

Physics

2014 Chief Assessor’s Report

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## Overview

Chief Assessors’ reports give an overview of how students performed in their school and external assessments in relation to the learning requirements, assessment design criteria, and performance standards set out in the relevant subject outline. They provide information and advice regarding the assessment types, the application of the performance standards in school and external assessments, the quality of student performance, and any relevant statistical information.

## School Assessment

The school assessment grades submitted by the teacher are reviewed for a selected sample of students in the moderation group at final moderation. Moderators examine student work samples, looking for evidence to confirm the teacher’s judgement. A fundamental premise at moderation is that teachers know their own students best, and so moderators look to confirm the teacher’s grade. It should be noted that it was much easier to confirm teacher judgment when there was clear evidence of how the student grade was determined. As mentioned in previous years, moderators found it much easier to see why teachers had assigned a particular grade when a sheet for each task or assessment type summarising student achievement against the performance standards was included. Teachers need to ensure that the grade that they assign is consistent with the evidence presented against the performance standards.

Assessment Type 1: Investigations Folio

Assessment Type 1 is made up of school-assessed practical work and an issues investigation. This assessment type contributes 40% towards a student’s final grade.

Moderators noted that task design again had an impact on student achievement in the investigations folio. When designing tasks for the investigations folio, teachers need to ensure that they give students the opportunity to meet a range of performance standards at the higher levels of achievement. It is important that tasks are not too scaffolded, as this prevents students from showing that they can work critically, logically, and perceptively when designing investigations, analysing results, and evaluating procedures. Good examples of tasks provided students with the opportunity to show their creativity when designing the procedure. When designing investigations, hypotheses should be stated quantitatively. This allows for more meaningful analysis, conclusion, and evaluation.

It may be appropriate for the particular student group to have the first task more scaffolded and directed. However, there should then be a progression to less directed tasks as the year progresses. By including at least one task that is more open ended, teachers allow students the opportunity to be more critical, more logical, and more perceptive in their analysis.

Some teachers conducted the entire set of assessment tasks for the investigations folio under timed, directly supervised conditions. This allows teachers to more confidently verify that it is the student’s work that is being assessed. Teachers should also be aware that time constraints can limit the opportunity for students to demonstrate achievement at the highest level.

Practical tasks should allow appropriate specific features to be addressed and require students to demonstrate their application of physics knowledge, group/collaborative work, measurements taken in data collection, use of measuring instruments, significant figures of numerical answers, and safety. Often, insufficient evidence of these aspects was provided.

Again this year, the majority of practical work showed little or no evidence of assessment of specific features I3 and A3 (as stated in the subject outline). It would be advisable to have particular practical investigations that target the assessment of I3 and A3. Moderators commented that it was easier to confirm the results when teachers detailed how the assessment of I3 and A3 in specific tasks was undertaken; however, this was rarely done.

While many tasks allowed for the assessment of specific features AE1 and AE2, the assessment of work against these performance standards appeared to be weighted too much towards lower-order skills, as was the case in previous years. The higher levels of achievement of these performance standards require work of a higher order than what was frequently presented. The A grade band of AE1 requires that the student ‘Critically and systematically analyses data and their connections with concepts …’ and AE2 requires that the student ‘Critically and logically evaluates procedures and suggests a range of appropriate improvements.’ In contrast, the instructions in many practical tasks required students to ‘state one random error’ or ‘state one improvement’, rather than allowing the students to critically analyse the procedure, including a broader discussion of errors, and hence suggest a range of appropriate improvements. Students should focus on a range of improvements relevant to the identified errors in the specific investigation upon which the report is based.

Practical tasks that allowed students to discover and explore the relationship between variables (as opposed to simply taking measurements to calculate a value) were more conducive to the effective assessment of AE1 at higher levels. High-quality tasks give students the opportunity to plot raw data points that are non-linear and then choose the appropriate values to show a linear relationship or proportion.

Again this year, many of the issues investigations seen at moderation were longer than 1500 words. When making their decisions, moderators are required to not include what is presented by the student beyond the limit of 1500 words. For instance, if an investigation is 2000 words in length, then the final 500 words are not to be considered. If the last section of the report is where students have presented evidence of formulating a conclusion (AE1), then they place themselves at a disadvantage. A significant proportion of the word-count in many issues investigations was used for an analysis of the information sources or an article analysis. While in the past this may have been an appropriate way to assess research skills, it is not necessarily the best way to provide evidence of the critical and logical selection of information about physics (I2). A summary or annotations indicating the reasons (for example, relating to accuracy and suitability) for the selection of reference materials may provide clearer evidence.

Many questions formulated by students in the issues investigation limited their opportunity to achieve at the higher grade levels. It should be noted that the task is identified as an *issues* investigation in the subject outline, rather than a research project.

It is very difficult for a student to demonstrate evidence for AE1 when the investigation is not of an issue, but simply researching a phenomenon, unless the question formulated around the phenomenon allows for a discussion of the alternative interpretations of its significance and hence a conclusion which can be substantiated. Alternatively, teachers may divide the issues investigation into sections with one that properly allows for assessment of specific feature AE1 up to the A grade band.

Assessment Type 2: Skills and Applications Tasks

Assessment Type 2 consists of the school assessment of skills and applications tasks. This assessment type contributes 30% towards a student’s final grade.

The overwhelming majority of tasks in this folio were timed tests of a similar format to the external examination. As was the case in previous years, the majority of approved learning and assessment plans (LAPs) indicated that four or five tasks would make up this assessment type.

It is not appropriate to set more than the prescribed number of tasks and allow students to choose which tasks are included in their assessment. Moderators expect to see a consistent set of tasks unless a student has been granted special provisions based on the Special Provisions policy.

There were good examples seen of the assessment of specific features such as I4, AE2, and KU3. The inclusion of experimental skills and extended-response questions is recommended. Some assessment of the assessment design criterion of investigation is required by the subject outline in skills and applications tasks.

There were again examples of teachers putting together two or three short tests and masking them as one large test. (For example, Test A: projectile and 2D motion, combined with Test B: gravitation, satellites and momentum). It was clear that this resulted, in some cases, in teachers not having four tasks as indicated on their LAP, but instead having seven or eight or even more tests spread over the year. This does not comply with the specifications of the subject outline under ‘Evidence of Learning’, which allows for between three and five skills and applications tasks (depending on the number of investigations folio tasks included in the LAP). In addition, using short tests often precludes assessment of extended writing, depth of understanding, and the detailed analysis and evaluation of data.

It is important that the tasks in the skills and applications folio cover a significant portion of the key ideas and intended student learning in the subject outline in order to provide students with the opportunity to show broad knowledge. For example, including only the first three sections of the course in the skills and applications tasks limits students’ opportunity to show deep understanding of some of the more conceptually demanding sections of the course.

Some questions should allow students to show their achievement at the C grade band. Tasks should also have a variety of more challenging questions that allow students to demonstrate the depth of their understanding. They should include questions that assess experimental skills and also those that provide opportunities for students to plan and construct extended responses showing their understanding.

It was clear that many of the questions in tasks were past examination questions. With this in mind, teachers should examine the section on the examination in the relevant Chief Assessor’s reports to gain advice about marking standards and the related expectations of students.

## Operational Advice

School assessment tasks are set and marked by teachers. Teachers’ assessment decisions are reviewed by moderators. Teacher grades/marks should be evident on all student school assessment work.

As referred to earlier, when preparing moderation materials, it is important that the teacher provides as much information as possible to help the moderators confirm the allocated grades. It greatly assists moderators when there is clear evidence from the teacher about how a student’s overall grade was determined. Teachers who provided summary sheets of their students’ assessment across the range of tasks enabled moderators to better understand how the teacher came to a final decision.

When tasks are altered from their original description in LAPs, teachers must ensure that all the assessment design criteria are still covered in each assessment type. In some cases, teachers made changes that resulted in their LAP no longer meeting the requirements of the subject outline. This applies to the assessment conditions as well as the nature of the task and the specific features assessed in the task.

There were many examples of student work that appeared to have contributed to the final grade but were missing from the materials supplied for moderation, with no reason for absence given by the teacher. When any work for a student in the nominated sample is missing, details must be provided on a Variations — Moderation Materials form. If the student has simply failed to submit the work, it should be clear that the teacher has made an adjustment to the grade of that student, taking into account the missing work. This is how moderators approach such a situation.

It is important that teachers package their work correctly. Student work must be submitted sorted by assessment type within each student’s pack and clearly labelled. There is no need to either package work in separate folders or bind student bags with elastic bands or adhesive tape.

## External Assessment

Assessment Type 3: Examination

The mean mark for the Stage 2 Physics examination was approximately 6% higher than the previous few examinations. More than 95% of students received a grade of C− or higher for the examination component of their assessment.

Typical of Physics examinations, students were more successful in questions that required calculations. When an equation is used, it should be rearranged before any substitution. The substitution should be shown in the rearranged formula, before the calculated value is given. When an answer seems unreasonable, students should check the rearrangement or comment upon the unreasonableness.

Problem-solving methods and questions that instruct students to ‘describe’ or ‘explain’ often showed that many students have satisfactory knowledge but insufficient skills in communicating that knowledge.

Some questions that the examination setters consider to be ‘familiar’ were not answered as well as expected. Two specific examples of this are Questions 3(b) and 12(b).

#### Question 1

A significant number of students took what was meant to be a straightforward entry into the examination and turned it into a different question, and consequently often did not get the available marks. The best answers linked the continual change in direction and the resulting changes in velocity to the acceleration, whereas many students unsuccessfully attempted to justify the acceleration as a result of velocity perpendicular to a force.

#### Question 2

After the disappointment of the poor quality of answers to Question 1, markers were pleased with the answers provided to the different parts of Question 2. Approximately 60% of students achieved 7 marks or higher (out of 9). Many students were challenged by part (d). Some were allocated 1 mark for identifying that angles from 38° to 45° would give a greater horizontal distance, but less than one in five students gave a complete answer to this part. Many students simply stated that the greatest range would occur at 45°; which, although correct, does not answer the question.

#### Question 3

The calculation in part (a) was done successfully by the majority of students, although some were penalised for not giving their answer to two significant figures. Students were penalised for rounding their answer to 6 x 1024 or 6.0 x 1024. The best answers to part (b) included the ideas that the gravitational force causes the centripetal acceleration of the satellite, so it must be directed to the centre of the orbit. The link of the direction of the gravitational force towards the centre of the Earth was often missing.

#### Question 4

Question 4 had one of the highest percentage mean marks for the paper. In part (b)(i), students often assumed that the circular orbit was of a low altitude, which was in conflict with the values calculated in part (b)(iii). This calculation was challenging for many students, who did not square the period and/or use a cube root to determine the radius.

#### Question 5

It was common in part (a) for the vector for puck C to be drawn the wrong length. It was surprising how many students were unable to obtain any marks for part (a), drawing what could be described, at best, as three arrows indicating the approximate direction that the pucks travel and providing no information that was not already provided in the diagram. Part (b) required effective communication of whether momentum was conserved through a comparison of the total initial and total final momenta, which was rarely done well.

#### Question 6

Some students confused the electric field created by the proton with the coulombic force that the proton would exert on an electron. When the question was set, it was anticipated that the better students would be able to distinguish between them. The magnitude of the field was quoted in many different units, often incorrect units, although there was no penalty for missing or incorrect units in the question.

#### Question 7

To obtain the 3 marks for the electric field diagram in part (a), the diagram must have shown the correct shape (showing the curvature of the lines from a concentration at the sharp point of the conductor), the correct direction, and that the electric field lines meet/leave surfaces at 90°. Too few diagrams were drawn showing these three things and many appeared rushed or displayed a lack of care. It was surprising to see that a significant number of students believe that a corona discharge is simply due to a large collection of charge at the point leading to ‘overcrowding’ and therefore ‘leakage’, with no understanding of ionisation and of attraction/repulsion of ions from the charged conductor evident in many answers.

#### Question 8

The page opening that featured Questions 8 and 9 often did not give markers any joy. The best answers to Question 8 showed understanding of the link between the constant potential difference, a uniform electric field, and the constant force; often communicated well using the equations *E* =  and *F = Eq*. Over 40% of students were unable to achieve any marks in this question.

#### Question 9

As with Question 8, over 40% of students were unable to achieve any marks in Question 9. Too many students incorrectly assumed that the currents would have to be in opposite directions and then tried to justify this direction by referring to equal-sized, opposite-direction forces — but it was rarely clear what the force was being exerted on. Only one-fifth of students were able to apply physics concepts (superposition and the direction of the magnetic field of a current-carrying conductor) to suggest solutions to a complex problem in a new context.

#### Question 10

This question was a mixture of a straightforward calculation, a routine explanation, and a challenging concept to explain. Many answers in part (b)(i) lacked the depth required for 2 marks, and often repeated nothing more than the information in the question. For part (b)(ii), many students used the lack of *V* in the equation

*K* =  as their justification, whereas the question wanted students to explain why there is no *V* in the equation *K* = .

#### Question 11

Both parts of (a) were answered well by the vast majority of students, although it was surprising to note that showing an arrow perpendicular to the magnetic field lines and towards the top of the page was given as an answer more often than the incorrect direction was drawn on the conductor. Part (b) required students to identify that the graph does not pass through the origin and to explain why it would be expected to pass through the origin. The former was commonly stated, and markers commented positively upon the number who also included the latter statement.

#### Question 12

The calculations in parts (a) and (c)(ii) were handled well by most students, although a significant number used the incorrect radius for the path. The explanation in part (b) is a ‘stock-standard’ one, and the markers were disappointed by the low quality of student responses to this question given that there have been similar questions in many previous examinations. The derivation in part (c)(i), like almost every derivation that can be assessed, requires an opening statement which justifies the equations chosen. This statement was missing from many student responses.

#### Question 13

The majority of students were able to identify the direction of the oscillating electric fields in part (a) and the orientation of the antenna in part (b), but most struggled to effectively communicate their reasoning in part (b). The use of inexact language was a common problem.

#### Question 14

Question 14 was the most successfully answered question in the paper, with approximately 80% of students receiving full marks.

#### Question 15

Parts (a) and (b) of Question 15 did not cause many students too much difficulty, although a number incorrectly divided by 5 in part (a). Most students were able to use the concept of constructive interference to explain the production of bright fringes, but few successfully described the path difference that gave the bright fringe labelled A.

#### Question 16

The calculation in part (a) of this question did not prove problematic for students, although some were penalised for giving answers with an inappropriate number of significant figures. In part (b), it was common for the independence of the intensity and the number of emitted electrons to be explained well. The effect of the intensity on the energy of the emitted electrons was often stated correctly, but often the explanations were lacking depth.

#### Question 17

To achieve the full 3 marks for Question 17(a), students had to correctly use the law of conservation of energy in their explanations. Some students did this successfully by first deriving the relationship for the maximum frequency. Others described all the energy changes successfully, but many students did not adequately link the potential difference with the energy of the accelerated electrons. Some students attempted to do so thinking incorrectly that *E* = could be used to calculate energy. Answers to part (b) were often let down by vague terminology, with terms such as ‘ionise cells’ and ‘ionise tissues’ not judged as correct.

#### Question 18

Part (a)(i) required students to show the correct answer, which seems to have helped many students correctly work through the calculation, although only the very best students appropriately communicated their use of the law of conservation of energy to link the work done by the potential difference and the kinetic energy gained by the electrons. The calculation of the wavelength in part (a)(ii) helped students discuss the use of electron microscopes in part (b), although inexact terminology often reduced the quality of student answers.

#### Question 19

In Question 19, parts (a) and (b) did not prove problematic for students, although correct answers to parts (c) were rare. Most students could convert the energy into electronvolts for use in the problem-solving, but few were able to use it correctly. A number of students did correctly consider the magnitude of the energy transition, but incorrectly gave their final answer as positive 3.40 eV.

#### Question 20

The answers to part (a) showed that there are many misconceptions about population inversions, with numerous answers implying that a population inversion refers to the electrons of a single atom. While most students correctly referred to metastable states to explain what a population inversion is, few explained the use of a pump to maintain it. As in many other questions, answers to part (b) suffered from inexact language, and a significant number of students provided unnecessary information about the excitation before spontaneous or stimulated emission. Question 20 was the second-worst-answered question in the paper. The modal mark was zero, with less than 3% of students earning full marks.

#### Question 21

Although many students knew that a neutrino accompanies the positron in beta plus decay, almost every other conceivable option was included across the answers. Students were more likely to state the correct answers for part (b) when they showed their working-out.

#### Question 22

Well-communicated answers that correctly used the law of conservation of momentum were rare. The best answers made effective use of the law to support both the statements about the speed and the direction, but too many simply restated information given on the question. The number of answers that compared the kinetic energies of the uranium and helium suggests that this content is frequently rote-learnt, with low levels of understanding.

#### Question 23

The mass difference and energy released were correctly calculated by a majority of students, but too many stated that energy was released without sufficient justification. Markers found papers in which a student would suggest that energy was released because *m* was positive, and then the next student suggested that energy was released because *m* was negative. The fact that students had to *determine* whether energy was released or absorbed (and not just *state)* implied that a justified answer was needed. Student answers to parts (b) and (c) were again let down by poor communication. While most students could calculate using the half-life, and could identify that the claimed age was probably false, often the marker had to ‘put the pieces together’ and consequently full marks were not allocated in many cases. Poor communication, such as ‘2 decays have occurred’ instead of ‘2 half-lives have passed’, was common.

#### Question 24

Over half the students received zero marks for Question 24. While a small number of students did not provide an answer, few could justify the alpha decay or write a correct gamma decay reaction. The lack of student success in this question surprised markers. It had the lowest percentage mean of all questions in the paper.

#### Question 25

The poor placement of units and the inconsistent significant figures in the data table did not seem to affect the calculation of the average distance fallen, and gave most students information for part (b). The graphs for part (c) seem to be have been drawn better than in previous years, with the most common penalties being for poor lines of best fit or for incorrect labelling of axes. Part (f) showed many student misconceptions about accuracy and precision, with comments about inaccuracy since the line of best fit did not go through the origin appearing in many papers. The best answers to part (g) discussed why the new sphere would experience a smaller resistance force, as well as describing the higher terminal velocity that would be reached after a larger amount of travel.

#### Questions 26 and 27

Question Booklet 3 contained Questions 26 and 27. There was a very pleasing decrease in the number of blank booklets this year. More students were able to provide an answer to both extended-response questions. Although both questions had a mean mark below 50%, the markers commented that there was a clear improvement in student responses.

Both questions were marked out of 15, with 12 marks for content and 3 marks for communication. Two markers mark each paper, and the marks are averaged. A third person re-marks any questions where the first two marks are out of tolerance.

The best answers for the first dot point of Question 26 had clear statements of what enrichment is and why it is necessary, and showed knowledge of nuclear chain reactions. There were many possible advantages and disadvantages that could be described for the second dot point, with marks allocated based upon the Physics understanding shown in each.

The first dot point of Question 27 was easier for students to answer than the second. Some students confused absorption spectra with emission spectra, but many were able to show some knowledge of the production of absorption spectra. Descriptions of how absorption spectra can be used to identify elements often lacked detail, perhaps not surprising at this stage of the 3-hour paper. Less successful were students’ descriptions of the effect of temperature on the emissions from a hot body.

Physics

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