Physics

2013 Chief Assessor's Report

Government
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PHYSICS

2013 CHIEF ASSESSOR'S REPORT

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

At final moderation, moderators view work samples for a selected sample of students in the moderation group, looking for evidence to confirm the teacher's assessment decisions. A fundamental premise at moderation is that teachers know their students best, and so moderators look for reasons to support the grades they give. It should be noted that it is much easier for moderators to confirm teachers' judgment when there is clear evidence of how the student grade was determined. The inclusion of a sheet for each task or assessment type, summarising student achievement against the performance standards, helps moderators to see why teachers assigned a particular grade. When this information was not included, moderators often had to look critically at the work to try to determine how the grade had been arrived at.

Teachers are also advised to take care to ensure that the grades assigned to students reflect the rank order of students in the assessment group. Assigning the same grade to students whose achievements are clearly different may disadvantage one or more of the students.

This was the third year of final moderation for Physics. Many teachers addressed the issues encountered by moderators in previous years, and commented on in the Chief Assessor's reports of 2011 and 2012. However, for a significant number of teachers, the comments in the 2012 Chief Assessor's report still apply.

Assessment Type 1: Investigations Folio

Assessment Type 1 consists of school-assessed practical investigations 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. As was the case in 2012, there were good examples of well-designed tasks given to students. However, many of the tasks seen at moderation denied students these opportunities by being too prescriptive and giving students too much direction.

It was of particular concern this year that a significant number of assessment groups lacked a task that gave students the opportunity to design their procedure. Instead, in many cases, all practical tasks provided the students with a procedure and so the assessment of specific feature I1 was restricted to hypothesising and identifying variables. Consequently, it was difficult for students to demonstrate that they could design ‘logical, coherent, and detailed physics investigations’. Good examples of tasks gave students the opportunity to show their creativity when designing the procedure.

It is advisable that the design investigation practical, although not compulsory, is actually carried out. This enables students to more meaningfully address specific feature AE2, ‘Evaluation of procedures, with suggestions for improvement’.

Most practical work showed little or no evidence of assessment of specific features I3, ‘Manipulation of apparatus and technological tools to implement safe and ethical investigation procedures’, and A3, ‘Demonstration of skills in individual and collaborative work’. It would be advisable to have specific 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 was undertaken in specific tasks; however, this was rarely done.

Although many tasks allowed for the assessment of AE1, ‘Analysis of data and concepts and their connections, to formulate conclusions and make relevant predictions’, and AE2, the assessment of work against these specific features appeared to be weighted too much towards lower-order skills, as was the case in previous years. The higher levels of achievement require work of a higher order than what was frequently presented. The A level performance standard of AE1 requires students to ‘Critically and systematically analyse data and their connections with concepts …’ and AE2 requires students to ‘Critically and logically evaluate procedures and suggest 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 them to critically analyse the procedure, including a broader discussion of errors, and hence suggest a range of appropriate improvements.

It may be appropriate for the particular student cohort to have more scaffolding and direction for the first task. However, there should then be a progression to less directed tasks as the year advances. 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. 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. It should also be noted that specific feature AE3 no longer exists and teachers should refer to the subject outline for clarification so that assessments can be adjusted accordingly.

Again this year, many of the issues investigations seen at moderation exceeded 1500 words. When making their decisions, moderators are required to disregard what is presented by the student beyond the 1500-word limit. For instance, if an investigation is 2000 words long, the final 500 words will not be considered. If the last section of the report is where students have presented evidence of formulating a conclusion (AE1), 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. Although this may have been an appropriate way to assess research skills in the past, 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 is very difficult for a student to demonstrate evidence for AE1 when the investigation does not entail researching an issue, but simply a phenomenon, unless the question formulated allows for a discussion of the alternative interpretations of its significance, and hence a conclusion that 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 level.

Some issues investigations were used to assess specific feature I1. Although this can be done, greater evidence is necessary to show how a student has provided evidence of the design of the investigation. In some of these cases, this was the only task in which I1 was assessed. It is recommended that this specific feature is more effectively assessed in designing a practical investigation.

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.

Nearly all tasks for this assessment type were timed tests in a format similar to that of the external examination. As in previous years, most approved learning and assessment plans (LAPs) indicated that four or five tasks would make up this assessment type.

However, again there were examples of teachers who regularly put together two or three tests and described them as one large test. It was clear that this sometimes resulted in teachers not having four tasks, as indicated on their learning and assessment plan, but instead having seven, eight, or even more, tests spread over the year. This does not comply with the specifications of the subject outline, which allows for between three and five skills and applications tasks (depending on the number of investigations folio tasks included in the learning and assessment plan).

It is important in this assessment type that the tasks cover a significant portion of the key ideas and intended student learning in the subject outline in order to give students the opportunity to show broad knowledge. Some questions should allow students at C level to show their achievement, but 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 in the investigation assessment design criterion and also those that enable students to plan and construct extended responses that show their understanding.

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

As mentioned earlier, it is important that the teacher provides as much information as possible when preparing moderation materials, 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.

Teachers must ensure that electronic files are in a form that can be fully accessed. This includes checking that the sound is audible.

When tasks are altered from their original description in learning and assessment plans, teachers must ensure that all the assessment design criteria are still covered in each assessment type. The changes made by some teachers meant that their learning and assessment plan no longer met the requirements of the subject outline. This applies to the assessment conditions as well as to the nature of the task and the specific features assessed in the task.

There were many examples in which student work that appeared to have contributed to the final grade was missing from the materials supplied for moderation, without any reason for its omission being given by the teacher. Whenever work is missing, the reason for its absence must be provided on a Variations — Moderation Materials form. Moderators are required to assume that, if work is missing, the student has failed to submit the work, and hence moderate accordingly. Often the consequence is a lower grade.

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

EXTERNAL ASSESSMENT

Assessment Type 3: Examination

Assessment Type 3, the externally assessed examination, contributes 30% of the final grade.

Students’ performance continues to be lower than expected in the examination, with a mean mark for the cohort of just above 50%. The two extended-response questions and the questions that require written explanations were poorly answered in comparison with other types of questions. This indicates the need for students to be better prepared for questions of this type. Most calculation questions were answered well, and there were fewer penalties for inappropriate significant figures or missing/incorrect units this year.

Section A: Part 1

Question 1
Responses to this question were typical of responses to many questions in the examination. Students generally had the knowledge to answer the question but lacked the ability to completely communicate this knowledge. A common answer was to annotate the diagram correctly but then to state that the constant horizontal distance between images equates to a ‘constant velocity’. Surprisingly, almost a quarter of the students were unable to achieve any marks for this question.

Question 2
The ratio in part (a) was calculated well by most students, but very few of them used the ratio when drawing the vectors in part (b). Showing the direction was done well by most students, but nearly all drew the vector for the acceleration at point B, with double the length of that at point A, despite their ratio indicating that it should be the other way around.

Question 3
The calculation in part (a) was handled well by most students. Some students rearranged the formula incorrectly and consequently calculated an unreasonable answer with the correct substitution. Consequently, this earned only 1 mark, unless the student identified the unreasonableness. Very few of the answers to part (b) showed any understanding of the necessary centripetal acceleration being caused by friction.

Question 4
The straightforward use of a formula and application of Newton's third law was handled reasonably well by most students, although the common mistakes when using Newton's law of universal gravitation (failing to square the distance, answering with an inappropriate number of significant figures) were prevalent.

Question 5
Markers were frustrated that many students considered that all that was required for 3 marks was to say that the geostationary satellite must orbit above the equator, and that Australia is positioned below the equator. The derivation in part (b) required a written statement that the centripetal acceleration is caused by the gravitational force, and this would have been rewarded if it was in part (a). Many students cancelled m with m_1, with no explanation as to what these symbols represent or why they could be cancelled. Many of the answers to part (c) were vague and/or incomplete, and did not develop sound logical arguments.

Question 6
Students find drawing vector diagrams problematic. Consequently, identifying the equilateral nature of the triangle was not possible for many students, making the magnitude of the change in momentum harder to obtain. Suitably drawn vector diagrams also clearly showed the direction of the change in momentum.

Question 7
Many answers showed the misconception that the distance between a point and one of the plates affects the electric field at that point. Similarly it was common for students to assert that only the nearer plate influences the electric field at the point. As a consequence of these misunderstandings, just under 40% of students did not achieve any marks in this question.

Question 8
A very common mistake made in part (a) — similar to the use of Newton's law of universal gravitation in Question 4 — was to not square the distance Many answers did not include the correct direction of the force, in part (a) or in part (b). Many answers to part (b) discussed the total force on q_3 instead of q_2, or showed the misconception that having q_3 between q_1 and q_2 means that q_2 is shielded from q_1.

Question 9
Concise answers were rare, and problems arose when students discussed *why* the paper was given a charge, or when their discussion focused on the creation of ions in

the air near the wire. This answer had a surprisingly low mean mark; only 43% of students achieved any marks in this question.

Question 10
Parts (a) and (b) were done well by most students. Students commonly misread part (c), and discussed what might happen if the *length* of the plates was increased. Concise answers that linked the distance between the plates to the electric field between them, and hence the acceleration of the electrons, were rare.

Question 11
Only 52% of students were able to determine the direction of the magnetic field created by the coil.

Question 12
The best answers to part (a) addressed the stated aim of the practical, discussing whether or not the results verified the expected relationship. Many answers showed that students understood that a systematic error was probably present when the results were collected. Some students thought that such a linear relationship is ‘proportional but not directly proportional’.

Question 13
Students selected and used the correct formula well in part (a), but many students were penalised for giving the time in ‘secs’. The problem solving in part (b) was done either very poorly or very well: not many students achieved 1 or 2 marks for this part, but those who did obtain marks mostly achieved all 3.

Question 14
The orientation of the antenna was determined by approximately three-quarters of the students, but only one-third of these communicated their reasoning effectively. Too few answers showed the required understanding of the components of an electromagnetic wave.

Question 15
The wording of part (a) implies that a comparison of the two possible sources of the patterns was required, but this was rarely included. The misconception that the fringes produced by two slits show no decrease in intensity was common. Most students knew how to answer part (b) correctly, although inexact terminology (such as ‘deconstructive interference’ and path differences that were a ‘multiple of half a wavelength’) was common. Poor answers to part (c) discussed changes to quantities that the question specifies were held constant. Many students were able to determine that the distance between the slits was changed, but only the best answers stated that it was increased (for images A to D).

Question 16
Students did better in this question than in any other in the examination, working through the calculations and showing an understanding of the concept of ‘accurate’.

Question 17
Most students knew how to calculate the depth, although commonly the time in the water was not halved to give the depth.

Section A: Part 2

Question 18
Questions 18 and 19 both required the student to apply the law of conservation of energy in a specific scenario to obtain a mathematical representation of the physical situation. This process is best started with a clear written description of the energy changes. The best answers to Question 18 included the statement that the emitted electrons have a maximum energy when they use the smallest amount possible to escape the hold of the metal. This question had the second-lowest mean mark for the paper (including the extended-response questions), with more than half the students either not answering or earning no marks for their answer.

Question 19
Student performance in deriving an unseen formula was better than expected. The frequent omission of a clear description of the energy transformations resulted in only 3 marks being allocated for many answers. Students were able to use the formula derived in part (a) to link the potential difference to the momentum (although $p \propto \Delta V$ was often incorrectly stated), but the link between momentum and resolution (through de Broglie wavelength) was less well communicated.

Question 20
The best answers to part (a) were simple concise statements about energy changes. To obtain 4 marks for part (b) it was necessary to draw the correctly shaped spectrum, correctly label the two axes, and label the three key features (as specified in the subject outline). Very few answers met all of these requirements. The shape was frequently drawn poorly, appearing rushed or that little care had been given to its shape. Most graphs had the horizontal axis labelled as ‘frequency’, but the vertical axis was commonly labelled as ‘potential difference’.

Question 21
The skills assessed in this question were ones that most students could show in their answers.

Question 22
The differences between line absorption spectra and line emission spectra (and their production) are topics that students typically have difficulty explaining. Although it was common for students to discuss the absorption of specific photons, the explanations of why these photons were passing through the atoms, and why specific ones were absorbed, were often poorly communicated. This question had the lowest mean mark for the paper; 56% of the students either did not answer the question or earned no marks for their answer.

Question 23
Part (a) of this question was very similar to a question in the 2012 examination, and it was pleasing to see that the reason why the photons would not be absorbed was given more thoroughly by students this year. One of the allocated marks in part (b) was for clearly explaining what a metastable state is, and this is typical for questions worded in such a way. It was common for students to write sentences containing the terms ‘population inversion’ and ‘stimulated emission’, but these concepts were rarely explained properly.

Question 24
The instructive verb for part (a)(i) is ‘determine’, so simply stating the answer was insufficient: appropriate working-out (preferably using the graph) was required for both marks. For part (a)(ii) many students simply repeated the information in the

question (iodine-123 has a shorter half-life). The best answers described how the shorter half-life means that more gamma photons are emitted per unit time, and that this will give the required number of photons more quickly. It was common for answers to discuss potential damage to the human body by the radioisotopes, but these answers were rarely worthy of marks. Part (b) was answered well by most students, although some answers did not include any justification for why it was five half-lives.

Question 25
Like Question 6, poorly constructed vector diagrams were common in part (a) of this question. The use of Pythagoras' theorem to determine the magnitude of the sum of the momenta and right-angled trigonometry to determine an angle within the vector triangle were generally done well. However, the communication of the direction of the sum of the momenta was often poor. Answers given in terms of horizontal were not accepted, with the best answers given in terms of the direction of true north provided in the question, or in terms of the direction of the momenta of one of the particles. Part (b) required the application of the law of conservation of momentum to this specific situation but many students simply stated the law.

Question 26
Most students correctly identified that boron would be used in control rods; however, when stating the reason, many students simply restated information given in the question rather than applying that information by showing knowledge of fission chain reactions. The calculation in part (b) was done well by most students, although a surprising number could not correctly convert from joules to MeV. Some students chose the approach of starting with calculating the binding energy of each nucleus. Only a very, very small number of students completed this problem-solving approach satisfactorily.

Question 27
A higher proportion of student than in previous years balanced the alpha decay reaction correctly. Students who drew transitions between the energy levels given on the diagram for part (b) typically determined the two answers correctly.

Question 28
Students who read this question carefully and consequently discussed the relevant property of the strong nuclear force, the relevant property of the electrostatic force, and the nature of fusion reactions usually obtained more marks than students who wrote about fusion but failed to answer the specific question.

Question 29
In setting Question 29 it was expected that many students would not identify that the graph would need to show *frequency squared* against *mass.* Therefore the question was structured so that students who chose *frequency* against *mass* would still obtain marks in later parts of the question. Students who chose *frequency* against *mass* should have found it easier to obtain marks in part (b) but harder to do so in part (e); whereas the marks scheme for parts (c), (d), and (f) was devised so that there were identical requirements, regardless of whether part (a) had *frequency* or *frequency squared*.

When the data tables in part (b) were marked, missing quantities or missing units in column headings were penalised, as were incorrect numbers of significant figures for calculated values. Markers rarely needed to deduct marks for an untidy table as most students whose table was becoming untidy created a new table further down the page or on another page.

Students who used the graph page in portrait orientation should have been able to choose suitable scales for both axes easily. Many students who graphed *frequency* broke their vertical axis, jumping from zero to 180 hertz. This is inappropriate in almost every situation unless it is done in a second graph to allow greater examination of a section of the first graph drawn.

Many students calculated the gradient of their line of best fit correctly and stated appropriate units, but correctly using the gradient in part (e) was problematic for all but the better students. Students should be encouraged to check the suitability of their answers, and comment on answers, such as metal wires with a density of thousands of kilograms per metre of length, that are unrealistic.

The suggestions for improvements to the experiment were better than in previous years, although it is clear than students still have misunderstandings about accuracy and precision. Question 29(f) was another example where poor communication featured. The response ‘repeat the experiment and average it’ does not effectively communicate an improvement.

Section B

One of the main reasons for the low examination mean was students’ performances in the two extended-response questions. Some students did not present an answer for one or both questions, although it is possible that they left these questions until last and ran out of time. The extended-response questions are ‘double-marked’; this means that a well-made point is worth 2 marks here as opposed to Section A, where it is worth 1 mark. For this reason, students who are confident of their ability to write a good answer to an extended-response question are encouraged to allocate appropriate time to answering it, not necessarily towards the end of the 3 hours of concentration.

In an attempt to allow students to communicate their knowledge and understanding of physics more readily in the extended-response section, two changes were made. The first change was in Question 31, where the examination setters made a specific effort to provide a question that could be answered in many different ways. The second change was to the marking of the questions. In previous years a 14-mark question would have been marked out of 7 by two markers, with the two marks added to get the final mark out of 14. In 2013 the 14-mark question was marked out of 14 by each marker, with the final mark obtained by averaging the two marks. It is important to note that the marking out of 14 did not change the expectations of the amount and quality of content required for a good answer. In effect, the change in the method of marking allowed ‘half-marks’ for partly correct points of content. These changes seem to have resulted in a minor increase in student achievement in the extended-response questions, although the overall quality of student work in this section of the examination was still disappointing.

Once again, the moderation of school-assessed work showed that many schools’ tests do not include extended-response questions. The two questions make up approximately 30 marks in each examination, which equates to approximately 5% of each student’s final grade when all the assessment types are combined. Teachers are doing a disservice to their students if they fail to prepare them for these questions.

Question 30

In addressing the first dot point most students identified suitable properties, and summarised the effect of these properties on the forces of air resistance. The best answers included details about *why* each property changed the force, usually by discussing collisions between the ball and air particles. It was common for students to identify the property of *surface area* as one that affects the force of air resistance. It was challenging for the markers to attempt to ascertain whether the students were poorly communicating the idea of size or whether they were specifically (erroneously) referring to surface area. The density of the air was not considered by the markers as a property of the ball and, although the speed is a property of the ball's motion, not of the ball, answers that correctly described how the speeds of the balls affected the force were awarded marks. Many students incorrectly identified mass as a factor that affects the force.

The explanations included in the second dot point were of a lower standard. With the previous years' marking scheme statements such as 'the force of air resistance is in the opposite direction to the motion of the ball' would not have been allocated the content mark, whereas the new marks scheme allows for this to be partially rewarded. The best answers described how the force is in the opposite direction to the velocity of the ball. The link between the direction of the forces of air resistance and a greater vertical deceleration of the ball was rarely made. Many students stated that the flight time was reduced because the ball does not travel as high (and assumed that the speed of the ball was not affected). The motion down from the maximum height (or the total path) was discussed in many answers, possibly by students who felt that their answer about the upwards motion was insufficient.

Question 31
This was the better answered of the two extended-response questions, with students able to show knowledge about the properties of radiations and their paths in a magnetic field. There were a number of different aspects that students could discuss, and most were able to explain some, with different levels of success. Most answers contained a suitable large, labelled diagram that was relevant. It was also pleasing was that most of these diagrams were referred to in students' writing. However, many diagrams incorrectly showed the particles travelling through the field for some distance before being deviated. Many misconceptions were apparent in students' answers, including the notion that beta plus decay involves the emission of protons. A surprising number of students wrote about electric fields instead of magnetic fields, or talked about alpha particles moving to the 'negative plate of the magnetic field'.

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