General Mathematics subject report

2022 cohort

February 2023

Queensland Government

QCAA
Queensland Curriculum & Assessment Authority

For all Queensland schools

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Introduction

Throughout 2022, schools and the QCAA worked together to further consolidate the new Queensland Certificate of Education (QCE) system. The familiar challenges of flood disruption and pandemic restrictions were managed, and the system continued to mature regardless.

We have now accumulated three years of assessment information, and our growing experience of the new system is helping us to deliver more authentic learning experiences for students. An independent evaluation will commence in 2023 so that we can better understand how well the system is achieving its goals and, as required, make strategic improvements. The subject reports are a good example of what is available for the evaluators to use in their research.

This report analyses the summative assessment cycle for the past year — from endorsing internal assessment instruments to confirming internal assessment marks, and marking external assessment. It also gives readers 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, including those 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 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 General subjects (including alternative sequences (AS) and Senior External Examination (SEE) subjects, where relevant) and General (Extension) subjects.

Report preparation

The report includes analyses of data and other information from endorsement, confirmation and external assessment processes. It also includes advice from the chief confirmer, chief endorser and chief marker, developed in consultation with and support from QCAA subject matter experts.

Subject data summary

Subject completion

The following data includes students who completed the General subject.

Note: All data is correct as at 31 January 2023. Where percentages are provided, these are rounded to two decimal places and, therefore, may not add up to 100%.

Number of schools that offered the subject: 454.

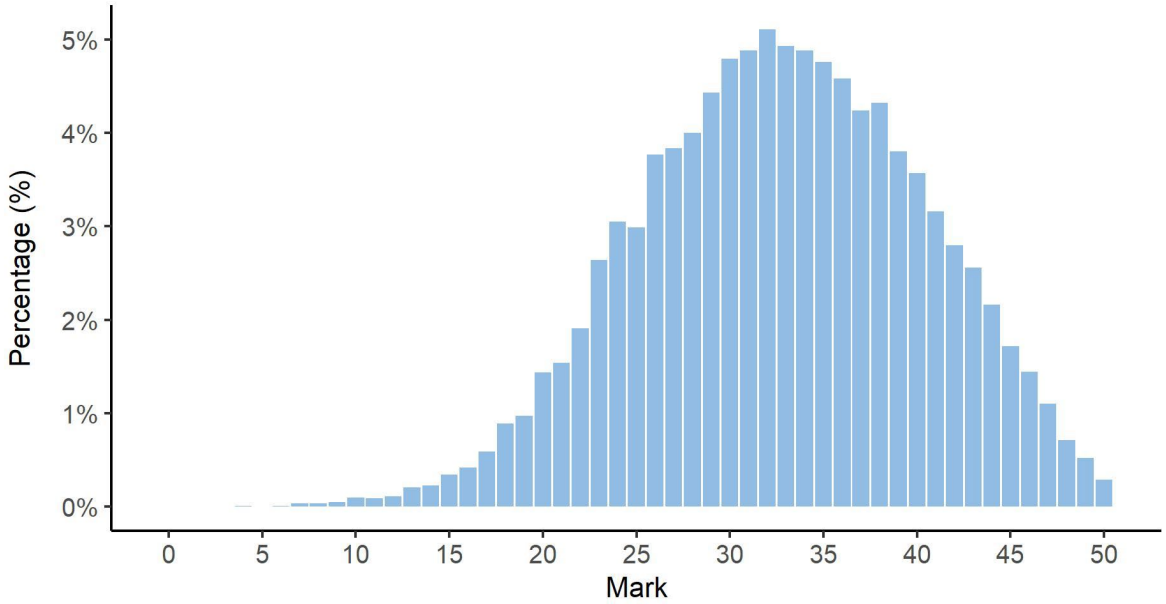
Completion of units	Unit 1	Unit 2	Units 3 and 4
Number of students completed	23 201	22 230	20 232

Units 1 and 2 results

Number of students	Satisfactory	Unsatisfactory
Unit 1	20 405	2796
Unit 2	19 280	2950

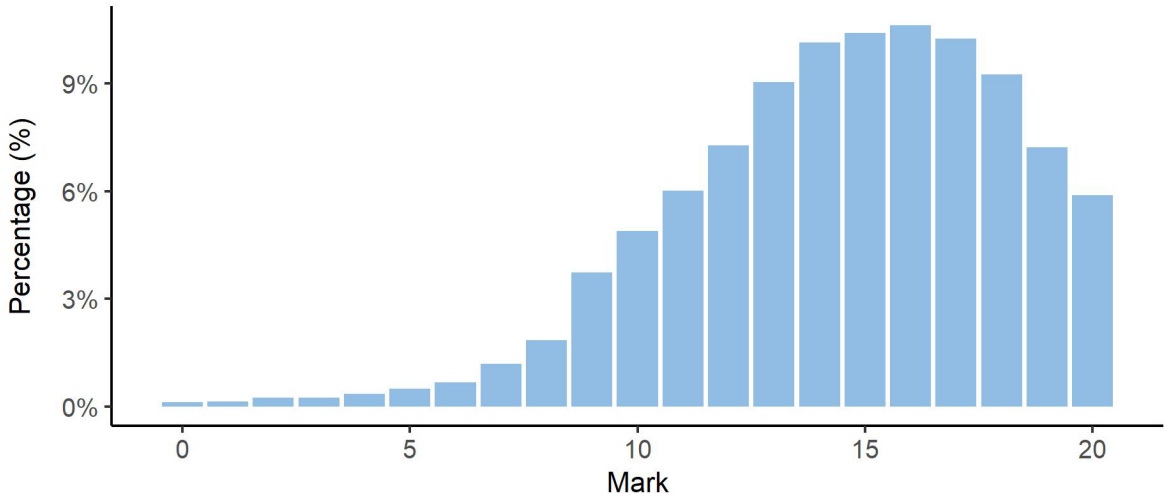
Units 3 and 4 internal assessment (IA) results

Total marks for IA

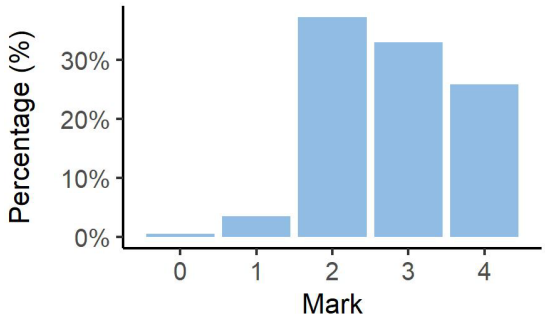


IA1 marks

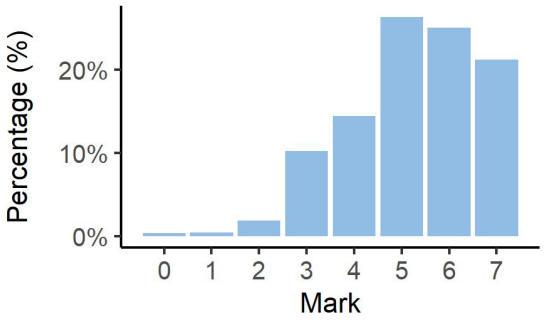
IA1 total



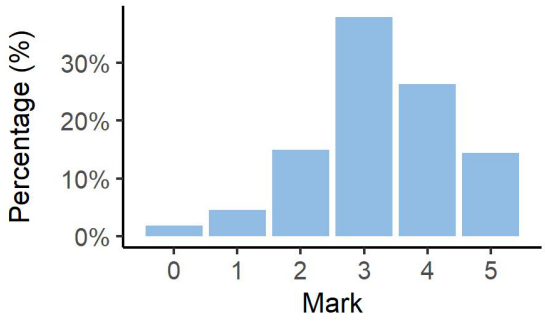
IA1 Criterion: Formulate



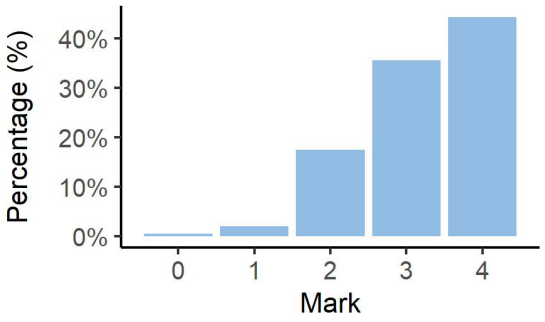
IA1 Criterion: Solve



IA1 Criterion: Evaluate and verify

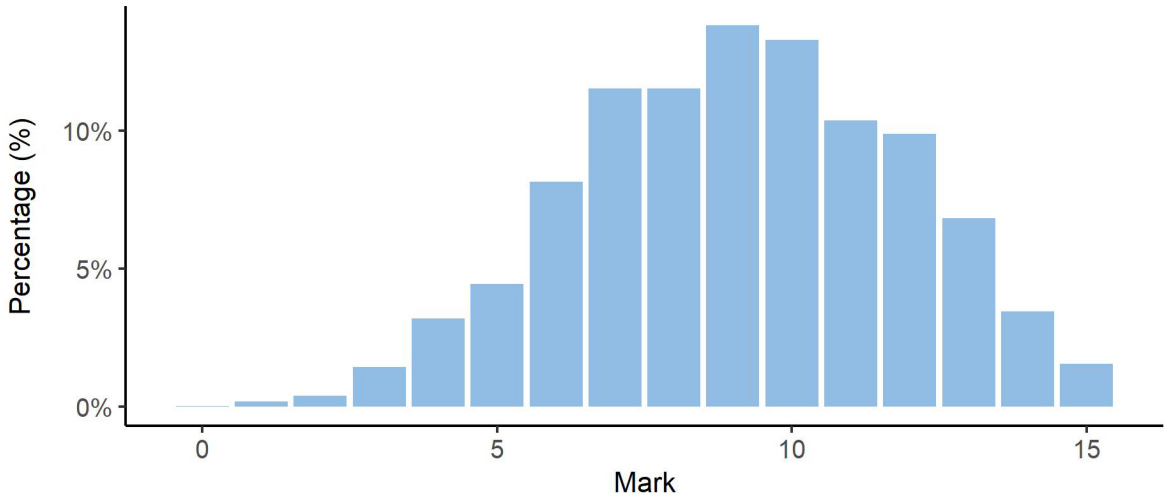


IA1 Criterion: Communicate

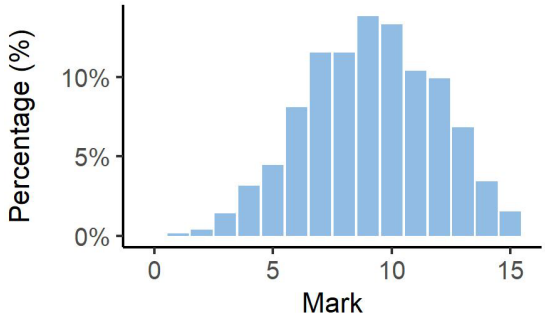


IA2 marks

IA2 total

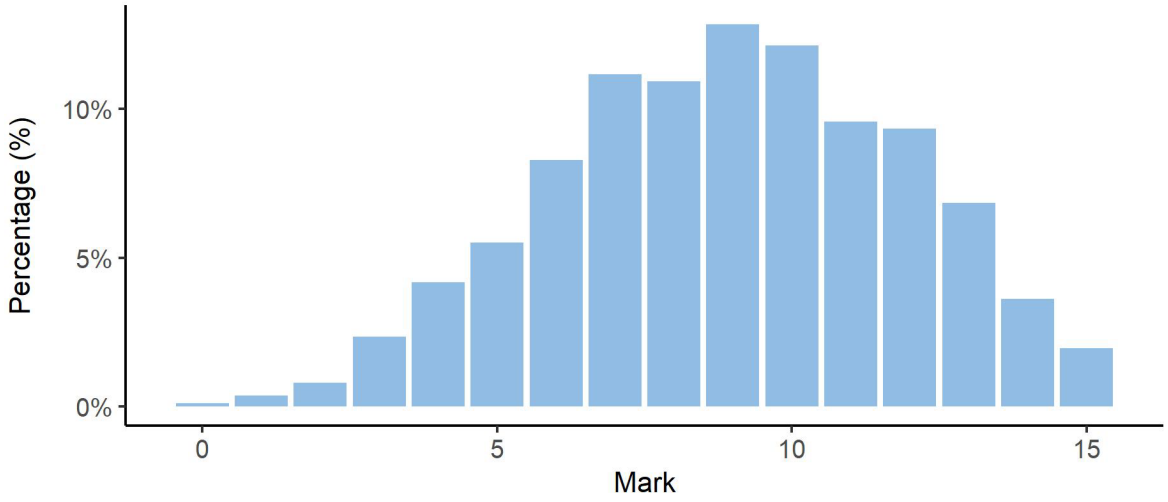


IA2 Criterion: Foundational knowledge and problem-solving

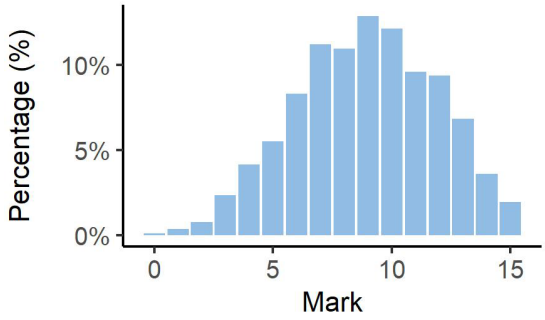


IA3 marks

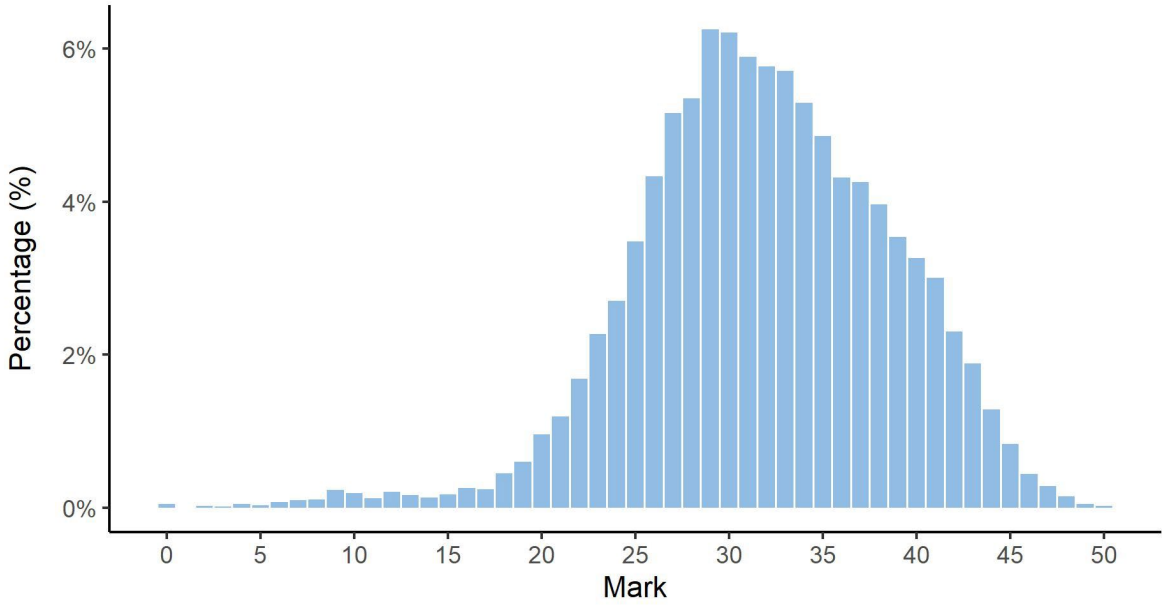
IA3 total



IA3 Criterion: Foundational knowledge and problem-solving

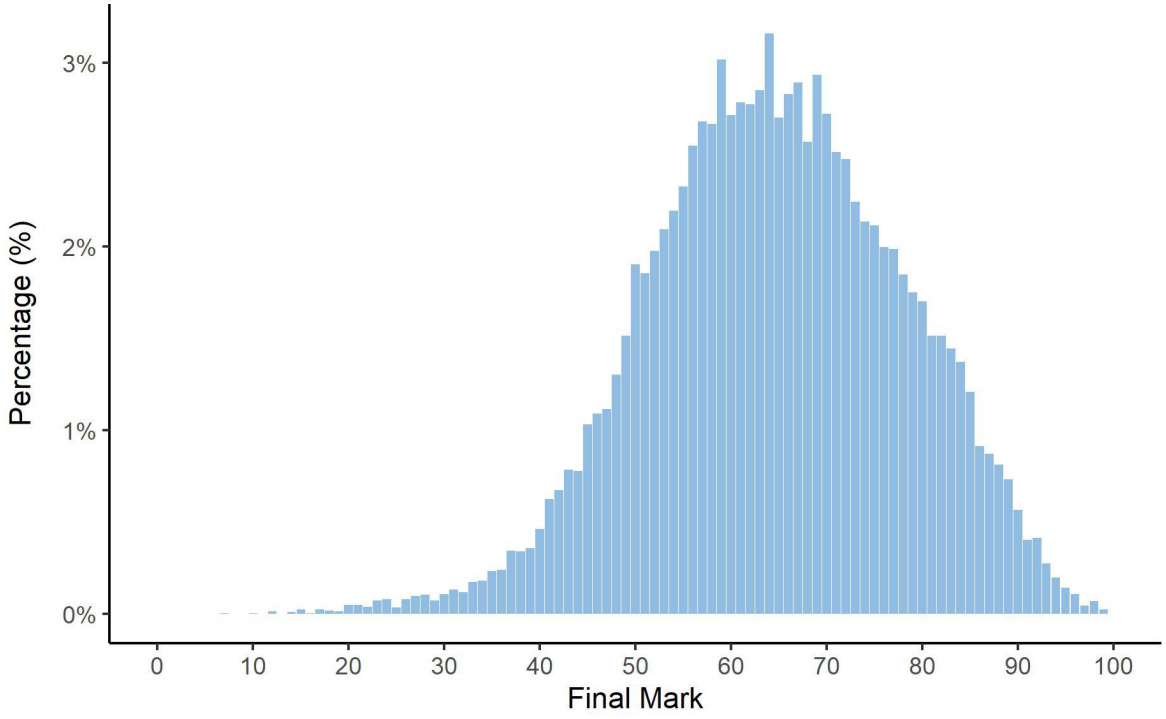


External assessment (EA) marks



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	100–82	81–64	63–45	44–20	19–0

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	2256	8518	8174	1260	24

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 assessments. 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 v4.0*, Section 9.5.

Percentage of instruments endorsed in Application 1

Number of instruments submitted	IA1	IA2	IA3
Total number of instruments	453	453	452
Percentage endorsed in Application 1	70%	35%	39%

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 v4.0*, 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	451	3947	1124	75.61%
2	448	3053	0	97.77%
3	448	3039	0	97.99%

Internal assessment 1 (IA1)

Problem-solving and modelling task (20%)

The problem-solving and modelling task 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	42
Authentication	29
Authenticity	27
Item construction	14
Scope and scale	43

*Each priority might contain up to four assessment practices.

Total number of submissions: 453.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- had clear and concise instructions on what was expected from students in completing the assessment item
- identified the topic/s from which students needed to independently select subject matter to solve the problem

- used realistic contexts, e.g. purchase cost of a car vs. kilometres travelled, or amount of rainfall vs. monthly temperature for a particular location
- provided an opportunity for students to develop a unique response, i.e. students made choices about how to use the data, what model to develop, and what concepts and techniques were relevant to investigate a relationship and/or solve the problem
- provided stimulus material relevant to the task, such as suitable websites and sample datasets that did not require students to undertake extensive research. Relevant stimulus material was age appropriate for language and readability and aligned to the context and task description.

Practices to strengthen

It is recommended that assessment instruments:

- avoid scaffolding or task instructions that indicate to students how to solve the problem, such as 'draw a scatter plot, determine a least-squares line and then complete a residual analysis', so students can demonstrate their own knowledge and understanding of the relevant criteria and produce a unique response
- are sufficiently different from modelling problems in textbooks and QCAA sample assessment instruments that provide sample solutions, so as not to compromise the authenticity of student responses
- have sufficient scope to enable students to complete the problem-solving and modelling task independently, in particular to address the stages of Formulate and Evaluate and verify through a focus on making assumptions and observations relevant to the task, exploring strengths and limitations of a solution and/or model, and evaluating the reasonableness of their solutions.

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	2
Language	16
Layout	3
Transparency	8

*Each priority might contain up to four assessment practices.

Total number of submissions: 453.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- were well presented with appropriate page breaks and other formatting features, which schools could check using the 'Print preview' function within the Endorsement application before submitting the IA1 for endorsement (see *Developing internal summative assessment instruments: Endorsement user guide*, Section 4, available from the Endorsement application in the QCAA Portal).

- used relevant diagrams, stimulus material and images.

Practices to strengthen

It is recommended that assessment instruments:

- use appropriate language and mathematical terms that are free of punctuation, grammatical, spelling and typographical errors
- only include information required by the students to complete the problem-solving and modelling task and not include distracting material.

Additional advice

- When developing the task description for the IA1, schools are encouraged to consider what elements an expected student response to the problem-solving and modelling task would have, and whether students will be able to demonstrate all characteristics in the ISMG criteria. This does not require writing a full report. This process will also allow schools to identify, with clarity, what stimulus material is required for the task.
- Tasks should include well-described checkpoints that reflect syllabus conditions and academic integrity guidelines to authenticate student responses.

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	85.37%	12.86%	1.11%	0.67%
2	Solve	86.92%	8.65%	3.55%	0.89%
3	Evaluate and verify	89.58%	8.2%	1.77%	0.44%
4	Communicate	94.46%	1.33%	3.99%	0.22%

Effective practices

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

- in the Solve criterion, accurate and appropriate use of technology was demonstrated by the inclusion of spreadsheet formulas in the body of the report, as appendixes are not marked, even though complete spreadsheets may be included in the appendixes
- in the Evaluate and verify criterion, strengths and limitations were discussed and supported by evidence in relation to the solution and/or model

- in the Communicate criterion, judgments matched to the upper performance-level characteristics were supported by use of appropriate report genre and reports written in a concise, organised and logical manner using appropriate procedural and technical vocabulary.

Samples of effective practices

The following excerpts demonstrate documentation of relevant observations and appropriate assumptions, detailed translation of all aspects of the problem, explanation of mathematical thinking for the application of concepts and techniques, and use of complex procedures supported by the inclusion of sample calculations and spreadsheet formulas in the body of the report, with referral to appendixes for repeated calculations.

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

Excerpt 1

Observations

Observation	Explanation
It is observed that:	
World War I and II caused the cancellation of the 1916, 1940 and 1944 Olympic Games.	No data values recorded for these years, leaving a gap in the raw data, which could have a negative impact on calculations and drawing conclusions.
The 2020 Olympic Games were postponed due to Covid-19, being held one year later in 2021.	Athletes had one extra year to train, allowing extra time to improve, meaning results could've been significantly higher than average.
The high jump technique was changed to the Fosbury Flop in 1968.	When there was a change to the improved technique, jumped heights could have been significantly higher than the average previous to the change.
From 1896 until 1904, there was a shortage of male high jumpers (only five in each final).	This may have caused the average values to differ significantly to that of other years, which could cause outliers and compromise the model.

Formulate [3-4] - documentation of appropriate assumptions

Assumptions

Formulate [3-4] - accurate documentation of relevant observations

Assumption	Explanation
It is assumed that:	
There was no presence of performance enhancing drugs in the Olympics.	If they were used, athletes' performance would be unethically enhanced which could result in higher achievements, creating false results and (possible) outliers.
The relationship between year of Olympics and height of the Men's jump is linear.	The data needs to be linear to extrapolate/interpolate for future/previous games, or to determine the strength and direction of the data.
All data collected is accurate and reliable, and has been collected from the official Olympics website.	If the data was inaccurate or unreliable, the values could be untrue, compromising the results and the outcome of the task.

Excerpt 2

2.2 Mathematical concepts and techniques

A random sample of 40 height (cm) and weight (kg) measurements will be obtained from the Hong Kong Growth Survey data set based on the assigned subject numbers. Height will be converted into meters by dividing by 100. A scatterplot will be generated in Microsoft Excel using height (m) as the explanatory variable and weight (kg) as the response variable. With the support of Microsoft Excel functions, the Pearson's correlation coefficient will be calculated to indicate the strength of the correlation between the variables. This will also be used to determine the y-intercept (a) and slope (b) of the least-squares regression line $y = a + bx$ using appropriate formulas. The regression analysis will be confirmed in Microsoft Excel by inserting a linear line of best fit onto the scatterplot and generating the equation and coefficient of determination. This will be used to assess the strength of the correlation.

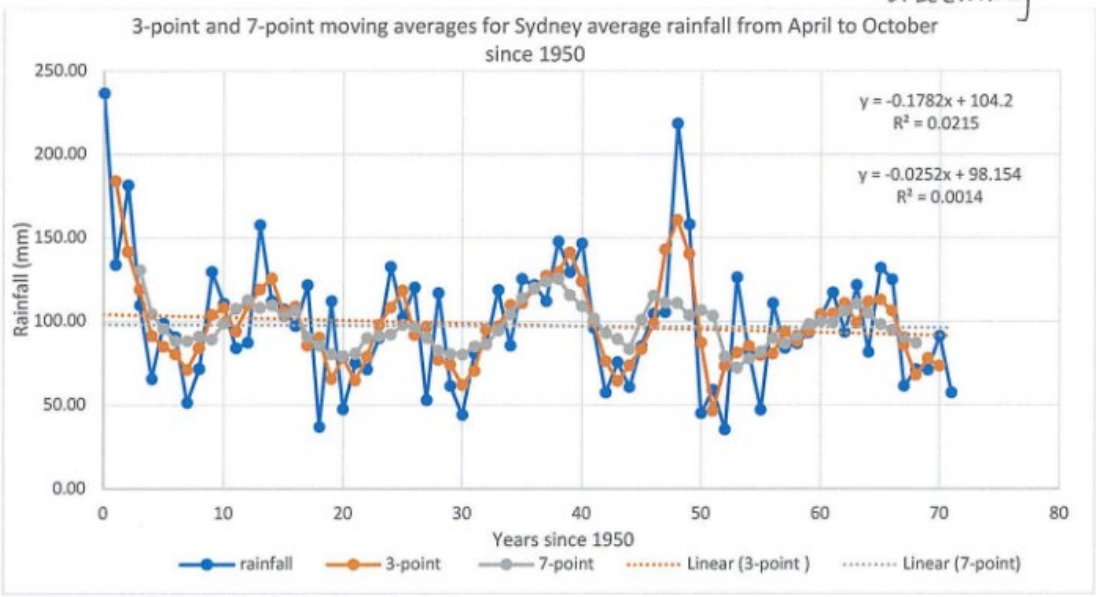
To evaluate the appropriateness of the linear model, residuals will be calculated based on the actual and predicted weights from the model. The residuals will be graphed against height and any trend in the plot identified. This will allow for the assessment of the assumption of linearity. Percentage differences will be found for actual and predicted weights and the results averaged to gauge the error in the model. A larger random sample of the data set will be used in an attempt to improve the model by repeating the regression analysis. The conclusions will be presented in this report along with an assessment of the strengths and limitations of the model and the relevance of BMI as a measure of health for Australians.

Excerpt 3

Graph 3: Rainfall, 3-point and 7-point moving point average scatterplot

Moving point averages were calculated and graphed against the initial time series plot to smooth the data and see any underlying trends by removing irregular and cyclic fluctuations. Repeated moving average calculations are listed in Appendix 3.

discerning



The smoothing process of the data, depicted in Graph 3 above, removes the irregular and cyclical patterns to determine any underlying trends occurring. It is observed by the Bureau of Meteorology that Australia's climate is strongly influenced by drivers such as El Nino and La Nina. El Nino events are associated with a weakening or reversal Pacific winds and as a result, Australian rainfall is usually reduced through winter-spring, particularly in northern and eastern parts of the country (Commonwealth of Australia, 2021). Therefore, it is assumed that El Nino is a significant factor that causes the low amounts of rainfall for Southeast cities evident at cyclical fluctuations. It was observed that El Nino events typically occur irregularly at intervals of 2-7 years and hence 3-point and 7-point moving averages were calculated to smooth out these fluctuations. Since the cyclical fluctuations have been removed in Graph 3, the gradient of the 3-point (-0.18) and 7-point (-0.03) is less than the gradient of rainfall (-0.32) in Graph 1. Hence the steepness of the downwards trend decreases due to the smoothing process.

Justification

documented observations

$$3\ point = \frac{236.5 + 133.81 + 181.47}{3}$$

$$7\ point = \frac{236.5 + 133.81 + 181.47 + 109.6 + 65.7 + 98.86 + 90.64}{7}$$

The calculation of 3-point and 7-point moving average in excel, is shown below:

Complex procedure, accurate

	A	B	C	D
1	years since	rainfall	3-point	7-point
2	0	=AVERAGE(Sydney!H2:N2)		
3	1	=AVERAGE(Sydney!H3:N3)	=AVERAGE(B2:B4)	
4	2	=AVERAGE(Sydney!H4:N4)	=AVERAGE(B3:B5)	
5	3	=AVERAGE(Sydney!H5:N5)	=AVERAGE(B4:B6)	=AVERAGE(B2:B8)

Practices to strengthen

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

- in the Formulate criterion
  - the distinction between assumptions and observations is clear and judgments distinguish between statements and documentation. Assumptions provide evidence of the logic of the mathematisation process, as identified in the flowchart (Syllabus section 1.2.4). Assumptions should form part of the modelling process and support the student's justification for selecting particular rules and procedures. Documentation of appropriate assumptions includes not only assumptions about the student's model and/or solution, but also evidence to support the assumption, e.g. the likely effect of an important assumption and how this is considered in the model and/or solution, or the impact of not making the assumption. Accurate documentation of relevant observations provides evidence to support the data and information used in a student's model and/or solution. This can be demonstrated by explaining how and why the observations were collected, the source of the observations, and what made the observations relevant, valid and reliable for the proposed model and/or solution
  - accurate translation of all aspects of the problem is supported by clearly detailing the method used to investigate the problem, including identifying mathematical concepts and techniques and what use of technology is intended
- in the Solve criterion
  - discerning application of mathematical concepts and techniques involves making thoughtful and astute choices, so the report must clearly outline what was done and why, and how it helped to develop a solution. Students are required to explain their mathematical thinking by discussing what their labelled calculations, tables and graphs show and what the next step will be to progress toward a solution to the problem
  - appendixes are referred to, where appropriate, e.g. 'see Appendix 4: Raw data collection'
- in the Evaluate and verify criterion
  - judgments about strengths and limitations at the mid and upper performance levels require that both strengths and limitations are addressed in relation to the model and/or solution
  - demonstration of documentation of strengths and limitations at the upper performance level requires statements supported with evidence and relevancy.

Additional advice

- Schools should unpack a variety of sample responses to problem-solving and modelling tasks with students — such as the IA1 high-level annotated sample response — to demonstrate and discuss alignment to the characteristics in the performance-level descriptors in the ISMG.
- When a student's response exceeds the specified conditions for word length and/or page count, the school must clearly indicate what action was taken, e.g. annotate the student response to indicate the evidence used to determine a mark. See Section 8.2.6 of the *QCIA and QCE policy and procedures handbook v4.0* for advice on managing response length.
- Schools should apply a range of moderation processes to ensure consistent application of the ISMG for all students. See *Sample quality assurance of judgments workflow* and *Strategies for quality assuring judgments*, available from the Noticeboard application in the QCAA Portal.

Internal assessment 2 (IA2)

Examination (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	233
Authentication	0
Authenticity	20
Item construction	23
Scope and scale	59

*Each priority might contain up to four assessment practices.

Total number of submissions: 453.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- used questions that were relevant to the school context
- used questions that were sufficiently different from textbook questions and QCAA sample questions to ensure responses were the student's own and not rehearsed
- were well constructed, using items that ask students to respond to short response activities identified in the syllabus conditions
- were of a suitable scale, including an appropriate number of questions to be answered in the set time, matched to the degree of difficulty and assessing Unit 3 subject matter. This practice was supported by a correct marking scheme that clearly indicated how marks would be allocated, assisting schools to check the scope and scale of the assessment and promoting consistency in the awarding of marks.

Practices to strengthen

It is recommended that assessment instruments:

- representatively sample subject matter from all Unit 3 topics. Where relevant, the focus should be on subject matter not assessed in the problem-solving and modelling task
- provide opportunities in questions for students to demonstrate all syllabus objectives; in particular, Objective 4: Evaluate the reasonableness of solutions. The mark allocation in the marking scheme should reflect the assessment of this objective
- include Complex unfamiliar opportunities matching the degree of difficulty, so relationships and interactions have a number of elements, and all the information to solve the problem is not immediately identifiable, i.e. not having a series of parts that step students through the problem, and not providing cues that indicate the procedure to use, or diagrams or graphs that simplify the nature of the problem
- correctly align Complex familiar questions to the specified degree of difficulty, so relationships and interactions in the question have a number of elements, 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, e.g. incorporating speed in situations involving time zones and distances between locations on the Earth's surface, or applying algebraic techniques to find a missing term in a geometric sequence using two given terms.

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	36
Language	67
Layout	28
Transparency	24

*Each priority might contain up to four assessment practices.

Total number of submissions: 453.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- provided adequate space for students to respond to all questions. This may include adding extra working space, graphs or diagrams at the end of the instrument for students to use if required
- provided clear and legible tables, images and graphs, where relevant to the questions, so that students could access the necessary information

- were constructed so the layout within questions and across the instrument was not distracting. The 'Print preview' function within the Endorsement application can be used to check for possible distractors such as latitude and longitude coordinates, equations or sequence rules being split across lines of text, and that stimulus items such as tables, diagrams and graphs appear in their entirety on a page (see *Developing summative internal assessment instruments: Endorsement user guide*, Section 4, available from the Endorsement application in the QCAA Portal).

Practices to strengthen

It is recommended that assessment instruments:

- model correct language conventions, including the use of correct mathematical textual features such as R^2 or t_{n+1}, and are free of punctuation, grammatical, spelling and typographical errors
- are developed by tracking the allocation of marks to Unit 3 topics so as to avoid over-representation of certain subject matter, and using approximate response times to gauge if students are able to respond to the examination within syllabus time conditions.

Additional advice

- For assessment instruments requiring modifications for subsequent applications during the Endorsement event, the marking scheme should be updated to reflect any changes made to questions.
- The marking scheme should be completed on the printed examination document to enable teachers to ensure that visual elements (such as time series plots and maps) are suitably sized and sufficient response space has been provided for students to answer each question.

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	97.77%	1.12%	0.89%	0.22%

Effective practices

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

- the submitted marking scheme clearly showed how marks were allocated, and had sufficient detail to explain how the school allowed for situations such as alternative solutions and follow-through marks

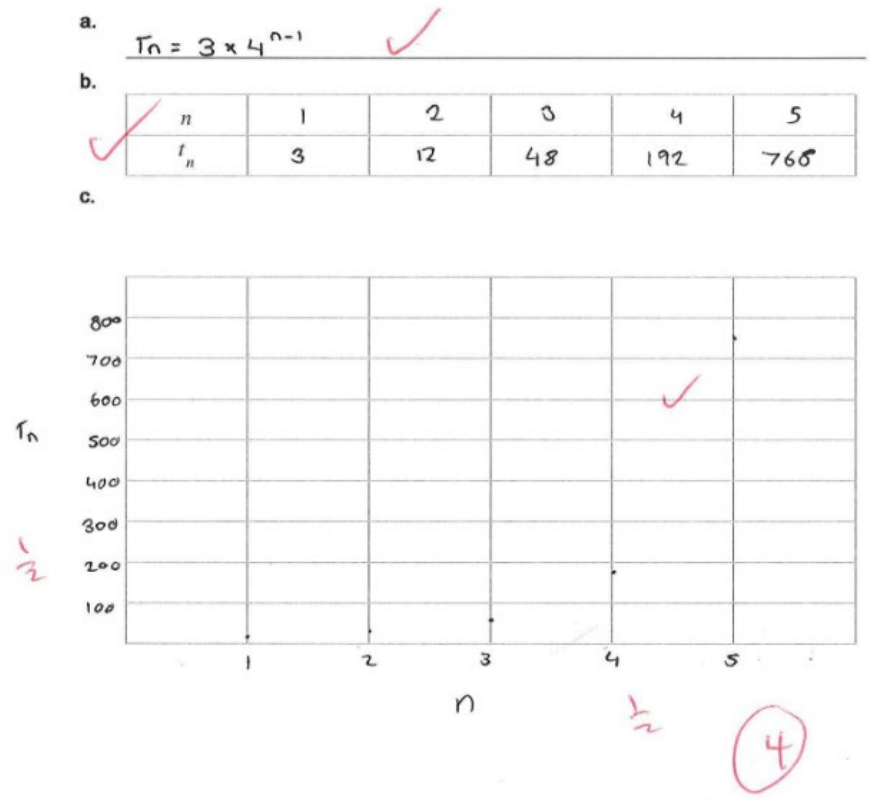
- totalling of marks was checked for accuracy, percentages were not rounded before applying the ISMG, and the ISMG was applied correctly using the 'greater than' percentage cut-offs to determine the provisional mark. See *Advice to schools: How to correctly apply a percentage cut-off*, available from the Noticeboard application in the QCAA Portal, and the Making judgments webinar, available from the Syllabuses application (Resources tab) in the QCAA Portal.

Samples of effective practices

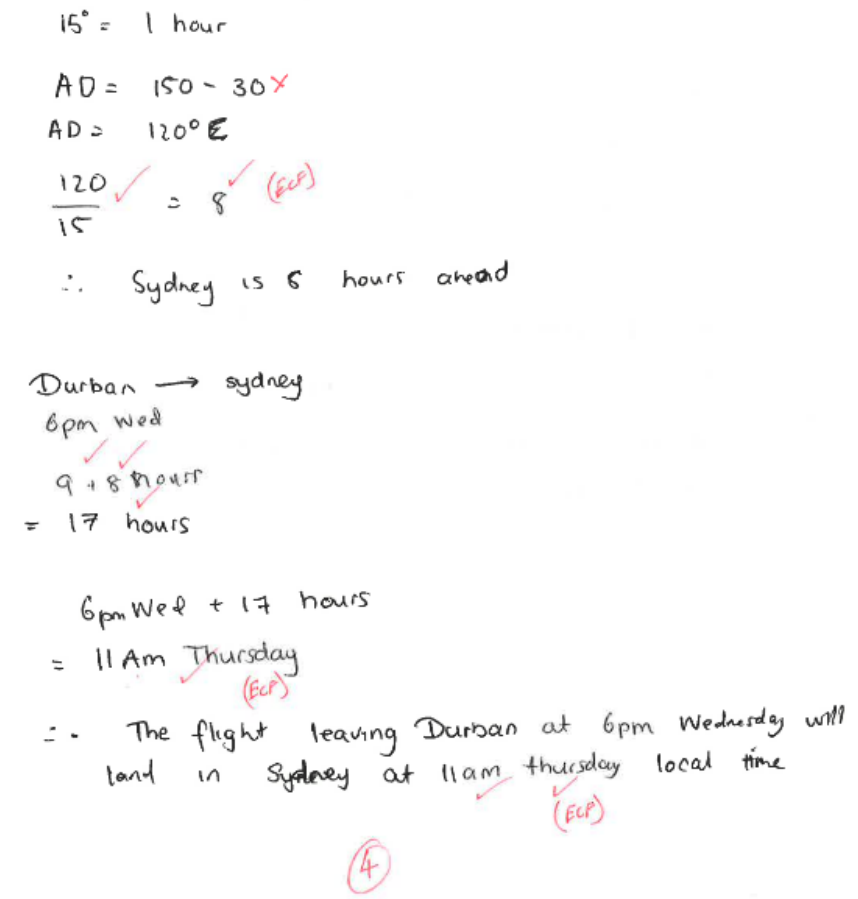
The following excerpts demonstrate the use of ticks and annotations to show where full and half marks were awarded in responses to obtain the identified number of marks, the awarding of follow-through marks as allowed in the provided marking scheme, and appropriate annotation on the ISMG for how the percentage was determined to support the correctly awarded ISMG mark out of 15.

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

Excerpt 1



Excerpt 2



Excerpt 3

15/15

67/72 = 93.1%

Instrument-specific marking guide

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

Practices to strengthen

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

- teachers annotate a student's response to each question to indicate clearly how and where marks are awarded using the marking scheme, e.g. ticks and crosses, circled marks
- teachers identify on the ISMG the raw score a student attained, the total number of marks used in the examination, the achievement percentage aligned to the correct percentage cut-off and the ISMG mark out of 15, e.g. 64/80 = 80%, so the ISMG mark is 12/15. See the confirmation submission information available from the Noticeboard application in the QCAA Portal

- schools provide a revised PDF copy of the marking scheme when submitting required samples for confirmation if the marking scheme is updated after endorsement, e.g. an alternative response is included, or an incorrect calculation is fixed
- if a comparable assessment is administered to a sample student, the comparable assessment and its matching marking scheme must be provided for confirmation.

Additional advice

- Highlighting of the characteristics on the examination ISMG is not required.
- Cross marking is a valuable strategy for quality assuring the accuracy and consistency of allocated results. This may be done within the school for larger cohorts with multiple classes and different teachers, or with teachers from other schools if there is only one teacher of the subject. This process includes checking the accurate application of the marking scheme and the correct totalling of final marks. See *Sample quality assurance of judgments workflow* and *Strategies for quality assuring judgments*, available from the Noticeboard application in the QCAA Portal.

Internal assessment 3 (IA3)

Examination (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	185
Authentication	0
Authenticity	6
Item construction	9
Scope and scale	107

*Each priority might contain up to four assessment practices.

Total number of submissions: 452.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- used realistic contexts and stimulus material for questions related to Unit 4 subject matter such as critical paths, minimal spanning trees and flow networks
- included well-constructed items matching the Simple familiar degree of difficulty, so relationships and interactions are obvious and have few elements, and all the information to solve the problem is identifiable.

Practices to strengthen

It is recommended that assessment instruments:

- assess subject matter within the scope and scale of the syllabus, e.g. the syllabus does not require students to use the Hungarian algorithm beyond a 3 x 3 matrix or construct a given graph or digraph from an adjacency matrix
- provide opportunities in questions for students to demonstrate all syllabus objectives; in particular, Objective 4: Evaluate the reasonableness of solutions. The mark allocation in the marking scheme should reflect the assessment of this objective

- include Complex unfamiliar opportunities matching the degree of difficulty, so relationships and interactions have a number of elements, and all the information to solve the problem is not immediately identifiable, i.e. not having a series of parts that step students through the problem, and not providing cues that indicate the procedure to use, or diagrams or graphs that simplify the nature of the problem
- correctly align Complex familiar questions to the specified degree of difficulty, so relationships and interactions in the question have a number of elements, 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, e.g. incorporating construction costs in situations involving minimum spanning trees, or calculating total travel time for Hamiltonian graph problems.

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	15
Language	42
Layout	8
Transparency	42

*Each priority might contain up to four assessment practices.

Total number of submissions: 452.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- provided adequate response space for each question, including those that may have required construction of an adjacency matrix, project network diagram or bipartite graph
- provided clear and legible tables, images and graphs, where relevant to the questions, so that students could access the necessary information
- were constructed so the layout within questions and across the instrument was not distracting. The ‘Print preview’ function within the Endorsement application can be used to check that visual elements are accessible and appear in their entirety on a page, e.g. network diagrams for students to show forward and backward scanning and clearly label the critical path (see *Developing summative internal assessment instruments: Endorsement user guide*, Section 4, available from the Endorsement application in the QCAA Portal).

Practices to strengthen

It is recommended that assessment instruments:

- model correct language conventions, including the use of correct mathematical textual features such as subscripts for recurrence relations, e.g. $A_{n+1} = r\,A_n - R$
- are proofread for punctuation, grammatical, spelling and typographical errors

- use mathematical terminology that matches syllabus subject matter, e.g. reducing balance loan, earliest and latest starting times, float time for non-critical activities.

Additional advice

- Provide a correct marking scheme that indicates clearly how marks will be allocated. This assists schools to check the scope and scale of the assessment, such as time allocation, adequacy of response space and match to the identified degree of difficulty.

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	97.99%	1.56%	0.45%	0%

Effective practices

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

- the submitted marking scheme clearly showed how marks were allocated and had sufficient detail to explain how the school allowed for situations such as alternative solutions and follow-through marks
- totalling of marks was checked for accuracy, percentages were not rounded before applying the ISMG, and the ISMG was applied correctly using the 'greater than' percentage cut-offs to determine the provisional mark. See *Advice to schools: How to correctly apply a percentage cut-off*, available from the Noticeboard application in the QCAA Portal, and the Making judgments webinar, available from the Syllabuses application (Resources tab) in the QCAA Portal.

Samples of effective practices

The following excerpts demonstrate the use of ticks and annotations to show where full or half marks were awarded in responses to obtain the identified number of marks, and appropriate annotation on the ISMG showing the total awarded and available marks and calculated percentage to support the correctly awarded ISMG mark out of 15.

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

Excerpt 1

(4 marks)

BAE Bank:

$i = 0.084$

$n = 52$

$i_{eff} = \left(1 + \frac{i}{n}\right)^n - 1$

$= \left(1 + \frac{0.084}{52}\right)^{52} - 1$ ✓

$i_{eff} = 0.0875$

$= 8.756\%$ p.a. ✓

VDS Bank:

$i = 0.086$

$n = 12$

$i_{eff} = \left(1 + \frac{i}{n}\right)^n - 1$ ✓

$= \left(1 + \frac{0.086}{12}\right)^{12} - 1$

$i_{eff} = 0.0894$

$= 8.94\%$ p.a. ✓

Excerpt 2

$i_{effective} = \left[1 + \frac{i}{n}\right]^n - 1$

loan 1 : $n = 4$ $i_{effective} = \left(1 + \frac{0.06}{4}\right)^4 - 1 = 0.06136$ ✓

$\times 100$

$= 6.136\%$

$\approx 6.14\%$ ✓

Loan 2 : $n = 12$ $\left[1 + \frac{0.059}{12}\right]^{12} - 1 = 0.0606$ ✓

$\times 100$

$= 6.06\%$ ✓

∴ Indi's suggestion that loan (1)^2 is the best loan is reasonable as it provides an effective interest rate of 6.19% compared to loan 2's 6.06%. × −1

3

Excerpt 3

Instrument-specific marking guide (IA3): Examination (15%)

48+17+15 = 80/85 = 94.12%

Criterion: Foundational knowledge and problem-solving

Assessment objectives

1. select, recall and use facts, rules, definitions and procedures drawn from all Unit 4 topics
2. comprehend mathematical concepts and techniques drawn from all Unit 4 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 4 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

Practices to strengthen

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

- teachers annotate a student's response to each question to indicate clearly how and where marks are awarded using the marking scheme, e.g. ticks and crosses, circled marks
- teachers identify on the ISMG the raw score a student attained, the total number of marks used in the examination, the achievement percentage aligned to the correct percentage cut-off and the ISMG mark out of 15, e.g. 64/80 = 80%, so the ISMG mark is 12/15. See the confirmation submission information available from the Noticeboard application in the QCAA Portal
- schools provide a revised PDF copy of the marking scheme when submitting required samples for confirmation if the marking scheme is updated after endorsement, e.g. an alternative response is included or an incorrect calculation is fixed
- if a comparable assessment is administered to a sample student, the comparable assessment and its matching marking scheme must be provided for confirmation.

Additional advice

- Highlighting of the characteristics on the examination ISMG is not required.
- Cross marking is a valuable strategy for quality assuring the accuracy and consistency of allocated results. This may be within the school for larger cohorts with multiple classes and different teachers, or with teachers from other schools if there is only one teacher of the subject. This process includes checking the accurate application of the marking scheme and the correct totalling of final marks. See *Sample quality assurance of judgments workflow* and *Strategies for quality assuring judgments*, available from the Noticeboard application in the QCAA Portal.

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 (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).

The examination assessed subject matter from Units 3 and 4.

The assessment required students to respond to multiple choice and short response questions.

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	33.9	**36.67**	13.4	14.78
2	0.55	2.07	**91.79**	4.97
3	**85.81**	4.12	7.43	1.86
4	16.03	13.88	5.48	**63.59**
5	4.07	**88.7**	5.21	1.2
6	2.87	8.28	**84.17**	3.78
7	37.05	2.35	**57.08**	2.72
8	**65.99**	29.67	1.53	1.96
9	2.16	**73.46**	5.24	18.27
10	2.45	2	21.03	**73.69**
11	2.71	6.1	9.63	**80.58**
12	1.04	1.77	**95.42**	1.06
13	1.05	14.61	46.48	**36.9**
14	**72.21**	9.95	3.91	13.07
15	**29.8**	15.38	25.42	28.07

Effective practices

Overall, students responded well to:

- questions that required substitution into selected rules or given or derived equations to make predictions
- questions that required a description of the association between two numerical variables or the long-term trend and seasonality of time series data
- questions that required interpretation of maps to determine latitude or time zone or to calculate distance or time difference between two places
- network questions that required construction of an adjacency matrix, use of the Hungarian algorithm to determine an optimal assignment, identifying a minimum spanning tree to solve a minimal connector problem, or construction of a network diagram to determine the shortest path to solve a practical problem.

Samples of effective practices

Short response

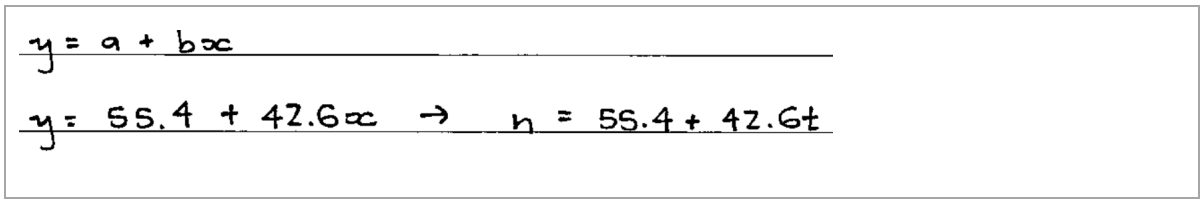
The following excerpt is from Question 16a) from Paper 1. It required students to use their calculator to determine the equation of the least-squares line for sales data that was provided with defined variables.

Effective student responses:

- correctly determined the equation of the least-squares line
- stated the equation using the given defined variables n and t.

This excerpt has been included:

- to demonstrate the least-squares line equation correctly stated using the given defined variables n and t.



The following excerpts are from Question 17 from Paper 1. This question provided the recurrence relation that modelled an investment of $50 000 that compounds interest monthly. Question 17a) required students to determine the advertised interest rate per annum, compounding monthly. Question 17b) required students to determine how many months it would take for the value of an investment to exceed $51 000.

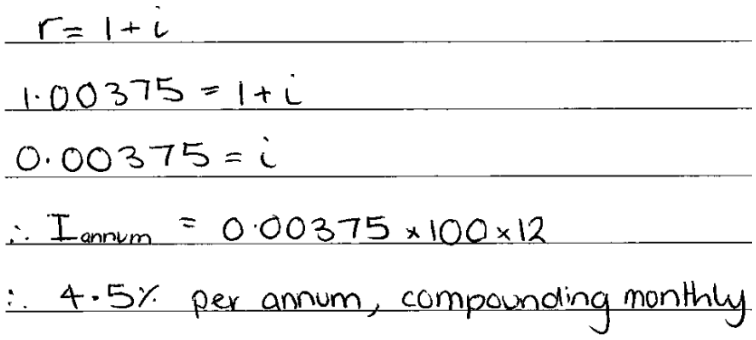
Effective student responses:

- correctly substituted into an appropriate rule to calculate the annual interest rate
- correctly used an appropriate method, such as recursion or the compound interest rule, to determine when the investment would exceed $51 000
- showed mathematical reasoning and/or working to support the answer.

These excerpts have been included:

- to demonstrate mathematical reasoning and/or working to support the answer of 4.5% p.a. for the annual interest rate
- to show mathematical reasoning and/or working to support the answer of 6 months for when the investment would exceed $51 000 by showing a sequence of amounts leading up to and exceeding that amount.

Excerpt 1



Excerpt 2

$A_{n+1} = 1.00355A_n$

$A_0 = 50\,000$

$A_1 = 1.00353 \times 50000$

$A_1 = 50176.5$ $A_6 = 51068.39$

$A_2 = 50353.62$

$A_3 = 50531.37$ It would take 6 months

$A_4 = 50709.75$ for the investment to

$A_5 = 50888.75$ exceed $51000.

The following excerpts are from Question 19b) from Paper 1. This question provided the equation for the least-squares line that was fitted to graphed data showing amount of rainfall data each quarter since the beginning of 2016. It required students to interpret the y-intercept and slope of the fitted line.

Effective student responses:

- appropriately interpreted the y-intercept
- appropriately interpreted the slope.

These excerpts have been included:

- to demonstrate statements that interpret the y-intercept and the slope as they identify or give meaning to the information presented in the graphed data.

Excerpt 1

The y-intercept was 156·5, thus in the last quarter of 2015, there was 156·5mm of rainfall. The slope of the line is 1·763 which suggests the amount of rainfall is increasing at a rate of 1·763mm per quarter.

Excerpt 2

The y-intercept (a) is equal to 156.5 (mm rainfall), showing that this is the average rainfall ~~th~~ at the intercept of y where $x = 0$, which would be quarter 4 in 2015. The slope (b) shows that there is an average increase of 1.763 mm of rainfall each quarter, showing a positive ~~cor~~ relationship between time (in quarters) and amount of rainfall.

The following excerpt is from Question 21b) from Paper 1. It required students to identify whether a provided graph is Eulerian or semi-Eulerian and to justify their response.

Effective student responses:

- correctly identified the graph as semi-Eulerian
- justified the decision.

This excerpt has been included:

- to demonstrate statements that refer to the degree of each vertex to appropriately justify the graph as semi-Eulerian.

This graph is semi-eulerian. An Eulerian graph has all vertices with an even degree. In the graph above, ~~above~~ R and C both have an odd degree of 3. As 2 vertices have an odd degree and the rest are even, the graph is semi-eulerian.

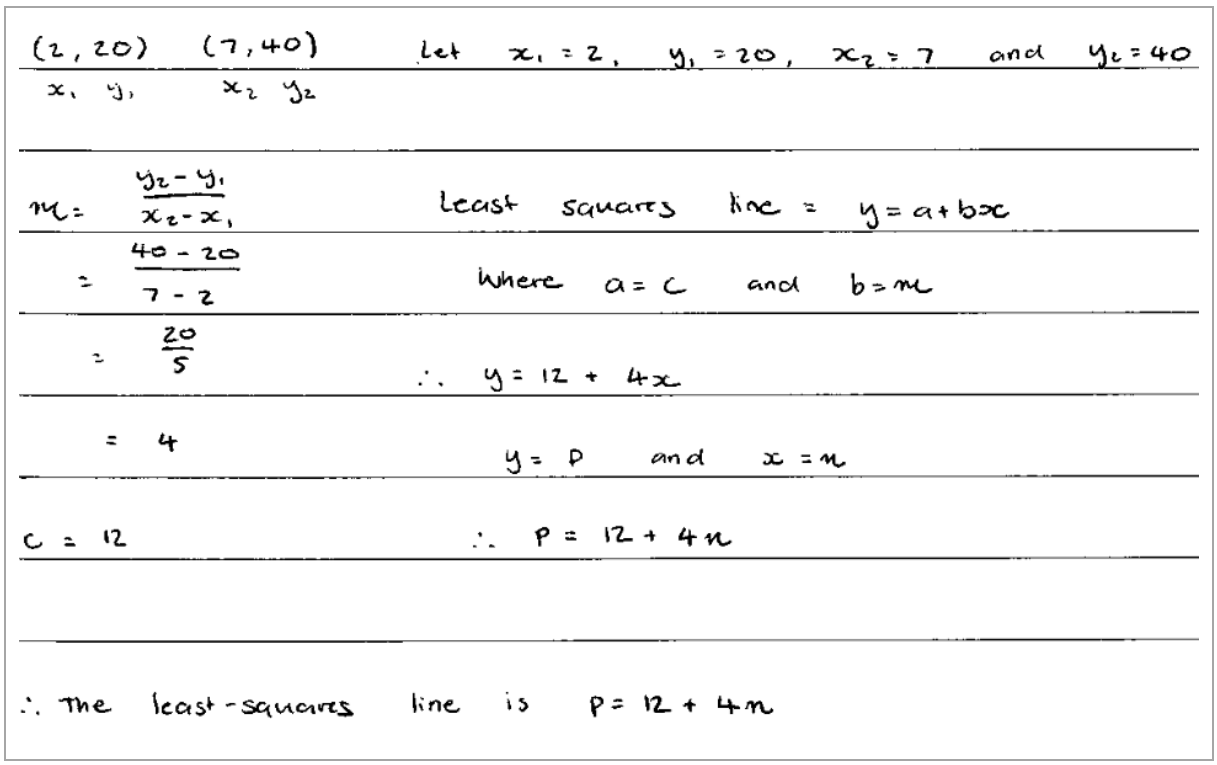
The following excerpt is from Question 23a) from Paper 1. This question defined the variables and provided the coordinates for two given points on a scatterplot showing the association between an employee's years of experience, n, and their hourly pay, p. It required students to determine the equation of the least-squares line that passes directly through the two points.

Effective student responses:

- correctly determined the slope
- determined the equation of least-squares line using the given defined variables p and n.

This excerpt has been included:

- to demonstrate the slope and the least-squares line equation correctly determined using the given defined variables p and n.



The following excerpts are from Question 25 from Paper 1. Question 25a) required students to determine the amount of money borrowed for a loan at 2.4% p.a. compounding monthly with repayments of $993.14 each month for 15 years. Question 25b) required students to write a recurrence relation for the amount owing after n months.

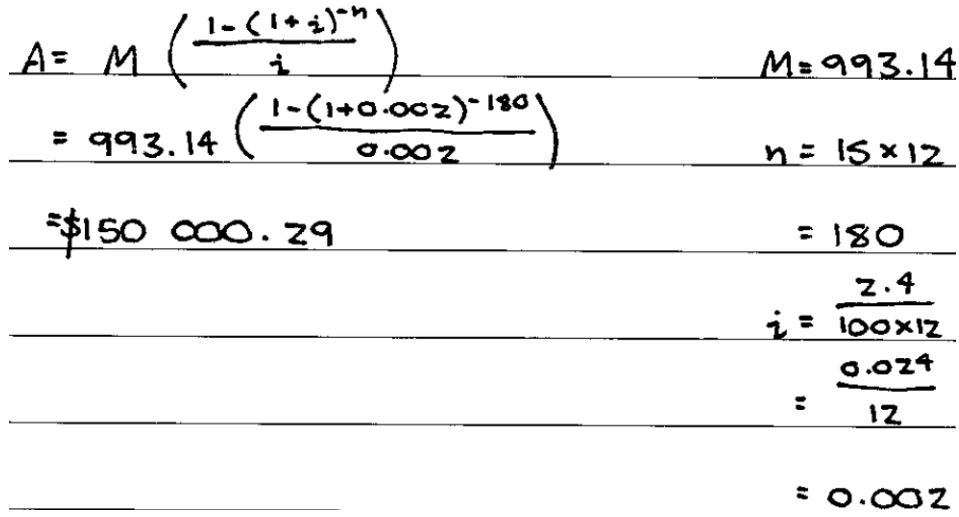
Effective student responses:

- correctly determined the i, n and M values
- substituted into the appropriate annuity formula
- determined the amount of money borrowed, including units
- correctly selected the appropriate recurrence relation formula for reducing balance loans
- determined the recurrence relation.

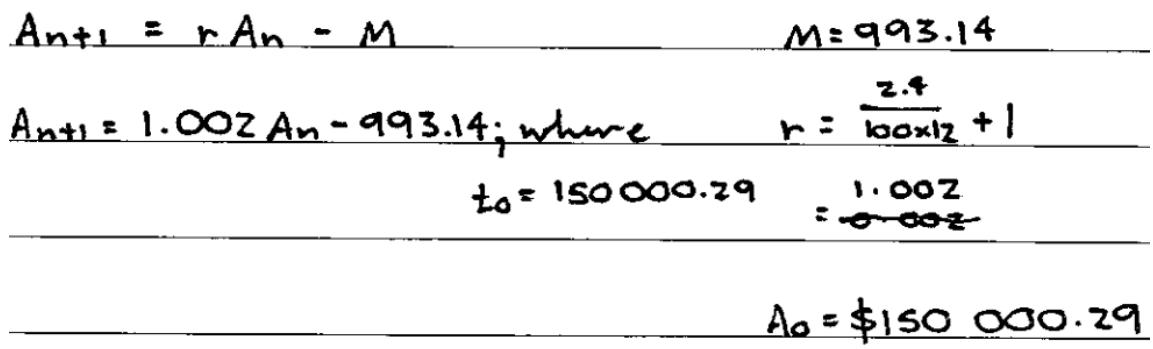
These excerpts have been included:

- to demonstrate succinct setting out of working that identifies the correct values for all required parameters and their correct substitution into the appropriate annuity and recurrence relation formulas in order to determine the amount of money borrowed, including units, and the recurrence relation for the amount owing after n months.

Excerpt 1



Excerpt 2



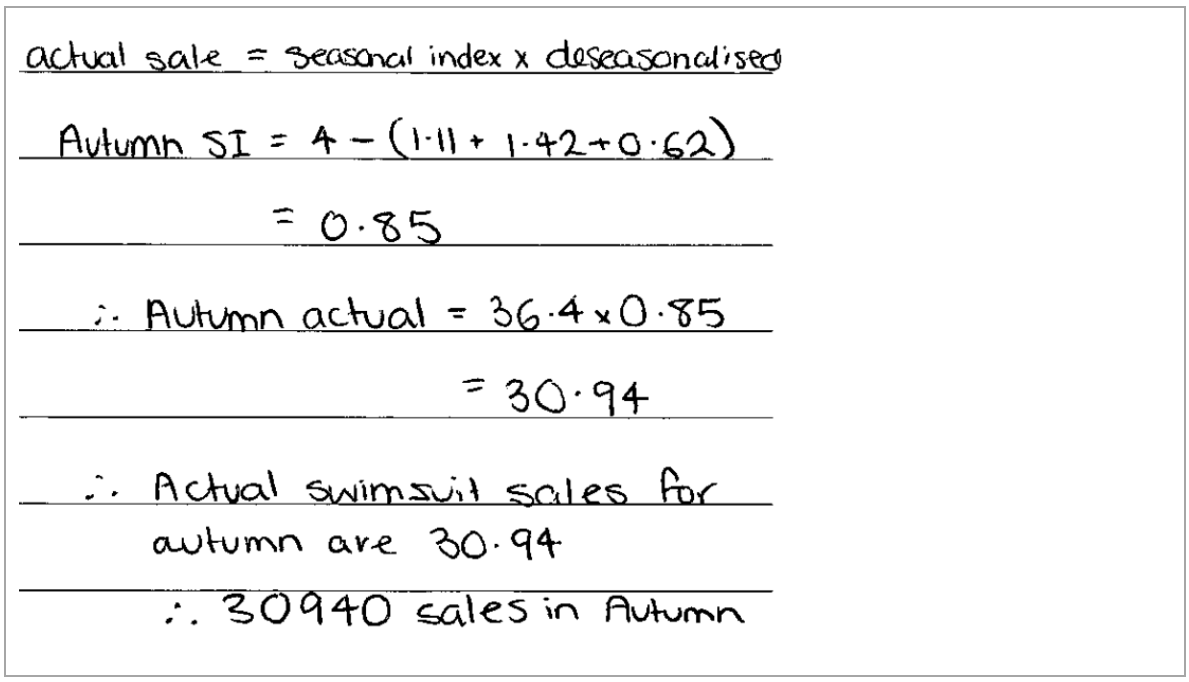
The following excerpt is from Question 1 from Paper 2. This question provided seasonally adjusted sales data for four seasons and the seasonal indices for three of the four seasons — spring, summer and winter. Students were required to determine the actual sales amount for autumn.

Effective student responses:

- correctly identified the sum of all the seasonal indices as 4
- correctly determined autumn's seasonal index
- used an appropriate method to determine actual sales for autumn.

This excerpt has been included:

- to demonstrate that summing the seasonal indices for four seasons to 4 is a key step for correctly determining autumn's seasonal index, in order to then use an appropriate method to determine actual sales for autumn.



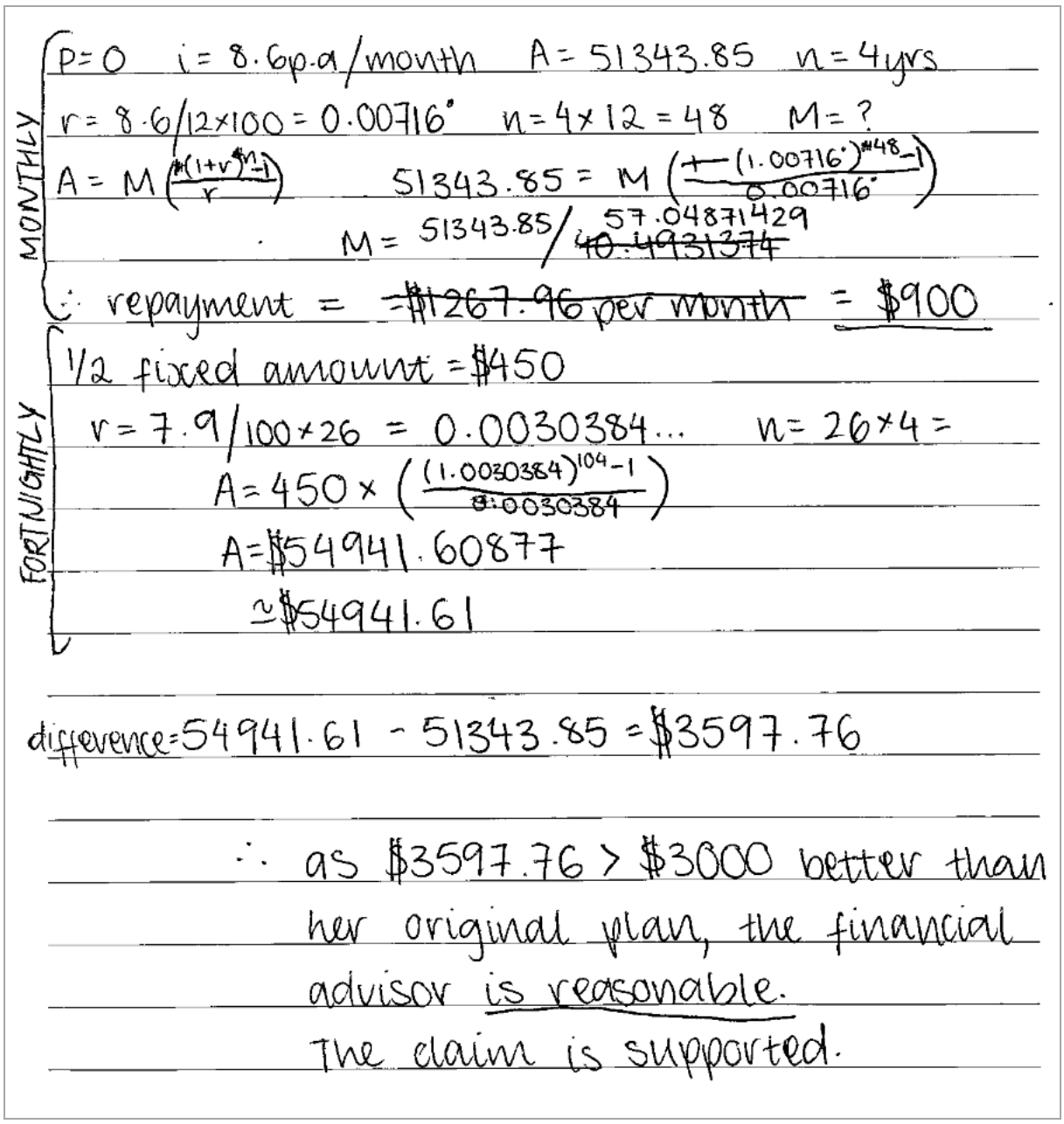
The following excerpt is from Question 2 from Paper 2. This question required students to evaluate the reasonableness of advice that a person would have been at least $3000 better off if, instead of depositing a fixed amount at the end of each month into an account paying interest compounding monthly, they had deposited half of the fixed amount at the end of each fortnight into an account paying interest compounding fortnightly.

Effective student responses:

- correctly substituted parameters into the appropriate annuity rule
- correctly determined the monthly amount
- determined the value of fortnightly annuity
- determined the difference in annuity balances
- compared values to evaluate the reasonableness of the advice.

This excerpt has been included:

- to demonstrate that selecting the appropriate annuity rule to use for both accounts (monthly and fortnightly) is a key requirement for correctly determining the monthly amount and the subsequent value of the fortnightly annuity
- to show effective evaluation of the reasonableness of the advice, as it provides evidence of a comparison of the given $3000 value to the difference in annuity balances.



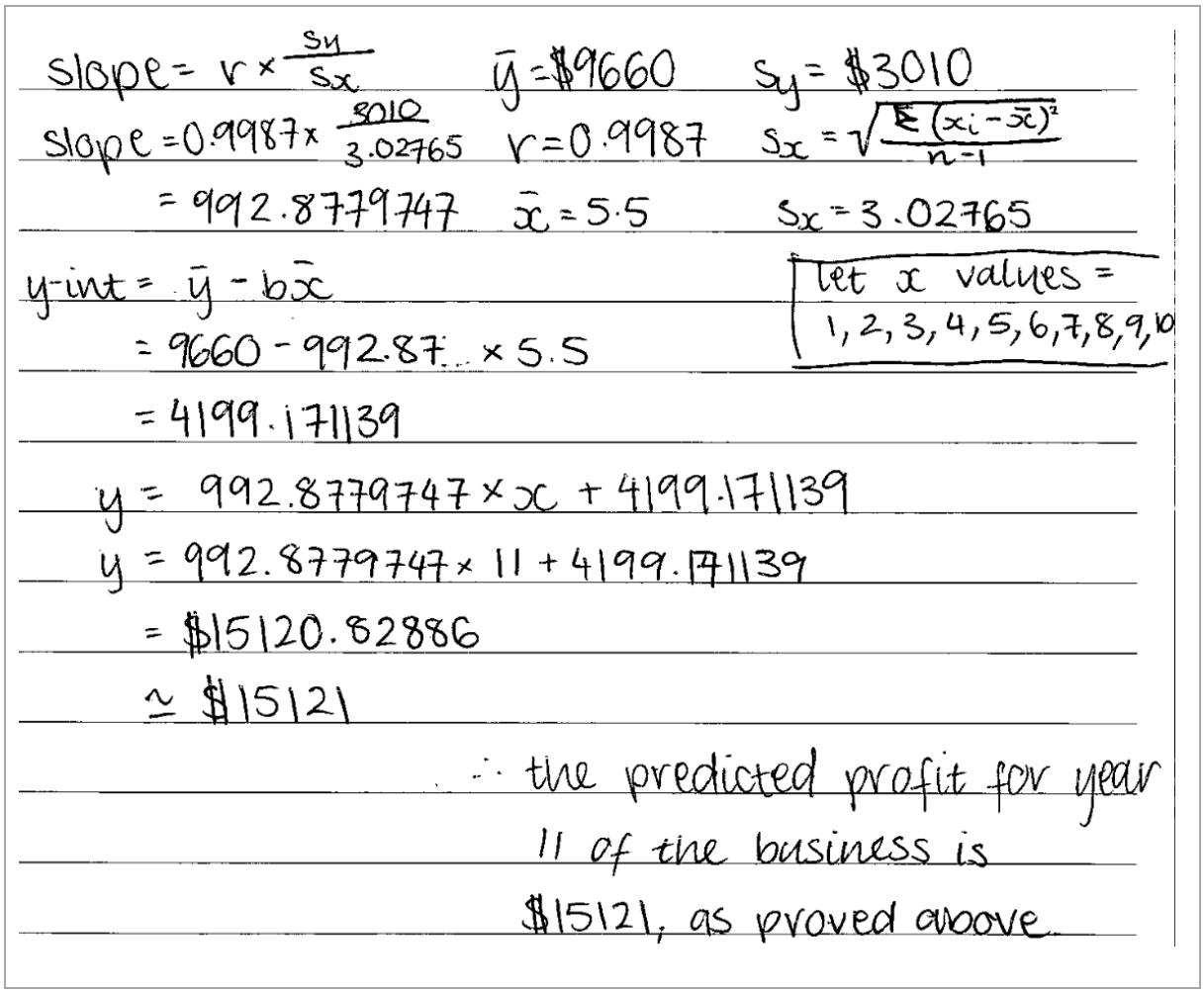
The following excerpt is from Question 3 from Paper 2. This question used the context of fitting a least-squares line to data comparing a company's annual profit (y) in the year of operation (x) to provide values for $\bar{y}$, s_y and the correlation coefficient, r, for the first 10 years of operation. It required students to verify the predicted profit, to the nearest dollar, for this company in its 11th year of operation.

Effective student responses:

- correctly determined $\bar{x}$ and s_x
- determined b using $b = r\frac{s_y}{s_x}$
- determined a using $a = \bar{y} - b\bar{x}$
- determined 11th year profit to the nearest dollar
- showed logical organisation and communication of key steps.

This excerpt has been included:

- to demonstrate that assigning x values for the first 10 years of operation is a key step for correctly determining $\bar{x}$ and s_x, in order to then substitute into appropriate rules to determine b and a
- to show logical organisation and communication of key steps.



The following excerpt is from Question 6 from Paper 2. This question provided equations for the first three lines in a pattern such that their slopes and y-intercepts form the terms of different sequences, which are either arithmetic or geometric. It required students to determine the coordinates of the point where Line 5 in the pattern intersects Line 1.

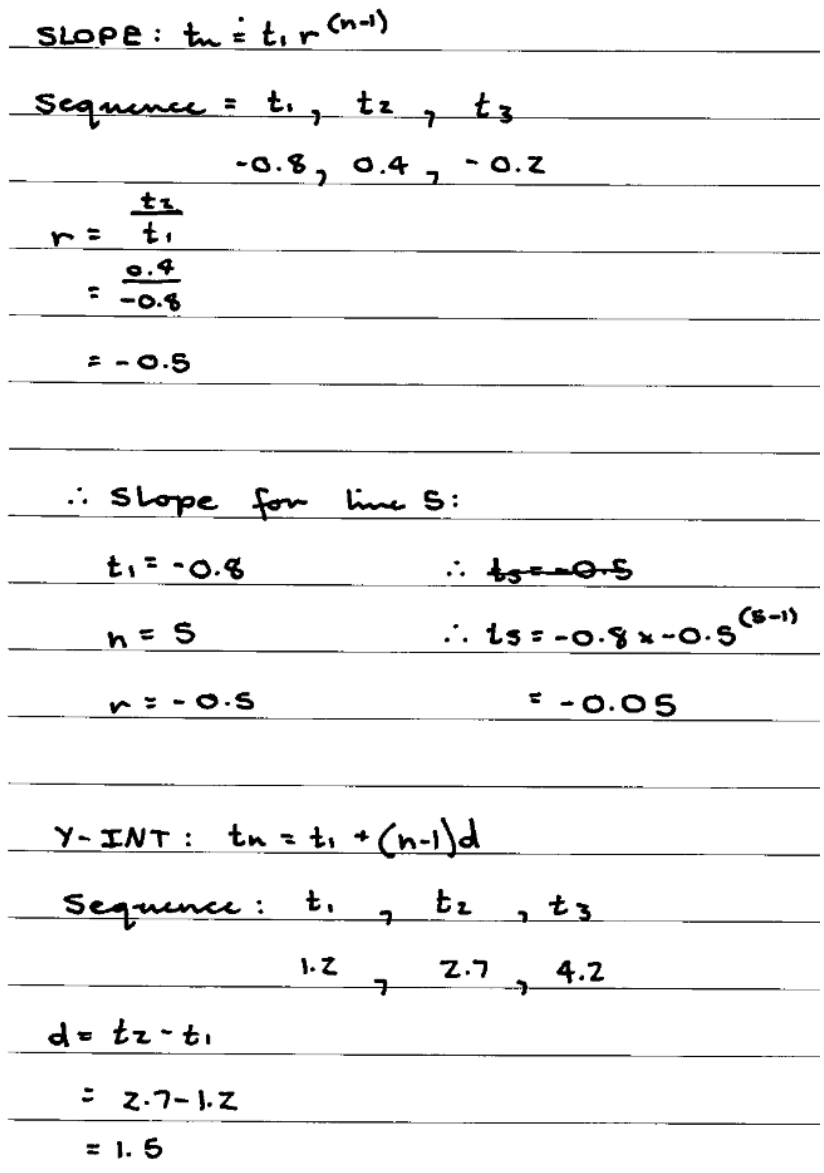
Effective student responses:

- correctly determined the geometric sequence parameters for the slopes
- correctly determined the arithmetic sequence parameters for the y-intercepts
- determined the slope and y-intercept for Line 5
- determined the x-coordinate and y-coordinate of the intersection point
- showed logical organisation and communication of key steps.

This excerpt has been included:

- to demonstrate correctly determined geometric sequence parameters for the slopes by identifying values for t_1 and r, and correctly determined arithmetic sequence parameters for the y-intercepts by identifying values for t_1 and d
- to illustrate the solving of simultaneous equations to determine the x-coordinate and y-coordinate of the intersection point
- to show logical organisation and communication of key steps.

Excerpt



Excerpt (continued)

∴ y-int for line 5:

$t_5 = 1.2$ $\quad t_5 = 1.2 + (5-1) \times 1.5$

$n = 5$ $\quad = 7.2$

$d = 1.5$

∴ Line 5 = $-0.05x + 7.2$

∴ Intersect when line 1 = line 5

$-0.8x + 1.2 = -0.05x + 7.2$

$-0.8x = -0.05x + 6$

$0 = 0.75x + 6$

$-6 = 0.75x$

$-8 = x$

∴ y-coord:

let $x = -8$ in line 5

$y = -0.05 \times -8 + 7.2$

$= 7.6$

∴ The coordinates when line 5 and 1 intersect is $(-8, 7.6)$

Practices to strengthen

It is recommended that when preparing students for external assessment, teachers consider:

- familiarising students with the appropriate rules to select from the General Mathematics formula book, such as for annuities, sequences, and Earth geometry, and encouraging students to identify values for parameters before substitution
- instructing students that when stating mathematical models, they should use the given symbols if variables are defined in the question; otherwise, to define the variables themselves
- supporting students to use technology effectively to generate values for a recurrence relation and a least-squares line equation, and solve complex equations such as an annuity calculation without early rounding
- supporting students to practise constructing scatterplots by correctly identifying, and deciding on which axis to plot, the explanatory variable, and the response variable, and using given data to plan appropriate scaling for each axis, write scaling values clearly and plot points

accurately. If axes are not provided, students may draw labelled axes and show scaling values inside the provided grid space

- supporting students to practise constructing network diagrams by showing vertices as dots (or boxes for nodes in a project network) and edge or arc lines connected to the vertices, using defined symbols to label vertices, drawing arrows on directed edges, clearly writing the weighting on each edge, and checking that the number of vertices and edges matches the provided information
- providing opportunities for students to use a variety of methods, such as using both 12-hour time (e.g. 6:30 am) and 24-hour time (e.g. 0630), responding to annuity questions using either the relevant formula or a recurrence relation for fewer payments, and drawing graphs with crossed edges if the question does not require demonstration that the graph is planar
- modelling setting out to show logical organisation and communication of key steps, such as using a new drawing to show the resultant matrix after applying each step of the Hungarian algorithm; naming locations when stating longitude and latitude, time zones, times (e.g. hours, minutes and day) and time differences; clearly identifying on a network diagram a minimum spanning tree or shortest path, stating the vertex sequence, sum of lengths calculation and total length; and writing all EST and LST values when completing forward and backward scanning.

Additional advice

- Students should be supported to make connections between the subject matter and the glossary terms (e.g. *evaluate*, *describe*, *interpret*) so that terminology used to scaffold questions is familiar and students can provide clear and accurate explanations about their thinking.
- If a mistake is made during the construction of a scatterplot, individual points can be crossed out and replotted without beginning a new construction. Similarly, any draft network diagrams a student draws must be crossed out to clearly identify the network diagram to be marked.
- 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.
- While not all questions will award marks for logical communication of key steps, students should be encouraged to do this. This communication helps students in the development of their solution and assists markers when looking for evidence of specific concepts or techniques.

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: 1.

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