Physics

2010 ASSESSMENT REPORT

Science Learning Area

Government of South Australia

SACE Board of SA

PHYSICS

2010 ASSESSMENT REPORT

ASSESSMENT COMPONENT 1: EXAMINATION

The mean mark for the 2010 Physics examination was slightly above the 60% expected from a large student cohort. As has been common over many years, students' performance in calculation questions was superior to their performance in questions that required them to describe or explain phenomena.

Students and teachers would have seen a change in instruction 6 on the front page of the examination. In previous years, the correct use of significant figures has been assessed in one particular question, and this has been indicated by the wording of the question. For 2010, the correct use of significant figures was assessed throughout the paper in a variety of questions because the correct use of significant figures is seen as a skill that should be employed as a matter of routine. Marking procedures were set in place so that a student would not be penalised for poor significant figure usage more than once per booklet in Section A and more than once in Section B. It was pleasing to see that the majority of students gave numerical answers with appropriate significant figures on most occasions.

Due to the nature of the questions used in Physics examinations, there are limited places where students have to determine which units to give for their numerical answers. Consequently, use of correct units was only assessed in a few questions in each booklet, and again marking procedures were set in place so that a student would not be penalised more than once per booklet in Section A and more than once in Section B.

Some numerical questions instructed students to 'show' the required answer. This is done so that the value can be used in future parts of the question, and means that later parts of questions are not closed to students who are unsuccessful in earlier parts. These questions require as much discipline as any other calculated answer — showing which formula (or formulae) is used, showing its rearrangement, showing the substitution, and arriving at the specified answer are all required. It was common for students to show a different numerical value to that stated in the question, and this was penalised. This was most common in Question 23 (c), where answers of 4.02×10^{-24} were given instead of the required 4.0×10^{-24}, and as such were not allocated a mark.

In questions that required short written answers, students had knowledge of the correct answer, but were undisciplined in communicating that knowledge. This was particularly evident in Questions 11 (a), 16 (a), and 24. Students who considered how to communicate their knowledge in all types of questions were generally much more successful. Communication includes drawing field lines and vectors, labelling diagrams, using exact terminology, and answering the specific question asked.

The 2010 examination was similar to other recent examinations in requiring students to derive two expressions — one specifically stated as an intended student learning from the curriculum statement, and the other as application of the required course knowledge. These questions require students to demonstrate their knowledge, justifying why specific formulae apply to the situations. In these questions, students are penalised if the formulae they start with do not appear on the provided equation sheet.

Section A

Question 1
This calculation-based projectile motion question provided a successful start for most students, with approximately 36% of students achieving the maximum 12 marks.

(a) Most students successfully calculated the horizontal and vertical components. Students who used v_x and v_y without defining these quantities were penalised. A number of students correctly used these quantities after showing them on the diagram provided.

(b) Most students correctly calculated the range using the flight time and the initial horizontal velocity component. Some students used a mixture of vertical and horizontal quantities, while others did not read the question correctly and proceeded to show that the flight time was 2.10 seconds.

(c) Students were generally successful at dealing with acceleration due to gravity and initial velocity that were in opposite directions. To calculate the speed of the projectile required a labelled vector diagram. Few diagrams were not properly labelled with either the quantity or the value, and most were drawn as vectors with clear arrowheads. Students who carried a mistake from earlier in the question typically obtained a final speed higher than the launch speed, and were penalised for presenting an unrealistic answer without comment. Many students wasted time calculating the angle, which was not required in this question.

Question 2

(a) Most students were successful in setting up the right-angled triangle of vectors in the first part of this question, although the vector lengths were often incorrect. When using this triangle to derive the expression in part (a)(ii) the most common problem was communicating clearly why the magnitude of the vertical component of the normal force was equal to mg. Many students incorrectly stated that $\vec{F}_v = \vec{F_g}$, while most made the substitution with no explanation. Few students attempted to derive the expression starting with the banking angle formula from the provided equation sheet, not appreciating that this is only applicable to the optimal angle.

(b) The calculations of the horizontal component of the force and the speed were done well by most students.

Question 3
Most students had an understanding of the motion of a geostationary satellite. Rather than explaining the cost benefits of launching west-to-east, a number of students repeated statements from the earlier part of the question. While it was clear that many students understood why a west-to-east launch is used, their ability to concisely communicate this understanding was often unsuccessful.

Question 4
Approximately 85% of answers showed an understanding that the gravitational forces that two masses exert on each other cause attraction to the centre of the other mass. Just under two-thirds of students showed that they understood that the two forces are equal in size.

Question 5
Students who drew the electric field lines in pencil and with care were the most successful in this question. It was common for the field to be drawn with no regard for the sphere. When drawing field diagrams such as this, it is beneficial to decide how many field lines need to be

drawn before starting the diagram. Many students had varying spacing of the field lines leaving the positive plate.

Question 6
Students tended to use electric field strength rather than electric force, and many did not use the distance-squared nature of the force. Many answers contained undefined symbols, so answers such as '$F_1 = 16F_2$' did not communicate whether the force was stronger or weaker in the ground state. This question had the lowest mean of all the questions in Section A.

Question 7

(a) Many students attempted to answer this question by referring to the potential difference between the dees, rather than the electric field. It is important that students carefully read the question and follow the instructions given.

(b) Few students properly explained their choice of formulae, often $r = \frac{mv}{qB}$. Some students started with rearrangements of formulae from the equation sheet rather than showing the rearrangement, and this was penalised by markers. Most students were successful in using the formula to calculate the period to an appropriate number of significant figures and with correct units, although many gave their answer in 'secs'.

Question 8
Approximately two-thirds of students correctly identified the direction of the current in the loop.

Question 9
With this question broken into intermediate steps, many students were able to successfully calculate each answer. Some students confused horizontal and vertical data when calculating the displacement, resulting in unrealistic answers.

Question 10
Calculating electric field strengths and determining their directions was correctly done by many students. When finding the total electric field, many students obtained the correct answer by subtraction, but made no attempt to communicate why the subtraction was necessary. Many other students incorrectly justified the subtraction with statements such as $\vec{E}_{\text{total}} = \vec{E}_1 - \vec{E}_2$.

Question 11

(a) Many students related chemical properties to the number of protons within a nucleus. The most successful student responses related the chemical properties to the orbiting electrons, and these electrons to the number of protons within the nucleus.

(b) Explaining the uniform circular motion of an ion in a magnetic field is a typical question, but it was generally unsuccessfully answered. Few answers contained reference to the constant magnitude force on the ion. Most students did not discuss the magnitude of the force, or did so erroneously, referring to a 'constant force'. Identifying the sign of the C-12 ion, and explaining the larger radius of the C-14 ion was done satisfactorily by most students.

Question 12
The calculation was correctly done by most students. There was great variety in the quality of student responses discussing the operation of a moving-coil loudspeaker.

Question 13
This question assessed knowledge of the concept, with communication not as significant to the answer. Only 56% of students correctly determined both orientations.

Question 14
Most students related the larger angles to the higher wavelength of red light (compared to blue). Many students incorrectly attempted to use $\Delta y = \frac{\lambda L}{d}$, whereas those who correctly used $d \sin \theta = m\lambda$ often went on to state that $\theta \propto \lambda$.

Question 15
(a) Typically, students understood that the bright fringes were due to constructive interference, but few clearly explained why the light from the two slits arrived having travelled different distances. Poorly worded answers were common, with many statements such as 'because of a path difference of *m*'.

(b) Many students measured a single width, but most used more than one and averaged to get a fringe separation. The scale of the diagram was problematic for some students, with incorrect readings and poor labelling. Calculation of the wavelength was done well by most students. It was pleasing for markers to see some students identify the unreasonableness of their answer after they carried through an incorrectly determined Δy.

Question 16
(a) While the significant majority of students identified that the results of metal surface A showed greater precision, the evidence provided was unsuccessfully communicated. Student answers often lacked clarity; for example, 'they are all on the line' does not convey the answer sufficiently. The wording of many answers implied that the line of best fit would be drawn before the data was plotted, and this is not possible.

(b) This explanation of a fundamental concept was generally unsuccessfully completed, with most students only obtaining 1 mark of a possible 3. There was significant confusion between the photoelectric effect and the ionisation of an atom.

Question 17
(a) Calculation of the required potential difference was done well by the majority of students. However, this question featured inappropriate numbers of significant figures, more than any other question.

(b) The most successful answers related the penetrating power of X-ray photons to their energy, and justified why the increase in potential difference resulted in higher-energy photons. In many answers, the penetrating power was only linked to the frequency of the photons.

Question 18
This was the question that students found easiest, with the conversion of GHz and use of the wave equation dealt with correctly.

Question 19
Just over half of the students were able to identify that the proton's wavelength would be shorter and communicated the reasons why. Many students lost marks for their poor communication of the relationship between wavelength and mass. Some students attempted to use the concepts summarised by $E = hf$ and $c = f\lambda$ to justify their answer.

Question 20

(a) Students who included details of the transition caused by the photon typically obtained both marks for this question.

(b) This calculation, including the conversion of electronvolts to joules, was well answered by most students.

(c) Many students confused fluorescence with stimulated emission. Those who did not make this mistake often did not show a proper understanding that the fluorescence process starts with the absorption of a photon.

(d) This question was answered well by few students. There was significant confusion between emission and absorption spectra. Answers that did discuss absorption spectra were typically poorly constructed.

Question 21

Identifying the likely decay for the Cu-69 isotope was generally correctly done. The second part of the question required students to determine that the Cu-57 will undergo a beta plus decay, and hence emit a positron paired with a neutrino. Many different pairs of particles were proposed by students.

Question 22

Around two-thirds of students correctly solved this half-life question. Of the remainder, almost half did not achieve any marks.

Question 23

(a) Many students correctly determined the atomic and mass numbers, but a significant proportion did not read the question carefully, and wrote the atomic number as 7 and the mass number as 3.

(b) The majority of students calculated the mass difference and the energy released correctly, giving their answer with appropriate units. Many students rounded off too early, resulting in incorrect answers.

(c) The most successful answers to part (c)(i) showed an understanding that the total initial momentum was due solely to the neutron since the boron was stationary. Using the conservation of momentum in part (c)(ii) proved difficult for the significant majority of students. Many started with incorrect concepts such as $\overrightarrow{p_i} + \overrightarrow{p_f} = 0$, or undefined terms such as 'LCM' or 'LOCOM'. Many students completely ignored the vector nature of momentum, while others subtracted momenta with no explanation or justification. Organised, well-structured answers that used the vector nature were successful.

Question 24

This question had a low mean. Often the low marks allocated were due to poorly communicated answers. Students need to be taught that simply writing 'much heat' is rarely sufficient in a Physics exam. A significant number of students incorrectly claimed that fusion produces *no* radioactive waste.

Section B

Question 25

The distribution of marks in this experimental skills question very closely mirrored the distribution of marks in the overall exam. Calculating an average of tabulated data did not prove much of a hurdle for Stage 2 Physics students, and nor should it. Similarly, the majority of students were able to correctly identify variables and constants within the experiment, and to determine how the data should be graphed.

The nature of the data in this question means that this is a rare case where using 3 of the larger squares on the grid paper for each 1 volt was acceptable, although 4 squares per volt is the best choice. Students who used 2 squares or less per volt were penalised. The scale used for the current should have been straightforward, with the highest value of 0.180 amperes being on the 18th large square (if the page was kept in portrait orientation). However, many students still chose poor scales. Students usually plotted the data points correctly and made the plotted point clearly visible, although many did not plot the point of 0 volts, 0.009 amperes. When drawing a line of best fit, students are encouraged to use pencil, and to lightly draw their line first. Once they are satisfied with its position, then the line can be made darker. Students often presented two lines of best fit — their first attempt which had not been properly erased, and their second attempt. Many students forced their line of best fit through the origin, either by missing the data point at 0 volts, 0.009 amperes, or simply by choice.

Many students showed confusion when dealing with proportionality. Some claimed that the graph showed *V* was proportional to *I* due to a straight-line graph, but then went onto claim that the two variables were not directly proportional because the graph did not pass through the origin. When suggesting the likely source of the systematic error, students tended to give vague answers, or tried to cover all possibilities with sweeping statements such as ‘one of the pieces of equipment was faulty’.

Students calculated the slope of their line of best fit and stated its units well in most cases, although many students did not use two points that sat on their line of best fit. Some students gave the units of the slope using the symbols *I* and *V* rather than the units. Most students correctly used their slope to find the resistance of the wire, although the reasoning used was often poorly communicated. The majority of students correctly handled the concept of resolution of a measuring device, despite this being its first appearance in a Stage 2 Physics examination.

Extended-response Questions

Students’ performance in the two extended-response questions (Questions 26 and 27 in 2010) continues to be less successful than their performance in the other sections of the examination. Both questions had a mean of less than 50%, with Question 26 being done marginally better than Question 27. The two questions in this year’s examination allowed students to write longer responses than in previous years. In some cases this allowed students to write material that, while correct, did not address the dot points of the question. Such material can impact on the communication marks allocated. Secondly, students should avoid making incorrect ‘factual’ statements in their responses, such as ‘every fission reaction releases 3 neutrons’ or ‘stimulated emission only occurs when an atom drops from a metastable state to the ground state’. Both of these statements are true for *some* cases, not all.

Question 26

Most students displayed a sound understanding of chain reactions, although too many used a dictionary definition that was not linked to nuclear fission. Satisfactory descriptions of the role of moderators were provided by many students, but the need for moderators was not as well explained. Inexact statements describing the moderators colliding into the neutrons were common. It was surprising how many students claimed that if the neutrons were too fast, they would travel straight through a uranium nucleus. Some students confused moderators with control rods, and many were not able to clearly and concisely connect the properties of the moderator materials with their function.

Question 27

The first dot point of this extended-response question was generally unsuccessfully answered, and responses showed many misconceptions. Students needed to show their understanding of stimulated emission, coherence of light, and the link between these two concepts (from different sections of the course). When describing the LADS depth-determination process, many students started well. Often, though, answers degenerated into statements of algebraic expressions that were not properly explained. There was significant confusion among students about the need for, and the use of, two different-coloured lasers. The image included with the question may have inspired students to discuss the two lasers, but its purpose was very different. Many students provided poor diagrams of aircraft, water surfaces, and lasers that were untidy and unlabelled, and that did not communicate anything not shown in the provided diagram. Students who used diagrams to aid their explanation of stimulated emission were usually much more successful in obtaining the marks for knowledge and the allocated communication marks. Teachers should encourage students to only include diagrams with their extended-response answers that add to the explanations.

Chief Assessor
Physics