Physics

2011 Assessment Report

Government
of South Australia

SACE
Board of SA

PHYSICS

2011 ASSESSMENT REPORT

OVERVIEW

Assessment reports give an overview of how students performed in 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

Assessment Type 1: Investigations Folio

Assessment Type 1: Investigations Folio is made up of at least three practical investigations and an issues investigation. This assessment type now contributes 40% of a student’s final grade (an increase from the previous 25%), making it the highest of the three assessment components. This work was centrally moderated for the first time in 2011. These two things mean that, when designing tasks, teachers need to be very careful to give students the opportunity to meet a range of performance standards at the higher levels. This was not always evident in the work submitted. One common example of this was in the assessment of specific feature I4 (‘the obtaining, recording, and display of findings of investigations using appropriate conventions and formats’) in the investigation assessment design criterion. The better-designed practical tasks allowed assessment of this specific feature by requiring the students to organise the data that they collect without teacher direction. Other tasks did not give students this opportunity. Similarly, well-designed tasks gave students the opportunity to provide a range of improvements for a practical investigation, whereas other tasks required stating just one improvement.

When setting a design practical, teachers should keep the choices and requirements open enough so that students can fully demonstrate their skills, especially against specific features I1, AE1, and AE3. The subject outline lists a number of things that ‘must be included across the range of reports presented’, and one of these is ‘designing and performing an experiment to test a hypothesis’. Evidence indicated that many tasks limited students’ ability to address the analysis and evaluation and the application assessment design criteria.

The majority of tasks seen by the moderators allowed for the assessment of AE1 and AE2. However, the assessment of these performance standards appeared to be weighted too much towards lower-order skills. The higher levels of achievement of these performance standards require work of a higher order than what was frequently presented.

It was unclear in many tasks which specific features were being assessed. The majority of practical work showed little or no evidence of assessment of I3 and A3. It would be advisable to have specific practical investigations that target the assessment of I3 and A3. Moderators commented that it was easy to confirm the results when teachers detailed the assessment of I3 and A3 in specific tasks; however, this was rarely done.

Teachers are recommended to construct their learning and assessment plan (LAP) so that it provides more than one opportunity for students to demonstrate achievement against the specific features (other than I3 and A3).

Many of the issues investigations seen at moderation were over the1500-word limit, with referencing tending to be brief or not done at all. Well-designed tasks featured clear processes that guided students in their research and scaffolded how to reference.

Many questions in the issues investigations limited the opportunity for students to achieve at the higher grade levels. The better investigations tended to be produced by the students who formulated a question about a physics issue. Investigations that did not have a clear question, or addressed physics phenomena, typically limited the opportunity for students to achieve certain performance standards, especially AE3, at higher levels.

Assessment Type 2: Skills and Applications Tasks

Assessment Type 2: Skills and Applications Tasks was also centrally moderated for the first time in 2011. The majority of approved LAPs indicated that four or five tasks would make up this assessment type. However, there were many examples of teachers who had recycled old tests and put them together to create one larger test; for example, Test A (projectile and 2D motion), Test B (gravitation/satellites and momentum). It was clear to moderators that some teachers did not have four tasks, as indicated on their LAP, but instead had seven or eight smaller tests put together.

A well-designed sequence of tests includes extended-response questions and experimental-skills questions. These allow for assessment of performance standards from all four assessment design criteria, as required by the subject outline. Specific feature I4 was the most commonly assessed performance standard from the investigation assessment design criterion. The best sequences of tests facilitated the development of student skills in answering extended-response questions, increasing their length and importance within the tests as the year progressed. If teachers do include extended-response opportunities, they should remember that the extended-response questions are double-marked in the exam and to adjust the allocation of marks within a test accordingly.

Careful design of the individual tasks is also very important in this assessment type. Good tasks tended to have a variety of ‘describe’ and ‘explain’ questions, calculation questions of a range of difficulties, and the opportunity for problem-solving. As a consequence, these tasks allowed students to show the A level against the performance standards. Careful question choice when constructing tests allows the best students to demonstrate that they are worthy of an A+ range, while still allowing the A level to be achieved by other students. Moderators commented that the design of tasks often limited the opportunity of students to achieve at the higher levels, particularly against performance standards A1, A2, KU1, and KU2.

EXTERNAL ASSESSMENT

Assessment Type 3: Examination

Assessment Type 3: Examination has changed from 50% of the final grade in 2010 to 30% in 2011. The incorporation of performance standards only made small changes to the structure and question content.

The mean mark for the 2011 examination increased by a few percentage points to just over 65%; however, many exam markers commented that, while marking, they felt that some aspects of student performance were lower than in previous years. It is possible that this is due to the inclusion of questions that were designed to clearly distinguish the A-grade students from the others. It may be that markers are observing that many students were unable to provide clear, complete answers to these questions, while still achieving some marks in them.

Many of the exam questions required students to demonstrate, apply, and/or communicate their knowledge through short written answers. Typically these answers lacked clarity and depth, and frequently it seemed that students were rushing to put down an idea, rather than communicating their knowledge and understanding coherently and effectively.

Questions that required use of physics formulae and equations were typically done better than questions that required written answers. Some markers commented that they observed that the correct use of significant figures was better than in previous years. As in 2010, students were penalised no more than once per booklet for answers with inappropriate significant figures. In contrast, there seemed to be an increase in incorrect rounding-off in answers. One example where this occurred was in Question 5 where a calculator display of 5.8157894×10^{-7} was often written down as 5.81×10^{-7}, instead of 5.82×10^{-7}.

One of the most common mistakes that markers commented upon was that students did not seem to have correctly read many questions, often providing answers which may have been correct for a different question.

Specific comments on each question are given below.

Part 1 of Section A (Questions 1 to 14)

Question 1

Most students correctly drew arrows to indicate the direction of the velocity and acceleration; however, many confused the situation with projectile motion and drew the acceleration arrow directly downwards. Almost every student correctly selected and used the centripetal acceleration equation, although it was surprising that students did not use this idea from circular motion to realise that their answer to part (a) was incorrect.

Question 2

The majority of students correctly stated that the horizontal velocity of the projectile is 65 m s^{-1} when it hits the ground, but too frequently the justification for this was lacking sufficient depth. The examiners are looking for students to explain *why* the horizontal component of the velocity is unchanged, not simply to state that it is. A few students were unable to calculate the flight time and range, and this was typically when horizontal and vertical components were confused.

Students displayed varying levels of understanding about air resistance in part (d), but rarely was the actual question answered. Often the characteristics of the shuttlecock that caused air resistance or how air resistance affects velocity and range were discussed. Many students incorrectly used unspecific statements such as ‘air resistance decreases the vertical velocity’, which is not true for an object travelling downwards. Concise, accurate answers were rare.

Question 3

Previous SACE Stage 2 Physics exams have almost always contained a question that used the law of conservation of momentum, so it is surprising how poorly students responded to this question. The best answers to this question clearly showed how the law was applied, discussed the initial and final total momenta, correctly worked with the larger mass of piece P_3, and included a vector triangle for the momenta. Some very good answers included Pythagoras’ theorem and trigonometry to find the final momentum of piece P_1, but this was not correctly transferred to the grid on the diagram. A number of students incorrectly claimed that, since they have the same mass, P_1 and P_2 must have the same magnitude momentum.

Question 4

Since the practical skills question did not require students to determine the units of a gradient, this idea was assessed in Question 4. Correct units and equations were given by most students, although the equation $y = 1.55x$ was common (and not allocated a mark).

It was pleasing to see students persist with part (c) when they did not know the correct method to solve this problem. Students used points from the graph rather than the slope, and were able to obtain a reasonable answer when they identified that the data points were for v^2 and r (not for v and r). Students who had not correctly set their calculators to degrees would have received an answer that was unrealistic — and should have commented on this. Any time that a student obtains an answer that seems unrealistic, they should check their working and at least comment on their answer. When the unrealistic answer comes in a question that uses a trigonometric function, it should prompt the student to check the settings of their calculator.

Question 5

Students were able to correctly calculate the photon wavelength to the correct number of significant figures, but struggled to calculate the change in momentum. Approximately a third of the students obtained no marks for part (b) of this question, typically through not understanding that a change in momentum is equal to the initial momentum subtracted from the final momentum. The best answers had large, clear, correctly labelled vector diagrams that also showed the position of the solar sail. Such diagrams clearly showed the equilateral nature of the vector triangle. Equilateral triangles and 3–4–5 triangles are common in questions where the focus is upon the problem-solving, and not the calculation. Highly successful students may be using their reading time to identify where a vector addition or subtraction focuses on the calculation (such as in Question 6) and where it is a step within problem-solving, and is more likely to be a simpler calculation.

Question 6

Poor performance in proportionality questions disappoints markers because, like using the law of conservation of momentum, a question using proportionality has consistently featured in SACE Stage 2 Physics exams. The answers to part (a) that received two marks clearly identified the proportionality that was relevant and then proceeded to show how this provided the required answer. In too many answers both of these components were missing, and illogical arguments were used to obtain the required figure. Many students started with $E = F/q$ and consequently claimed that E was inversely proportional to q.

The use of Pythagoras' theorem to calculate the vector sum of two electric fields was done successfully by many students. A number of students calculated the angle (below horizontal) of the vector even though this was not required. However, this did not assist in showing the approximate direction of the total electric field on the diagram. The best answers to part (b)(i) showed the different length vectors due to q_1 and q_2, and the sum of these. This is an example of a one-mark question that requires a higher order of thinking.

Question 7

The vast majority of students correctly answered this question. This was the most common place where students were penalised for giving an answer with an inappropriate number of significant figures.

Question 8

Only a small number of students correctly identified the atomic number and mass number of the yttrium isotope. Some gave the relevant numbers of the strontium isotope, and some had the correct values but did not know which was the atomic number and which was the mass number — and both of these answers earned one of the two marks available. Others attempted to balance a radioactive-decay equation but used an incorrect type of decay, with alpha decay being the most commonly chosen.

After correctly calculating the magnitude of the electric field between the plates, students used one of two methods to calculate the work done. A number used the relationship between work, force, and distance, while others used the relationship between work, charge, and potential difference. The best answers showed how both these methods gave the same answer. The most frequent mistake made by students was to not use the fact that point B is midway between the two plates. There was significant variation in units stated for work done.

Question 9

Accurate, well-drawn field lines were not common. Often the lines were in the incorrect direction, starting from or ending at the middle of the magnet structure or broken by the voice coil. When the direction of the force on the voice coil was stated, it was often inconsistent with the field lines drawn, or the answers lacked sufficient detail: 'up' or 'out' were not allocated marks.

Question 10

This question showed that many students have minimal knowledge of some of the applications included in the subject outline.

More than half the students identified that the cyclotron shown is used for accelerating positive ions, although very few effectively linked both the direction of travel required to hit the target and the direction of the magnetic field with the ions' charge. Many simply used the initial direction of the electric field as their justification. Students often claimed 'the right-hand rule' as the reason for the charge being positive.

Many of the answers given for part (b) were lacking depth. The question instructs students to 'describe' the purpose of the two different fields, but often students simply *stated* the purpose, showing a lack of understanding.

Part (c) required students to solve a problem rather than simply select and use a formula, and therefore assessed the performance standard A1. There was a clear correlation between correct answers to part (c) and coherent, effective descriptions of the purpose of the electric field in part (b).The most common mistake made during the problem-solving was to calculate the number of times the ion was accelerated across the gap between the dees rather than the number of rotations made.

Question 11

The majority of students correctly answered part (a), with incorrect answers typically only stating one section and not listing three sections.

The best answers to part (b) dealt with the need to give the force per unit length either by calculating the force on a one-metre length and clearly communicating this, or by calculating F/l.

Question 12

Question 12 proved to be the most difficult question in the exam, with many students receiving no marks. Most frequently these students attempted to find the separation by calculating the difference in the radii. Then, to introduce the factor of 2, many students made inappropriate algebraic claims.

Question 13

While many students knew that monochromatic light is light of a single wavelength, a significant number also believed that monochromatic implied that the light was coherent. A considerable number of students did not read this question carefully, stating in part (a)(ii) that the light was not coherent because there were multiple wavelengths, despite having said in part (a)(i) that there was only one wavelength. Students who did not know why the light was not coherent, but clearly communicated what not being coherent meant, were allocated one of the two marks.

Showing information on a graph is one way that students can demonstrate that they can use a variety of formats to communicate knowledge and understanding (KU3). It was surprising to see how little care was put into so many answers. Correctly drawn graphs were rare, with the single-slit diffraction pattern commonly presented here.

While many students described how the fringe at the centre of the pattern was the result of constructive interference, many incorrectly stated that this was due to a path difference of one wavelength or an integer number of wavelengths.

Question 14

Most students were not challenged by the calculation in this question, and the majority were able to correctly state the plane of polarisation.

Part 2 of Section A (Questions 15 to 25)

Question 15

A significant number of students could not explain the speckle effect, either confusing it with, or instead choosing to explain, reading data from a CD or double-slit interference. Rarely did the included diagrams aid the explanation.

Question 16

Students struggled to link the concepts of photon energy, work function, and stopping voltage with formulae. Many students attempted to use the formula $E = hf$ to calculate the kinetic energy of the electrons, or the maximum frequency X-ray formula.

The fact that there would be no change to the stopping voltage was correctly determined by many students. However, the justifications usually focused solely on the energy of each photon not changing, and did not link this to the energy of the electrons. It was common for students to claim that the photons' energies would increase, and hence the stopping voltage would increase.

Question 17

Most students offered a reasonable safety requirement, although their communication of it was often quite poor. The use of dark glasses or safety goggles was a fairly common response, but it was not accepted as suitable.

The table was usually constructed adequately, although not all included appropriate headings or units. Occasionally students missed that the position of the $m = 0$ maximum was not at the zero marking from the third result and consequently had an incorrect value for that result.

Students were successful at determining d and finding the average separation (of the first and central maxima). However, many then proceeded to use the double-slit fringe equation: $\Delta y = \lambda L / d$. As with Question 10(c), this question was for the assessment of specific feature A1.

Question 18

Part (a) of this question was often omitted by students. Those who did answer often did so poorly, with descriptions of the features of the graph provided rather than explanations of how these features arise.

Attenuation was often confused with penetrating power, and relating the brightness or darkness in the X-ray image to the nature of the materials proved difficult for many students.

Question 19

Both of these calculations were generally well done. The most common mistakes were to calculate a frequency and then use $E = hf$ and the kinetic energy formula to determine the speed. When calculating the angle, some students thought that m was the electron mass and not the order.

Question 20

While most of the students were able to explain spontaneous emission, stimulated emission proved more difficult. It was a common mistake for students not to mention that the energy of the incoming photon had to exactly match the energy gap, although the need for a specific energy was often mentioned.

There were many incorrect answers provided for the need for a population inversion. Often irrelevant information about the helium and neon atoms or about the excitation of the helium was provided. The best answers discussed both having more atoms in the metastable state and the need for emission to dominate over absorption.

Question 21

The calculation of the frequency was usually completed successfully, although the conversion between joules and electronvolts was problematic for some students.

Rather than discuss line emission spectra, a number of students discussed absorption spectra. Often the structure of the students' arguments was to explain the fact that energy levels existed and hence a line emission spectrum resulted. These answers received a maximum of two of the three marks.

Question 22

The concept of activity seems to be very poorly understood by many students, who often confused it with half-life.

Most students were able to correctly calculate the time taken to decay, although some students simply divided 110 minutes by 16.

Linking the time to get the radioisotope to Australia with the reduction in activity was successfully done by the majority of students.

Question 23

Most students were able to successfully identify a relevant property of alpha particles, but often the link to the killing of the cancer cells was not made or was poorly explained.

Similarly, the short range or low penetrating power of alpha particles was correctly identified, but the explanation of the cause of the property was omitted by many students.

Question 24

Too often the large number of protons in the nucleus was not offered as an explanation of the large electrostatic forces of repulsion. Occasionally students discussed induced fission, but overall students provided reasonable, but not always well-expressed, explanations.

The errors within the calculation of the energy released typically involved a mistake when calculating the difference in mass between the products and the reactants. In some instances this occurred when the mass of only one neutron was included.

Question 25

Part (a) was well answered by most students, although ‘improving accuracy’ was a common misunderstanding. A large number of students received no marks for part (b) because they did not correctly convert to metres and did not give the values to the correct number of significant figures. The practical skills question is regularly used to assess the correct use of significant figures, and teachers should be preparing students for this during the year.

Students were able to plan their graph and complete it. The most common error was the selection of an inappropriate scale for *W*, and a surprisingly high number of students ‘broke’ their axis to set up a scale. Students were able to calculate the gradient of the line of best fit, but relating it to the wavelength proved more challenging. The line for a thicker hair was usually drawn correctly, although the reasoning used was not communicated effectively. A number of students stated that *W* was inversely proportional to the thickness with no justification.

Section B (Questions 26 and 27)

Question 26

Question 26 was answered by more students than Question 27, and yielded a higher mean mark. Both means were well below the exam mean, as has often been the case in recent years. Good, clear diagrams that aided the answer were rare, with small diagrams in margins common.

The first dot point was about the similarities between electrostatic and gravitational forces. A significant number of students discussed the similarities, while only a small number focused on the differences between the forces. Many students wrote about the uniform circular motion caused by the forces, and these students rarely achieved more than one mark.

The second dot point allowed students to discuss one feature of the orbit of a geostationary satellite. Often the feature being discussed was not clear, or was expressed poorly. Many students wrote anything and everything they knew about geostationary satellites, including their uses and their launching. These answers rarely addressed one feature of the orbit satisfactorily. Many students claimed that the satellite’s period is proportional to its radius, or that the equation $v = \sqrt{GM / r}$ is sufficient to calculate the radius of the orbit.

Question 27

A few students identified chemical reactions, atomic energy-level transitions, interactions between atoms, nuclear fission, or nuclear ‘fussion’ as the source of the sun’s energy, although most knew that it is fusion. It was rare for the fusion process to be discussed well, with the conversion of mass into energy rarely properly described.

It seems that some students used the second dot point to write about uniform circular motion for the fourth time. Many students claimed that *every* charge that enters a magnetic field will undergo uniform circular motion. The best answers discussed the interactions between the Earth's magnetic field and that of the moving charge, which caused the charge to feel a force, and hence there was acceleration and a change in velocity. A number of students used the formula $F = qvB\sin\theta$, to claim that a greater force will cause a greater velocity, or that a weaker field will cause a greater velocity.

OPERATIONAL ADVICE

When preparing moderation materials, it is important that the teacher provides as much information as possible to help the moderators to confirm the teacher's assessment decisions. It is important that there is clear evidence from the teacher about how a student's overall grade was determined.

Teachers who provided summary sheets for their students helped moderators greatly, as it made it clear how the teacher came to their final decision.

Teachers must ensure that electronic files are in a form that can be read completely, and this includes checking that the sound can be heard. They should use the advice about the submission of electronic files in the learning area manual.

When revising 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.

There were many examples of student work missing and with no reason given by the teacher. Moderators are required to assume that the student has failed to submit the work and, as a consequence, students receive a lower grade. Teachers are encouraged to provide as much information as possible about their group. If there is no Variations in Materials for the Sample for Final Moderation form from the learning area manual, it is assumed that the student work is missing for an invalid reason.

It is important that teachers package their work correctly. Student work has to be submitted by assessment type.

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