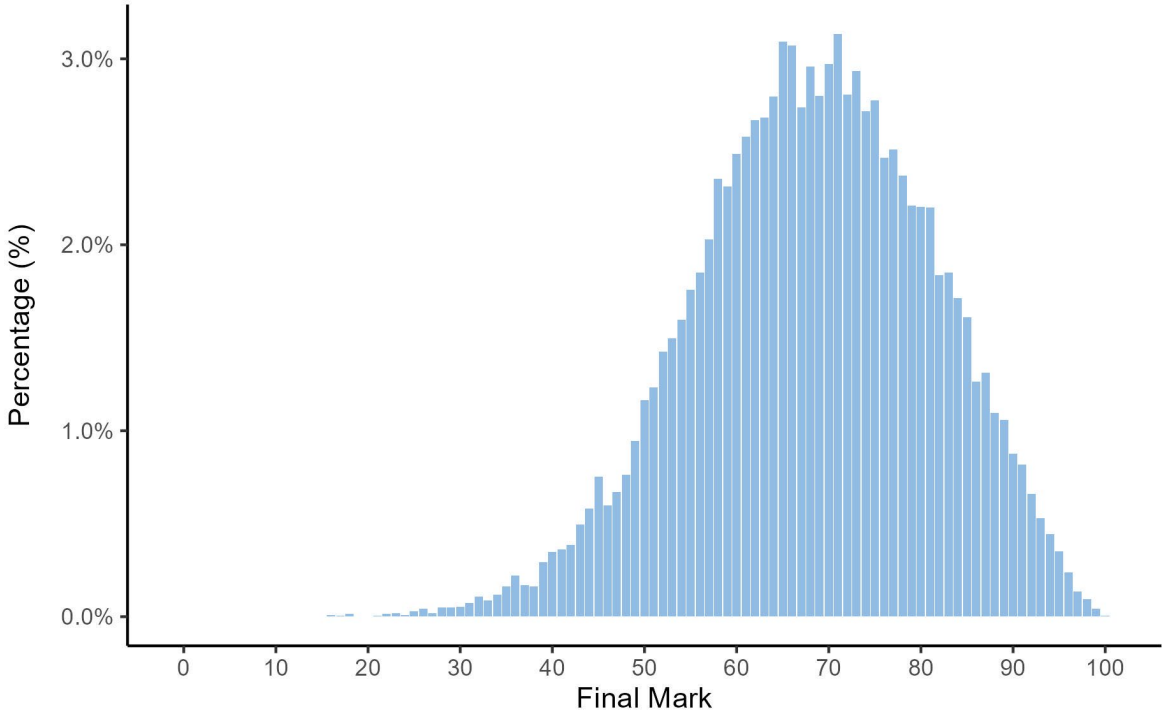


External assessment (EA) marks



Final subject results

Final marks for IA and EA



Grade boundaries

The grade boundaries are determined using a process to compare results on a numeric scale to the reporting standards.

Standard	A	B	C	D	E
Marks achieved	100–84	83–67	66–45	44–22	21–0

Distribution of standards

The number of students who achieved each standard across the state is as follows.

Standard	A	B	C	D	E
Number of students	2,503	8,880	8,236	788	7

Internal assessment

The following information and advice relate to the assessment design and assessment decisions for each IA in Units 3 and 4. These instruments have undergone quality assurance processes informed by the attributes of quality assessment (validity, accessibility and reliability).

Endorsement

Endorsement is the quality assurance process based on the attributes of validity and accessibility. These attributes are categorised further as priorities for assessment, and each priority can be further broken down into assessment practices.

Data presented in the Assessment design section identifies the reasons why IA instruments were not endorsed at Application 1, by the priority for assessment. An IA may have been identified more than once for a priority for assessment, e.g. it may have demonstrated a misalignment to both the subject matter and the assessment objective/s.

Refer to *QCE and QCIA policy and procedures handbook v6.0*, Section 9.5.

Percentage of instruments endorsed in Application 1

Instruments submitted	IA1	IA2	IA3
Total number of instruments	463	463	461
Percentage endorsed in Application 1	64	49	37

Confirmation

Confirmation is the quality assurance process based on the attribute of reliability. The QCAA uses provisional criterion marks determined by teachers to identify the samples of student responses that schools are required to submit for confirmation.

Confirmation samples are representative of the school's decisions about the quality of student work in relation to the instrument-specific marking guide (ISMG), and are used to make decisions about the cohort's results.

Refer to *QCE and QCIA policy and procedures handbook v6.0*, Section 9.6.

The following table includes the percentage agreement between the provisional marks and confirmed marks by assessment instrument. The Assessment decisions section of this report for each assessment instrument identifies the agreement trends between provisional and confirmed marks by criterion.

Number of samples reviewed and percentage agreement

IA	Number of schools	Number of samples requested	Number of additional samples requested	Percentage agreement with provisional marks
1	459	4,479	238	76.74
2	460	4,492	0	100.00
3	460	4,486	0	100.00

Internal assessment 1 (IA1)

Problem-solving and modelling task — extended response (20%)

The problem-solving and modelling task (PSMT) must use subject matter from at least one of the following topics in Unit 3:

- Topic 1: Bivariate data analysis
- Topic 2: Time series analysis
- Topic 3: Growth and decay in sequences.

The task is an assessment instrument developed in response to a mathematical investigative scenario or context. It requires students to respond with a range of understanding and skills, such as using mathematical language, appropriate calculations, tables of data, graphs and diagrams. Students must provide a response to a specific task or issue that is set in a context that highlights a real-life application of mathematics. The task requires students to use relevant stimulus material involving the selected subject matter and must have sufficient scope to allow students to address all the stages of the problem-solving and modelling approach. Technology must be used.

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment

Validity priority	Number of times priority was identified in decisions
Alignment	49
Authentication	39
Authenticity	6
Item construction	28
Scope and scale	75

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- included well-described checkpoints and authentication strategies that aligned with the QCAA drafting and academic integrity procedures, including a checkpoint that indicated the submission of one complete or near-complete draft for feedback (*QCE and QCIA policy and procedures handbook v6.0*, Section 8.2.5)
- used realistic contexts that allowed students to respond to an open-ended task, e.g. an analysis of rental cost versus distance of the rental property from the CBD, or healthy food star rating versus the amount of sugar or salt in a food product

- enabled students to demonstrate simple through to complex procedures and independently make decisions about the data to be used, what model to develop, and what technology and mathematical techniques were relevant to solve the problem
- referred to the approach to problem-solving and modelling in the syllabus (Section 1.2.4, Figure 4) or included an appropriate task-specific approach.

Practices to strengthen

It is recommended that assessment instruments:

- avoid instructions that indicate how to formulate and use mathematical techniques to solve the problem, so students can demonstrate their knowledge and understanding of the criteria. For instance, a task-specific flowchart should not identify the subject matter to use, and stimulus material should not show how to compare the linear relationships between two variables or provide a scatterplot that analyses and compares linear relationships between variables
- focus the context and task statement on a particular situation or issue that allows students to select the relevant subject matter to use for solving the problem, e.g. whether the problem requires application of bivariate data analysis to model an association between variables and make predictions, or time series analysis to model and analyse data over time with adjustments for seasonality
- provide students with appropriate stimuli such as the dataset to use or relevant links to access data, because research is not the focus of the PSMT. For instance, students should not be required to interpret unrelated or specialist information to obtain data from provided website links. The inclusion of sample data for the endorsement review allows for the scope and scale of the task to be determined.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment

Accessibility priority	Number of times priority was identified in decisions
Bias avoidance	4
Language	18
Layout	3
Transparency	4

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- were well presented with appropriate page breaks and other formatting features. (Schools can check formatting using the **Print preview** function within the Endorsement application (app) before submitting the IA1 for endorsement.)

Practices to strengthen

It is recommended that assessment instruments:

- use accessible language free from jargon or specialist or technical terms so students can engage with the assessment.

Additional advice

- When developing the task description, schools should consider the expected components of a typical response to determine whether all aspects of the problem-solving and modelling approach can be demonstrated and matched to the ISMG characteristics. This will also help schools identify relevant and necessary stimulus material.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and confirmed marks

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional	Percentage both less and greater than provisional
1	Formulate	88.24	10.68	1.09	0
2	Solve	90.63	8.50	0.87	0
3	Evaluate and verify	89.98	9.37	0.65	0
4	Communicate	97.60	0.65	1.74	0

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- for the Solve criterion, judgments matched to the top performance-level characteristics were made where the student response
  - demonstrated accurate use of complex procedures drawn from Unit 3 subject matter to provide a plausible or valid solution
  - showed discerning application of mathematical concepts and techniques, chosen for their relevance to the task, e.g. applying a smoothing technique to reduce fluctuations in data to determine if a trend could be observed
  - demonstrated accurate and appropriate use of technology within the body of the report as a tool to develop the solution or to justify the use of a mathematical technique, e.g. using a residual plot to support the appropriateness of a linear model
- for the Communicate criterion, judgments matched to the top performance-level characteristics were made where the student's response
  - demonstrated appropriate use of language that accurately applied technical vocabulary and used procedural vocabulary
  - included an introduction relevant to the task and a conclusion that responded to the problem that had been solved.

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG for this IA, it is recommended that:

- for the Formulate criterion, judgments matched to the top performance-level characteristics are made where the student's response
  - provides evidence for identified assumptions and observations, such as including a referenced source for an observation and giving a reason for why or how an assumption is relevant to the problem to be solved
  - demonstrates accurate translation of all aspects of the problem by identifying relevant mathematical concepts and techniques that are specific to the problem, rather than a list of general definitions
- for the Evaluate and verify criterion, judgments matched to the top performance-level characteristics are made where the student's response
  - evaluates the reasonableness of the solution by interpreting their results and referring back to previously identified assumptions and observations
  - demonstrates documentation of strengths and limitations relevant to the solution and/or model by providing supporting evidence for each strength and limitation, such as stating why decisions and refinements contributed to the success or otherwise of the model or solution
  - explains the mathematical reasoning to justify procedures used and decisions made.

Samples

The following excerpts demonstrate characteristics in the Formulate criterion of documentation of accurate and appropriate assumptions and observations relevant to the problem by providing explanations to support the inclusion of each point, including references where appropriate. The responses show accurate translation of all aspects of the problem by identifying relevant mathematical concepts and techniques.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

2.1 Observations

- The students in grade 11 were within the same age range (16-17 years old), whilst age is a factor that can affect average heart rate, this was a relatively consistent variable that did not necessarily need to be taken into account.
- To ensure accuracy and validity, every students' resting heart rates were recorded using the same Apple smart watch, to eliminate possible variations or inconsistencies between brands of watches and individual watches.
- Generally the recommended sample size to gather data that is representative of a population under 1000 is 30% of the given population (St. Olaf College, n.d). The year 11 cohort consists of 48 students, 30% of this figure is 14 students, a sample size of 17 students exceeds this minimum standard, therefore the recorded sample is a suitable representation of the cohort.

2.2 Assumptions:

- The watch measured and recorded the heart rates correctly and there was little to no technological faults or errors, the process of measuring was observed, there was no significant irregularity in the heart rate measurements to suggest any errors.
- The approximate average amount of sleep from each student reported was accurate
- External factors that will not be measured or accounted for in the experiment will most likely affect a student's heart rate.
- Based on external research, it can be assumed that the less sleep a student gets, the more likely they are to have a higher than average heart rate (American college of cardiology, 2016).

2.3 Mathematical concepts and Techniques:

To investigate the effect of sleep on resting heart rate the following steps were taken:

- Each student's heart rate was measured in class using an Apple smart watch, each student was sitting down when the measurements were taken, to alleviate possible inconsistencies in heart rate due to physical activity (standing or walking during measuring).
- The approximate average amount of sleep was self reported by each student and recorded.
- The amount of sleep and heart rate of each student was graphed in the form of a scatter plot, to determine whether or not correlation was present in the data set. Additionally a regression line was added using the google sheets trendline function to find any linear correlation. The equation of the regression line and the coefficient of determination was calculated and verified using the functions on google sheets

Excerpt 2

Assumption	Evidence
We can assume that all data collected from the Bureau of metrology is accurate and correct in all aspects of temperature data.	Climate data pass through a number of stages in quality control which occurs over a period of time. Data are only included in this product if either one of the following is true: i) If the Quality Flag = Y, then we have, as a minimum requirement, a medium degree of certainty that the data have no errors; ii) If the Quality Flag = N, then no significant errors have yet been detected, although this may change during a later stage of the quality control process. *"Bureau of meteorology, BOM, 2024" (See References for Citation)*
We can make assumptions of the data becoming cooler during winter and autumn and hotter during summer and spring.	"Seasonality is a characteristic of a time series in which the data experiences regular and predictable changes that recur every calendar year. Any predictable fluctuation or pattern that recurs or repeats over a one-year period is said to be seasonal." *Investopia, 2024" (See References for Citation)*
We can assume that no outliers have been collected in the data	There have been no recorded cyclones after the year 1986 from cyclone *Winifred. "Bureau of Meteorology, 2024" (See References for Citation)*

Kenton W (2019) Seasonality: What It Means in Business and Economics, Examples, Investopedia, https://www.investopedia.com/terms/s/seasonality.asp

Excerpt 3

[F1]

$$Deseasonalised\ Value = \frac{Original\ Data\ Point}{Average\ Seasonal\ Index(Monthly)}, Where\ Seasonal\ Index = \left(\frac{Data\ point\ (Original)}{Yearly\ Average}\right)$$

2. This de-seasonalised was then compiled into a table along with the seasonal indexes (see appendix 1) and graphed for interpretation reasons. With this table, (see forecast section of report) the following least squares regression line was formulated. $y = 0.0026x + 27.479$. The following formula could then be used to make predictions on future values.

[F2]

$$y = (0.0026x + 27.479) \times (Average\ seasonal\ index\ value(monthly)), where\ x = Month\ Number$$

a) The Month number was calculated using a simple index counter e.g. January 1987 is calculated as 1, February 1987 is calculated as 2, etc.

b) The average seasonal index value (monthly) was then used for calculations in correlation with the following table.

[T2]

January	February	March	April	May	June	July	August	September	October	November	Decemb
1.10773081	1.102332596	1.066836129	1.015039662	0.94477452	0.878260917	0.861594429	0.893062038	0.95807765	1.01102834	1.06052729	1.09773

c) The last data point in recording was 31.3°C recorded from December 2019 with a month number of 396. For example, to extrapolate month number 397, the data would be subbed into the formula as followed.

[F3]

$$y = (0.0026 \times 1.10773081 + 27.479) \times 397$$

Therefore, retrieving a predicted value for January 2020 as 31.58°C.

The following excerpts demonstrate characteristics in the Solve criterion of accurate use of complex procedures as well as accurate and appropriate use of technology, e.g. using a spreadsheet to generate graphs, linear models and associated statistical measures. The relevance of the generated graph and data to the development of the solution is explained. Responses show discerning application of mathematical concepts and techniques relevant to the task.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

3.5 Correlation Coefficient

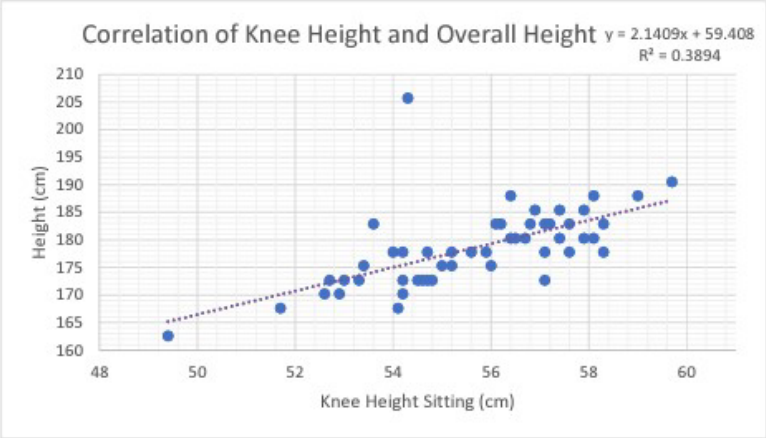
The correlation coefficient (r) of the data was calculated using the CORREL function in Excel. It was found to be 0.6240.

Refer to verification of Microsoft Excel calculation section for Excel.

3.6 Interpretation

Assuming linearity, the correlation coefficient r = 0.6240, in the interval $0.5 \leq r \leq 1$ confirms a moderate positive association between knee length and total height.

3.7 Least Squares Model



3.7 Interpretation

In the least square model, 2.1409 is the slope and the 59.408 is the intercept. The slope predicts that, on average, for every 1cm increase of knee height the overall height will increase 2.1409cm. The intercept predicts that when the knee height is at 0cm then the overall height will be 59.408cm.

3.8 Coefficient of Determination

The coefficient of determination R^2 of the data was calculated as 0.3894. (*As indicated on the scatterplot above)*

3.9 Interpretation

The coefficient of determination shows that 38.9% of changes in overall height can be explained by changes in knee height.

Excerpt 2

	B	C	D
55		Math Calculate	Excel Verified
56	n	50	50
57	$\bar{x}$	55.632	55.632
58	$\bar{y}$	178.51	178.51
59	s_x	2.089	2.089
60	s_y	7.167	7.167
61	r	0.6240	0.6240

	B	C	D
55		Math Calculated	Excel Verified
56	n	50	=COUNT(B3:B52)
57	$\bar{x}$	=B53/C56	=AVERAGE(B3:B52)
58	$\bar{y}$	=C53/C56	=AVERAGE(C3:C52)
59	s_x	=SQRT(E53/(C56-1))	=STDEV.S(B3:B52)
60	s_y	=SQRT(G53/(C56-1))	=STDEV.S(C3:C52)
61	r	=(1/(C56-1))*H53	=CORREL(B3:B52,C3:C52)

5.1.2 Correlation of determination

$R^2 = (0.64006)^2 = 0.3894$

5.1.3 Least Squares Equation

The least square model is represented by $y = mx + c$

$b = r\frac{s_y}{s_x} = 0.624 \times \frac{7.167}{2.089} = 2.141$

$a = \bar{y} - b\bar{x} = 178.51 - (2.141)(55.632) = 59.402$

Excerpt 3

Therefore, by calculating the predicted value for the number of extremely hot days, it can be seen that the value is not accurate or close to the actual value for the number of extremely hot days.

Calculating the residual for data points and plotting them on a residual plot would be a more accurate and reliable method for evaluating the association.

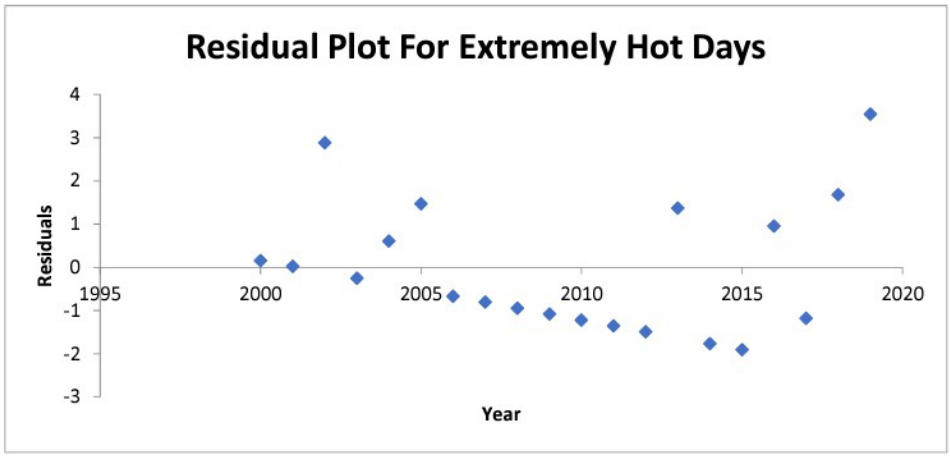


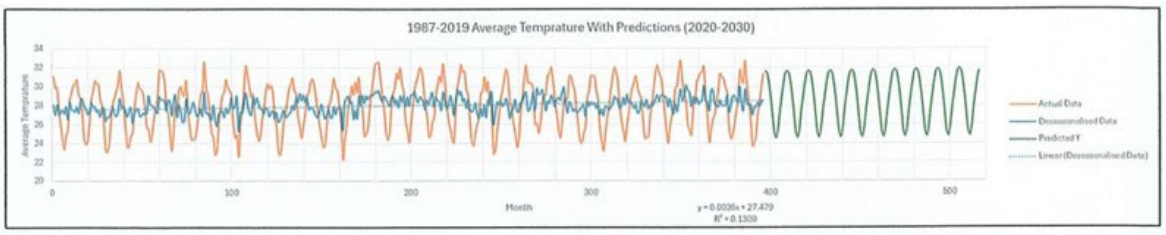
Figure 4: Residual plot for the model of extremely hot days

The residuals and residual plot were calculated through EXCEL using the Data Analysis function (Appendix 4). The residual plot and the residuals determine the appropriateness of the model to use in the regression analysis. In an ideal scenario, residuals would cluster closely around the x-axis, indicating that the model is an appropriate depiction of the association between the two variables. It can be seen in figure 4 that most data points are spread far from the x-axis. Therefore, it can be concluded that the scatter plot and regression line are not an appropriate model for the modeling of the number of extremely hot and cold days.

Excerpt 4

Forecast | Discussion of mathematical predictions

Using the mathematical equations outlined in the *methodology*, *[F1]* and *[F2]*, we can now investigate into making predictions into a future temperature pattern. Through these steps we output a table displaying *raw data* collected, *Seasonal indexes* calculated and *De-seasonalised* data calculated. we also output the following graph created using the *De-seasonalised* data points and the *forecasted* data points [G5].



With this graph we can visually see the continuing seasonal trend thought the predicted **y** values displayed in a green colour. We can also gauge that the predicted **y** values are symmetrical with similarity to the original collected data points. Evaluating **graph 5 [G5]** we can use the **b** value from the least squares regression line and the **R^2** value to diagnose the gradient of the graph. With a **b** value of **0.0025** and an **R^2** value of **0.1309** we can see that there is a **13.09%** change in the temperature due to the time (Months) using the de-seasonalised values. With a gradient of **0.0026** we can see that each month the temperature rises by **0.0026°C**.

With this we can establish that formula 2 [F2] can be used to predict any future value with the use of the monthly seasonal index value and the month number correlated with the time. See *Reasonableness of solution* section of report for **reliability** of the solution.

The following excerpts demonstrate characteristics in the Evaluate and verify criterion of evaluation of the reasonableness of solutions by considering the results, assumptions and observations as well as documentation of relevant limitations of the solution and/or model.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

Overall, the prediction that the suspect would be 168.03cm tall is reasonable but due to the weak correlation is not as reliable as it should be. The weak correlation may be due to the assumption that male and females had the same correlation. Research shows that separating the two will help to eliminate outliers and give a more accurate relationship. The additional assumption that shoe size was similar to foot length may also have affected the results. Foot size would be a more accurate dataset to use as it is an exact measurement and does not rely on the assumption of well-fitting shoes. The observation that no anomalies was present may also have weakened the correlation. There could have been outliers at one extreme of data set that affected the results. Also, the observation that research showed a theoretical positive linear correlation of r = 0.6222 and an R^2 =0.3871 could have created bias towards a linear relationship.

Excerpt 2

The same can be said for the improved model on the number of extremely cold days, this is because of the R^2 value being 0.0406. Therefore, the number of extremely hot and cold days in a year would not be feasible for linear modeling. This is further evident as there is still no association between the year and number of extremely cold days as determined through the correlation coefficient value of -0.2. This could be due to the assumptions and considerations made, further factors such as outliers could also impact the model. The temperatures required for an extremely hot and cold day were assumed, therefore, predictions would have a low association with real-world temperatures affecting the reasonableness of the solution. Further assumptions made such as, there would be no external events or disasters affecting the data. This could have resulted in outliers or fluctuations in the data and overall affecting the reasonableness of the model.

Excerpt 3

Some limitations include:

- The improved model relies on assumptions. These assumptions may not be a real-world representation of a situation causing inaccuracies.
- The small sample size may be insufficient to make general predictions and claims about the increase in extremely hot days and decrease in the number of extremely cold days.
- The model was created based on the data of a small region within Australia, therefore a prediction for the increase in the number of extremely hot and cold days may not correlate with other regions in Australia.

Additional advice

- The ISMG from the syllabus must be used to award a mark for each criterion and must not be altered, added to, or reformatted in any way (*QCE and QCIA policy and procedures handbook v6.0*, Section 7.3.3).
- Each summative internal assessment instrument should be printed directly from the Endorsement app for use with students to ensure the correct instrument and ISMG are used (*QCE and QCIA policy and procedures handbook v6.0*, Section 8.3).
- It is recommended that teachers annotate the student's work to indicate where key evidence in the assessment response matches the ISMG characteristics and that the accuracy and

consistency of judgments across the cohort are reviewed through internal moderation practices.

- Schools must apply the best-fit approach to using the ISMG to determine the correct mark for each criterion after matching student response evidence to performance-level descriptors (*QCE and QCIA policy and procedures handbook v6.0,* Section 9.6.1). It is recommended that teachers and schools refer to *Module 3 — Making reliable judgments* in the Assessment Literacy app, the 'Using marking guides' section in the *Understanding General and Applied (Essential) syllabuses* course in the Learning Hub app, and the *Making judgments* webinar in the Syllabuses app.
- Schools are responsible for ensuring that students are aware of the school-based assessment policy and procedures, particularly regarding the management of response length. For a student response that exceeds the IA1 conditions outlined in the syllabus (maximum of 2000 words and maximum of 10 pages), teachers must clearly annotate the student's work to reference the school's assessment policy and how it has been applied when making judgments (see *QCE and QCIA policy and procedures handbook v6.0*, Section 8.2.6).

Internal assessment 2 (IA2)

Examination — short response (15%)

This examination assesses the application of a range of cognitions to a number of items, drawn from all Unit 3 topics. Student responses must be completed individually, under supervised conditions, and in a set timeframe.

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment

Validity priority	Number of times priority was identified in decisions
Alignment	176
Authentication	0
Authenticity	5
Item construction	9
Scope and scale	56

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- assessed a representative sample of subject matter from all Unit 3 topics using an appropriate number of questions for the time condition, i.e. 120 minutes plus 5 minutes perusal
- included items that were appropriate to the school's context and distinct enough from QCAA-provided sample questions to enable students to produce responses that were original and not pre-rehearsed.

Practices to strengthen

It is recommended that assessment instruments:

- ensure that all assessment objectives are assessed, including Objective 4: evaluate the reasonableness of solutions, and that the mark allocation in the marking scheme reflects the assessment of this objective, e.g. an item may require students to complete a percentaged two-way frequency table and evaluate the reasonableness of a claim based on interpretation of the results
- correctly align complex familiar questions to the degree of difficulty specification (Syllabus section 4.7.2), i.e. relationships and interactions have a number of elements so connections are made with subject matter within and/or across the domains of mathematics, and all of the information to solve the problem is identifiable. In particular, a question is not complex if it is scaffolded by having multiple parts that each involve only simple familiar aspects

- correctly align complex unfamiliar questions to the degree of difficulty specification for both complexity and unfamiliarity (Syllabus section 4.7.2), i.e. relationships and interactions have a number of elements, and all of the information to solve the problem is not immediately identifiable.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment

Accessibility priority	Number of times priority was identified in decisions
Bias avoidance	13
Language	37
Layout	9
Transparency	13

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- were designed so the layout of questions and the overall instrument was not distracting. The **Print preview** feature in the Endorsement app can be used to check for potential distractions, such as related content being split across lines (e.g. latitude and longitude coordinates, equations, or sequence rules) and to confirm that stimulus items such as tables, diagrams and graphs are fully visible on a page
- provided adequate space for students to respond to all questions, which may have included adding extra working space, graphs or diagrams at the end of the instrument for students to use, if required.

Practices to strengthen

It is recommended that assessment instruments:

- are free from punctuation, grammatical, spelling and typographical errors and model correct language conventions, including the use of syllabus-specific terms such as seasonal index, geometric sequence and prime meridian, and correct mathematical textual features such as the use of subscripts for equations, e.g. $t_n = t_1 + (n-1)d$. Schools are encouraged to thoroughly proofread assessment tasks so all the information and contexts in a particular question match, e.g. check that the names of variables and people are consistent throughout the question.

Additional advice

- Schools with a non-endorsed assessment instrument from Application 1 are advised to consult with the Lead endorser before submitting their revised assessment instrument for Application 2. These consultations are supportive and can provide further feedback about issues to school communities to strengthen the endorsement process.
- Ensure that the marking scheme matching the assessment instrument is checked for accuracy and uploaded for the Endorsement review. When a school is required to submit a revised assessment instrument for Application 2, an updated marking scheme should be included that

reflects the changes to the examination. The *Endorsement submission information* for Mathematics is available under Resources in the Syllabuses app.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and confirmed marks

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional	Percentage both less and greater than provisional
1	Foundational knowledge and problem-solving	100	0	0	0

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- the marking scheme provided at confirmation accurately matched the school's endorsed instrument, including any updates that may have arisen during the marking process
- teacher annotations indicated where and how marks were awarded to the student response, e.g. ticking the evidence that matched the mark allocation, writing comments about marking decisions and showing the number of marks awarded to each question response.

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG for this IA, it is recommended that:

- teachers use the school-devised marking scheme to mark student work and implement internal quality assurance processes to ensure accuracy of the awarded marks and provisional marks across the cohort
- the ISMG is annotated with the
  - correctly determined achievement percentage (*QCE and QCIA policy and procedures handbook v6.0,* Section 9.6.1)
  - mark out of 15, obtained by correctly applying the 'greater than' percentage cut-off (see *Advice to schools: How to correctly apply a percentage cut-off ISMG*, available from the Internal Assessment and Certification resources for schools tile in the Noticeboard app).
- when a student's response is for a comparable assessment, the school checks that the matching marking scheme is provided at confirmation, e.g. corresponding question order, numerical values and contexts.

Samples

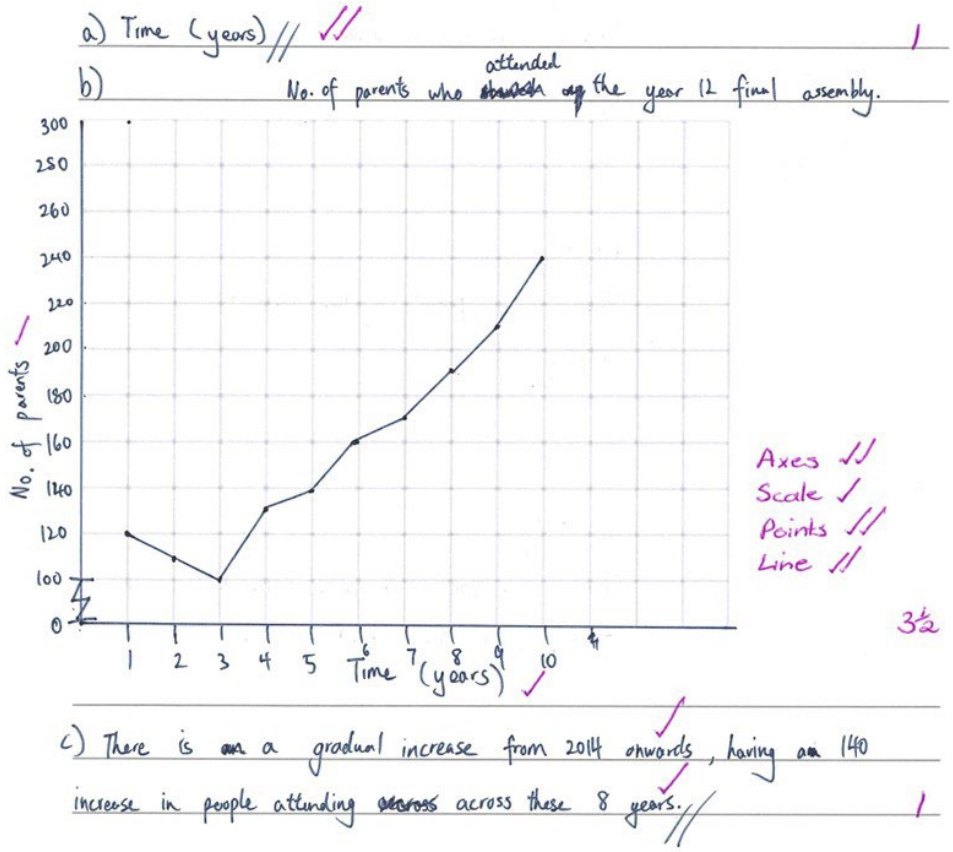
The following excerpts illustrate teacher annotations and the use of ticks to indicate:

- the number of marks awarded for each question

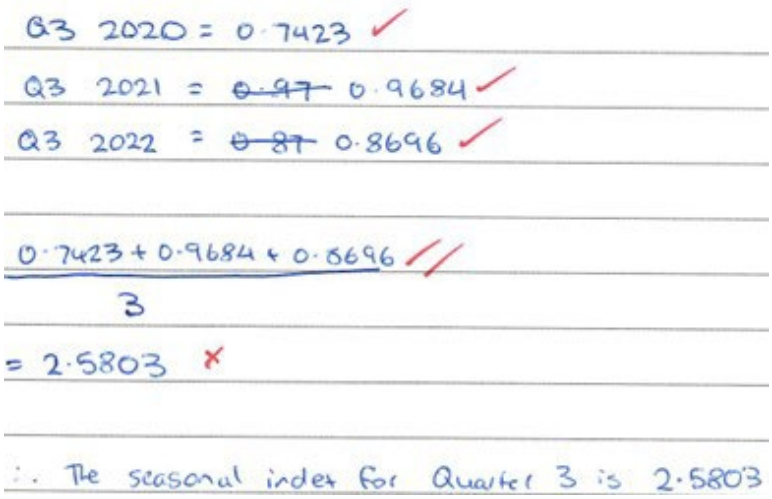
- which particular response components were awarded part marks for evidence matching the school-provided marking scheme.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

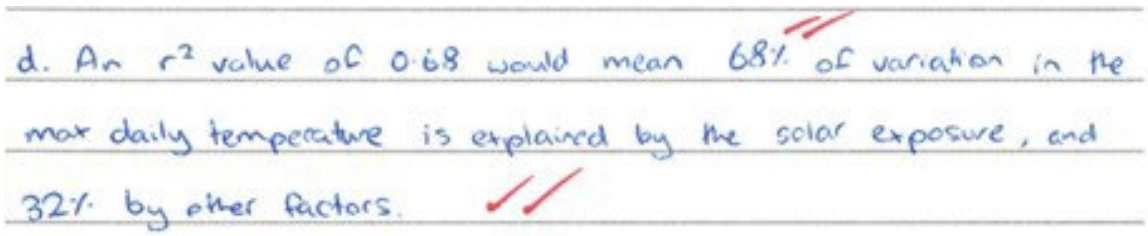
Excerpt 1



Excerpt 2



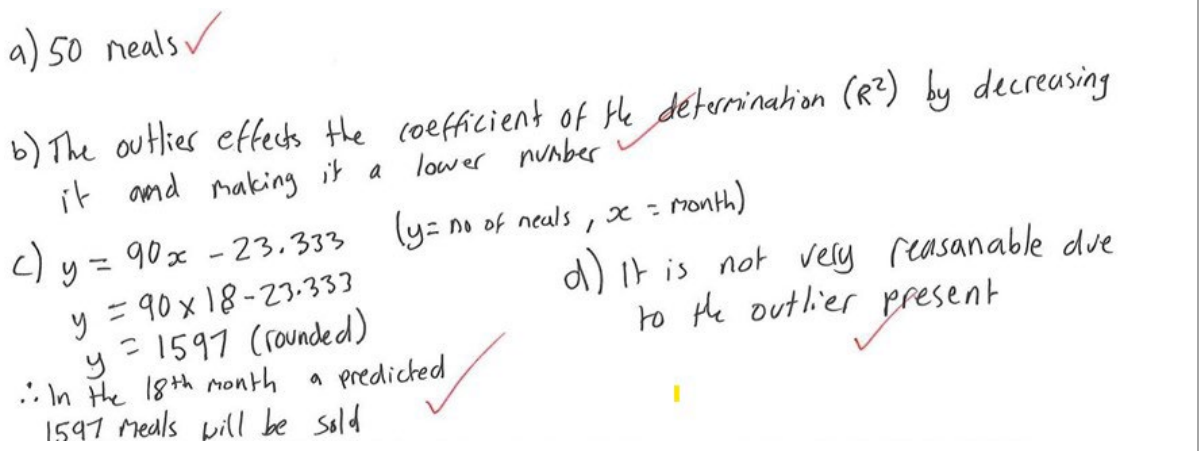
Excerpt 3



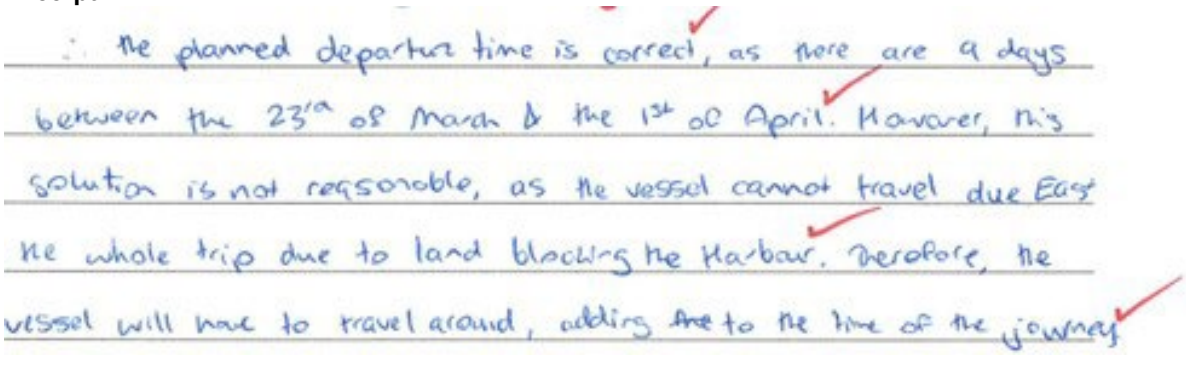
The following excerpts illustrate situations where marks were awarded for demonstration of Objective 4: evaluate the reasonableness of solutions.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1



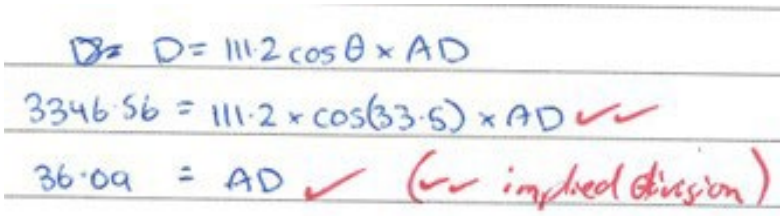
Excerpt 2



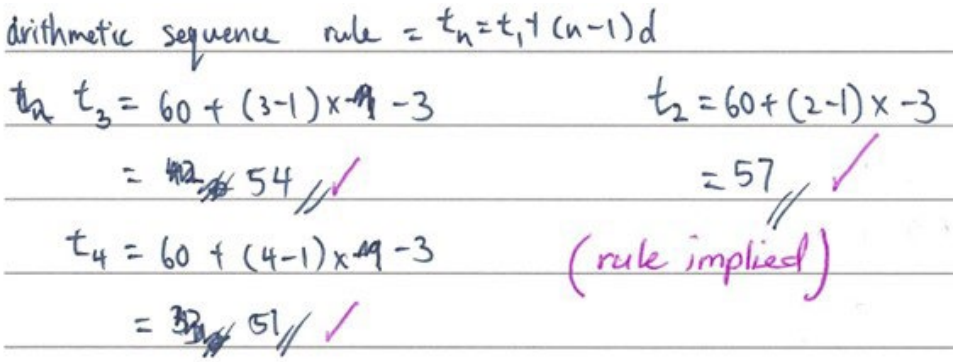
The following excerpts illustrate responses where marks were awarded for the implied understanding shown by subsequent mathematical working.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1



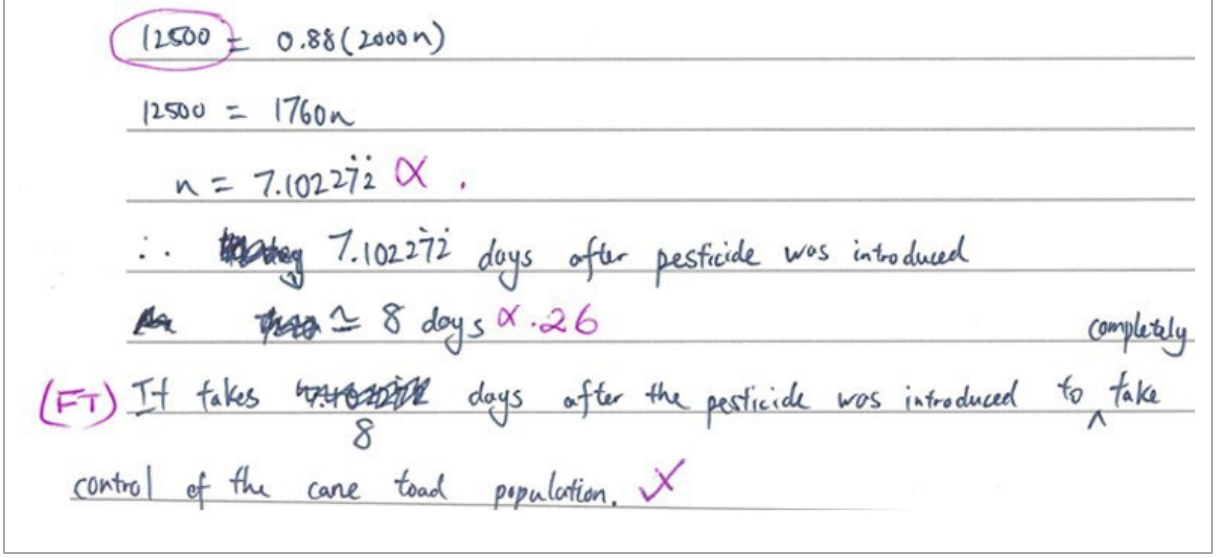
Excerpt 2



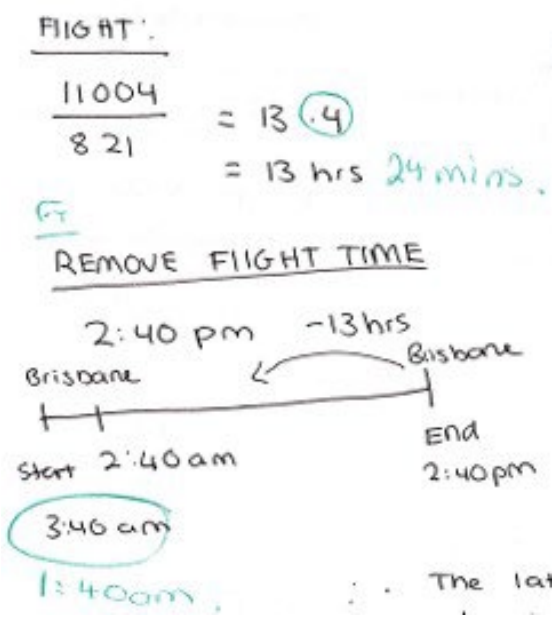
The following excerpts illustrate marking decisions for solutions where, if an error was carried through from an earlier step, follow-through marks were awarded for the remaining steps, unless a new error arose. Excerpt 2 notes a follow-through flight time from an earlier error. However, a follow-through mark was not awarded for the time of day due to a subsequent error.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1



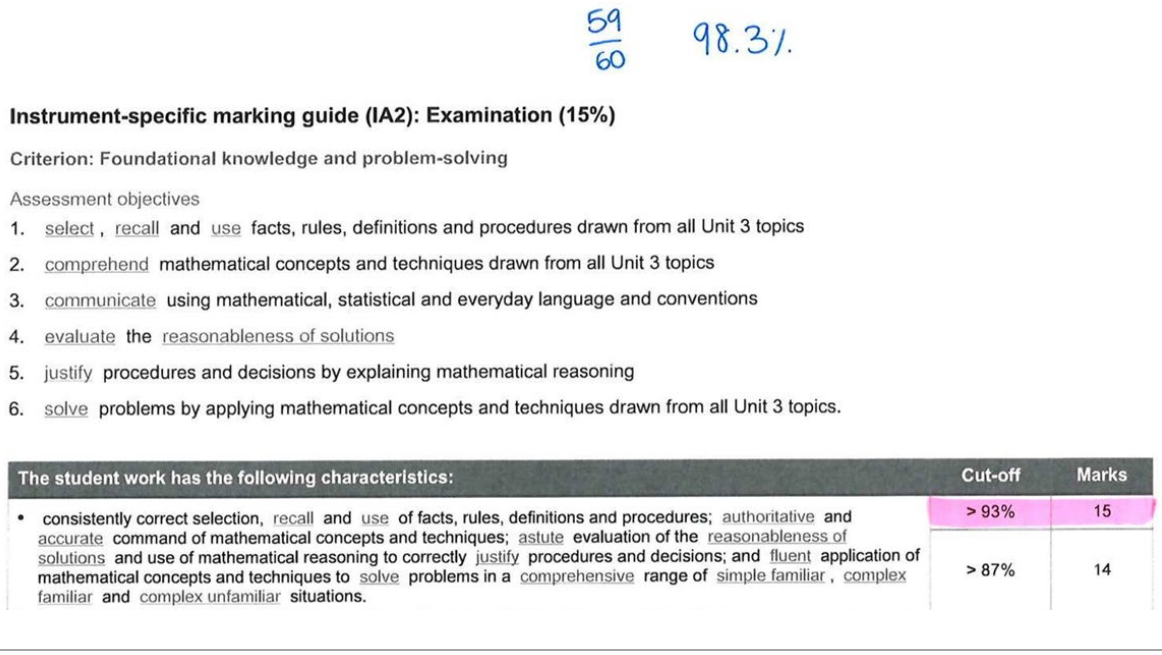
Excerpt 2



The following excerpts illustrate teacher annotations on the syllabus ISMG and/or examination cover to identify the total awarded marks out of available marks and the student's achievement percentage, which was aligned to the correct ISMG mark out of 15 by applying the appropriate 'greater than' percentage cut-off.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1



$\frac{59}{60}$ 98.3%.

Instrument-specific marking guide (IA2): Examination (15%)

Criterion: Foundational knowledge and problem-solving

Assessment objectives

1. select, recall and use facts, rules, definitions and procedures drawn from all Unit 3 topics
2. comprehend mathematical concepts and techniques drawn from all Unit 3 topics
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 all Unit 3 topics.

The student work has the following characteristics:	Cut-off	Marks
• consistently correct selection, recall and use of facts, rules, definitions and procedures; authoritative and accurate command of mathematical concepts and techniques; astute evaluation of the reasonableness of solutions and use of mathematical reasoning to correctly justify procedures and decisions; and fluent application of mathematical concepts and techniques to solve problems in a comprehensive range of simple familiar, complex familiar and complex unfamiliar situations.	> 93%	15
	> 87%	14

Excerpt 2

Marking summary

Criterion	Maximum possible marks	Marks allocated	Provisional marks
Foundational knowledge and problem-solving	53	15	15
Overall	**56.0**	**15**	

SF	CF	CU
33½/34	10½/11	9/11

94.6%

Additional advice

- Schools must administer the endorsed instrument and cannot change or modify an ISMG (*QCE and QCIA policy and procedures handbook v6.0*, Sections 7.3.3 and 8.3).
- If a comparable assessment instrument is administered to a sampled student, the school must indicate this in Student Management on the individual student's learning account and in the Confirmation app. Comparable assessments should be developed in the Endorsement app to ensure the correct examination and matching marking scheme are available for the confirmation review (*QCE and QCIA policy and procedures handbook v6.0*, Section 7.4). For further information, see the quick-step guide *Upload samples* in the Help section of the Confirmation app.
- Schools are required to submit samples of student assessment responses for review during confirmation. Submissions should align to the relevant *Confirmation submission information* (*QCE and QCIA policy and procedures handbook v6.0*, Section 9.6.3). The *Confirmation submission information* for General Mathematics is available under Resources in the Syllabuses app. Before submitting responses for confirmation, schools are advised to check that all scanning of student work has been completed without error. This includes ensuring that
  - no pages are missing from the response
  - all pages are visible and legible
  - the submitted response matches the student selected.

Internal assessment 3 (IA3)

Examination — short response (15%)

This examination assesses the application of a range of cognitions to a number of items, drawn from all Unit 4 topics. Student responses must be completed individually, under supervised conditions, and in a set timeframe.

Assessment design

Validity

Validity in assessment design considers the extent to which an assessment item accurately measures what it is intended to measure and that the evidence of student learning collected from an assessment can be legitimately used for the purpose specified in the syllabus.

Reasons for non-endorsement by priority of assessment

Validity priority	Number of times priority was identified in decisions
Alignment	225
Authentication	0
Authenticity	4
Item construction	9
Scope and scale	103

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- assessed a representative sample of subject matter from all Unit 4 topics using an appropriate number of questions for the time condition, i.e. 120 minutes plus 5 minutes perusal
- used authentic and realistic contexts and stimulus material for questions designed to assess critical paths, investments, loans, minimum spanning trees and flow networks
- included items that were sufficiently different from QCAA-provided samples and past assessments — in particular, graphs and networks were not the same as those used in these readily available resources.

Practices to strengthen

It is recommended that assessment instruments:

- ensure that all assessment objectives are assessed, including Objective 4: evaluate the reasonableness of solutions, and that the mark allocation in the marking scheme reflects the assessment of this objective, e.g. an item may require students to discuss the reasonableness of a superannuation fund amount based on the future value of an annuity, or the cost of a project based on a minimum spanning tree
- assess subject matter within the scope of the syllabus, e.g. the syllabus requires students to use the Hungarian algorithm, but not beyond a 3 x 3 matrix, and to construct an adjacency

matrix from a given graph or digraph, but not to construct a graph or digraph from a given adjacency matrix

- correctly align complex familiar questions to the degree of difficulty specification (Syllabus section 5.6.1), i.e. relationships and interactions have a number of elements so connections are made with subject matter within and/or across the domains of mathematics, and all of the information to solve the problem is identifiable. For instance, a number of elements could be incorporated into a question by requiring students to calculate the travel time through a network at a particular speed using the shortest path or the change in the cost of a project involving a minimum spanning tree
- correctly align complex unfamiliar questions to the degree of difficulty specification for both complexity and unfamiliarity (Syllabus section 5.6.1), i.e. relationships and interactions have a number of elements and all of the information to solve the problem is not immediately identifiable.

Accessibility

Accessibility in assessment design ensures that no student or group of students is disadvantaged in their capacity to access an assessment.

Reasons for non-endorsement by priority of assessment

Accessibility priority	Number of times priority was identified in decisions
Bias avoidance	8
Language	22
Layout	4
Transparency	10

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- were designed so the layout of questions and the overall instrument was not distracting. The **Print preview** feature in the Endorsement app can be used to check that diagrams are easy to read for students to access the necessary information and appropriately sized for students to demonstrate their solution, e.g. network diagrams are large enough for students to show forward and backward scanning and identify the critical path
- provided adequate space for students to respond to all questions, particularly those involving networks that require varying amounts of response space, which may include adding extra working space, graphs or diagrams at the end of the instrument.

Practices to strengthen

It is recommended that assessment instruments:

- are free from punctuation, grammatical, spelling and typographical errors, and model correct language conventions, including the use of syllabus-specific terms such as recurrence relation, Eulerian trail and bipartite graph, and providing clear instructions such ‘use forward and backward scanning to identify the critical path’. Schools are encouraged to thoroughly proofread assessment tasks so all the information and contexts in a particular question match, e.g. check that required tables or grids are provided and that diagrams are relevant to the question.

Additional advice

- Schools with a non-endorsed assessment instrument from Application 1 are advised to consult with the Lead endorser before submitting their revised assessment instrument for Application 2. These consultations are supportive and can provide further feedback about issues to school communities to strengthen the endorsement process.
- Ensure that the marking scheme matching the assessment instrument is checked for accuracy and uploaded for the endorsement review. When a school is required to submit a revised assessment instrument for Application 2, an updated marking scheme should be included that reflects the changes to the examination. The *Endorsement submission information* for Mathematics is available under Resources in the Syllabuses app.

Assessment decisions

Reliability

Reliability is a judgment about the measurements of assessment. It refers to the extent to which the results of assessments are consistent, replicable and free from error.

Agreement trends between provisional and confirmed marks

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional	Percentage both less and greater than provisional
1	Foundational knowledge and problem-solving	100	0	0	0

Effective practices

Accuracy and consistency of the application of the ISMG for this IA was most effective when:

- the marking scheme provided at confirmation accurately matched the school's endorsed instrument, including any updates that may have arisen during the marking process
- teacher annotations indicated where and how marks were awarded to the student response, e.g. ticking the evidence that matched the mark allocation, writing comments about marking decisions and showing the number of marks awarded to each question response.

Practices to strengthen

To further ensure accuracy and consistency of the application of the ISMG for this IA, it is recommended that:

- teachers use the school-devised marking scheme to mark student work and implement internal quality assurance processes to ensure accuracy of the awarded marks and provisional marks across the cohort
- the ISMG is annotated with the
  - correctly determined achievement percentage (*QCE and QCIA policy and procedures handbook v6.0,* Section 9.6.1)
  - mark out of 15, obtained by correctly applying the 'greater than' percentage cut-off (see *Advice to schools: How to correctly apply a percentage cut-off ISMG*, available from the Internal Assessment and Certification resources for schools tile in the Noticeboard app).

- when a student's response is for a comparable assessment, the school checks that the matching marking scheme is provided at confirmation, e.g. corresponding question order, numerical values and contexts.

Samples

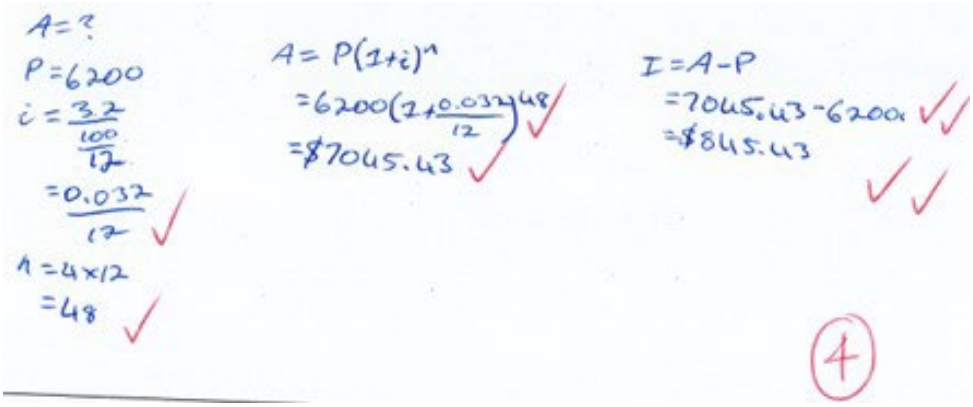
The following excerpts illustrate teacher annotations and the use of ticks to indicate:

- the number of marks awarded for each question
- which particular response components were awarded part marks for evidence matching the school-provided marking scheme.

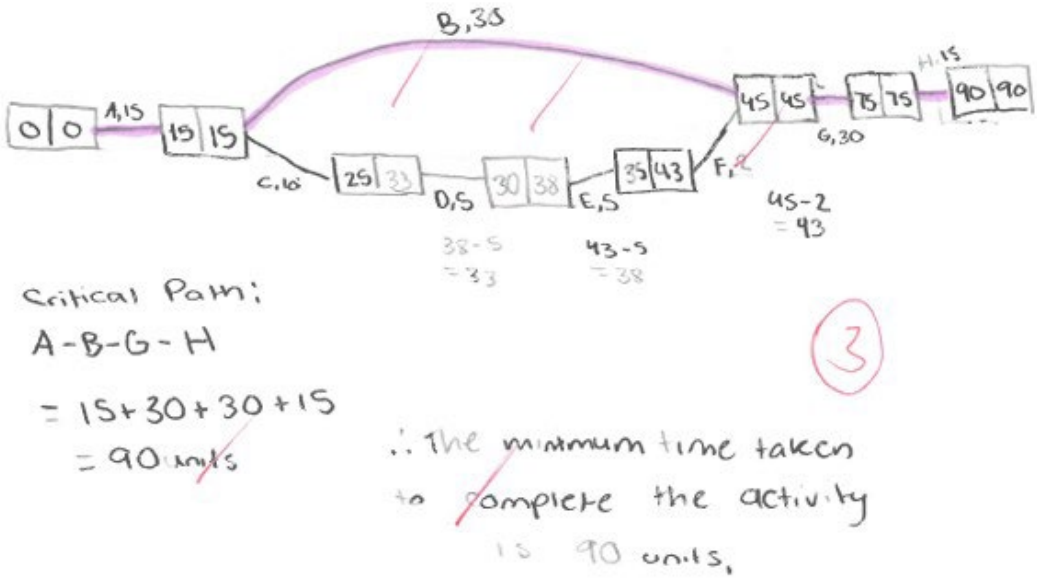
The document footer shown in Excerpt 3 indicates the instrument was printed from the Endorsement app and the school administered the endorsed General Mathematics IA3 for the 2023–2024 cohort.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

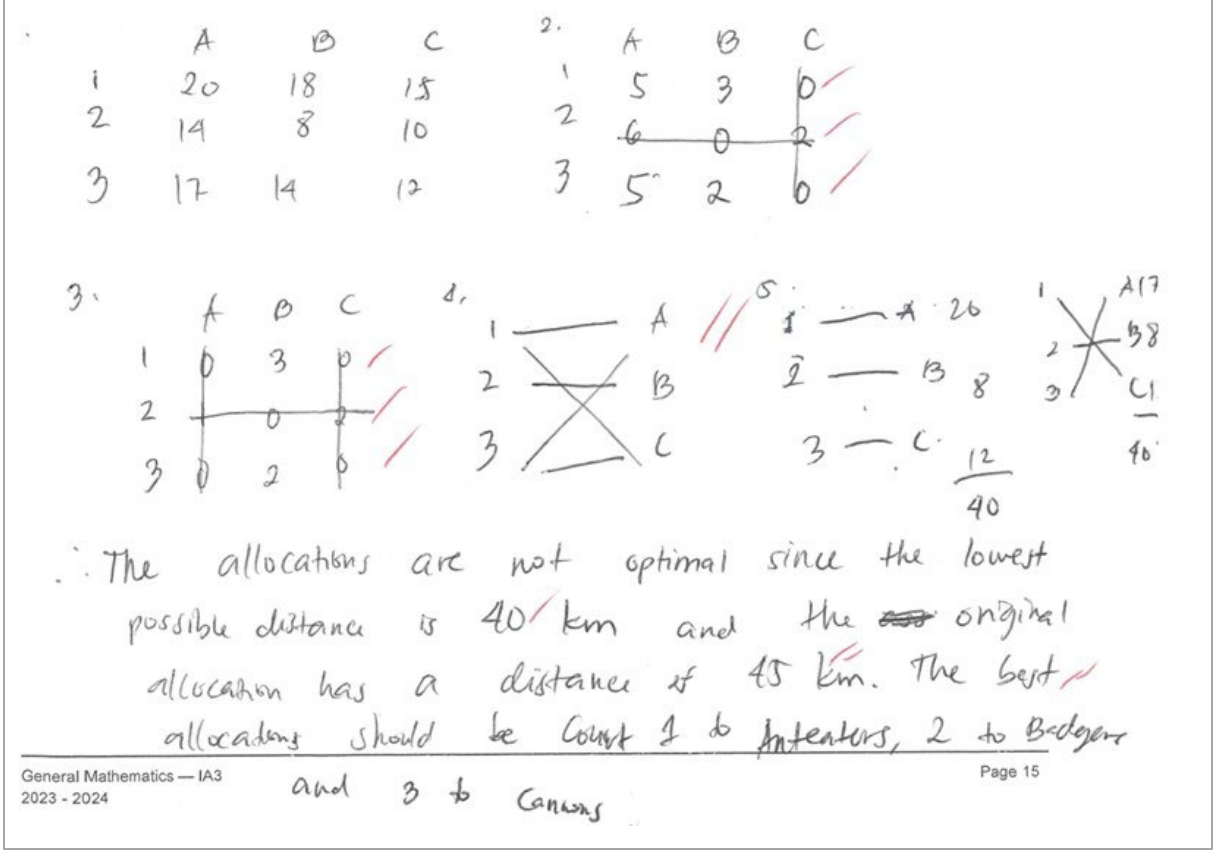
Excerpt 1



Excerpt 2



Excerpt 3



The following excerpts illustrate situations where marks have been awarded for students using a valid alternative method. The Excerpt 1 response determines the shortest route by first listing all possible paths and their distances, as an alternative method to locating the shortest path on a provided network diagram. The Excerpt 2 response is annotated by the teacher to indicate the acceptance of an alternative method to applying the 'maximum-flow, minimum cut' theorem.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

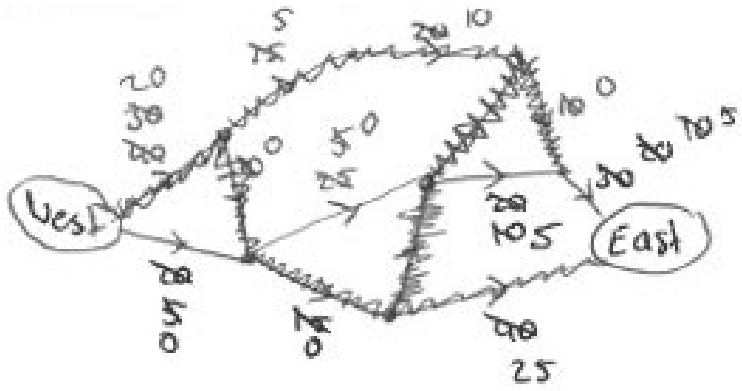
Marks: 3

is network from M to O. Justify your decision showing

M - N - O = 9 + 4 = 13 km
- M - T - O = 6 + 5 = 11 km ✓✓
M - V - O = 7 + 8 = 15 km
- M - S - Q - U - O = 2 + 3 + 2 + 4 = 11 km
M - S - Q - U - P - O = 2 + 3 + 2 + 2 + 1 = 10 km

Shortest route is:
M - S - Q - U - P - O = 10 km ✓

Excerpt 2



10
15
10
5 +
40 ✓

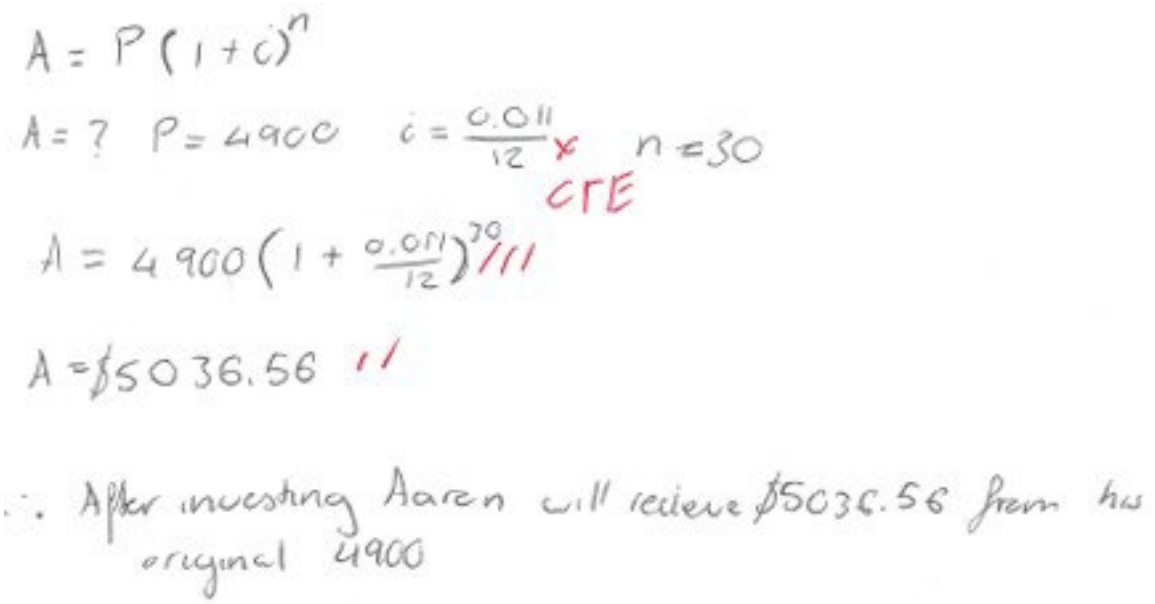
Maximum flow of 40 ML

Alternative method

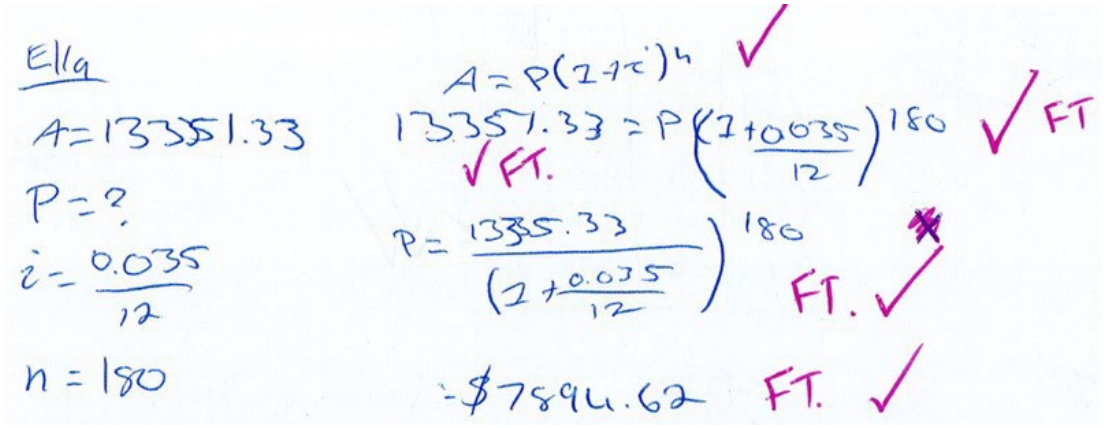
The following excerpts illustrate marking decisions for solutions where, if an error was carried through from an earlier step, follow-through marks were awarded for the remaining steps, unless a new error arose.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1



Excerpt 2



The following excerpt illustrates teacher annotations on the syllabus ISMG to identify the total awarded marks out of available marks and the student's achievement percentage, which was aligned to the correct ISMG mark out of 15 by applying the appropriate 'greater than' percentage cut-off.

Note: The characteristic/s identified may not be the only time the characteristic/s occurred throughout a response.

Excerpt 1

atical reasoning

$\frac{67.5}{71} = 95\%$

techniques drawn from all Unit 4 topics.

	Cut-off	Marks
definitions and procedures; ts and techniques; astute nematical reasoning to correctly thematical concepts and simple familiar , complex familiar	> 93%	15
	> 87%	14

Additional advice

- Schools must administer the endorsed instrument with students and cannot change or modify an ISMG (*QCE and QCIA policy and procedures handbook v6.0*, Section 7.3.3 and Section 8.3).
- If a comparable assessment instrument is administered to a sampled student, the school must indicate this in Student Management on the individual student's learning account and in the Confirmation app. Comparable assessments should be developed in the Endorsement app to ensure the correct examination and its matching marking scheme are available for the confirmation review (*QCE and QCIA policy and procedures handbook v6.0*, Section 7.4). For further information, see the quick-step guide *Upload Samples* in the Help section of the Confirmation app.
- Schools are required to submit samples of student assessment responses for review during confirmation. Submissions should align to the relevant *Confirmation submission information* (*QCE and QCIA policy and procedures handbook v6.0*, Section 9.6.3). The *Confirmation submission information* for General Mathematics is available under Resources in the Syllabuses app in the QCAA Portal. Before submitting responses for confirmation, schools are advised to check that all scanning of student work has been completed without error. This includes ensuring that:
  - no pages are missing from the response
  - all pages are visible and legible
  - the submitted response matches the student selected.

External assessment

External assessment (EA) is developed and marked by the QCAA. The external assessment for a subject is common to all schools and administered under the same conditions, at the same time, on the same day.

Examination — short response (50%)

Assessment design

The assessment instrument was designed using the specifications, conditions and assessment objectives described in the summative external assessment section of the syllabus.
The examination consisted of two papers:

- Paper 1, Section 1 consisted of multiple choice questions (15 marks)
- Paper 1, Section 2 consisted of short response questions (42 marks)
- Paper 2, Section 1 consisted of short response questions (38 marks).

Assessment decisions

Assessment decisions are made by markers by matching student responses to the external assessment marking guide (EAMG). The external assessment papers and the EAMG are published in the year after they are administered.

Multiple choice question responses

There were 15 multiple choice questions in Paper 1.

Percentage of student responses to each option

Note:

- The correct answer is **bold** and in a blue shaded table cell.
- Some students may not have responded to every question.

Question	A	B	C	D
1	10.91	**69.62**	2.89	15.96
2	2.76	9.59	36.96	**50.05**
3	35.16	**24.57**	29.38	9.96
4	25.00	8.20	2.93	**63.26**
5	6.62	5.80	**64.35**	22.59
6	**83.66**	6.55	2.88	6.34
7	10.34	16.89	**62.37**	9.70
8	12.47	15.62	**65.88**	5.25
9	4.53	8.84	31.37	**54.26**
10	9.16	16.05	**46.44**	27.39
11	3.94	**92.78**	1.63	1.08

Question	A	B	C	D
12	**33.66**	38.85	19.93	6.36
13	**43.89**	11.25	17.02	26.89
14	10.82	31.48	**44.25**	12.51
15	**43.29**	12.11	39.77	4.12

Effective practices

Overall, students responded well to:

- questions requiring the generation of values using a given arithmetic sequence and geometric sequence
- network graph situations requiring the construction of an adjacency matrix by identifying the number of adjacent edges
- application of Euler's formula by identifying the number of faces, edges and vertices
- an item requiring the completion of a two-way frequency table and calculation of an associated percentage
- a problem requiring the identification of a Hamiltonian after constructing a weighted graph using given tabulated data.

Practices to strengthen

When preparing students for external assessment, it is recommended that teachers:

- support students to develop solutions using mathematical conventions and valid ways of working and communicating results, such as
  - defining variables when developing equations/models
  - writing formulas and identifying values for variables before substituting
  - using appropriate units and rounding numbers correctly, e.g. not rounding money values beyond the nearest cent
  - only drawing arrows on edges for directed networks
  - beginning and ending project network diagrams with a respective start node and end node
- support students to practise constructing scatterplots with labelled axes and accurately plotted data points. Students must decide where the scaling values will begin on each axis, and then write the scaling values at equally spaced increments. Students must show a 'broken scale' symbol on any axis where zero is written as the first value and the increment between zero and the next written value does not follow the scaling pattern
- instruct students to use a blue or black pen (not a highlighter) when identifying the sequence of edges and vertices for a minimum spanning tree or shortest path contained in a provided network diagram. For response evidence to be clearly visible when scanned, students should draw a thicker line or use a squiggly line or write the vertex sequence in the diagram response space
- teach students to complete steps in the correct order using the average percentage method (Syllabus sections 4 and 6) when calculating seasonal indices across multiple years, i.e. first, calculate the average of the data values for each distinct year (not for each season and not for all years). Then express each data value as a percentage (or ratio) of the average for its year.

Then average the percentages (or ratios) for the corresponding seasons for different years to arrive at each seasonal index

- teach students to write separate matrices to show the outcome for each step when applying the Hungarian algorithm, i.e. after row reduction and after column reduction (either order), and when continuing the algorithm until the minimum number of lines to cover all zeroes is equal to the number of assignments.

Samples

Short response

Paper 1, Questions 17a) and 20b)

The following excerpts are from Question 17a) and Question 20b) in Paper 1. Question 17a) required students to define *planar graph*. Question 20b) required students to define *confounding variable*.

Effective student responses:

- correctly defined each subject matter term.

These excerpts have been included:

- to illustrate a range of appropriate definitions for *planar graph* and *confounding variable*.

Excerpt 1

a planar graph is a graph with connections allowing it to be drawn so that no edges intersect / cross over one another.

Excerpt 2

A planar graph is a graph that has or can be rearranged to have no overlapping Edges

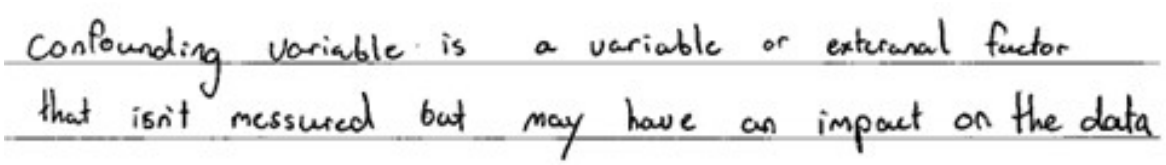
Excerpt 3

A planar graph is a graph where there are no overlapping edges, or edges that cross over.

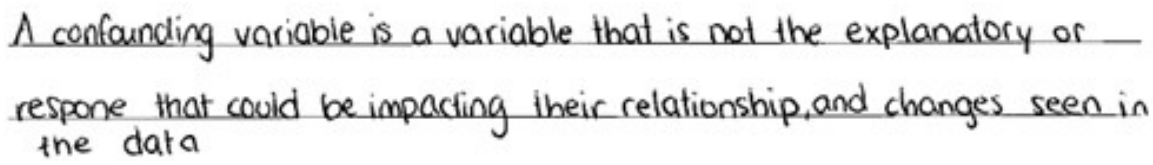
Excerpt 4

a confounding variable is a variable other than the explanatory (x) that impacts the response variable (y).

Excerpt 5



Excerpt 6



Paper 1, Question 18

The following excerpt is from Question 18 in Paper 1. It required students to calculate the amount of interest earned from an 18-year investment account earning interest compounding monthly.

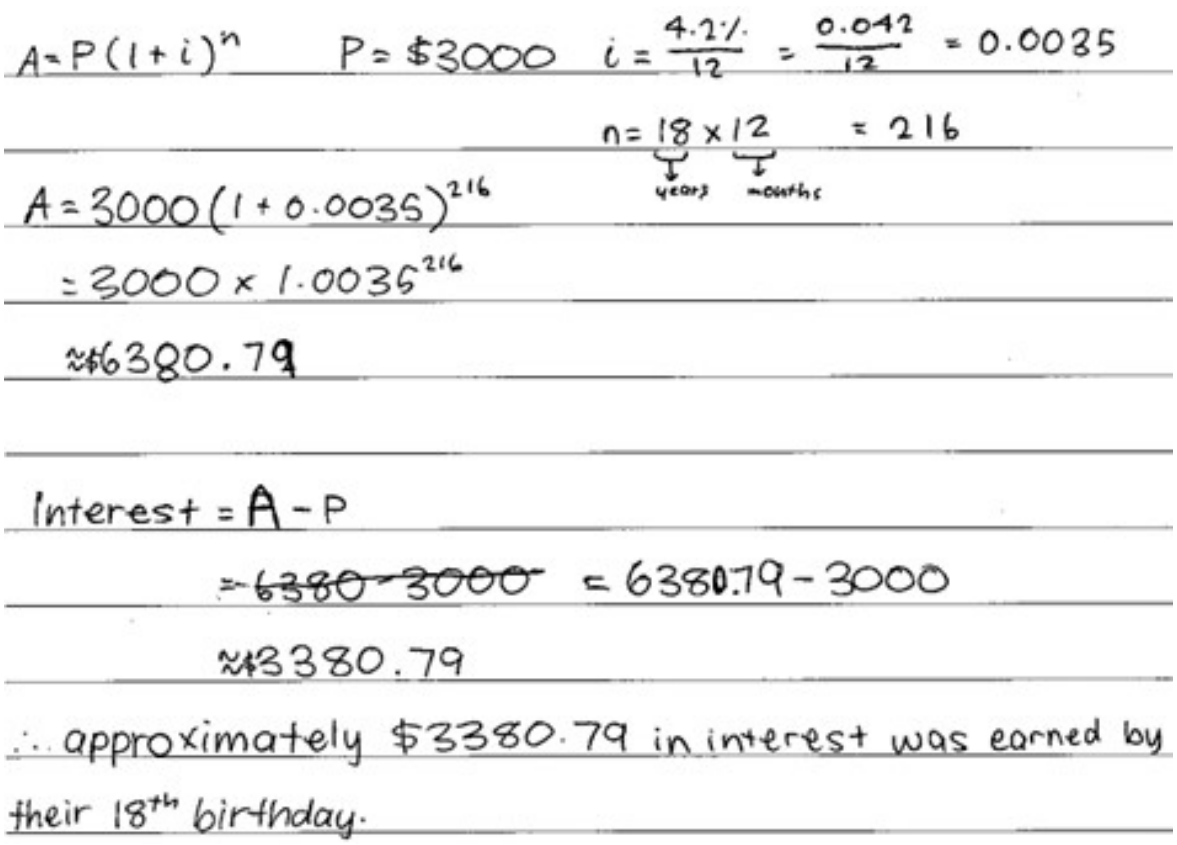
Effective student responses:

- correctly determined the i and n values
- substituted into an appropriate rule
- determined the value of the investment
- determined the amount of interest earned.

This excerpt has been included:

- to demonstrate a fully developed solution that identifies the monthly interest rate, i, and the total number of months, n, before substituting values into the stated compound interest formula
- to illustrate clear labelling for the separate calculation of the amount of interest earned and appropriate rounding of money values, e.g. to the nearest cent.

Excerpt 1



Paper 1, Question 19a)

The following excerpt is from Question 19a) in Paper 1. It required students to construct a scatterplot to display data from a mobility test that counts the number of times a person can stand from a seated position in 30 seconds.

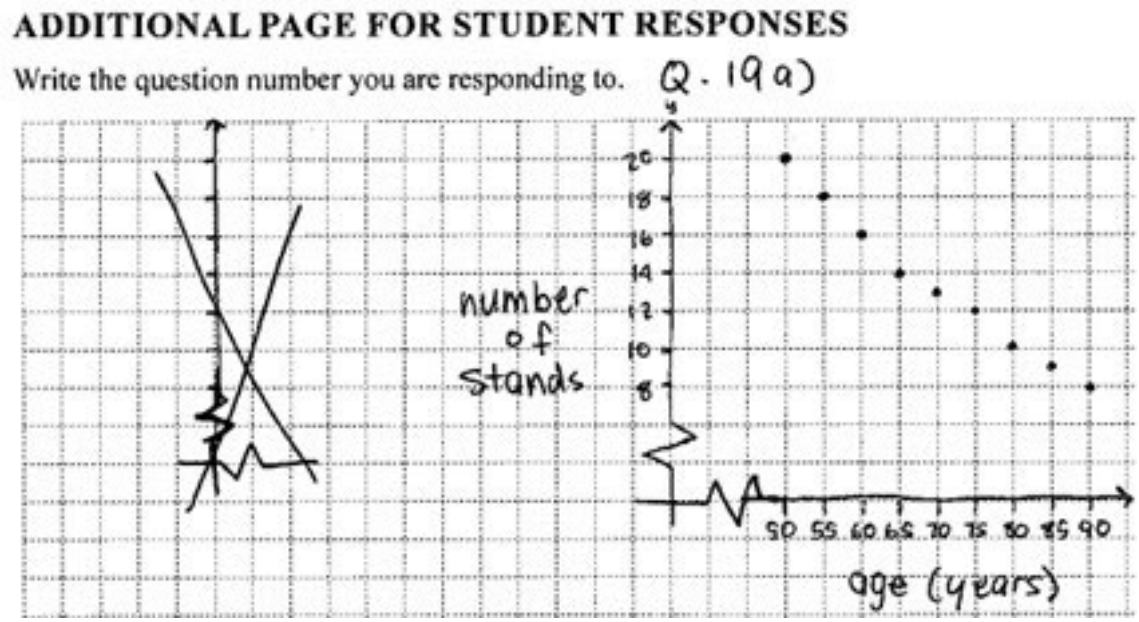
Effective student responses:

- correctly identified the explanatory and response variables
- accurately plotted the points
- formatted the scatterplot with appropriate scaling and labelling of axes.

This excerpt has been included:

- as an example of a correctly constructed scatterplot with labelled axes and accurately plotted points
- to illustrate a ‘broken scale’ symbol used on each axis before the scaling pattern begins
- to demonstrate how to cancel a response by ruling a single diagonal line through the work and to write the question number for a response completed on an additional page in the question and response book.

Excerpt 1



Paper 1, Question 22a)

The following excerpt is from Question 22a) in Paper 1. It required students to use the monthly interest rate for a balance loan to write a recurrence relation for the loan balance after n months. The annual rate of interest and the monthly repayment were provided.

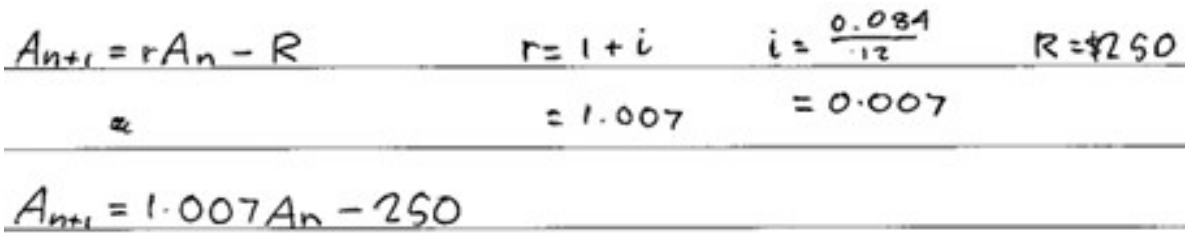
Effective student responses:

- correctly calculated the monthly interest rate
- determined the recurrence relation.

This excerpt has been included:

- to illustrate a well-constructed response that correctly distinguishes the monthly interest rate, i, from the r value used in the recurrence relation.

Excerpt 1



Paper 1, Question 23

The following excerpt is from Question 23 in Paper 1. Part a) required students to draw the minimum spanning tree for a pipeline network that transports natural gas between eight towns on a provided diagram. Part b) required students to evaluate the reasonableness of 2000 km of pipeline being sufficient to transport natural gas to the eight towns.

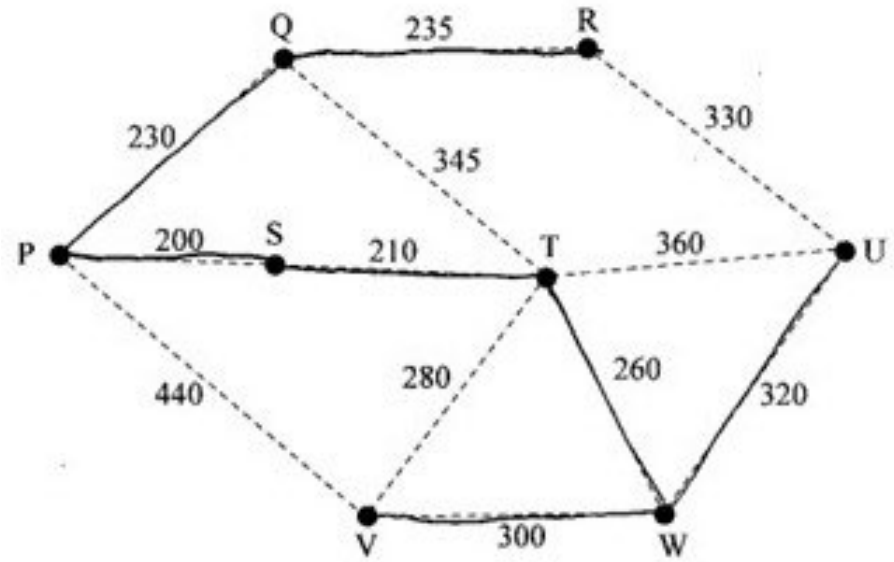
Effective student responses:

- correctly drew the minimum spanning tree on the diagram
- determined the minimum total pipeline length
- provided an appropriate statement of reasonableness linked to prior working.

This excerpt has been included:

- to illustrate a scanned response where the minimum spanning tree can be clearly seen drawn on the provided diagram when a blue or black pen (not a highlighter) is used
- to show a statement of reasonableness that links the outcome of prior working to the proposed length of pipeline using comparative words or symbols.

Excerpt 1



200 + 210 + 260 + 230 + 235 + 300 + 320

= 1755 km

∴ The minimum length to connect all 8 towns is 1755km, so it is reasonable to state 2000km of pipeline is sufficient to transport natural gas to all 8 towns.

[2000 > 1755 2000 - 1755 = 245 245 excess]

Paper 1, Question 25a)

The following excerpt is from Question 25a) in Paper 1. This question provided a table showing Darwin's actual rainfall each season for two years. Students were required to calculate the seasonal index for each season.

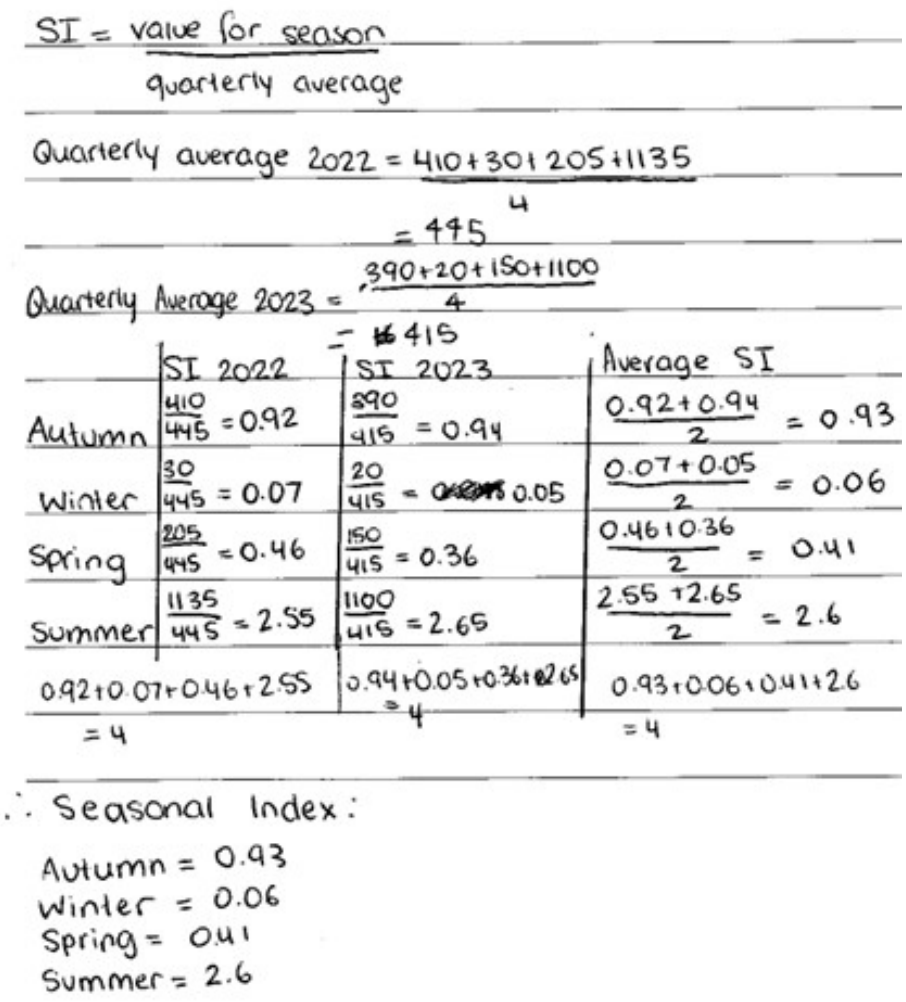
Effective student responses:

- correctly calculated the mean rainfall for each year
- calculated all seasonal ratios for each year
- calculated seasonal indices for each season.

This excerpt has been included:

- to demonstrate succinct setting out of working with steps completed in the correct order to calculate the seasonal indices across the two years. The response calculates the mean of the rainfall data values for each year before each rainfall data value is expressed as a ratio of the mean for its year. The ratios for the corresponding seasons for different years are then averaged to calculate the seasonal indices.

Excerpt 1



Paper 2, Question 2

The following excerpt is from Question 2 in Paper 2. This question provided a table showing the travel time between five islands in the Torres Strait for a ferry service. Students were required to construct a weighted graph and use it to calculate the total travel time for a ferry that completes a Hamiltonian cycle beginning at Waiben.

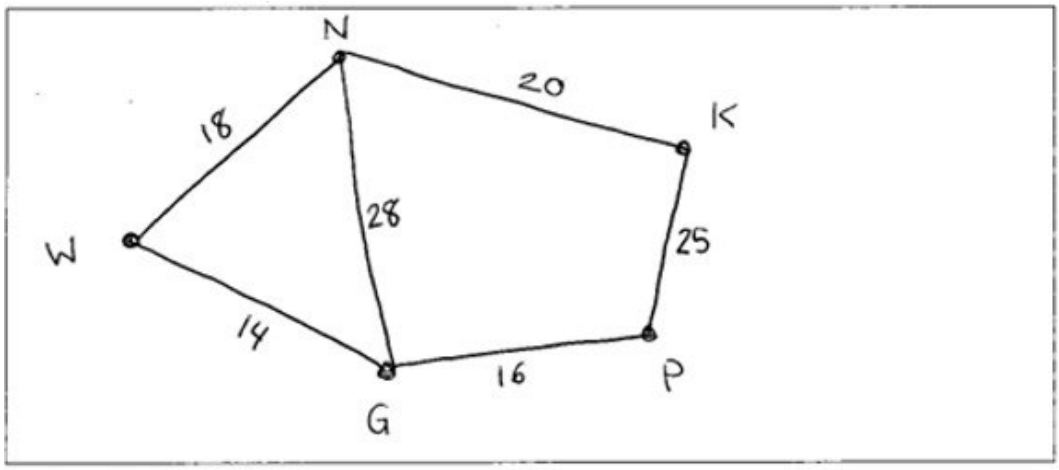
Effective student responses:

- correctly constructed a graph showing all 5 labelled vertices and all 6 edges
- correctly showed weights on all 6 edges
- identified a Hamiltonian cycle beginning at Waiben
- determined the total travel time.

This excerpt has been included:

- to illustrate a well-constructed graph with labelled vertices and correct weights on all edges
- to demonstrate clear communication of the Hamiltonian cycle by listing the vertex sequence and showing the sum calculation for the total travel time.

Excerpt 1



Hamiltonian cycle - W-N-K-P-G-W

Total travel time = 18 + 20 + 25 + 16 + 14

= 93 minutes

Total travel time will be 1 hour and 33 minutes to complete a Hamiltonian cycle beginning at Waiben.

Paper 2, Question 4

The following excerpt is from Question 4 in Paper 2. This question provided a table showing the durations and interdependencies of six tasks (A–F) that a person completed to make a loaf of bread. It required students to use a project network diagram with completed forward and backward scanning to determine the float time for any non-critical activity.

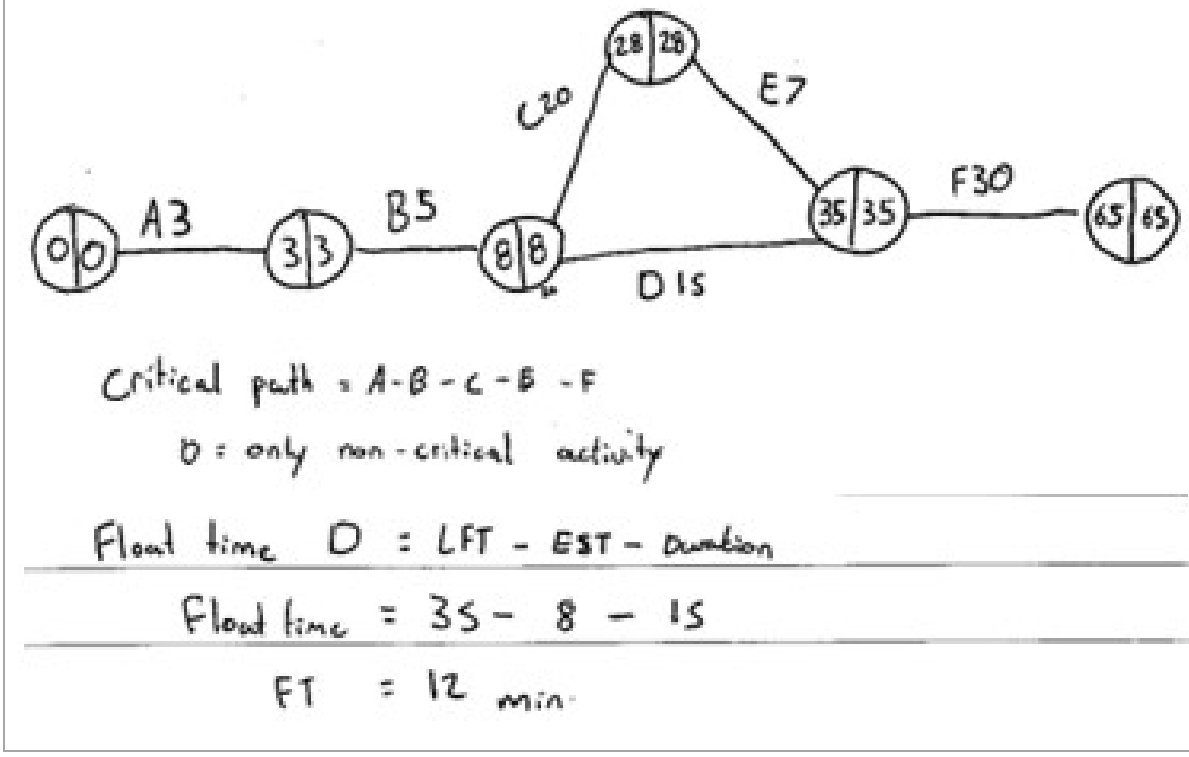
Effective student responses:

- correctly translated information into a network diagram showing all activities and durations
- completed forward scanning to determine the earliest starting time (EST) for each activity
- completed backward scanning to determine the latest starting time (LST) for each activity
- identified the non-critical activity
- determined the float time for the non-critical activity.

This excerpt has been included:

- to illustrate a correctly constructed network diagram that shows a start node and a finish node and all tasks and durations appropriately sequenced and labelled
- to demonstrate the completion of forward and backward scanning by writing the earliest and latest starting times for tasks within the nodes
- to show clear identification of the non-critical activity and its float time.

Excerpt 1



Paper 2, Question 5

The following excerpt is from Question 5 in Paper 2. This question provided a matrix showing some longitude and latitude coordinates and some distances between three flying doctor airbases and three sites where medical care was to be provided. Students first needed to calculate the angular distance and distance between two locations. Students were then required to determine the optimal allocation for a plane from each of the three airbases to one of the three sites and to calculate the minimum total distance flown.

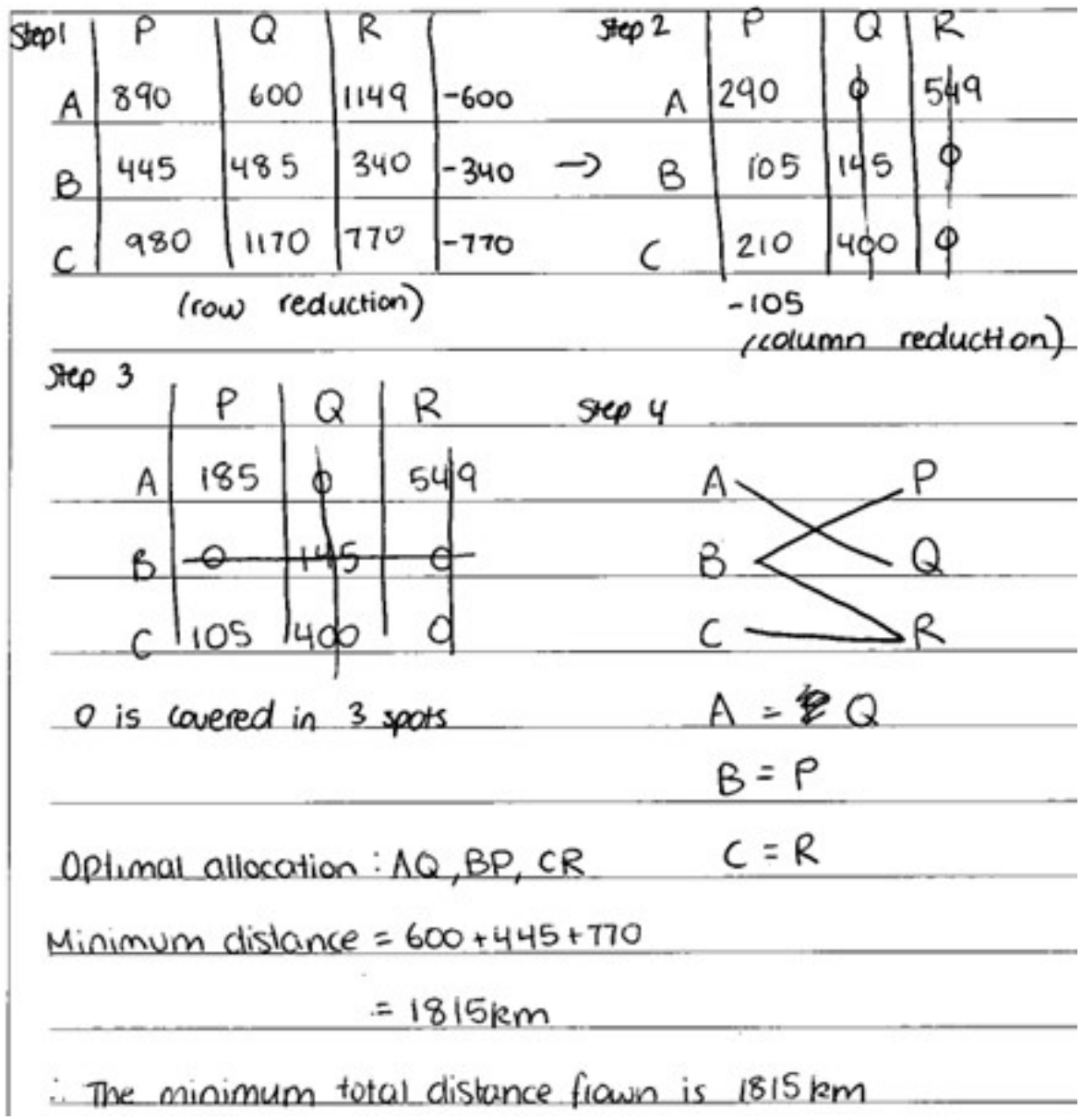
Effective student responses:

- correctly calculated each required distance in kilometres
- applied the Hungarian algorithm to reduce each column and reduce each row
- identified the optimal allocation for each plane
- determined the minimum total distance flown.

This excerpt has been included:

- to demonstrate (using the correctly determined distances) a correct application of the Hungarian algorithm with separate matrices drawn to show the outcome for each separate step, e.g. row reduction then column reduction
- to show clear communication of the optimal allocation for each plane and the minimum total distance flown.

Excerpt 1


Step 1
P Q R
A 890 600 1149 -600
B 445 485 340 -340
C 980 1170 770 -770
(row reduction)
Step 2
P Q R
A 290 0 549
B 105 145 0
C 210 400 0
-105
(column reduction)
Step 3
P Q R
A 185 0 549
B 0 145 0
C 105 400 0
0 is covered in 3 spots
Step 4
A P
B Q
C R
A = Q
B = P
C = R
Optimal allocation : AQ, BP, CR
Minimum distance = 600 + 445 + 770
= 1815km
∴ The minimum total distance flown is 1815 km

Paper 2, Question 6

The following excerpt is from Question 6 in Paper 2. This question provided an arithmetic model for the daily cost of meals and a geometric model for the daily cost of accommodation based on the number of years after 2020. Students were required to evaluate the reasonableness of a total cost estimate for seven days for meals and accommodation in 2025.

Effective student responses:

- correctly determined values for m_1 and a_1
- correctly determined $n = 5$
- used the arithmetic model to determine the daily cost for a person for meals (m_5) in 2025
- used the geometric model to determine the daily cost for a person for accommodation (a_5) in 2025
- calculated the total cost for a person in 2025 for 7 days
- provided an appropriate statement of reasonableness linked to prior working.

This excerpt has been included:

- to demonstrate the effective communication of well-constructed reasoning to determine each daily cost
- to illustrate an appropriate statement of reasonableness that includes a comparison of the student's solution for the total cost (obtained from prior working) to the cost estimate values given in the question.

Excerpt 1

$2021 = m_1$ (meals) $c = 60$; (accommodation)

$2025 = m_5$; 2021: $2c = 2 \times 60$

~~$A_{n+1} = m_1$~~ ; $2021 = a_1 = 120$

$n_5 = m_1 + 3(n-1)$; $2025 = a_5$ ~~$= 2025$~~

$n_5 = 60 + 3(5-1)$;

$= 60 + 12$; $a_5 = a_1 \times 1.1^{(n-1)}$

$= \$72$; $a_5 = 120 \times 1.1^{(5-1)}$

∴ 2025 daily meal cost is \$72 ; $= 175.692$

7 days meal cost: ; $\approx \$175.69$

$72 \times 7 = 504$; ∴ 2025 daily accommodation

∴ 2025 7-day meal cost is ; cost is \$175.69

\$504 ; 7 days accommodation cost:

$175.692 \times 7 = 1229.844$

≈ 1229.84

∴ 2025 7-day accommodation cost is approx. \$1229.84

2025 total 7 day cost:

$1229.84 + 504 = \$1733.84$

$\$1500 < \$1733.84 < \$2000$

∴ As the total cost for a person for 7 days for meals and accommodation is \$1733.84, the estimate of \$1500 - \$2000 is reasonable.

Paper 2, Question 7

The following excerpt is from Question 7 in Paper 2. It required students to interpret and analyse departure and arrival information using UTC for a flight from Sydney to Los Angeles to determine the local time and day in Sydney when the flight had travelled a proportion of the total distance.

Effective student responses:

- correctly calculated the total flight distance and the absolute time difference between locations
- applied the relative time difference to Los Angeles arrival time (or Sydney departure time) to determine the local time and day in the other location
- calculated total flight duration
- showed use of an appropriate method to determine the flight duration
- determined flight duration when 4828 km was travelled
- determined the local time and day in Sydney when 4828 km was travelled
- showed logical organisation, communicating key steps.

These excerpts have been included:

- to show the use of two alternative approaches for developing the solution. In Excerpt 1, the flight speed is calculated and used to determine the local time and day in Sydney. In Excerpt 2, the proportional distance is applied to the total flight duration to determine the required time and day
- to demonstrate the logical organisation and the communication of key steps, including stating rules/procedures before use, writing connecting and concluding statements, and the use of equality signs.

Excerpt 1

Sydney (UTC+10) ~~Los Angeles (UTC-8)~~

∴ Sydney is ahead 18 hours

Arrival time in Sydney = 6:50pm (Tues) + 18 hours

= 12:50pm (Wednesday)

Duration of flight =

9:50pm (Tues) + duration = 12:50pm (Wed)

9:50pm (Tues) + 15 hours = 12:50pm (Wed)

∴ The flight took 15 hours

Speed of flight = $\frac{\text{Distance}}{\text{Time}}$

Distance = 4828 + 7242

= 12070 km

Time = 15 hours

∴ Speed = $\frac{12070}{15}$

Speed = 804.67 km/h

∴ The speed of the flight is 804.67 km/hr

Time in Sydney when flight distance = 4828km:

Time = $\frac{\text{Distance}}{\text{speed}}$

Time = $\frac{4828}{804.67}$

Time = 5.99 hours

∴ It had been approx 6 hours when the flight had travelled 4828km

Time in Sydney = 9:50pm (Tues) + 6 hours

= 3:50am (Wed)

∴ It was 3:50am Wednesday in Sydney when the flight distance travelled was 4828km

Excerpt 2

Sydney (UTC +10) 10 - -8 = 18

LA (UTC - 8)

∴ Sydney is 18 ahead of LA

	Depart	Arrive
Sydl	9:50pm tue	← 12:50pm Weds
LA		6:50pm tue

9:50pm tue + 18hrs

∴ Flight time = 15 hrs

Total distance of flight = 4828 km + 7242km

d = 12 070 km

$\frac{4828 \text{ km}}{12\,070} = 0.4$ or $\frac{2}{5}$

$\frac{2}{5} \times 15$ hrs

= 6 hrs

∴ 4828 km is 6hrs into the flight

∴ Local time in sydney when flight has traveled 4828 km is = 9:50pm tues + 6hrs

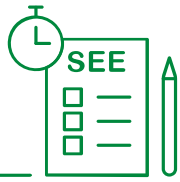
= 3:50 am Wednesday

∴ Local sydney time when flight has traveled 4828 km is = 3:50 am Wed

Additional advice

- Students should be aware that a question worth more than one mark requires mathematical reasoning and/or working to be shown to support answers. The number of available marks for each question is commensurate to the amount of knowledge and understanding of subject matter that needs to be demonstrated to be awarded the marks described in the mark allocation statements in the external assessment marking guide. For instance, a response awarded five marks provides evidence for five mark allocation statements in the marking guide and a response awarded two marks provides evidence for two mark allocation statements in the marking guide.
- If additional pages are required to complete a response, students should continue their solution on the additional pages at the back of the response book. On the additional pages, they should clearly indicate the question they are responding to. If a new response is provided, students must rule a single diagonal line through any work to be cancelled; otherwise, the original response will be marked.

Senior External Examination



The General Mathematics Senior External Examination (SEE) is a standalone examination offered to eligible Year 12 students and adult learners. It contributes 100% to a student's final subject result.

Assessment design

The assessment was designed using the specifications, conditions and assessment objectives described in the summative external assessment section of the General Mathematics Senior External Examination syllabus.

The SEE consisted of two assessments:

- SEE 1 contributed 50% of the marks
- SEE 2 contributed 50% of the marks.

Note: The SEE information should be read in conjunction with the rest of the subject report.

Number of students who completed the General Mathematics Senior External Examination: 3.

There were insufficient student enrolments in this subject to provide useful analytics.