External Assessment Report 2009

Subject	**Physics**
Level	**Higher**

The statistics used in this report are pre-appeal.

This report provides information on the performance of candidates which it is hoped will be useful to teachers/lecturers in their preparation of candidates for future examinations. It is intended to be constructive and informative and to promote better understanding. It would be helpful to read this report in conjunction with the published question papers and marking instructions for the Examination.

Comments on candidate performance

General comments

Markers commented that only a small number of candidates were very poorly prepared for this year's examination.

As in previous years it was found that questions requiring candidates to perform calculations were generally answered very well. However, most candidates continue to perform quite poorly in questions requiring written descriptions and explanations.

Areas in which candidates performed well

The multiple choice section of the paper was found to be fairly straightforward by most candidates, with questions 9, 11, 13 and 20 being answered particularly well.

Question 21 – Part (a) was well answered by many candidates. Most candidates were able to state and use correctly the relationships to find the horizontal and vertical components of the velocity of the basketball.
In part (b) most candidates realised that they needed to divide the horizontal distance by the horizontal component of velocity in order to find the time taken for the ball to reach the basket.

Question 22 – Part (a)(i) required candidates to calculate the mean and approximate random uncertainty in a series of results – this was well done.
Part (b)(i), involving the relationship between force, time and change in momentum, was generally done well. However, a significant minority of candidates substituted the values for ***u*** and ***v*** the 'wrong way round' and so lost most of the marks.

Question 23 – The calculations in part (b)(i) and (b)(ii) [requiring the use, respectively, of the relationships $P = \rho g h$ and $PV = k$] were generally well done.

Question 24 – In part (a), which required selection of information from the graph and use of the relationship between e.m.f., internal resistance and 'lost volts', most candidates gave correct answers.

Question 25 – In part (a), most candidates were able to use information from the diagram (showing the trace and settings on an oscilloscope) to calculate the peak voltage and frequency of the signal.
In part (b)(i), the large majority of candidates were able to state that the op-amp was being used in inverting mode. However, a small minority wrongly stated 'inverted' or 'differential'.

Question 26 – In part (c), most candidates realised that maximum energy would be stored in the capacitor when the p.d. across its plates equals the supply voltage. Most also carried out a correct calculation, although a few neglected to square the voltage in $E = \frac{1}{2} C V^2$.

Question 27 – Part (c), which required the use of the grating formula applied to the second order spectrum, was well done by most candidates.

Question 28 – Part (b), where a 'double stage' calculation was required to find the wavelength of the light in the glass, was done well. Most candidates were able to work through this correctly. However, some candidates inappropriately rounded their answer in the first stage of their calculation, resulting in an inaccurate final answer.

Question 29 – The calculations in part (a), involving the kinetic energy and speed of photoelectrons, were generally well done.

Question 30 – A high proportion of candidates were able to gain full marks in part (a)(iii) where they were required to calculate the energy released in the given fission reaction. However, a significant minority of candidates rounded the values of the masses and so their value of 'lost mass' was not sufficiently accurate. Part (b) was well done.

Areas which candidates found demanding

In the multiple-choice section of the examination, the most poorly answered questions were 2, 16 and 17. These questions were correctly answered by less than half of the candidates.

Question 21 – In part (c), a significant number of candidates only carried out a calculation to find the **maximum** height reached by the ball and made no allowance for it having fallen below this height by the time it reached the top of the basket. Others attempted to draw triangles and use geometry, apparently unaware of the parabolic nature of the path.
Part (d) was a more open-ended question than most candidates might be used to. They needed to analyse the given statement and use their knowledge of projectile motion to identify the mistake in the statement. Some candidates failed to make it clear that the ball would now 'miss the basket'. A small, but significant, minority failed to answer the question; rather than explaining why the student's statement was incorrect, they made statements like "with a higher speed the ball should be thrown at a different angle to go in the basket".

Question 22 – In part (a)(ii), many candidates made a comparison of only the mean contact time with the required standard of 257 μs and said that the club did meet the standard. They failed to take into account the random uncertainty of ±3 μs, which takes the **maximum** value of the mean contact time outwith the standard.
In part (b)(ii), many justifications (of why the ball's speed is greater when the same average force is exerted for a greater time) were weak because of a lack of rigour in analyses. For example, candidates referred to 'momentum', rather than 'change in momentum' and 'speed' rather than 'change in velocity'.

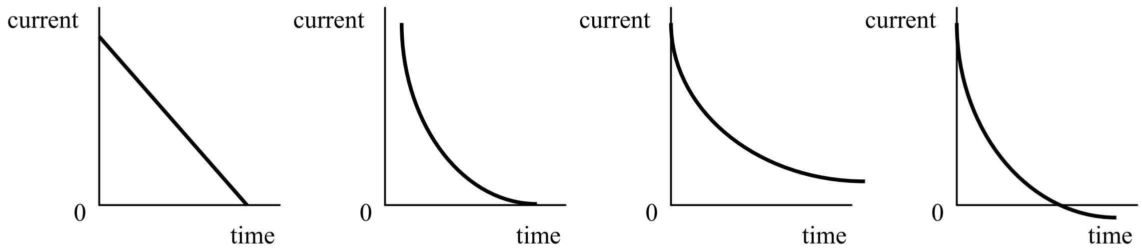
Question 23 – In part (a)(i) candidates were asked to use "**all** the data" to "establish the relationship between the pressure and volume of the gas". Despite this instruction, a large number of candidates did not use the data at all to carry out a calculation in order to justify a statement such as "pressure x volume is constant".
A significant number of candidates who did use the data to show that P x V is constant then wrongly concluded that "pressure is directly proportional to volume".
In part (a)(ii), when attempting to explain why pressure increases as the volume of the gas decreases at constant temperature, it is essential to include a description of molecules colliding with the container walls as the basic cause of pressure. A significant number of candidates missed out this step of the argument. Many candidates also failed to mention changes in the <u>frequency</u> of collisions of the molecules with the walls, which is an important part of the argument. Some candidates wrongly stated either that the kinetic energy of the molecules changed or that individual collisions of molecules with the container walls were 'harder'.
Part (b)(i) was generally well done. However, many candidates set out their answers poorly. It was common for markers to see answers such as;
$P = \rho g h = 1020 \times 9.8 \times 12.0 = 119952 + 101\,000 = 2.21 \times 10^5$ Pa.
A better way to set out the answer would have been;
Pressure due to water $= P = \rho g h = 1020 \times 9.8 \times 12.0 = 119952$
Total pressure = pressure due to water + atmospheric pressure $= 119952 + 101\,000 = 2.21 \times 10^5$ Pa
In part (b)(ii), a surprisingly high number of candidates did not realise that they should use a pressure x volume calculation. They attempted to answer using the density relationship.
In part (c), candidates' explanations of why there is a risk of lung damage often neglected to include reference to the relationship between pressure and depth (i.e. $P = \rho g h$).

Question 24 – In part (a), some candidates attempted to find internal resistance by calculating the gradient of the given graph, presumably in the mistaken belief that it was a voltage-current graph.

Question 25 – Although part (a)(ii) was well done by most candidates using the relationship between frequency and period, some wrongly attempted to find the frequency of the signal by using the relationship '$v = f \lambda$'.

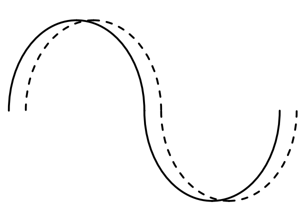
In part (b)(i), it was disappointing that some candidates, albeit a small minority, could not identify that the op-amp was being used in the inverting mode.
In part (b)(iii), many candidates showed poor understanding of the effects of saturation. Many said that when the supply voltage was decreased from ±15 V to ±9 V, the output would become “a square wave”. They clearly did not understand that lower input voltages would be amplified ‘properly’ and that only the peaks would be ‘flattened’. The use of a diagram in the answer could have aided candidates’ explanations. However, very few candidates drew any diagram in their answer.

Question 26 – In part (a), candidates were asked to sketch a current-time graph for the charging of a capacitor. Many answers were wrong because the shape of the graph was incorrect. Examples of wrong answers given by candidates:



There were also many poorly drawn graphs, for example axes were curved. Many candidates did not label the origin.
In part (b), a significant number of candidates carried out a calculation using Ohm’s law and only found the p.d. across the 500 Ω resistor. They failed to then subtract this from the supply voltage in order to find V_C. The three marks allocated to this part should have been an indication that there was more to be done than a single calculation.
In part (d), to justify that the maximum energy stored is not affected by increasing the resistance, candidates should have referred back to an appropriate formula (such as $E = ½ C V^2$) and discussed how each of the quantities did, or did not, vary. Many candidates thought that it was sufficient to state that “increasing the resistance increases the time taken to charge the capacitor”. Although this is a correct statement of fact, it is not a justification of why there is no change in the maximum energy stored in the capacitor.

Question 27 – In part (a), candidates’ answers frequently omitted stating that waves “combine” perfectly out of phase to produce a minimum.
Some answers referred to waves being “not in phase” which would not necessarily cause destructive interference; for example,



Correct terminology for the cause of destructive interference (minima) would be “waves combine perfectly out of phase” or “waves combine 180° out of phase”.
In part (b), many candidates appear to believe, wrongly, that the reason why maxima for blue light are closer together than those for red light is because blue light diffracts less than red light. There were also inappropriate references to ‘refraction’ in many candidates’ explanations.

Question 28 – In part (a)(i), the answers of most candidates lacked any details of the relationships between energy and frequency (i.e. $E = h f$) and between frequency and wavelength (i.e. $f = v/λ$).
In part (a)(ii), candidates needed to substitute a value for the energy gap into $E = hf$ in order to calculate frequency. A significant minority substituted a negative value for this energy.
Part (b) was generally well done. However, some candidates carried out a calculation which indicated that they thought frequency can change during refraction.

Question 29 – In part (b), few candidates gave the essential reason why the maximum speed of an emitted electron remains the same, that is that the energy of each photon has not changed. Many candidates appeared not to understand the effects and consequences of reducing irradiance. The photoelectric effect continues to be an area of poor candidate understanding and response.

Question 30 – In part (a)(ii), candidates were asked to 'explain why a nuclear fission reaction releases energy'. This was very poorly answered. Very few candidates gave the desired response of 'there is a loss of mass which is converted into energy according to $E = mc^2$'.
These poor answers were all the more surprising as most candidates were able, in the next part of the question, to carry out a calculation for the loss in mass and substitute into $E = mc^2$ to find the energy released!
In part (a)(iii), a significant number of candidates rounded values of mass before finding the loss in mass. Some markers indicated that this error, although still recurring, was less frequent than in previous years.

Other general issues:

- Some candidates were poor at labelling their answers to match the appropriate part of the question.
- Some candidates wrote two, mutually contradictory, attempts at an answer.
- Some candidates did not set out their answers in a clear and logical way which could be followed easily by a marker.
- Markers reported that, in written explanations, there was an increase in the occurrences of candidates using '↑' to indicate that a variable is increasing in value, '↓' to indicate that a variable is decreasing in value, and even '→' to indicate that a variable is remaining constant. This could cause lack of clarity or lead to confusion and it is in the interest of candidates' that it be discouraged.
- Answers to questions 21(d) and 25(b)(iii) could have been enhanced by the use of a diagram. Few candidates did this and many answers lacked clarity as a result.
- A significant number of candidates lost marks because they did not know the values of prefixes. For example, in question 22(b), the time of contact was given as "450 μs".
  This was substituted by some as "450×10^{-3}" or "450×10^{-9}" instead of "450×10^{-6}".
- In answers requiring a double stage calculation, some candidates rounded an intermediate answer to so few significant figures that their final answer became inaccurate.
- There were many candidates who left their final answer to a calculation to an inappropriate number of significant figures.
  For example, in question 29(a)(ii), where the data provided was given to three significant figures, many candidates left their final answer as 765616.8 m s^{-1} (i.e. to seven significant figures).
- Markers reported that the number of instances of incorrect rounding appears to be increasing.
  For example, in question 29(a)(ii), many candidates rounded 7.656168×10^5 m s^{-1} to 7.65×10^5 m s^{-1} instead of 7.66×10^5 m s^{-1}.

Advice to centres for preparation of future candidates

- Candidates must take care to label each answer to match the correct part of a question. A wrongly labelled answer can result in no marks being awarded.

- Candidates must leave only one answer to any question. When they make more than one attempt at an answer, they must finally score through any work which they wish the Marker to ignore.

- Candidates should be encouraged to present their numerical analyses in a clear and structured way – markers need to be able to follow the logic in their answers.

- Candidates must read each question very carefully and ensure that their response really does answer what has been asked. Candidates should be encouraged to re-read a question immediately after writing their answer. This procedure could reduce the frequency of inappropriate or incomplete answers.

- Candidates must take great care to substitute the initial velocity value for ***u*** and the final velocity value for ***v*** in the equations of motion.

- Candidates must be careful to take into account the vector nature of ***u***, ***v*** and ***a*** in the equations of motion and other relationships such as change in momentum to ensure that they substitute the values as being positive or negative as appropriate.

- To be full and complete, many written explanations require inclusion of an appropriate formula. Candidates must ensure that they quote that formula and state what happens to each of the listed variables, including any which remain constant.

- It is preferable that candidates, in their explanations, use <u>words</u> like ‘increases’, ‘decreases’ and ‘remains constant’ to describe what happens to the values of variables. The use of arrows could cause confusion.

- Information on the number of marks allocated to each part of a question should be used by candidates as a guide to the extent of calculation or explanation required. For example, it is very unlikely that a question which has been allocated three marks can be answered fully by a single calculation using one formula.

- Candidates should label the origin and axes on sketch graphs and indicate any important values. Care should be taken to present these sketches as neatly as possible. For example, a ruler should be used to draw the axes.

- Most candidates need more practice in writing descriptions and explanations. They need to be more careful in the detail and precision of the language used in their descriptions and explanations. For example, in question 23(a)(ii), saying that decreasing the volume of the gas in the syringe causes “more collisions and a higher pressure” is inadequate. A precise description would be to say “A decrease in volume means that the gas molecules are closer together. This means there are more collisions per second between the molecules and the container walls. This produces a larger force on the walls and so increases the pressure”.

- In numerical calculations, candidates should round off values only at their <u>final</u> answer for a part of a question.

- Some candidates would benefit from further advice and practice on presenting their final answers to an appropriate number of significant figures.

- Candidates should be encouraged to consider using a diagram, where appropriate, to clarify any points they wish to make in their answer(s).

- Candidates should memorise and practise using all the prefixes listed in the content statements.

Statistical information: update on Courses

Number of resulted entries in 2008	8762

Number of resulted entries in 2009	9001

Statistical information: Performance of candidates

Distribution of Course awards including grade boundaries

Distribution of Course awards	%	Cum. %	Number of candidates	Lowest mark
Maximum Mark - 90				
A	31.1%	31.1%	2797	68
B	26.0%	57.0%	2338	56
C	19.0%	76.0%	1709	45
D	8.0%	84.1%	722	39
No award	15.9%	100.0%	1435	-

General commentary on grade boundaries

- While SQA aims to set examinations and create marking instructions which will allow a competent candidate to score a minimum of 50% of the available marks (the notional C boundary) and a well prepared, very competent candidate to score at least 70% of the available marks (the notional A boundary), it is very challenging to get the standard on target every year, in every subject at every level.
- Each year SQA therefore holds a grade boundary meeting for each subject at each level where it brings together all the information available (statistical and judgemental). The Principal Assessor and SQA Qualifications Manager meet with the relevant SQA Business Manager and Statistician to discuss the evidence and make decisions. The meetings are chaired by members of the management team at SQA.
- The grade boundaries can be adjusted downwards if there is evidence that the exam is more challenging than usual, allowing the pass rate to be unaffected by this circumstance.
- The grade boundaries can be adjusted upwards if there is evidence that the exam is less challenging than usual, allowing the pass rate to be unaffected by this circumstance.
- Where standards are comparable to previous years, similar grade boundaries are maintained.
- An exam paper at a particular level in a subject in one year tends to have a marginally different set of grade boundaries from exam papers in that subject at that level in other years. This is because the particular questions, and the mix of questions are different. This is also the case for exams set in centres. If SQA has already altered a boundary in a particular year in say Higher Chemistry this does not mean that centres should necessarily alter boundaries in their prelim exam in Higher Chemistry. The two are not that closely related as they do not contain identical questions.
- SQA's main aim is to be fair to candidates across all subjects and all levels and maintain comparable standards across the years, even as arrangements evolve and change.