External Assessment Report 2010

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 proportion of candidates were very poorly prepared for this year's examination. They believe that the paper provided good accessibility for 'C' candidates and at the same time had appropriate questions to provide good discrimination for those performing at 'A' and 'B'.

Over the last three years the performance of candidates in Higher Physics has gradually improved, resulting in better figures for the subject in the national ratings.

However, it is still the case that although questions requiring candidates to perform calculations are generally answered very well; most candidates continue to perform poorly in questions requiring written descriptions and explanations. It should be noted that the ability to write descriptive answers and explanations is likely to receive at least as much, or even more, emphasis in future assessment.

Areas in which candidates performed well

The multiple-choice section of the paper was found to be fairly straightforward by most candidates, with Questions 5, 6, 18 and 20 being answered particularly well.

Question 24 — Parts (a) (i) and (ii) required candidates to calculate the mean and approximate random uncertainty in a series of results — these parts were well done. However, a significant number of candidates failed to write the units 'seconds' (or 's') after their answers to **both** calculations.

In part (b) (i) the calculation to find the charge on a capacitor, given its capacitance and the p.d. across it, was very well done.

Question 25 — Part (a) (i) required candidates to calculate the resistance of an LDR in a balanced Wheatstone bridge — this was very well done.

Question 26 — The calculations in part (a) (i) and (ii) (to find the peak voltage and frequency of a signal displayed on the screen of an oscilloscope) were generally well done. However, a significant number of candidates lost marks by missing, or not knowing, the prefix 'milli' for the values on the time-base scale.

In part (d), the majority of candidates correctly performed a calculation to find the peak voltage and so concluded that, because V_p is greater than 15 V, the capacitor is damaged.

Question 28 — In part (a) (i), most candidates selected the appropriate relationship and used it correctly to find force, given pressure and area. In part (a) (ii) most candidates correctly used the relationship between pressure and volume to calculate the new volume of air in the tank. However, a significant proportion of candidates failed to realise that it was necessary to subtract the initial volume from the final volume in order to complete their answer — they should have realised that the 3 marks allocated were an indication that more was required to be done than just the straightforward use of a formula.

Parts (b) (ii) and (b) (iii) (using relationships involving angles, refractive index and critical angle) were very well done.

Question 29 — In part (b), most candidates were able to calculate correctly the energy of a photon in the laser beam.

In part (d), a large majority of candidates were able to calculate the wavelength of light and use this correctly in the grating formula in order to find the slit separation.

Question 30 — Part (b) was well done; most candidates showing that they had a good understanding of the changes which occur to the mass number and atomic number when alpha emission occurs. However, there was a significant minority of candidates who appeared not to know that an alpha particle consists of two protons and two neutrons.

Part (c) was also well done but some lost marks because they gave units after their calculated value for the number of decays.

Areas which candidates found demanding

In the multiple-choice section of the examination, the most poorly answered questions were 4, 15 and 16. These questions were correctly answered by less than half of the candidates. In Question 15, more than half of the candidates chose option ‘A’ which would have been correct if the question had been asking about the **emission** of energy rather than **absorption**. Did candidates not read this question carefully enough or is it more due to candidates having a poor understanding of electron transitions?

Question 21 — In part (a) (i), candidates who chose to answer by scale diagram showed a number of weaknesses. These included: no statement of the scale being used; too small a scale used, leading to inaccurate diagrams; no arrows drawn on lines representing vectors; wrong values of angles used and/or quoted in the answer; inability to use three-figure bearings.

Those who chose to answer by calculation also made mistakes. These included: attempting to use Pythagoras’ Theorem in a triangle which is not right-angled; attempting to use SOH, CAH, TOA in a triangle which is not right-angled; choosing a wrong value of angle for use in the cosine rule; failing to utilise the sine rule in order to find an appropriate direction for the resultant.

In part (a) (ii), many tried to calculate velocity using ‘distance’ rather than ‘displacement’. Of those who correctly calculated the value of velocity, the majority failed to also give its direction.

In part (b) (i), ‘show that’ required candidates to explain that the forces must be balanced (because the helicopter is hovering) and so the lift force and weight must be equal and opposite. The appropriate next step was then to state the formula ‘$W = mg$’ before carrying out the calculation to find the required value of 119 kN. Many thought that it was sufficient simply to write down numbers without giving an explanation of where they came from. Some tried to use $F = ma$ using a value for '*a*' that was non-zero.

Part (b) (ii) was poorly answered. Candidates were asked to describe the vertical motion of the helicopter immediately after the crate was dropped. Answers were weak and imprecise such as 'It rises' or 'It goes up' rather than 'It accelerates upwards'. Candidates were also asked to give an explanation in terms of the forces acting. Many failed to refer to forces at all in their answers. Only a few attempted to draw a free-body diagram. Doing this could have helped more candidates both better understand the situation and more easily explain what had happened to each of the forces and the resulting unbalanced force upwards.

Question 22 — In part (a) (i), a worryingly high percentage of candidates were unable to state the law of conservation of momentum. Of those who did make a statement, most omitted to refer to *total* momentum or that the law only applies in the absence of external forces.

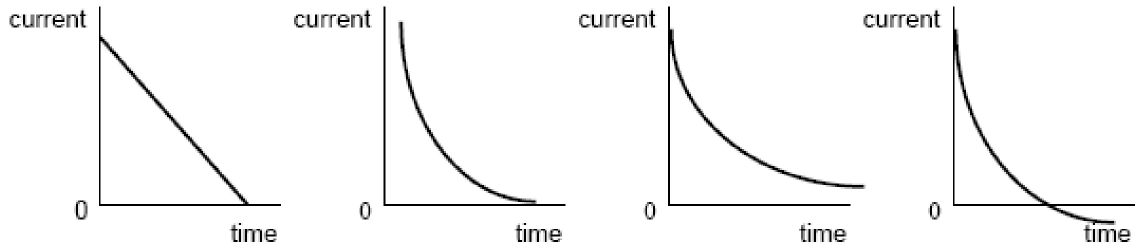
Part (b) was not well answered. A significant number of candidates carried out a correct re-calculation taking vehicle B as being stationary before the collision, but then made the mistake of comparing the new final combined velocity with the value of B's initial velocity in the first experiment — a very costly error.

Question 23 — In part (a) (i) candidates were asked to '**show** that the speed of the gymnast… is 6.3 m s^{-1}'. In a similar way as in Question 21 (b) (i), there were candidates who thought that it was sufficient simply to write down some numbers which they then 'manipulated' until the number '6.3' appeared. In a 'show' type of question it is necessary to state suitable relationships followed by appropriate substitutions and calculations.

Part (a) (ii) — very few candidates answered this correctly. The most common error was to ignore the vector nature of velocity, ie candidates failing to use opposite signs for the values of '*v*' and '*u*'. Almost as common were those who substituted the values for '*v*' and '*u*' the 'wrong way round', apparently unaware that change in momentum is defined as '$mv - mu$', and not '$mu - mv$'.

In part (b), only a very small number of candidates realised that this question was to do with the vertical component of tension balancing the weight of the gymnast. Most answers here were either very weak, irrelevant or wrong, for example candidates referring to the weight of the gymnast changing or attempting to use '$mg\sin\theta$'.

Question 24 (b) (ii) — here candidates were asked to sketch a current–time graph for the charging of a capacitor. In the same way as in a similar question in the 2009 examination, many answers were wrong because the shape of the graph was incorrect. Examples of wrong shapes are:



Again like last year, there were many graphs drawn very roughly, for example axes were curved and the origin or axes were not labelled. A ‘sketched’ graph only means that it is not to scale; it should still be drawn neatly and all appropriate labels and values clearly shown.

The question stated that ‘numerical values are required on the current axis’. However, many candidates did not show the starting value of current (2.5×10^{-4} A) on their graph — including some who had performed a correct calculation at the side of their page to find this value.

Question 25 — Part (a) (ii) was poorly answered. Most candidates did not realise that they needed to calculate both the potential at ‘P’ and the potential at ‘Q’, then find the difference between them. Many thought they could apply the equation for a balanced bridge to an unbalanced situation.

Part (b) showed up a number of weaknesses. Some candidates could not identify the correct relationship to use for this mode. Some showed a lack of knowledge of the prefixes ‘Mega’ and ‘kilo’. Many could not correctly identify which voltage was ‘V_1’ and which was ‘V_2’ and so went wrong in their substitution into the differential mode formula. Some correctly calculated that the formula gives the output voltage as 20 V, but failed to realise that this cannot be achieved as it is above the 12 V supply voltage. Others incorrectly referred to ‘saturation of the output voltage’ rather than ‘saturation of the op-amp’.

Question 26 — Parts (b) and (c) showed that many candidates do not know the difference between the current/frequency relationship for a resistive circuit and that for a capacitive circuit. A significant minority of candidates failed to give appropriate answers to these parts (which had asked about any changes in the ammeter reading) — their responses referred only to the display on the oscilloscope. Perhaps if they had re-read both the question and the words they had written, they would have realised that they had failed to answer the question.

Question 27 — In part (a), some candidates wrongly used the relationship for *constructive* interference (ie path difference = $n\lambda$). Others correctly identified the appropriate relationship (path difference = $(n + ½)\lambda$), but then, for ‘n’, used a value of ‘1’ (instead of ‘0’) for the first minimum.

In part (b), mistakes included failing to identify that destructive interference was no longer occurring or referring to it as ‘deconstructive’ interference.

Question 28 — As a whole, this question was well done by candidates. However, there were some errors. These include: in part (a) (ii) not subtracting the original volume of air and so failing to find the change in volume; in part (b) (ii) attempting to use the relationship $n = \lambda_1/\lambda_2$, thereby showing a lack of understanding that this relationship is only applicable to the change in wavelength of light as it travels from one medium into another — it does not apply to two different wavelengths of light travelling in the same medium.

In part (b) (iv), many candidates demonstrated poor understanding of the relationships between wavelength, frequency, refractive index and critical angle (ie content statements 3.2.4, 3.2.6 & 3.2.11).

Question 29 — In part (a), very few candidates were able to explain that, despite the low value of power, the incident area of the laser beam is very small and, because $I = P/A$, the irradiance is very large. Some candidates even claimed that the quoted power (0.10 mW) was ‘very large’.

Question 30 — It was disappointing that, in part (a), many candidates were unable to calculate the number of neutrons in the atom having been given both its mass number and its atomic number.

In part (d), where there was a need to calculate the current and voltages in a series circuit involving three resistances, a large number of candidates possibly even confused themselves by having little structure in their answers. Markers frequently were presented with an array of numbers and/or repeated formulae (such as $R = V/I$). As a result, it was unclear exactly what the candidate was attempting to find. Candidates would have increased the likelihood of gaining marks by using words, or subscripts, to clarify what it was that they were attempting to calculate, eg $I_{buzzer} = V_{buzzer}/R_{buzzer}$. Another technique to increase the chances of success in this question would have been to redraw the circuit in the answer script, adding appropriate labels for current(s) and voltages.

Other general issues

- Some candidates were careless in transferring data from the question paper to their answer script. For example, in Question 29 (d), substituting the number 4.47×10^{14} or 4.7×10^{14} for frequency (instead of the given ‘4.74×10^{14}’).

- A significant number of candidates lost marks because they did not know the values of prefixes. For example, in Question 24 (b), the capacitance of the capacitor was given as ‘1.6 mF’. This was substituted by some as ‘1.6×10^{-6}’ instead of ‘1.6×10^{-3}’.

- In answers requiring a double-stage calculation (eg Question 30 (d)), some candidates rounded an intermediate answer to so few significant figures that their final answer became inaccurate.

- The correct use and spelling of ‘technical’ words is important. Candidates at Higher should not be writing expressions such as ‘deconstructive interference’ or ‘lazer’.

- There were many candidates who quoted their *final* answer to a calculation to an inappropriate number of significant figures. For example, in Question 29 (b), where the data provided was given to three significant figures, some candidates left their final answer as 3.14262×10^{-19} J (ie to six significant figures).

- Markers reported that there were frequent instances of incorrect rounding. For example, in Question 29 (d), many candidates rounded their calculated value of the wavelength (= $6.329113924 \times 10^{-7}$ m) to 6.32×10^{-7} m instead of 6.33×10^{-7} m.

- A few candidates were insufficiently familiar with the relationships listed in the Data Booklet and the standard symbols used for the quantities in these relationships.

Advice to centres for preparation of future candidates

- 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 transfer data accurately from the examination paper to their answers. Developing a habit of double-checking that figures have not been transposed or omitted could reduce the number of such costly errors.

- When drawing vector diagrams, candidates should use arrows on their lines to show the direction of each vector and the resultant.

- Candidates must remember to quote direction as well as magnitude when giving vector quantities as answers.

- Many candidates need further practice in differentiating between distance and displacement, speed and velocity and the relationships between these quantities.

- Most candidates would benefit from further practice at writing descriptions of situations in which several forces act on an object and how the acceleration and velocity of the object are affected.

- 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 and when calculating the change in momentum.

- 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.

- Many candidates would benefit from more practice at problems using the conservation of momentum for situations in which two objects interact. Some of these problems should require descriptive answers, not just numerical calculations.

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

- Candidates must learn that their answers to 'show' questions should start by quoting an appropriate formula before any numbers/values are used.

- Most candidates would benefit from extra practice at problems in which it is necessary to resolve forces and either equate components or find resultants.

- 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 21 (b) (ii), saying that 'The helicopter rises because there is upward force' is inadequate. A more correct and precise description would be to say 'The weight decreases but the lift force remains constant. This produces an unbalanced force upwards and so the helicopter accelerates upwards'.

- Many candidates would benefit from spending time learning correct technical expressions (like **destructive** interference, not 'deconstructive interference'; **op-amps** saturate, not voltages; the **irradiance** of light on a surface, not intensity) and correct spelling (like laser, not lazer). To help them do this, candidates should be encouraged to study carefully the content statements for the Course.

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

- In numerical calculations, candidates should round off values only at their **final** answer for a **part** of a question. The answer(s) to any intermediate calculation(s) should not be rounded to the extent of causing inaccuracy in the final answer.

- 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.

- Candidates must ensure that they know well all the relevant parts of the Data Booklet — this includes all the relationships listed for Higher and all the standard symbols used in these relationships.

Statistical information: update on Courses

Number of resulted entries in 2009	9001
Number of resulted entries in 2010	9014

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	27.3%	27.3%	2457	67
B	27.6%	54.8%	2485	56
C	23.0%	77.9%	2077	45
D	9.0%	86.8%	809	39
No award	13.2%	100.0%	1186	–

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, therefore, SQA 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 Head of Service 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.