Physics subject report

2024 cohort

January 2025

Queensland Government | QCAA Queensland Curriculum & Assessment Authority

250037

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Contents

Introduction

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

The report also includes information about:

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

The report promotes continuous improvement by:

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

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

Audience and use

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

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

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

Subject highlights

8.95%
increase in enrolment since 2023

92%
of IA2 endorsed at Application 1

88.67%
agreement with provisional marks for IA3

Subject data summary

Subject completion

The following data includes students who completed the General subject or alternative sequence (AS).

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

Number of schools that offered Physics: 408.

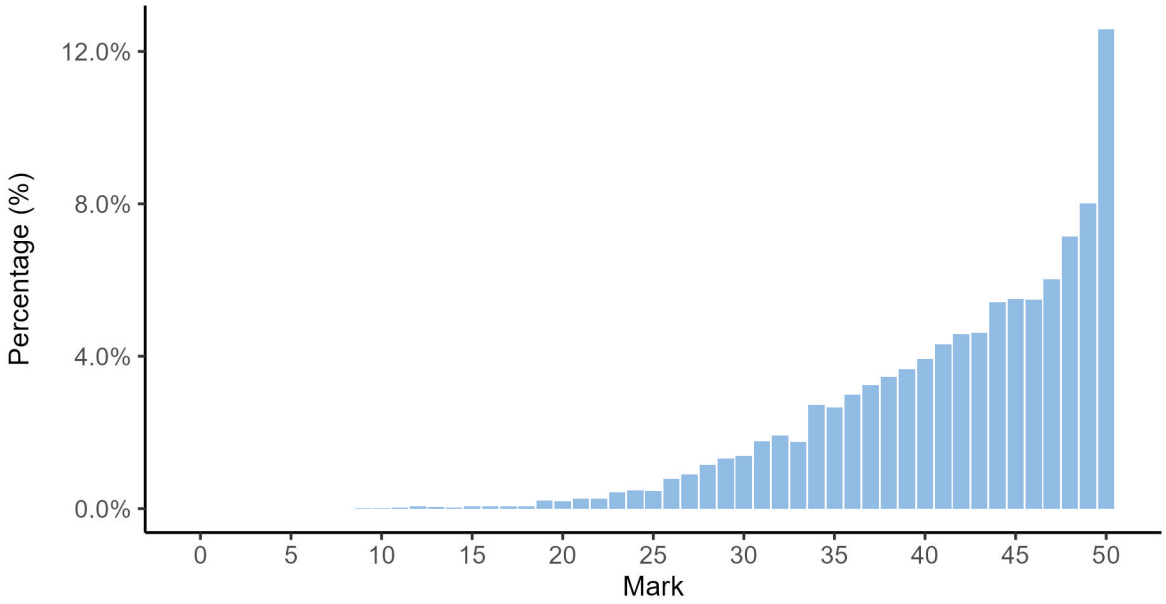
Completion of units	Unit 1	Unit 2	Units 3 and 4
Number of students completed	8,579	8,120	7,447

Units 1 and 2 results

Number of students	Satisfactory	Unsatisfactory
Unit 1	8,131	448
Unit 2	7,577	543

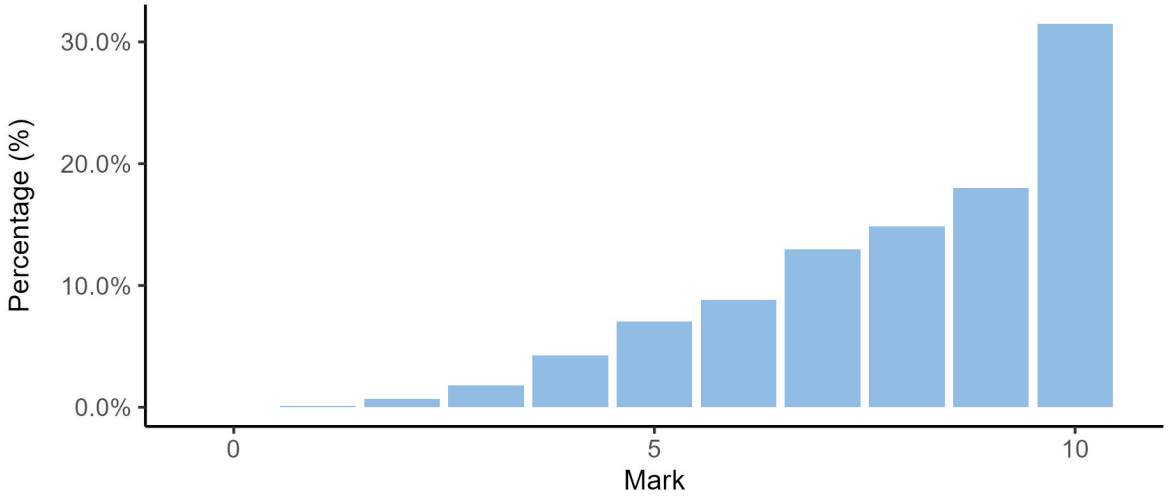
Units 3 and 4 internal assessment (IA) results

Total marks for IA

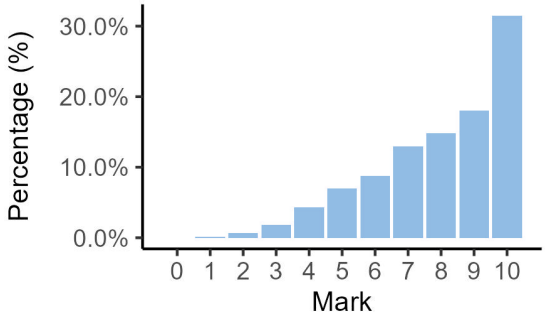


IA1 marks

IA1 total

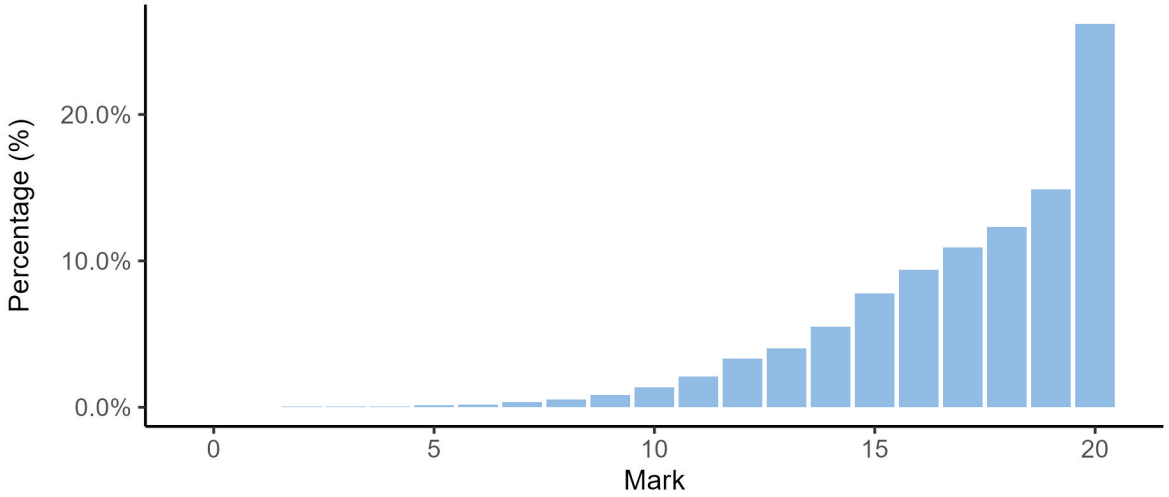


IA1 Criterion: Data test

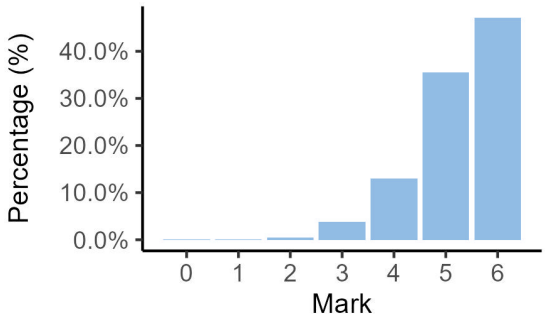


IA2 marks

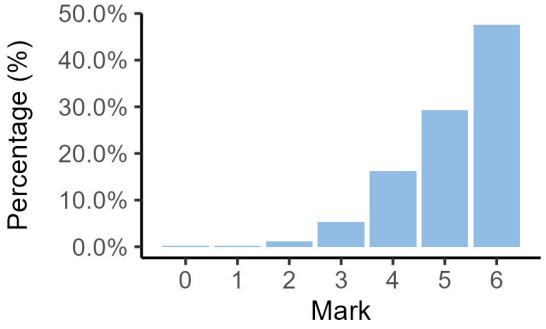
IA2 total



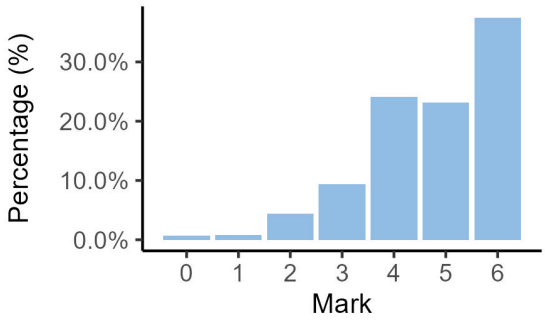
IA2 Criterion: Research and planning



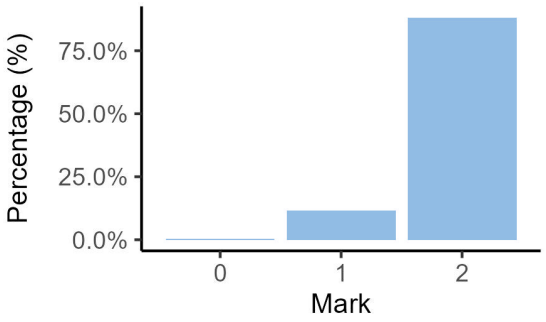
IA2 Criterion: Analysis of evidence



IA2 Criterion: Interpretation and evaluation

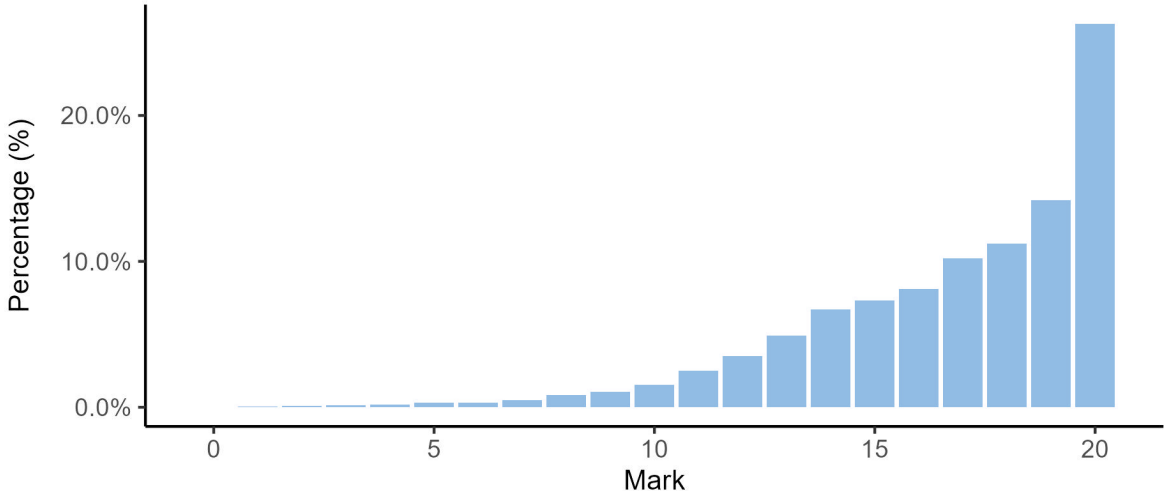


IA2 Criterion: Communication

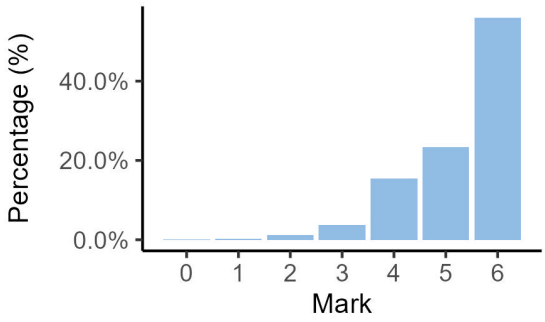


IA3 marks

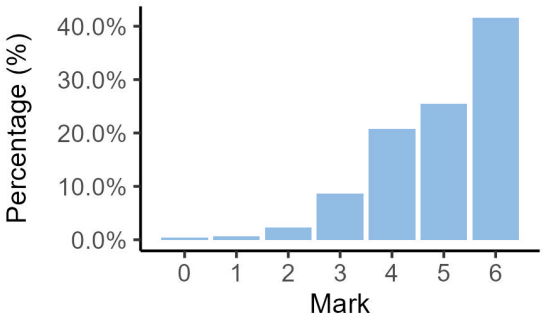
IA3 total



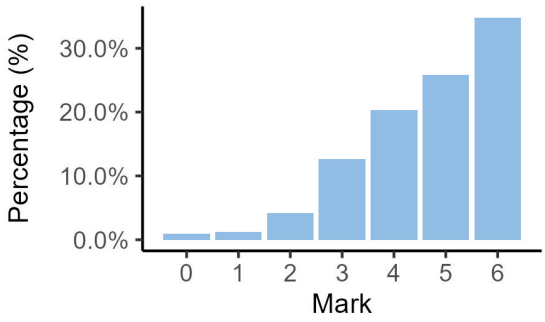
IA3 Criterion: Research and planning



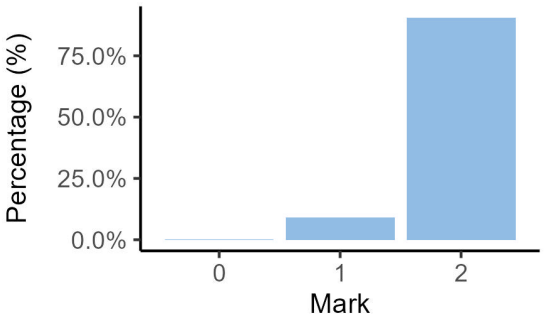
IA3 Criterion: Analysis and interpretation



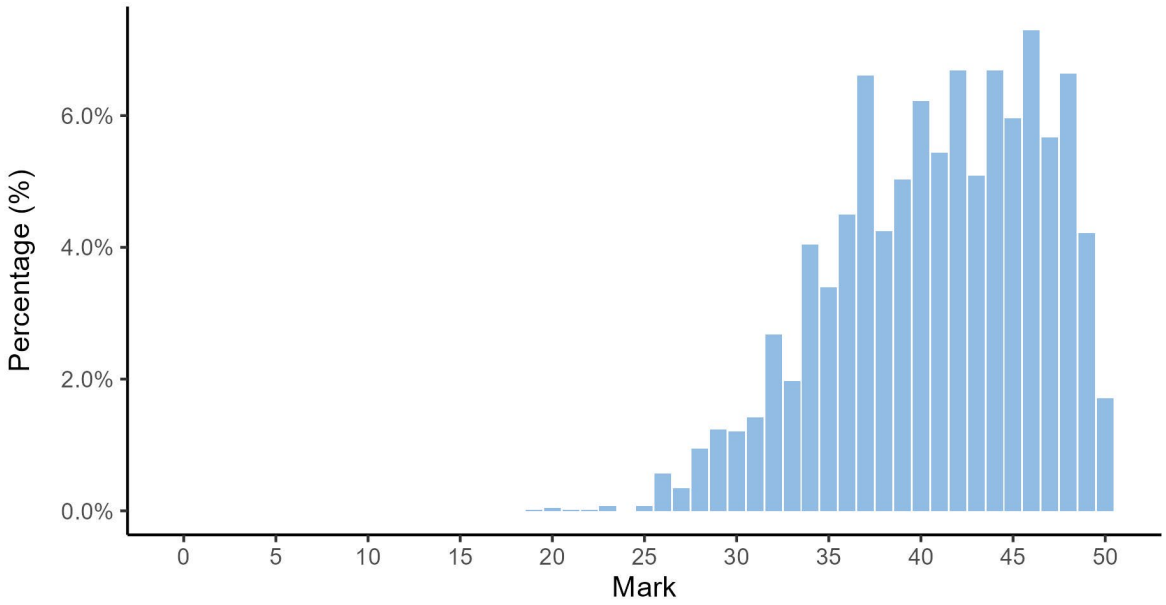
IA3 Criterion: Conclusion and evaluation



IA3 Criterion: Communication

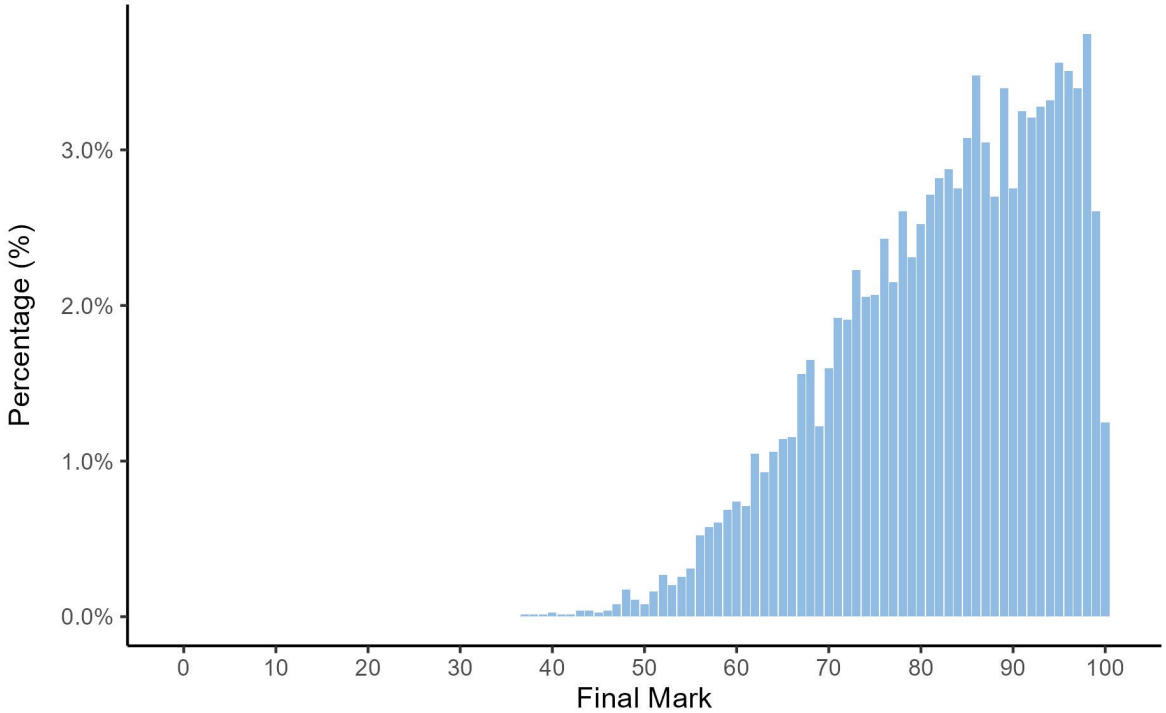


External assessment (EA) marks



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	100–87	86–72	71–50	49–20	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	3,203	2,829	1,370	45	0

Internal assessment

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

Endorsement

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

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

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

Percentage of instruments endorsed in Application 1

Instruments submitted	IA1	IA2	IA3
Total number of instruments	409	409	408
Percentage endorsed in Application 1	52	92	64

Confirmation

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

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

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

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

Number of samples reviewed and percentage agreement

IA	Number of schools	Number of samples requested	Number of additional samples requested	Percentage agreement with provisional marks
1	405	2,717	0	99.75
2	406	2,719	3	87.47
3	406	2,709	6	88.67

Internal assessment 1 (IA1)

Data test (10%)

This assessment focuses on the application of a range of cognitions to multiple provided items.

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	146
Authentication	0
Authenticity	11
Item construction	40
Scope and scale	16

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- comprised questions that were independent and did not rely on responses from previous questions, e.g. did not require the expected response in Question 1 to complete Question 2
- included only the relevant data required for students to respond to the given questions, e.g. if Table 2 is not required for any question in a dataset, it was not included as a distractor
- ensured students rely solely on the dataset for evidence without introducing new information within the questions themselves
- featured a variety of datasets clearly derived from Unit 3 (or AS Unit 3) subject matter that allowed for interrogation of the data, e.g. mandatory or suggested practicals, activities or case studies from Unit 3.

Practices to strengthen

It is recommended that assessment instruments:

- include only one cognition per question so that objectives can be assessed independently
- use the appropriate cognition to align with the objective being assessed, e.g. to use the cognitive verb *infer* would require a nature of response in the marking guide that aligns with interpreting evidence (see Mark allocations in Syllabus section 4.5.1, AS section 4.6.1)

- have each mark allocated to a significant feature in the expected response, e.g. if a table needs to be completed, assign one mark for each required response that demonstrates data interpretation.

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	16
Language	43
Layout	8
Transparency	35

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- were formatted to ensure adequate space was included to suit the expected response
- featured consistent language to direct students from each question to the data required to respond to the question, e.g. ‘Using Table 2 ... ’.

Practices to strengthen

It is recommended that assessment instruments:

- are checked using the **Print preview** function to ensure that units are displayed correctly, e.g. degrees are shown with the symbol ° and not as *0*
- contain the correct spelling within questions and datasets, e.g. ‘cerrect’ to ‘correct’, ‘combinded’ to ‘combined’, and ‘trail’ to ‘trial’
- include clear and legible datasets with legends, labelled axes, appropriate units, and figure labels.

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	99.75	0	0.25	0.25

Effective practices

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

- marking schemes were reviewed and updated as appropriate prior to confirmation to reflect the range of correct student responses observed
- student responses were clearly annotated (e.g. ticks and crosses) to indicate how the evidence aligned with the marking scheme (*QCE and QCIA policy and procedures handbook v6.0*, Section 9.6.1)
- marks were correctly totalled, percentages were accurately determined, and cut-offs from the ISMG were correctly applied to determine provisional marks, e.g. 14/20 is 70%, which is >60%, therefore, a mark of 7 should be awarded.

Practices to strengthen

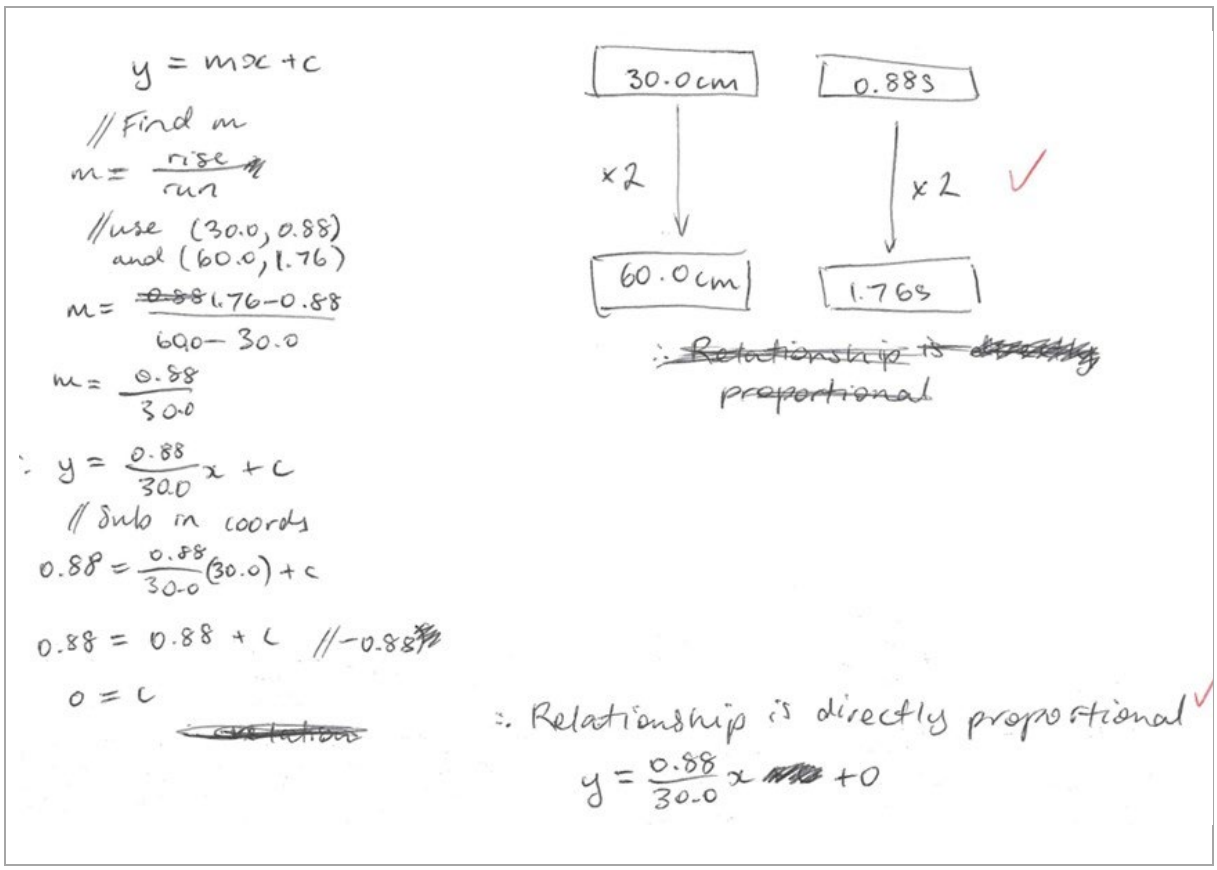
To further ensure accuracy and consistency of the application of the ISMG for this IA, it is recommended that:

- the marking scheme is confirmed to be accurate by matching the questions to the current endorsed data test and, if necessary, clearly identifying any comparable assessments
- the marking scheme is confirmed to be correct by showing exactly how marks will be allocated and what students are required to demonstrate
- marks entered in the Confirmation application (app) match the highlighted ISMG of the student sample
- student files are complete with all questions uploaded to the app, e.g. not every second page scanned.

Samples

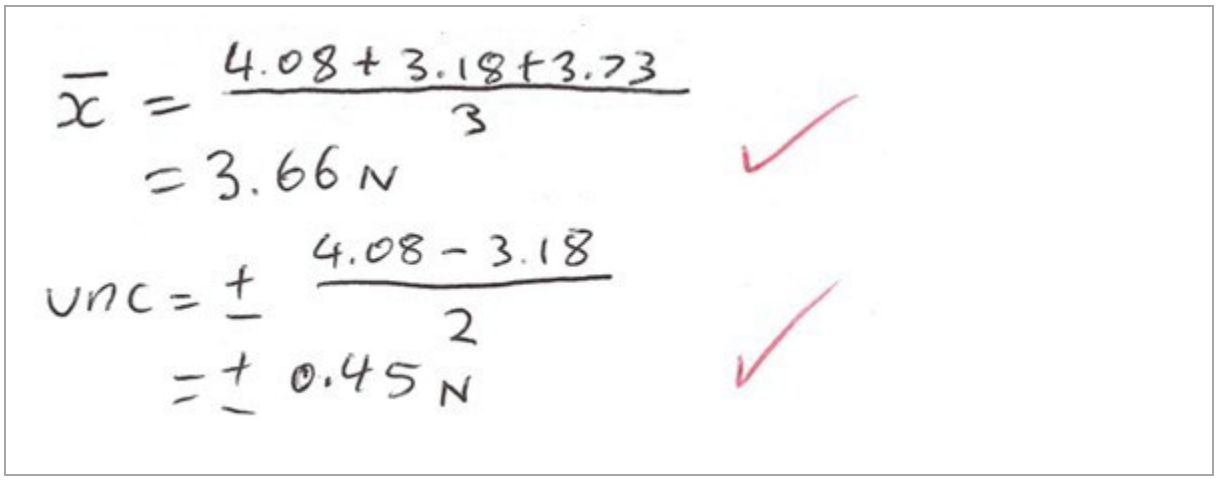
The following excerpt demonstrates the effective use of annotations on a student response to indicate where evidence matches the marking scheme. The marking scheme indicated that students would need to use the dataset to identify the linear relationship and provide an appropriate justification which has been clearly annotated on the student response.

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



The following excerpt demonstrates the effective use of annotations on a student response to indicate where evidence matches the marking scheme. The marking scheme indicated that students needed to calculate the correct average and the correct uncertainty.

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



Additional advice

- Schools should ensure that comparable assessments assess similar subject matter to the endorsed instrument and that they have uploaded the corresponding marking scheme, as required.

Internal assessment 2 (IA2)

Student experiment (20%)

This assessment requires students to research a question or hypothesis through collection, analysis and synthesis of primary data. A student experiment uses investigative practices to assess a range of cognitions in a particular context. Investigative practices include locating and using information beyond students' own knowledge and the data they have been given.

Research conventions must be adhered to. This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

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	15
Authentication	11
Authenticity	0
Item construction	5
Scope and scale	0

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- clearly identified that only one draft is submitted at one point in time (*QCE and QCIA policy and procedures handbook v6.0*, Section 8.2.5), i.e. partial submissions over multiple checkpoints should not be implemented as this does not give students holistic feedback on the mode specified by the syllabus
- offered students the chance to select from various relevant practicals based on the teachings and learnings of Unit 3 to form the foundation of their methodology and research question.

Practices to strengthen

It is recommended that assessment instruments:

- include all the specifications for the assessment task exactly as they are listed in the syllabus (Syllabus section 4.5.2, AS section 4.6.2)
- clearly identify with an asterisk (*) the sections that can be completed in groups, e.g. conduct a risk assessment and account for risks in the methodology*
- do not repeat information that has been stated in another section of the task, e.g. do not restate the specifications in the scaffolding section.

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	1
Layout	0
Transparency	0

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- provided appropriate scaffolding to support the development of the research question, avoiding steering students towards a predetermined response
- included checkpoints in a way that provided flexibility to insert week numbers at a later date, once timetabling has been established by the school.

Practices to strengthen

There were no significant issues identified for improvement.

Additional advice

- Teachers should direct students to use a practical related to Unit 3 subject matter to ensure relevancy (Syllabus section 4.5.2, AS section 4.6.2).

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	91.87	6.65	1.48	0
2	Analysis of evidence	95.57	3.69	0.74	0
3	Interpretation and evaluation	95.07	4.19	0.74	0
4	Communication	99.01	0.25	0.74	0

Effective practices

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

- for the Interpretation and evaluation criterion
  - *justified* conclusions referred to the trends, patterns or relationships identified in the analysis of evidence to indicate how the evidence matched with the theoretical concepts identified in the rationale
  - *logically derived* improvements were linked to the reliability of the experimental process and considered the uncertainties related to precision and random error
  - *logically derived* extensions were linked to the validity of the experimental process and made with reference to the limitations regarding the scope or applicability of the data collected, e.g. systematic errors related to the methodology and the accuracy of the results to the accepted/constant values from the rationale
- in the Communication criterion
  - findings, arguments and conclusions were *fluently* and *concisely* conveyed through precise and accurate use of
    - correct symbols, units and prefixes for the context
    - discipline-specific language
    - statistical language
    - indicators of uncertainty, e.g. significant figures
    - tables, graphs and diagrams, e.g. scatter graphs with a linearised line of best fit where possible
  - *appropriate* use of genre conventions was demonstrated by the adherence to accepted rules of spelling and punctuation and the expectations of particular generic forms, e.g. for a scientific report — appropriate headings and captions, an appropriately formal tone, use of past tense, etc.
  - *appropriate* referencing conventions acknowledged sources through the consistent use of an accepted methodology, e.g. APA or Harvard.

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 *specific* research question explicitly describes a relationship between the independent and dependent variables and is directly related to the quantitative data that will be collected. Controlled variables may be identified either in the research question or acknowledged in the rationale
  - a *relevant* rationale demonstrates the development of the research question and links to the experiment conducted. Equations that are directly related to the research question should be clearly identified and correct for the context, e.g. Coulomb's law does not relate to experiments using bar magnets
  - *justified* modifications to the methodology clearly state how each modification will improve the reliability and/or validity of the evidence or how the experiment was extended. Collecting more data using an unmodified experimental method is not sufficient

  - the impacts of risks associated with the investigation and their subsequent management is *considered* with respect to how the methodology is carried out.

- for the Analysis of evidence criterion
  - *thorough* identification of relevant trends, patterns and relationships of the data should be linearised, if appropriate, and linked to a relevant physics formula
  - *thorough and appropriate* identification of uncertainties should include correct calculations that account for measurement error, consideration of error bars on graphs, and maximum and minimum trendlines, where suitable
  - collection of raw data is *relevant* if it directly relates to the independent and dependent variable, and *sufficient* if it allows the student to conduct a meaningful analysis and draw a justified conclusion.

Samples

The following excerpts have been included to demonstrate the connections between justified modifications in the methodology and management of risks, identification of trends, patterns and relationships, and the use of calculated uncertainties and consideration of experimental reliability to inform suggested improvements.

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

Excerpt 1

Modification to the original method

Refinements	Extensions	Redirections
Comparing to the hot plane which used in original experiment, the use of closed kettles can reduce heat loss and improve the accuracy of results by providing a more controlled set-up for boiling the water.	By including a wider range of salt concentrations (0%,3.75%,7.5%,15%,22.5%) in the solution compared to the original method, allows sufficient data to be collected to show relationship between variables, the expected trend can hence be confirmed.	The refined experiment focuses on the concentration of salt in 800g of solution. This adjustment of the independent variable allows a more comprehensive investigation of the direct effect of changes in salt concentration on the c.
The use of a digital thermometer allows for more accurate temperature readings, reducing the potential error of manually recording as outlined in the original method, hence increasing the reliability.	The refined experiment consists of five trials for each concentration, allows sufficient data to be collected. Trial variance also provides a measure of random error, allowing further analysis on experiment data's accuracy and reliability.	

Safety considerations

Risk	Management Method
During the process of boiling water, students might get burned from the hot kettle surface and any water spills.	- keep a distance with the boiling kettle. - wearing lab coat and safety glasses.
Electric shock from kettles and electric meter might cause health hazards to students.	- avoid using damaged electrical cords or equipment. - Ensure electric cords have a tag from a qualified electrician indicating it is safe.
The electronic balance can be knocked off bench, with potential injury to feet.	- Place all equipment in the centre of the bench - Handle equipment with two hands.

Excerpt 2

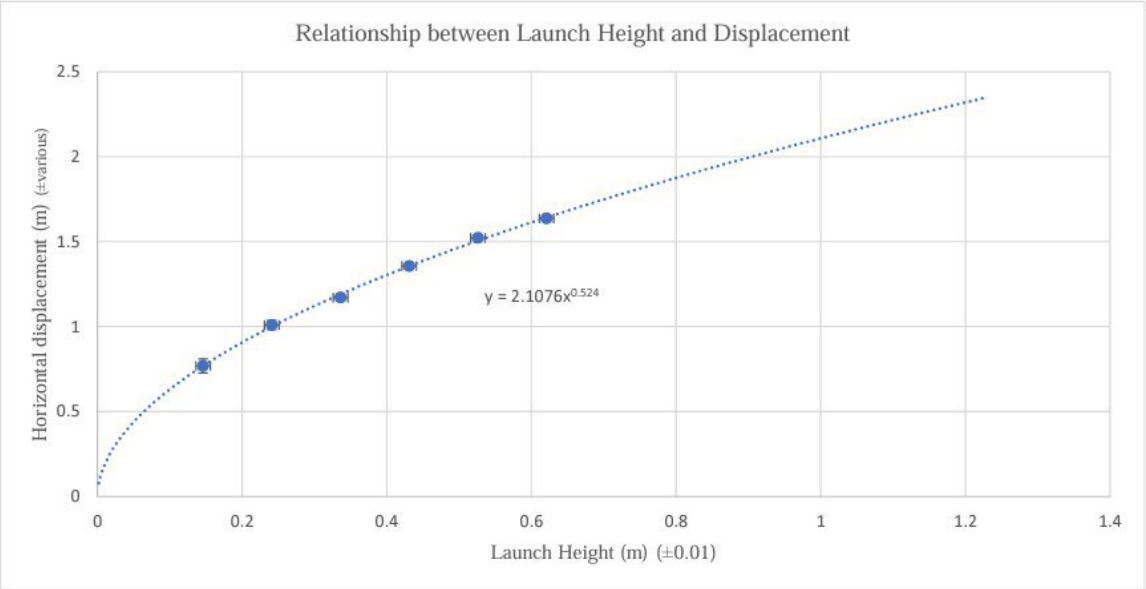


Figure 1: graph for the relationship between launch height (vertical displacement) and horizontal displacement

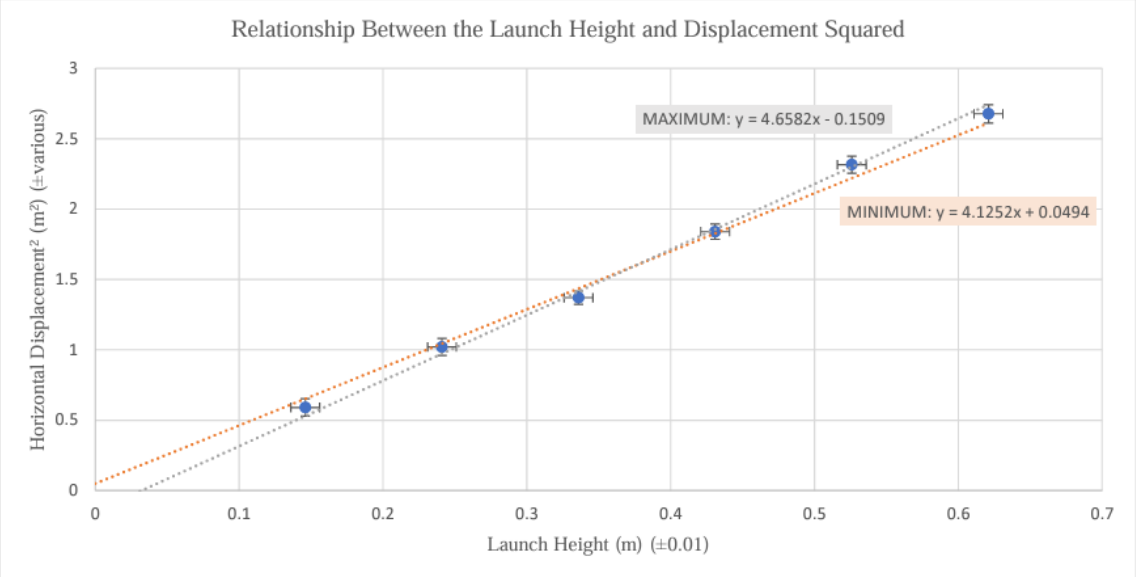


Figure 2: graph for the linearised graph for the relationship between launch height and horizontal displacement squared.

$s_x{}^2 = (m \pm \Delta m)s_y + (c \pm \Delta c)$
$s_x{}^2 = (4.4 \pm 0.3)s_y - (0.1 \pm 0.1)$

The theoretical relationship of $s_x \propto \sqrt{s_y}$ was investigated and supported through the trend established in *figure 1* as the shape of the graph resembled a square root curve. This was supported in *figure 2* as the linearised graph corroborated that $s_y \propto s_x{}^2$ through its positive linear trendline.

Excerpt 3

UNCERTAINTIES AND IMPROVEMENTS (RELIABILITY)

The experiment's reliability was considered good with low percentage uncertainties (±1.817, ±1.004, ±0.640, ±0.614, ±1.179, ±1.392%) however some sources of random error were identified to contribute to these uncertainties.

Using stacked textbooks to elevate the projectile introduces uncertainties due to the books' curvature, leading to varying projectile angles. Using wooden blocks instead could eliminate this uncertainty, maintaining a flat surface for consistent results.

It was noted that the projectile's angle was affected during firing, as the barrel or projectile would move downwards, compromising both reliability and validity. Placing a wooden block for the barrel to rest on during firing could prevent this downward movement, ensuring a consistent angle and enhancing reliability.

Surface area inconsistency was observed during the experiment as sand grains would stick to the projectile upon firing, impacting reliability. To improve reliability, the projectile should be cleaned with a tissue after each trial to prevent residual sand.

Additional advice

- Schools should ensure
  - marked ISMGs indicate the characteristics evident in the student response and the mark awarded for each criterion (*QCE and QCIA policy and procedures handbook v6.0*, Section 9.6.1)
  - that strategies for responses that exceed syllabus conditions for length are developed and enacted. This includes annotating responses to show how the school's assessment policy has been applied (*QCE and QCIA policy and procedures handbook v6.0*, Section 8.2.6).

Internal assessment 3 (IA3)

Research investigation (20%)

This assessment requires students to evaluate a claim. They will do this by researching, analysing and interpreting secondary evidence from scientific texts to form the basis for a justified conclusion about the claim. A research investigation uses research practices to assess a range of cognitions in a particular context. Research practices include locating and using information beyond students' own knowledge and the data they have been given.

Research conventions must be adhered to. This assessment occurs over an extended and defined period of time. Students may use class time and their own time to develop a response.

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	91
Authentication	15
Authenticity	6
Item construction	18
Scope and scale	38

Effective practices

Validity priorities were effectively demonstrated in assessment instruments that:

- formulated enough claims to enable students to develop unique responses to the task
- contained claims that sparked interest to students and could be used to develop multiple specific and relevant research questions, e.g. 'All experimental evidence indicates that light is a particle'
- clearly identified that only one draft is submitted at one point in time (*QCE and QCIA policy and procedures handbook v6.0*, Section 8.2.5), i.e. partial submissions over multiple checkpoints should not be implemented as this does not give students holistic feedback on the mode specified by the syllabus.

Practices to strengthen

It is recommended that assessment instruments:

- include the specifications for the assessment task exactly as they are listed in the syllabus (Syllabus section 5.6.1, AS section 5.5.1)

- contain claims that are clearly derived from Physics Unit 4 subject matter and not related to other subjects, e.g. use ‘Mobile phone towers can interfere with the performance of electronic devices’, not ‘Mobile phone towers increase the risk of cancer’
- feature checkpoints to monitor student progress through the task.

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	10
Layout	3
Transparency	6

Effective practices

Accessibility priorities were effectively demonstrated in assessment instruments that:

- contained clear instructions aligning to the specifications within the syllabus, the assessment objectives and the ISMG
- outlined checkpoints in a way that provided flexibility to insert week numbers at a later date, once timetabling has been established in each school.

Practices to strengthen

It is recommended that assessment instruments:

- model accurate spelling, grammar and punctuation
- are checked using the **Print preview** function to ensure formatting is appropriate, e.g. checkpoints and specifications are listed beneath each other and not in a paragraph separated by commas.

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	94.58	5.17	0.25	0

Criterion number	Criterion name	Percentage agreement with provisional	Percentage less than provisional	Percentage greater than provisional	Percentage both less and greater than provisional
2	Analysis of evidence	95.07	4.68	0.25	0
3	Interpretation and evaluation	95.07	4.68	0.25	0
4	Communication	99.01	0.00	0.99	0

Effective practices

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

- for the Analysis and interpretation criterion, *thorough* identification of relevant trends, patterns or relationships in the evidence were used to develop *justified* scientific arguments
- for the Communication criterion, *appropriate* referencing conventions acknowledged sources through the consistent use of in-text referencing.

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, research questions are *specific* if they have measurable independent and dependent variables, and *relevant* if they respond to a particular aspect of the claim using concepts directly related to Unit 4 subject matter
- in the Conclusion and evaluation criterion
  - *justified* conclusions relate directly to the research question and are supported by reliable scientific findings from a range of sources
  - an *insightful* discussion of the quality of evidence includes
    - verifying the credibility, bias, relevance, accuracy and recency of multiple sources
    - acknowledging the limitations in the methods used and data collected to respond to the student's research question
  - *considered* improvements address the identified limitations while *considered* extensions link to the experiment's validity.

Samples

The following excerpts have been included to demonstrate specific and relevant research questions with measurable variables relating to the claim and Unit 4 subject matter.

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

Excerpt 1

Subsequently, the research question is posed: **Is time dilation the main factor in delaying cellular aging for International Space Station (ISS) astronauts?**

Excerpt 2

Does the Photoelectric effect, the Compton effect, the Hale-Bopp comet and Solar-sailing suggest that photons transfer momentum to particles they collide with?

The following excerpt demonstrates considered and relevant improvements and extensions that relate to the limitations of the evidence.

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

Improvements:

Improvement	Justification
Observing other particles relativistic velocities	Analysing effects of time dilation on other particles would create a more justifiable argument that this phenomenon can only be observed at relativistic speeds.
Constant experimental temperature	Maintaing constant experimental temperature would allow for constant/proper calibration of measuring equipment, reducing error of conclusions drawn from sourced datasets.
Modern data	Sourcing data from modern reports means experimental equipment likely has smaller error margins, increasing accuracy of datasets/conclusions drawn.

Extensions:

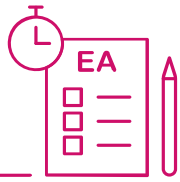
Extension	Justification
Observing effects of length contraction	Length contraction is another relativistic correction, working simultaneously with the effects of time dilation mentioned in this report. When travelling close to the speed of light, objects outside the focus reference frame appear to contract in length. This would extend the report, addressing how these corrections occur together to maintain Einstein's special relativity postulates.
Observing decay in storage rings	Storage rings accelerate muons almost to the speed of light in a circular track. Observing decay in a different environment would provide a greater understanding of how time dilation works and whether it varies from general decay.
Investigating 'moving clocks' experiment	The 'Hafele-Keating experiment' investigates time dilation, with precise clocks travelling varying flight paths relevant to a stationary clock. Investigating this further would extend the report, observing effects of time dilation beyond particle decay.

Additional advice

- Schools should ensure
  - students are supported through the research investigation process to develop a suitable research question related to Unit 4 for successful completion of the task, e.g. students may be tempted to focus on nuclear reactors, which is more closely aligned to Unit 2 subject matter for a claim such as 'Special relativity leads to the idea of mass–energy equivalence'

- authentication strategies identified in the *QCE and QCIA policy and procedures handbook v6.0* (Section 8.1.1) are administered and clearly identified on student responses to maintain student authorship
- accuracy and consistency in judgments when determining grades for each criterion by applying the best-fit approach (see Syllabuses app > QCAA Portal > *Using ISMGs for General Science syllabuses*). After determining the performance level that best fits the evidence matched to characteristics for a criterion within an ISMG, for a two-mark range performance level, the higher mark should only be awarded if there is evidence of all the characteristics in the performance-level descriptor (or better).

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 (20 marks)
- Paper 1, Section 2 consisted of short response questions (30 marks)
- Paper 2, Section 1 consisted of short response questions (47 marks)

The alternative sequence (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 (30 marks)
- Paper 2, Section 1 consisted of short response questions (47 marks)

Assessment decisions

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

Multiple choice question responses

There were 20 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.

Physics General

Question	A	B	C	D
1	1.65	**87.70**	6.57	3.85
2	2.05	3.65	**92.21**	1.86
3	1.76	3.73	9.46	**84.62**
4*	8.64	12.10	**77.48**	1.61
5*	**86.50**	3.10	8.70	1.38
6	4.76	33.20	7.06	**54.63**
7	**72.38**	8.17	14.23	4.54
8	3.28	13.63	8.98	**73.73**
9	**72.78**	10.37	2.52	14.09
10*	10.15	**75.62**	9.20	4.17
11	5.33	8.68	**74.23**	10.82
12	35.52	7.48	5.43	**51.27**
13*	6.34	**69.47**	10.07	13.46
14*	23.97	**67.92**	5.89	1.96
15	**68.62**	11.99	2.15	16.94
16	11.83	10.18	37.50	**40.15**
17	6.25	**59.67**	29.18	4.52
18*	16.08	4.20	**63.73**	15.65
19*	8.61	**56.36**	13.82	20.11
20*	**76.89**	11.52	6.77	4.48

Physics AS

Question	A	B	C	D
1	**61.57**	14.18	11.75	11.94
2	47.01	6.9	**42.16**	3.73
3	11.19	24.63	**41.42**	22.39
4*	12.5	22.39	**62.31**	2.8
5*	**69.22**	7.46	19.78	3.17
6	50.19	**36.01**	5.97	7.65
7	4.66	8.77	25.93	**60.45**
8	7.28	19.22	**58.77**	14.18
9	10.82	24.25	15.86	**48.69**
10*	20.9	**56.34**	11.75	9.89
11	5.6	8.02	**85.63**	0.56
12	8.58	14.55	24.44	**51.68**
13*	11.01	**50.93**	14.37	22.95
14*	30.78	**55.97**	9.14	3.92
15	5.78	**75.75**	4.1	14.18
16	**61.57**	4.66	6.16	26.87
17	**28.36**	16.42	53.36	1.68
18*	29.85	4.66	**48.88**	16.42
19*	13.62	**44.78**	21.08	19.22
20*	**75.56**	11.38	6.9	5.97

* Questions were common to both General and AS examinations.

Effective practices

Overall, students responded well to:

- calculation questions when they communicated their mathematical reasoning using textual and visual cues
- data analysis questions when they
  - identified *y*-intercepts and *x*-intercepts on graphs and related these values to physics formulas and/or concepts, e.g. using the *y*-intercept to determine the magnetic flux density or using the *x*-intercept to determine the work function
  - identified two points on the trendline to calculate a gradient and related this value to a physics formula and/or concept, e.g. using the gradient to determine the speed of an object.

Practices to strengthen

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

- review questions involving the cognitive verb *explain* to ensure that students

  - provide more than basic descriptions or a simple transcription of an equation from the *Physics formula and data book*
  - include detailed, relevant facts that demonstrate a thorough interpretation of the concept
- review questions involving the cognitive verb *contrast* to ensure that students
  - clearly differentiate between the two concepts
  - move beyond broad generalisations by focusing on precise details that reflect a deep understanding of the subject matter to achieve full marks
- support students to understand the meaning of formulas both conceptually and contextually (rather than as isolated, abstract tools) to promote correct usage and enhance problem-solving accuracy.

Samples

Short response

Paper 1, Question 25a)

The following excerpt is from Question 25a) in Paper 1 of the Physics General examination. It required students to explain how a transformer worked in terms of Faraday's Law and electromagnetic induction.

Effective student responses:

- described Faraday's Law
- explained that changing voltage in the primary coil affects the rate of change of magnetic flux in the secondary coil
- explained that an AC voltage is induced in the secondary coil by electromagnetic induction.

These excerpts have been included to demonstrate the most common ways students answered this question effectively.

Excerpt 1 and Excerpt 2 demonstrate alternative correct responses, highlighting the different ways students could explain how changes in the primary coil affect the rate of change of magnetic flux in the secondary coil.

Excerpt 3 demonstrates an alternative correct explanation for how transformers work, and while it refers to Lenz's law this was not a requirement to get full marks.

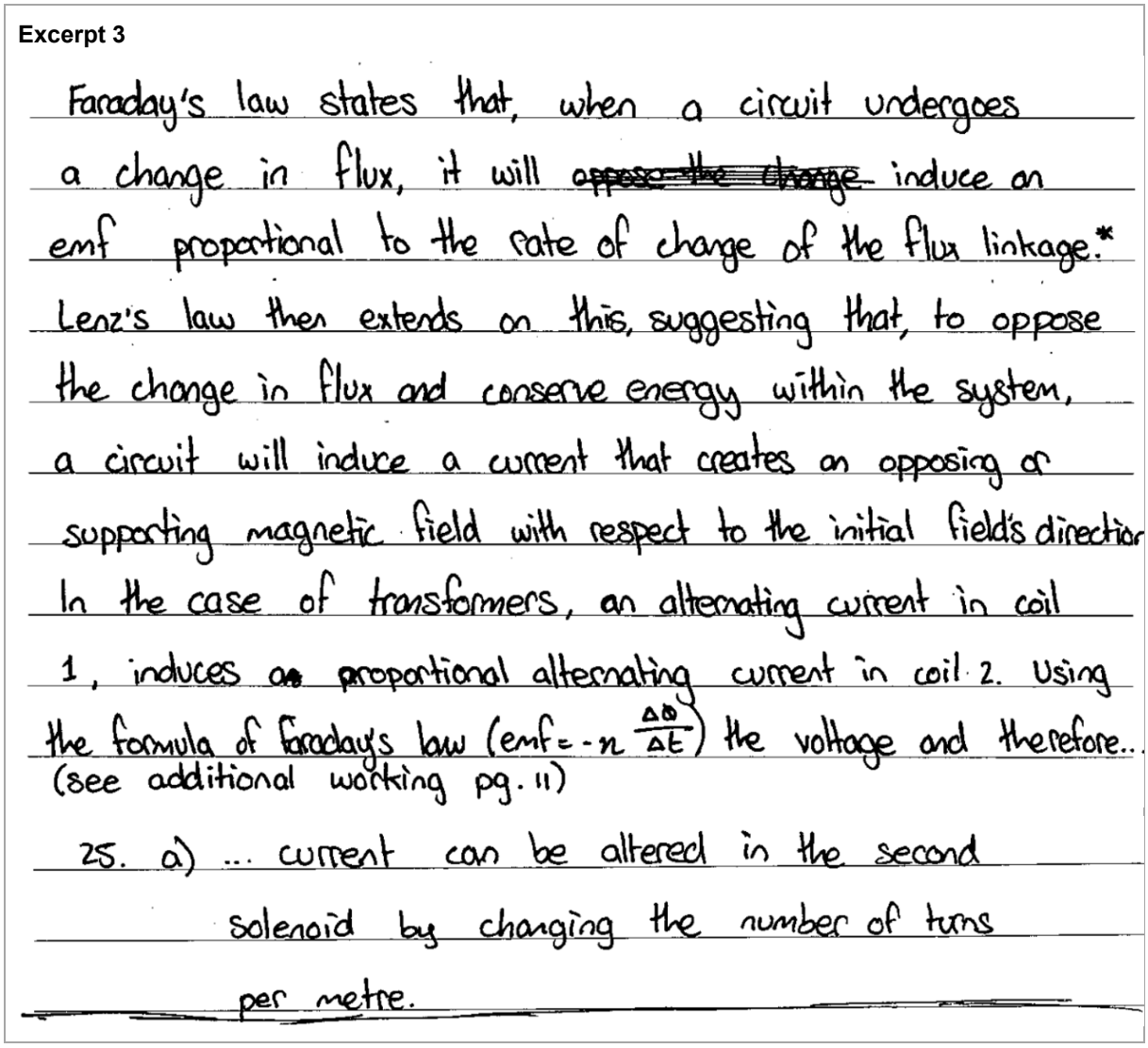
Excerpt 1

A transformer works from mutual induction by using a primary and secondary winding. AC is turned on in the primary winding wire. The change in current in the primary winding creates or changing magnetic field coming out of it, which causes a change in flux in the secondary winding, which creates an EMF as said in Faraday's Law. This EMF produced from the changing magnetic field creates an induced electric current in the secondary. This mutual induction repeats it self, causing an AC current to be induced through the secondary winding.

Excerpt 2

Electromagnetic induction refers to the process of generating electromotive force (EMF) when it is exposed to a changing magnetic flux which links to Faraday's Law that states a changing flux induced EMF. Transformer's works based on Faraday's Law. A changing current in the primary coil generates a changing flux through the coil which induced an EMF in the secondary coil. This transfer of energy allows for a voltage change depending on the number of turns in each coil and the rate of change of flux.

Excerpt 3



Paper 2, Question 7b)

The following excerpt is from Question 7b) in Paper 2 of both the Physics General and Physics AS examinations. It required students to contrast quarks and leptons in terms of the possible fundamental forces they experience.

Effective student responses:

- identified that quarks experience all forces whereas leptons do not experience the strong nuclear force
- demonstrated a deep understanding by identifying that only charged leptons can experience the electromagnetic force.

These excerpts have been included to demonstrate the most common ways students answered this question effectively.

Excerpt 1 and Excerpt 2 demonstrate the typical way students responded by listing the forces that each particle experiences.

Excerpt 3 shows a correct alternative response including a diagram to demonstrate a visual representation of the contrast.

Excerpt 1

Quarks experience the strong nuclear force, electromagnetic force, weak nuclear force and gravitational force (although it is nearly negligible). Whereas, leptons do not experience the strong nuclear force. charged leptons experience the electromagnetic force, and all leptons experience the weak nuclear force and gravitational force (almost negligible).

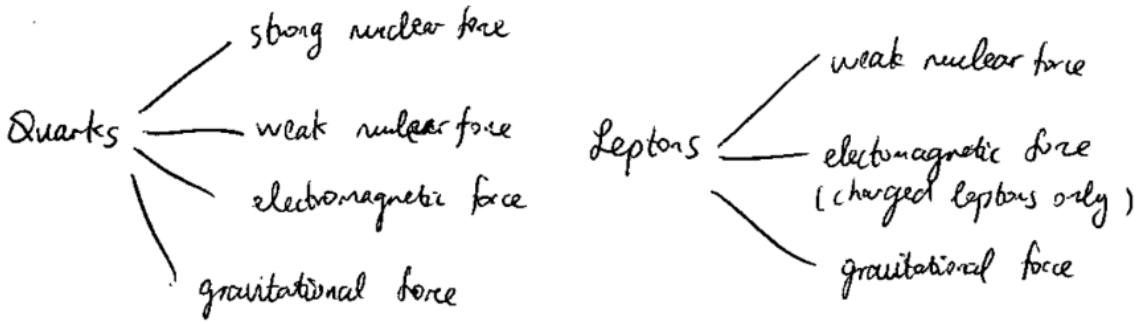
Excerpt 2

Quarks experience all forces (Strong Nuclear Force, Electromagnetic Force, Weak Nuclear Force, and Gravitational Force), whilst Leptons do not experience * see page 15

Q 7.

the Strong Nuclear Force, they only experience Electromagnetic Force, Weak Nuclear Force, and Gravitational Force, however, uncharged leptons do not experience Electromagnetic Force.

Excerpt 3



Paper 2, Question 3c)

The following excerpt is from Question 3c) in Paper 2 of the Physics AS examination. It required students to determine the power dissipated in a resistor when a switch was closed in a given circuit.

Effective student responses:

- recognised that a change in resistance in a circuit can result in a different current and/or potential difference in the circuit
- determined ratios of current and/or potential difference with different resistors in the circuit.

These excerpts have been included to demonstrate the most common ways students answered this question effectively.

Excerpt 1 and Excerpt 2 demonstrate a typical response using $P = VI$.

Excerpt 3 demonstrates a correct alternative solution using $P = I^2R$.

Excerpt 1

$$\frac{1}{R_{24}} = \frac{1}{R_2} + \frac{1}{R_4} = \frac{1}{1.6} + \frac{1}{8} = \frac{5}{8} + \frac{1}{6} = \frac{6}{8}$$

$R_{24} = \frac{8}{6} = 1.33\ \Omega$

~~$V = IR = 3.75 \times 1.33 = 5\ V$~~ ~~$I = \frac{V}{R} = \frac{6}{1.33} = 4.5\ A$~~

$R_T = R_{13} + R_{24} = 1.6 + 1.33 = 2.93\ \Omega$

$I_T = \frac{V_T}{R_T} = \frac{12}{2.93} = 4.091\ A$

$V_{24} = I_T \times R_{24} = 4.091 \times 1.33 = 5.455\ V$

$I_4 = \frac{V_{24}}{R_4} = \frac{5.455}{8} = 0.6182\ A$

$P_4 = I_4 V_4 = 0.6182 \times 5.4545$

$= 3.72\ W$

Power = 3.72 W

Excerpt 2

Voltage at start = 12V $R_T = \left(\frac{1}{3.2}+\frac{1}{3.2}\right)^{-1} + \left(\frac{1}{1.6}+\frac{1}{8}\right)^{-1}$

$= 2.93\,\Omega$

$I_T = \frac{V}{R} = \frac{12}{2.93} = 4.1\,A$ $R_{1+3} = \left(\frac{1}{3.2}+\frac{1}{3.2}\right)^{-1} = 1.6\,\Omega$

$V = 4.1 \times 1.6$

Finding voltage across $R_1 + R_3$: $V = IR$ $V = 6.56\,V$

Remaining voltage = $12 - 6.56 = 5.44\,V$

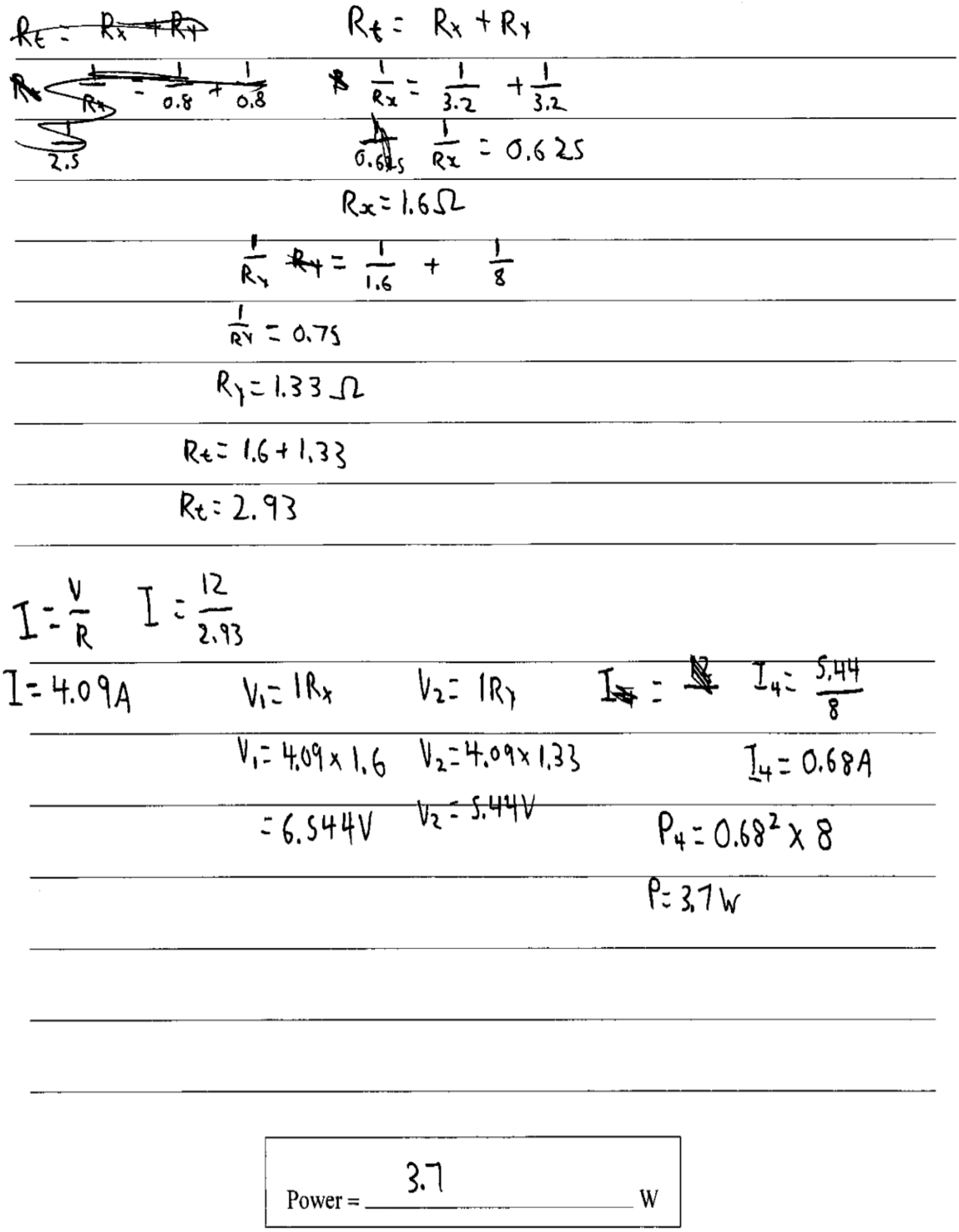
I through R_4: $I = \frac{V}{R}$ $\frac{5.44}{8} = 0.68\,A$

$P_{R4} = (5.44)(0.68)$

$= 3.7\,W$

Power = 3.7 W

Excerpt 3



Additional advice

- Teachers should
  - ensure students work in the correct angular unit (i.e. degrees) questions using trigonometry in physics

- emphasise to students when it is appropriate to use linear motion equations and when to use projectile motion equations
- encourage students that have difficulty *contrasting* or *explaining* to draw a detailed diagram as this often demonstrates sufficient understanding to be awarded marks.