Physics subject report

2021 cohort

February 2022

Queensland Government

QCAA
Queensland Curriculum & Assessment Authority

For all Queensland schools

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Introduction

Despite the challenges brought about by the COVID-19 pandemic, Queensland's education community can look back on 2021 with satisfaction at having implemented the first full assessment cycle in the new Queensland Certificate of Education (QCE) system. That meant delivering three internal assessments and one external assessment in each General subject.

This report analyses that cycle — from endorsing summative internal assessment instruments to confirming internal assessment marks, and designing and marking external assessment. It also gives readers information about:

- applying syllabus objectives in the design and marking of internal and 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 of best practice where relevant, possible and appropriate.

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 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 or AS.

For the purposes of this report, while the 2021 summative units for the AS are AS units 1 and 2, this information will be included with the General summative Units 3 and 4.

Note: All data is correct as at 17 December 2021. 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: 394.

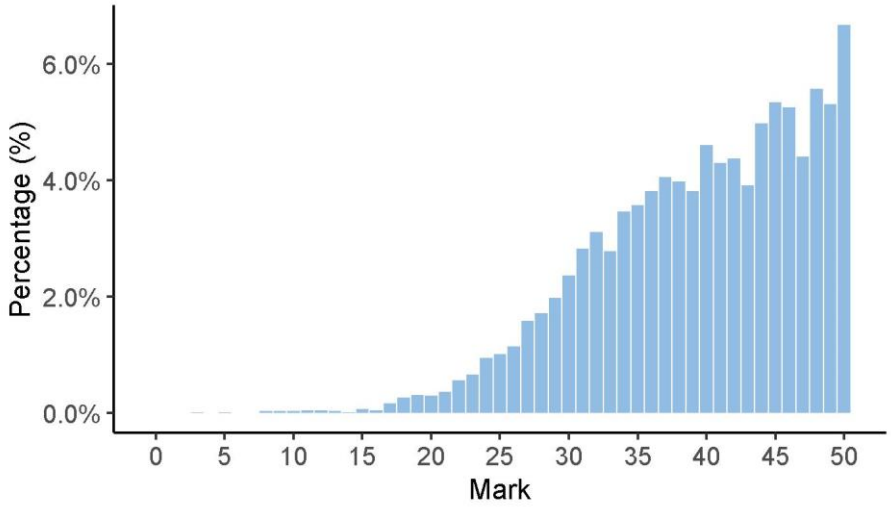
Completion of units	Unit 1	Unit 2	Units 3 and 4
Number of students completed	6668	6316	5980

Units 1 and 2 results

Number of students	Satisfactory	Unsatisfactory
Unit 1	6310	358
Unit 2	5885	431

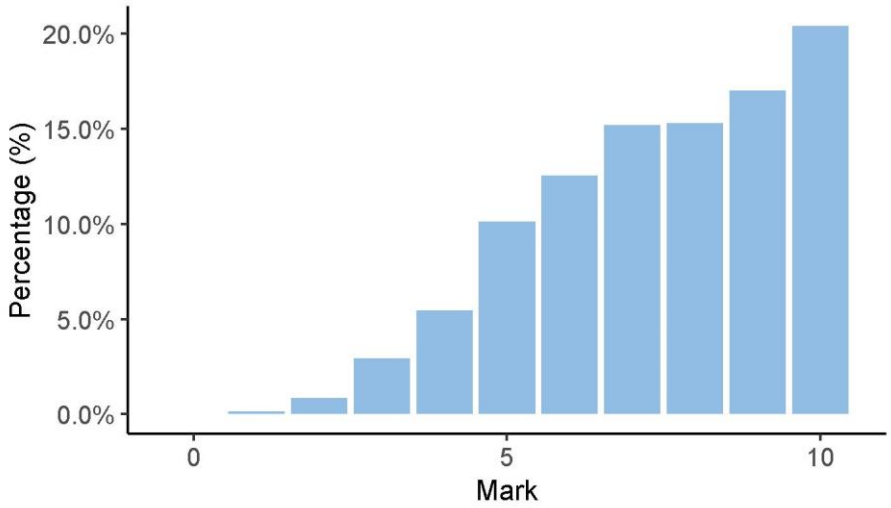
Units 3 and 4 internal assessment (IA) results

Total marks for IA

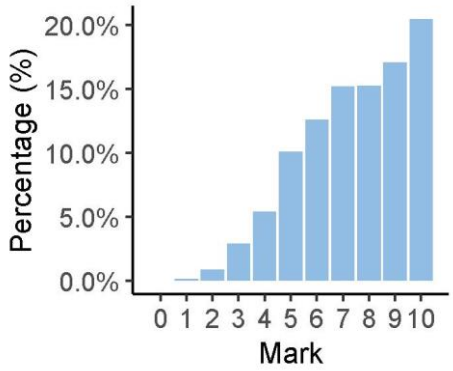


IA1 marks

IA1 total

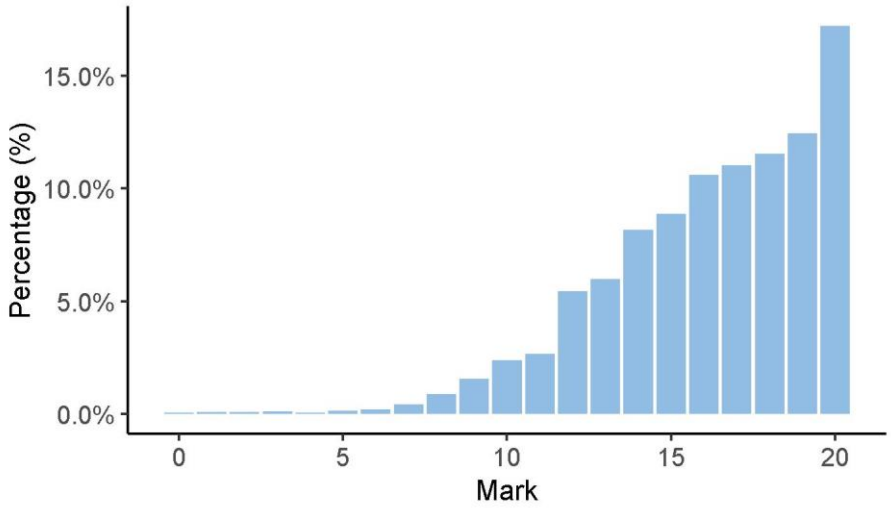


IA1 Criterion: Data test

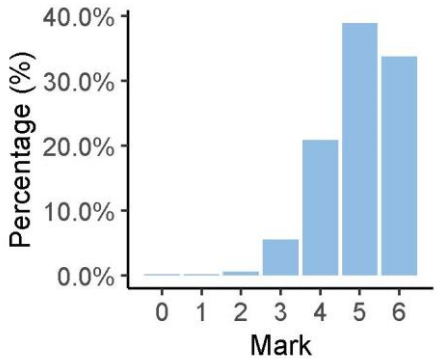


IA2 marks

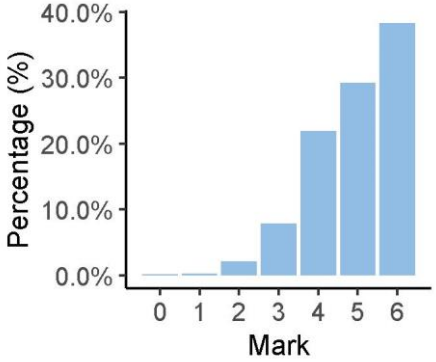
IA2 total



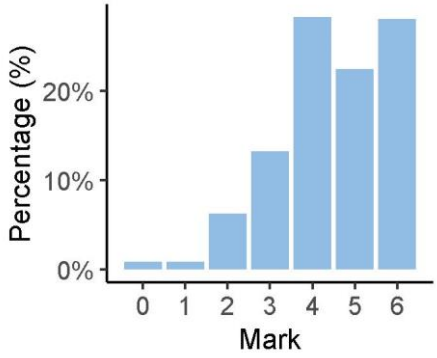
IA2 Criterion: Research and planning



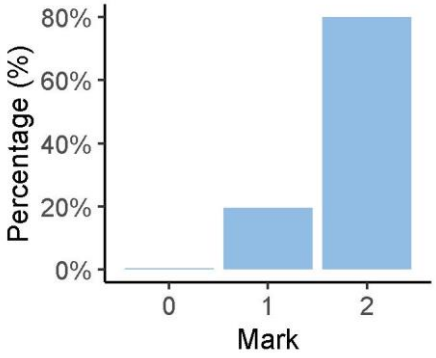
IA2 Criterion: Analysis of evidence



IA2 Criterion: Interpretation and evaluation

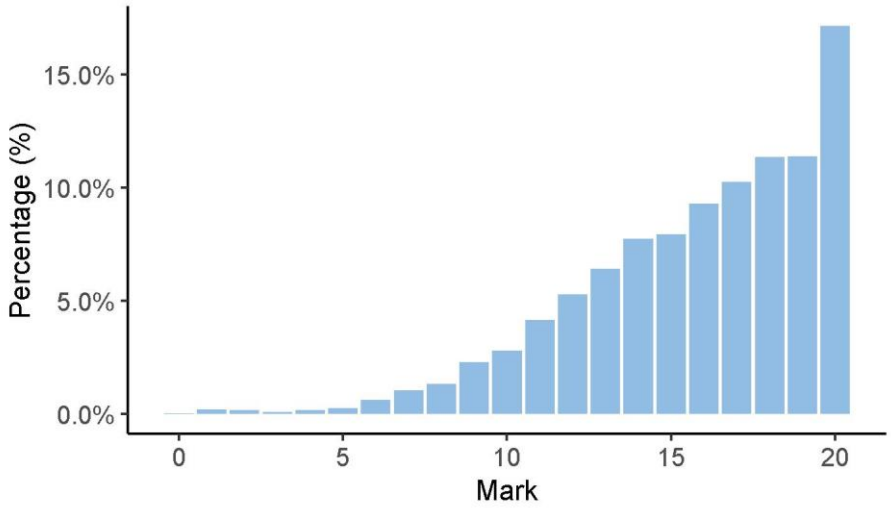


IA2 Criterion: Communication

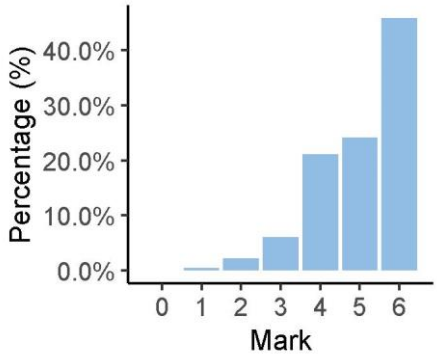


IA3 marks

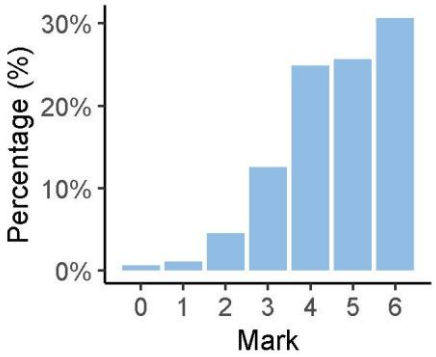
IA3 total



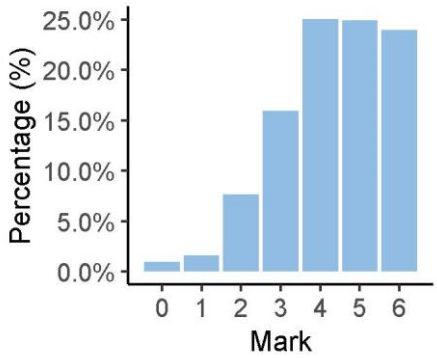
IA3 Criterion: Research and planning



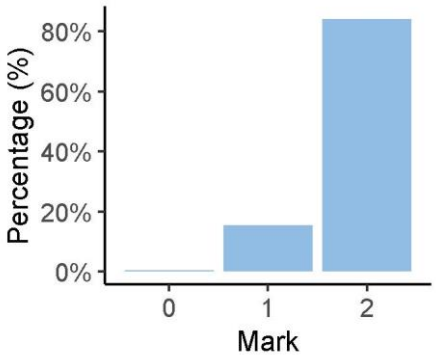
IA3 Criterion: Analysis and interpretation



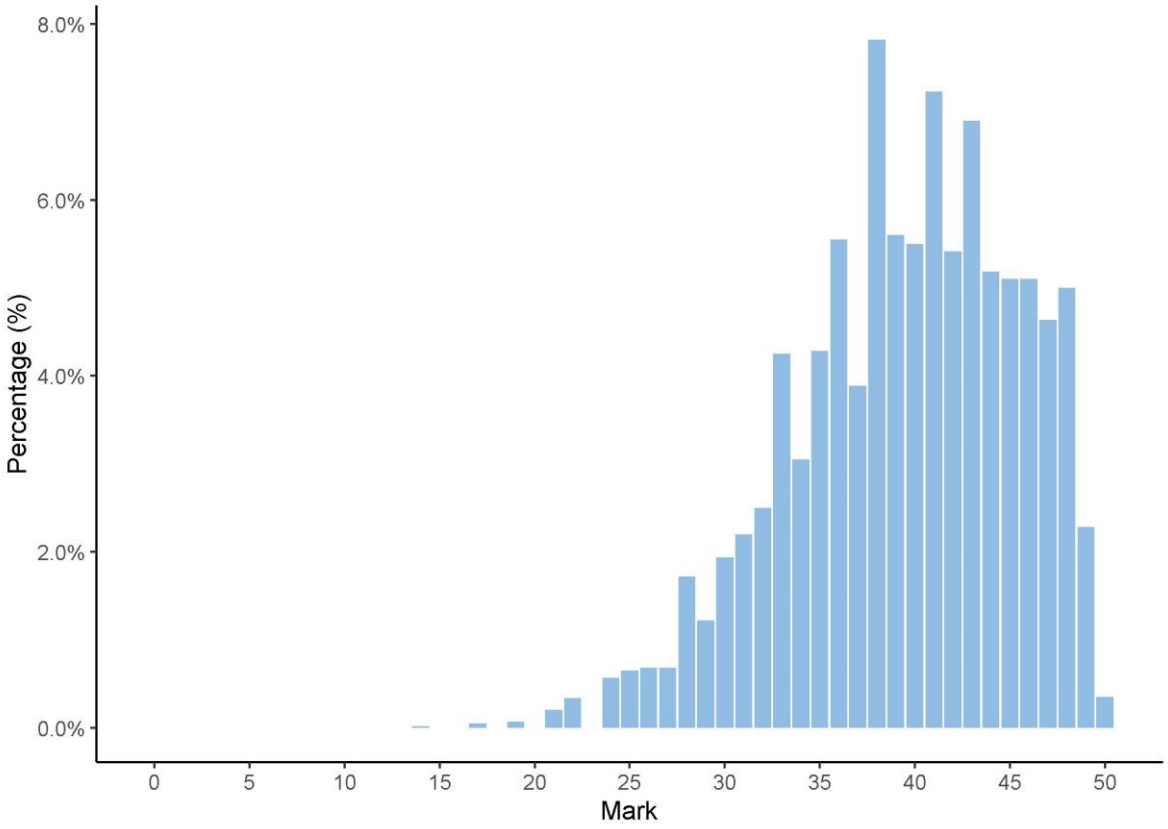
IA3 Criterion: Conclusion and evaluation



IA3 Criterion: Communication

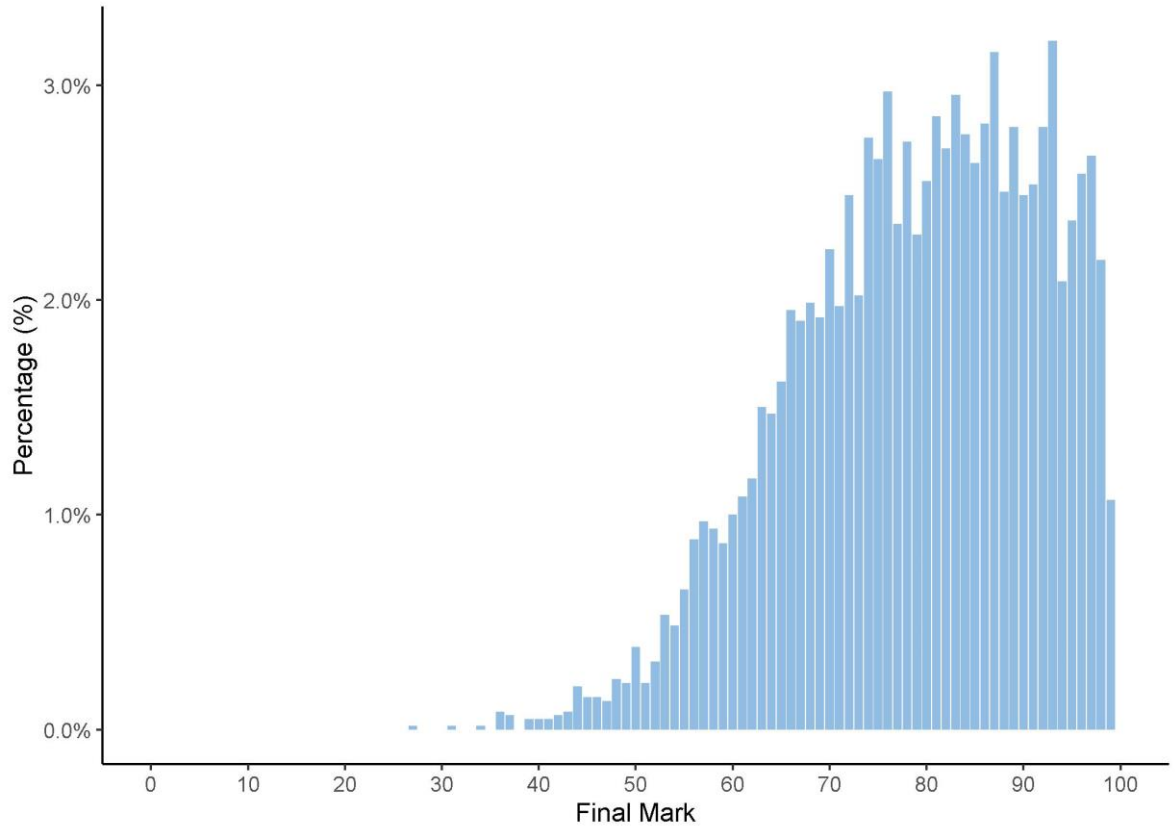


External assessment (EA) marks



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	83–70	69–46	45–20	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	2455	2129	1347	51	0

Internal assessment

The following information and advice pertain 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 the quality assurance tools for detailed information about the assessment practices for each assessment instrument.

Percentage of instruments endorsed in Application 1

Number of instruments submitted	IA1	IA2	IA3
Total number of instruments	397	397	396
Percentage endorsed in Application 1	47%	92%	86%

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 ISMG and are used to make decisions about the cohort's results. If further information is required about the school's application of the ISMG to finalise a confirmation decision, the QCAA requests additional samples.

Schools may request a review where an individual student's confirmed result is different from the school's provisional mark in one or more criteria and the school considers this result to be an anomaly or exception.

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	391	1949	0	99.49%
2	391	2004	180	84.65%
3	391	2002	114	87.72%

Internal assessment 1 (IA1)

Data test (10%)

The IA1 data test requires students to apply a range of cognitions to multiple provided items. Students respond to items using qualitative and/or quantitative data derived from practicals, activities or case studies. The task requires students to identify unknown scientific quantities or features; identify trends, patterns, relationships, limitations or uncertainty in datasets; and draw conclusions based on the analysis of data.

In the General syllabus, data is drawn from the Unit 3 topics Gravity and motion and Electromagnetism. In the Alternative Sequence in 2021, data was drawn from the AS Unit 1 topics Linear motion and force and Gravity and motion.

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	143
Authentication	0
Authenticity	15
Item construction	48
Scope and scale	32

*Each priority might contain up to four assessment practices.

Total number of submissions: 397.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- contained 2–4 datasets that were clearly derived from the subject matter of the relevant unit, e.g. mandatory or suggested practicals
- featured authentic datasets and questions that were unambiguous and clearly based on the teaching and learning activities students experienced in the relevant unit, e.g. ‘Conduct an experiment to investigate the parallel component of the weight of an object down an inclined plane at various angles’
- contained questions that assessed only one cognition each
- featured questions that did not follow on from previous questions.

Practices to strengthen

It is recommended that assessment instruments:

- contain items that are clearly aligned with the corresponding objective by using an appropriate cognitive verb and requiring an appropriate nature of response, e.g. in an objective 3 item, '*identify* a trend in the dataset'. Teachers should refer to the Mark allocations table in the syllabus for guidance on the appropriate cognitive verbs and nature of response that are appropriate for each objective
- only include questions that require the use of the dataset to answer the question, i.e. the question cannot be answered using a formula without the use of data contained in the dataset
- use datasets with diagrams and/or graphs rather than asking students to sketch or draw these in their responses
- include a marking scheme that clearly and consistently matches each mark to an important feature in the expected response, e.g. one mark for correctly substituting values into the formula and one mark for calculating the correct value.

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	20
Language	44
Layout	10
Transparency	38

*Each priority might contain up to four assessment practices.

Total number of submissions: 397.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- clearly asked students to show their working in questions when required
- allocated appropriate spaces for responses according to the marking guide
- featured clear links between the items and the data required to answer the question, e.g. see Figure 1 in Dataset 1
- contained brief and succinct instructions that avoided unnecessary complexity or details.

Practices to strengthen

It is recommended that assessment instruments:

- are formatted in the Endorsement application using the page break tool to ensure datasets, figure labels and items are not separated across pages. The print preview function will help teachers to ensure the layout of the task is appropriate

- use consistent language with correct units and spelling in datasets, including legends, titles of graphs/tables and labelled axes.

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	Data test	99.49%	0%	0.26%	0.26%

Effective practices

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

- schools developed accurate marking guides that clearly showed the link between the expected response and the number of marks to be awarded
- schools updated their marking schemes to support the range of student responses to the task
- provisional marks were calculated accurately from the ISMG.

Samples of effective practices

There are no student response excerpts because either the student/s did not provide permission or there were third-party copyright issues in the response/s.

Practices to strengthen

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

- partial credit (i.e. half marks) should not be awarded for responses that demonstrate incomplete cognition, e.g. working that would not lead to a correct response, two contradictory responses to the same item.

Internal assessment 2 (IA2)

Student experiment (20%)

The IA2 student experiment requires students to modify (i.e. refine, extend or redirect) an experiment to address their own hypothesis or question. Students may use a practical performed in class as the basis for their methodology. They develop a research question, collect and process primary data, analyse and interpret evidence, and evaluate the reliability and validity of their experimental process.

In the General syllabus, practicals are drawn from the Unit 3 topic Gravity and motion and Electromagnetism. In the Alternative Sequence in 2021, practicals were drawn from the AS Unit 1 topics Linear motion and force and Gravity and motion.

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	25
Authentication	3
Authenticity	0
Item construction	1
Scope and scale	0

*Each priority might contain up to four assessment practices.

Total number of submissions: 397.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- provided practicals that were more closely related to the topics of the relevant summative unit than topics from earlier formative units or from other subjects
- showed clear alignment of cognitions and language with the syllabus and the assessment objectives
- contained a clear statement that feedback can only be provided on one draft
- featured a range of mandatory or suggested practicals from the relevant unit to use as the foundation for students' methodology and research question.

Practices to strengthen

It is recommended that assessment instruments:

- include all the syllabus specifications in the task description. These are listed in section 4.5.2 in the General syllabus and section 2.5.2 in the Alternative Sequence
- indicate how students can work collaboratively and how the school will manage authentication of student work in these situations, e.g. the teacher will compare the responses of students who have worked together.

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	0
Language	3
Layout	0
Transparency	2

*Each priority might contain up to four assessment practices.

Total number of submissions: 397.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- expressed checkpoints in a way that provides schools flexibility within a defined timeline (e.g. ‘Week 5’)
- avoided jargon and specialist language that did not contribute understanding of subject matter
- had clear instructions aligned to the syllabus specifications, assessment objectives and ISMG
- avoided repeating elements of the task in different sections, e.g. repeating task specifications in the stimulus.

Practices to strengthen

There were no significant issues identified for improvement.

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	Research and planning	87.98%	9.46%	2.3%	0.26%
2	Analysis of evidence	90.54%	8.7%	0.51%	0.26%
3	Interpretation and evaluation	92.58%	6.39%	0.77%	0.26%
4	Communication	97.95%	1.28%	0.77%	0%

Effective practices

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

- in the Analysis of evidence criterion, sufficient and relevant raw data was systematically and effectively analysed using correct and relevant processes such as
  - calculation of indicators of uncertainty, e.g. percentage uncertainty
  - linearisation of data
  - calculation of measures of correlation, e.g. Pearson's correlation coefficient, *r*
- in the Interpretation and evaluation criterion, experimental processes were critically evaluated through justified discussion of their reliability and validity that referred to the uncertainty and limitations identified in the analysis of the evidence.

Samples of effective practices

The following are excerpts from responses that illustrate the characteristics for the criteria at the performance level indicated. The excerpts may provide evidence of more than one criterion. The characteristics identified may not be the only time the characteristics have occurred throughout a response.

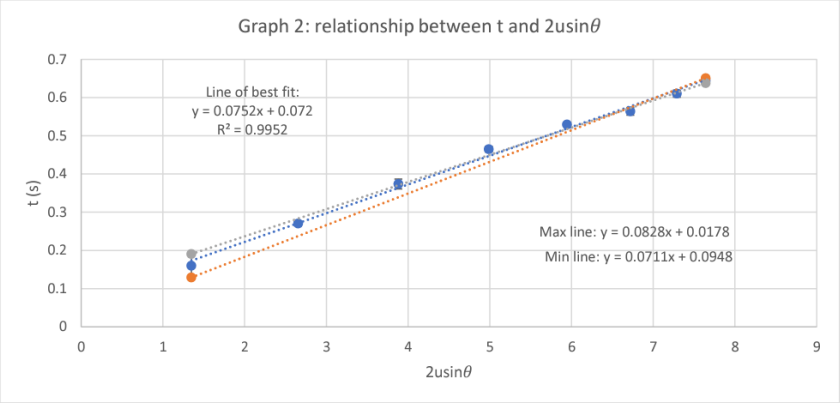
This student response excerpt has been included:

- to demonstrate justification of modifications to the methodology

Research and planning (5–6 marks) • justified modifications to the methodology	**Modifications:** To ensure sufficient, and more accurate data was collected the experiment was: 1. Extended by a) Increasing the separation distance (independent variable) between magnets to determine to the effect distance has on force (dependent variable) and the inverse squared relationship. The separation distance in the original investigation began at 30cm. However, it was modified to be five times the size of magnet used to determine how an extended range impacted the relationship between force and separation distance. 2. Refined by: a) Using 'rare' earth magnets: 'rare' earth magnets produce a stronger magnetic field than other magnets (Stanford, Unknown). By increasing the force of the magnetic field, more accurate measurements can be produced. b) Increasing the number of trials to five in order to produce more accurate measurements than in the original experiment.

This student response excerpt has been included:

- to demonstrate systematic and effective analysis of experimental evidence through the identification of relationships that are relevant to the research question.

Analysis of evidence (5–6 marks) • thorough identification of relevant trends, patterns or relationships	Analysis of Evidence The relationship shown by graph 1 looks like the first quarter period of a sine curve (only approximately considering the angle was measured from $10°$ to $80°$), as it increases steadily and then flattens as it approaches $90°$, or it could be half a parabola. To determine if the data follows the expected relationship of a sine curve, t vs $2u\sin\theta$ was graphed as the expected theoretical relationship $t = \frac{2u\sin\theta}{g}$ can be rearranged so $g = \frac{2u\sin\theta}{t}$. Hence the reciprocal of the gradient is the observed acceleration due to gravity. Mean u was used as data and theory shows that u is not affected by θ. Additionally, it can be inferred from graph 1 that time would be greatest at $90°$, as $80°$ and $100°$ give the same angle from the horizontal. This also supports the expected relationship. 

This student response excerpt has been included:

- to demonstrate critical evaluation of the experimental processes
- to show a justified discussion with references to the uncertainties and limitations identified in the analysis of the evidence.

Interpretation and evaluation (5–6 marks) • justified discussion of the reliability and validity of the experimental process	Evaluation The reliability and hence precision of the results was acceptable. Although the maximum percentage uncertainty for time was 19%, this is likely due to random error from the timing method or if the launcher slipped in some way. The percentage uncertainty for time other than this was between 3.5% and 0.94%, which is acceptable. The data was consistent as R^2 from graph 2 is 0.9952. The method for timing allowed moderate random error, evident in primarily the last four data points for graph 2 when compared to the first four, also decreasing the reliability. This suggests that the precision of the measurements was acceptable, but the accuracy of the measurements was low (as shown by the percentage error of 36%) due to significant systematic error. The data was not valid as the observed g value has a 36% percentage error and the expected value did not fall within the uncertainty of this value ($13.298 \pm 7.5\%$ is 14.3 ms^{-2} to 12.3ms^{-2}). The y-intercept of the line of best fit suggests that the error and hence invalidity is from systematic error. It is possible that the expected relationship was not appropriate because it did not consider some unknown factors. This is not likely to be air resistance because the distance travelled by the projectile and the radius of the projectile was small, and this would slow the projectile, increasing time of fall. Observed *g* is 36% greater than expected, so the times recorded were smaller than in reality rather than greater. Additionally it was observed that the vertical displacement was in fact not 0 but negative, however this would increase the distance and hence the times, and this displacement was not significant enough to have such a large effect. So although this was a source of systematic error it is not the primary one. Systematic error could be due to the phones and videoing software used to calculate times—the videos may not have been slowed down to the necessary 240 fps or may have recorded the videos with too many fps, hence decreasing the times from what they were in reality. Alternatively, this error could be the result of an unknown source. Furthermore, the projectile may not have passed through the centre of the photogate, consequently recording initial velocity incorrectly. This would affect the y-intercept (already affected by the gradient), so it is unknown if this source of systematic error was present. Therefore, the experimental process was not appropriate as it allowed significant systematic error, resulting in invalid evidence.

Practices to strengthen

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

- in the Research and planning criterion
  - each justified modification to the methodology identifies how it will improve the validity or reliability of a familiar experiment
  - a methodology that enables the collection of sufficient, relevant data ensures that the experiment produces enough data for the uncertainty and limitations of the evidence to be identified and for valid conclusions to be drawn.

Additional advice

- Experimental methodologies should be based on practicals that consider only one dependent variable (e.g. mandatory or suggested practicals from the syllabus) rather than complicated investigations that consider more than one dependent variable.

Internal assessment 3 (IA3)

Research investigation (20%)

The IA3 research investigation requires students to gather secondary evidence related to a research question in order to evaluate a claim. Students develop a research question, collect and analyse secondary data, interpret evidence to form a justified conclusion, discuss the quality of the evidence and extrapolate the findings of the research to the claim.

In the General syllabus, claims are based on the Unit 4 topics Special relativity, Quantum theory and The Standard Model. In the Alternative Sequence in 2021, claims were based on the AS Unit 2 topics Special relativity, Ionising radiation and nuclear reactions and the Standard Model.

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	32
Authentication	9
Authenticity	1
Item construction	10
Scope and scale	5

*Each priority might contain up to four assessment practices.

Total number of submissions: 396.

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- provided claims that were more closely related to the topics of the relevant summative unit than topics from earlier formative units or from other subjects, e.g. ‘Blackbody radiation allows for highly effective modelling of climate change’
- featured claims written as statements without any accompanying evidence
- contained claims that could generate multiple research questions, e.g. ‘Everyone will soon have access to quantum computers’
- provided sufficient claims for the size of the cohort, allowing students to develop unique responses to the task.

Practices to strengthen

It is recommended that assessment instruments:

- include all the syllabus specifications in the task description. These can be found in Section 5.6.1 of the General syllabus and Section 3.6.1 of the Alternative Sequence.

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	0
Language	6
Layout	0
Transparency	1

*Each priority might contain up to four assessment practices.

Total number of submissions: 396.

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- avoided jargon and specialist language that did not contribute understanding of subject matter
- used clear instructions aligning to the syllabus specifications, assessment objectives and ISMG
- provided claims written using clear, succinct language and featuring accurate spelling and grammar
- expressed checkpoints in a way that provides schools flexibility within a defined timeline (e.g. ‘Week 5’)

Practices to strengthen

There were no significant issues identified for improvement.

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	Research and planning	92.58%	6.14%	1.02%	0.26%
2	Analysis and interpretation	92.33%	6.91%	0.51%	0.26%
3	Conclusion and evaluation	93.35%	6.14%	0.26%	0.26%
4	Communication	98.47%	1.02%	0.51%	0%

Effective practices

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

- in the Analysis and interpretation criterion, thorough identification of trends, patterns and relationships and thorough and appropriate identification of limitations was sufficient to ensure that credible findings of the research could be extrapolated to the claim
- in the Conclusion and evaluation criterion, insightful discussion of the quality of evidence
  - was clearly related to the research question
  - referred to the limitations identified in the analysis of the evidence
  - led to improvements and extensions to the investigation being considered in relation to the claim.

Samples of effective practices

The following are excerpts from responses that illustrate the characteristics for the criteria at the performance level indicated. The excerpts may provide evidence of more than one criterion. The characteristics identified may not be the only time the characteristics have occurred throughout a response.

This student response excerpt has been included:

- to demonstrate thorough and appropriate identification of the limitations of evidence
- to show justified scientific arguments.

Analysis and interpretation (5–6 marks) • thorough and appropriate identification of limitations of evidence • justified scientific arguments	*Figure 6* displays these results after processing data. It was found that the amount of precipitable water dramatically increased following a doubling of CO_2 which heated the environment (expressed as surface temperature on x-axis). Specifically, as the CO_2 created more heat due to the greenhouse effect, the amount of precipitable water increased substantially. Plotted below the precipitable water-surface temperature graph, a smaller graph features the number of observations made at each temperature (in thousands). The inclusion of the graph increases the reliability and accuracy of the results. Furthermore, the pattern existing between water vapor and CO_2 is displayed in *Figure 7*. This model shows (from top left corner) that an increase in atmospheric CO_2 initially creates a small increase in temperature. This causes amplification of the greenhouse effect and an increased humidity. It is here the feedback loop can be observed as the surface temperature increased leading to further infrared blackbody radiation. Intriguingly, the change in temperature caused by direct increase of CO_2 concentration equates to only 22.73% of the total increase in temperature (2.2°C). Stephens et. al then concluded from this, that the water vapor feedback loop actually contributed to over half of the total increase of global warming. Unfortunately, due to the equilibrium on Earth that leads to precipitation, the long-term extent of this feedback loop was hard to determine. This model is also very general and different climates would experience varied impacts. Furthermore, the article was written when there was less of an understanding of the equilibrium, meaning the results found were broad and may have only been accurate for a proportion of models both modern and past.

This student response excerpt has been included:

- to demonstrate extrapolation of credible findings of research to the claim.

Conclusion and evaluation (5–6 marks) • extrapolation of credible findings of the research to the claim	**V. Evaluation of the Claim** The claim of the investigation was 'The theory of relativity explains the cosmos and everything in it'. All aspects of the claim were validated with respect the research question. The first element was satisfied as the comparison between the uncertainty in traditional methods to INS systems indicated a difference in the measurements recorded. Graph two enabled further investigation, which revealed an error was determined in which the positioning of the vehicle within different dimensions with respect to time. This enabled the identification of the positional error because of length dilation, a property of special relativity. Furthermore, the flowchart in figure 1 describes the different reference frames that are involved in the situation. As such, the understanding of the relation between objects is described as relativistic, in which the distance travelled by the vehicle is different to that of the observed. This further explains why positional error exists and deepens the understanding of the relativistic nature of the cosmos as the relationship between two objects cannot be described in the same way for two different frames of reference.

Practices to strengthen

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

- in the Research and planning criterion
  - a considered rationale should clearly demonstrate how the research question was developed from the claim
  - a research question is specific if it allows a justified conclusion to the claim to be reached within the response length conditions of the syllabus, e.g. How has the understanding of the uncertainty in position of vehicles using inertial navigation systems furthered the understanding of the spatial relation between objects?
  - if a research question focuses more on subject matter from Units 1 and 2 than Unit 4 it is considered inappropriate and not relevant.

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.

Summative external assessment — 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 (20 marks)
- Paper 1, Section 2 consisted of short response questions (23 marks)
- Paper 2, Section 1 consisted of short response questions (32 marks).

The examination assessed subject matter from Units 3 and 4. Questions were derived from the context of:

- Gravity and motion
- Electromagnetism
- Special relativity
- Quantum theory
- The Standard Model

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

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

- Paper 1, Section 1 consisted of multiple choice questions (20 marks)
- Paper 1, Section 2 consisted of short response questions (26 marks)
- Paper 2, Section 1 consisted of short response questions (34 marks).

The AS examination assessed subject matter from AS units 1 and 2. Questions were derived from the context of:

- Linear motion and force
- Gravity and motion
- Special relativity
- Ionising radiation and nuclear reactions
- The Standard Model

The AS 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.

General multiple choice item responses

There were 20 multiple choice items 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	10.71	**58.94**	19.89	10.24
2	10.01	**84.64**	4.17	1.01
3	**85.52**	2.28	2.81	9.28
4	5.85	10.06	35.44	**48.4**
5	**81.3**	4.26	3.48	10.8
6	1.47	13.29	32.03	**53.12**
7	3.96	**82.23**	11.91	1.84
8	18.35	**65.53**	7.32	7.92
9	2.21	13.74	4.1	**79.71**
10	**74.4**	6.12	1.27	18.14
11	4.65	5.94	**65.51**	23.79
12	**51.94**	12.46	25.76	9.42
13	5.59	24.48	**60.33**	9.25
14	3.18	6.95	17.22	**72.41**
15	**78.13**	11.42	8.59	1.61
16	2.3	4.9	**90.91**	1.77
17	6.45	20.63	**56.99**	15.61
18	8.29	1.8	**83.54**	6.19
19	34.88	**56.07**	6.03	2.69
20	22.33	27.7	**37.37**	12.07

AS multiple choice item responses

There were 20 multiple choice items 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	15.38	**53.5**	18.88	12.24
2	12.59	**77.62**	8.39	1.4
3	**85.66**	2.1	2.45	9.79
4	6.29	10.84	19.23	**63.29**
5	**77.97**	3.5	3.85	14.34
6	4.2	27.62	**59.09**	9.09
7	8.74	**67.13**	16.78	7.34
8	12.94	**62.59**	9.79	13.99
9	29.02	9.09	6.29	**54.9**
10	**70.28**	6.99	2.8	19.58
11	8.39	8.39	**60.14**	23.08
12	**39.16**	14.34	34.97	11.19
13	5.94	35.31	**44.06**	13.64
14	6.64	**68.18**	5.94	19.23
15	**75.17**	10.49	11.89	2.45
16	3.15	8.04	**85.66**	3.15
17	3.15	7.69	11.19	**77.62**
18	11.19	3.15	**77.97**	7.69
19	38.11	**44.06**	12.24	5.59
20	1.4	27.62	**10.14**	60.84

Effective practices

Overall, students responded well to:

- short response questions requiring them to calculate a numerical value
- opportunities to apply their understanding of electrostatics
- opportunities to apply their understanding of quantum theory.

The following excerpts have been selected to illustrate effective student responses in one or more of the syllabus assessment objectives. The characteristics identified may not be the only time the characteristics have occurred throughout a response.

Samples of effective practices

Short response

Assessment objective: 1

Paper 2 (Alternative Sequence)

Question 1

This question required students to provide an explanation of the causes of beta positive radiation formation.

Effective student responses identified the:

- cause of instability leading to the formation of beta positive radiation
- particles involved in the decay
- particle related to beta positive radiation and its source within the atom.

This student response excerpt has been included:

- to demonstrate how a situation can be made clear by revealing the relevant evidence and describing it in more detail.

Describe and explain (3 marks)	An excess of positive charge, or too many protons present in the nucleus results in an unstable nuclide as the electrostatic repulsive force & strong nuclear forces acting are not balanced. Consequently, in the shifting & rearrangement of the nucleus, a proton decays into a neutron to relieve the excess positive charge and a positron and electron neutrino are released to ensure the conservation of charge is obeyed. The nuclear decay results in a stable nucleus that has a lower atomic number ∴ transmutation has occurred. $^{A}_{Z}X \longrightarrow {}^{A}_{Z-1}Y + {}^{0}_{+1}e + \nu_e + \gamma$

Assessment objective: 3

Paper 2 (General)

Question 7a

This question required students to determine the mathematical relationship for linear-trending data.

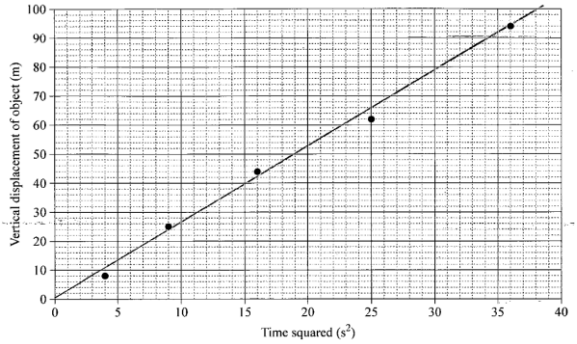
Effective student responses:

- determined the gradient for a line of best fit appropriate to the data
- identified the associated y-intercept
- identified the mathematical equation that demonstrated the relationship between variables.

This student response excerpt has been included:

- to demonstrate how a mathematical relationship may be determined by calculating the gradient and identifying the y-intercept for a line of best fit for the data.

Analyse evidence (3 marks)



$S \propto t^2$

$\therefore S = 2.61t^2$

y-intercept = 0 $\therefore c = 0$

vertical displacement and time squared have a directly proportional relationship, therefore vertical displacement and time have a parabolic/quadratic relationship.

gradient of line of best-fit:

$m = \frac{94-0}{36-0}$ $m = \frac{y_2-y_1}{x_2-x_1}$

$\therefore m = \frac{47}{18} \approx 2.61$

Assessment objective: 4

Paper 1 (General)

Question 23

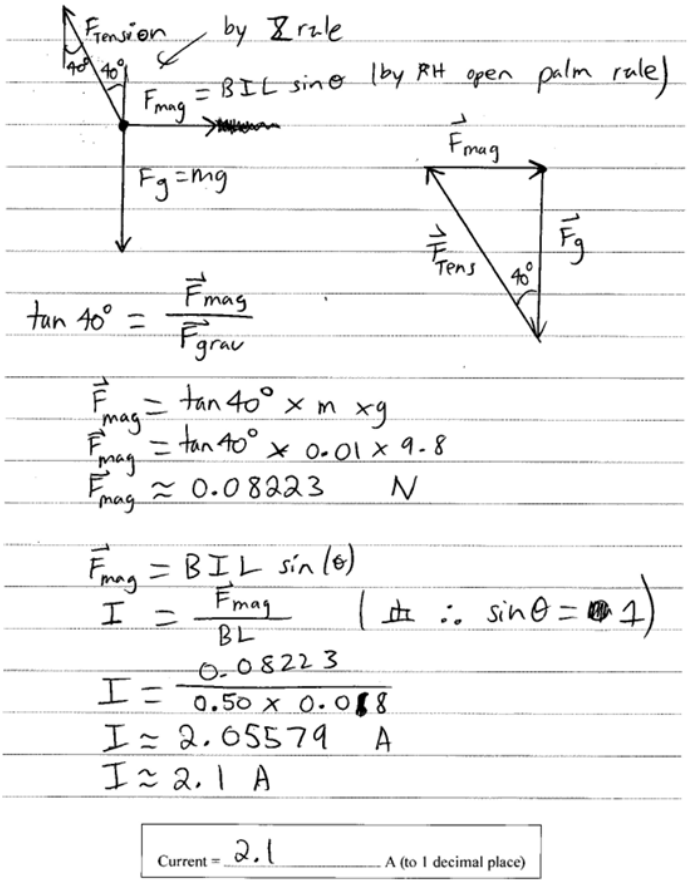
This question required students to determine the magnitude of a current in a metal rod using vector analysis.

Effective student responses:

- identified forces acting on the wire
- recognised the two given forces could be added together to find a third force
- identified the relationship between the two given forces to determine the third force
- demonstrated appropriate mathematical reasoning
- determined the magnitude of the current in the wire.

This student response excerpt has been included:

- to demonstrate a conclusion following consideration and calculation
- as it provides evidence of vector analysis to solve a problem involving magnetic force on an electric current-carrying wire.

Interpret evidence (5 marks)	

Practices to strengthen

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

- the number of marks allocated to a question indicates the number of statements, cognitions or calculations required to achieve full marks
- the multiple choice items where students answered incorrectly to ensure subject matter is sufficiently covered
- responses to items relating to Assessment objectives 3 and 4 that require analysis of linear-trending data (e.g. line of best fit when determining gradient) to support conclusions
- responses that demonstrate an understanding of syllabus links within the syllabus.

Senior External Examination

The Physics 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.

The assessment was designed using the specifications, conditions and assessment objectives described in the summative external assessment section of the Physics 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 Physics Senior External Examination: 12.

Distribution standards

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

Assessment decisions

Effective practices

Overall, students responded well to:

- short response questions that required calculation of an unknown quantity or identification of a feature within supplied data.

It is recommended that when preparing students for the Senior External Examination, teachers consider:

- uncertainty in analysis of data
- justification for conclusions determined from data.