External Assessment Report 2012

Subject(s)	**Physics**
Level(s)	**Higher (Revised)**

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

This is the first examination for the revised Higher Physics Course.

Early adopter schools presented 457 candidates for this examination. Markers were generally impressed by the overall quality of the answers produced by these candidates.

This is the first national examination to include open-ended questions (Question 24 and Question 28). These questions permit candidates to answer the question in their own chosen way. Although there were examples of weak answers to these questions, Markers were impressed by the attempts made by most candidates to demonstrate their understanding of relevant physics facts and principles.

Candidates generally performed better in questions that required calculations than in questions that required written descriptions and explanations.

Areas in which candidates performed well

The multiple-choice section of the paper was found to be quite straightforward by most candidates, with Questions 5, 14, 19 and 20 being answered particularly well (at least 80% of candidates choosing the correct answers).

Question 21: Parts (a) (i) and (a) (ii) were well answered, most candidates carefully using an appropriate relationship and substitutions to analyse the projectile's motion.

Question 22: Part (b), which required candidates to utilise a relationship given in part (a) to calculate the surface temperature of a star, was very well done.

Question 23: Parts (a) (i) and (a) (ii) required candidates to calculate the electrical potential energy of a xenon ion and then use this in the kinetic energy relationship to find the final speed of the ion. Most candidates worked through this very well.

Question 25: In part (a), candidates used the relationship between work done, force and distance to find the total retarding force. They then had to subtract the given value of friction to find the car's braking force. The whole calculation was done very well by most candidates (although the vast majority used wrong spelling, writing 'breaking').

Question 26: Part (b) was particularly well done, most candidates having little difficulty in working out the charge on the strange quark.

Question 27: Part (a) was well done, most candidates correctly using the grating formula to calculate the slit spacing.

Question 29: Parts (a) and (b) (ii) required candidates to use Snell's law to calculate the angle of refraction and the critical angle respectively. These calculations were both done very well.

Question 30: Part (b), in which candidates had to carry out a calculation using the relationship between irradiance and distance, was done very well.

Question 31: Parts (a) (i), (a) (ii) and (a) (iii) required candidates to calculate the current, lost volts and power output. These calculations were generally done very well.

Areas which candidates found demanding

In the multiple-choice section of the examination, there were no questions that were answered correctly by less than half of the candidates. The three questions that were answered least well (only just over 50% of candidates being correct) were 13, 16 and 17.

Question 21: The numerical calculations in this question (parts (a) (i) and (a) (ii)) were generally answered well. The written descriptions and justifications given in part (b) were often unclear and imprecise.

Part (a) (i)

Despite the availability of the data sheet, a few candidates started by writing a wrong relationship, eg ‘distance = speed divided by time’.

Part (a) (ii)

The graphs in the question show that the time of flight of the ball is 3·06 seconds. Some candidates failed to use *half* of this value of time in their calculations to find the maximum height.

Part (b)

The question informs the candidate that when the effects of air resistance are **not** ignored, the golf ball follows a different path. It then asks ‘Is the ball more or less likely to hit the tree?’ A surprising number of candidates wrote ‘Yes’. Markers were often unable to discern which of the two options the candidate favoured and so could not award any marks.

There are a variety of ways a candidate could use to justify that it is more likely for the ball to hit the tree, but all of them require precision in the description. For example, an acceptable answer could be ‘On its way up, the ball’s vertical velocity would decrease *more quickly than before* and so the maximum height would be less than before. This would mean that it is more likely for the ball to hit the tree’.

Markers often read very vague statements such as ‘The ball’s speed would decrease and so it would not reach its maximum height’. Even when air resistance is ignored the ball’s speed decreases (due to gravitational effects). (This answer does not make clear that the vertical component of velocity has decreased more rapidly than before.) The ball always reaches a maximum height in its flight. (This answer does not make clear there is a *lower* maximum height when air resistance is taken into account.)

It is also important that an answer makes clear whether the candidate is referring to the vertical component of velocity or the horizontal component of velocity. Answers that vaguely refer to ‘velocity’ or ‘speed’ are not precise enough to receive the mark for the justification.

Question 22: Specific areas of weakness were as follows.

Part (c) (i)

Very few candidates were able to name the described radiation as 'cosmic microwave background radiation'.

Part (c) (ii)

This part of the question was also poorly answered indicating significant weakness in knowledge of this part of the Course.

Question 23: Specific areas of weakness were:

Part (a) (i)

This is a 'show' question and the candidate must start by writing the relevant formula ($E = QV$ in this case) and then substitute the relevant given data. It is not acceptable to start with just numbers in the answer to this type of question.

Part (a) (ii)

The candidate is asked to 'calculate the speed of a xenon ion'. This requires equating the given value of energy to the kinetic energy formula in order to find v. Several candidates substituted the mass of the *spacecraft* rather than the mass of the ion in $E_k = ½\ mv^2$. This careless mistake is very costly for a candidate.

A significant proportion of candidates demonstrated a lack of awareness of appropriate significant figures. It was not unusual for a Marker to see the final answer written as 'v = 42296·46 m s^{-1}'. In the question, *three* significant figures are used for the data. It is therefore appropriate to round the answer to the same number of significant figures, giving v = 42 300 m s^{-1} (or 4·23 x 10^4 m s^{-1}).

Part (b)

This part of the question asks for the change in velocity of the spacecraft. It is most efficiently answered using $v – u = Ft/m$. It can also be answered in two 'stages'. Firstly, finding a (from F/m) and then $v – u$ (from at). Candidates using this second method must avoid rounding their answer for a to the extent that it changes the final answer for $v – u$.

Part (c)

This part of the question gives the candidate various pieces of information about a 'different engine' which uses krypton ions. It then asks 'Which of the two engines produces a greater force?' Some candidates did not *name* an engine in their answer but just referred to the 'first' engine. The question did not state or imply that the engines were used in any time related order. (The first engine met at the start of Question 23 is the xenon engine, but the first engine mentioned in this part of the question is the krypton engine.) Markers could not award marks unless the correct engine was named.

Question 24: This is the first of two open-ended questions in this year's paper. It gained a mean mark of 50%.

An open-ended question allows candidates to answer the question in their own chosen way. Candidates should use the opportunity to show to the Marker that they know which areas of physics are relevant. They should also provide some discussion and/or analysis to demonstrate the depth of their understanding of that knowledge.

There is no 'checklist' that is used by Markers to allocate marks to a particular answer. Each candidate's answer is considered as a 'whole' and allocated a mark depending on the level of understanding demonstrated. Zero marks are awarded if the answer demonstrates 'no understanding' of relevant physics. The answer receives one mark if it shows 'limited understanding', two marks for 'reasonable understanding' and three marks for 'good understanding'.

Question 26: Areas of weakness were:

Part (a)

Few candidates gave a satisfactory answer as to 'why particles such as leptons and quarks are known as *fundamental particles*'. Many gave answers that discussed how these particles build up larger particles, such as protons and atoms. They missed the essential fact that these particles are not known to be made from even smaller particles.

Part (d) (i)

Only a small proportion of candidates were able to give the deflection direction of the protons as they move through the given magnetic field.

Question 27: Areas of weakness were:

Part (a)

Some candidates, as an intermediate calculation, worked out the sine of 35.3° but then rounded this value too much. This resulted in an incorrect final answer.

Part (b)

As this question is about determining whether a manufacturer's claim of 2% accuracy is correct, it is inappropriate for candidates to give an answer to only one significant figure.

Part (c)

Despite this question clearly requiring that the answer had to be justified with a calculation, there were a few candidates who failed to show any calculation. Future candidates need to be aware that no marks can be awarded for such an answer.

Question 28: This is the second of two open-ended questions in this year's paper. It gained a mean mark of 43%.

An open-ended question allows candidates to answer the question in their own chosen way. Candidates should use the opportunity to show to the Marker that they know which areas of physics are relevant. They should also provide some discussion and/or analysis to demonstrate the depth of their understanding of that knowledge.

There is no 'checklist' that is used by Markers to allocate marks to a particular answer. Each candidate's answer is considered as a 'whole' and allocated a mark depending on the level of understanding demonstrated. Zero marks are awarded if the answer demonstrates 'no understanding' of relevant physics. The answer receives one mark if it shows 'limited understanding', two marks for 'reasonable understanding' and three marks for 'good understanding'.

Question 29: Areas of weakness were:

Part (a)

Although most candidates were able to select the Snell's law relationship, a significant minority made errors at the substitution stage.

Part (b) (i)

The vast majority of candidates showed a lack of understanding of the term 'critical angle'. The correct answer was simply that 'θ_c is the critical angle because the angle of refraction is 90°'. Examples of wrong or poor answers seen by Markers were 'θ_c is the critical angle because the light is being totally internally reflected' and 'θ_c is the critical angle because total internal reflection is about to take place'.

Part (b) (ii)

Most candidates were able to calculate the critical angle from $\sin \theta_c = 1/n$. However, a significant number of candidates rounded their value for 1/1·33 in the middle of the calculation to the extent that their final answer for θ_c was inaccurate.

Part (c)

This part of the question was surprising poorly done. A correct answer was one in which total internal reflection was shown to be occurring. There were many examples of wrong physics in candidates' diagrams; the angle of reflection not being equal to the angle of incidence; a ray of refracted light being shown emerging from the liquid's surface; the internally reflected ray being labelled as 'refracted ray'; two rays being drawn inside the liquid, one labelled 'reflected' and the other 'refracted'; some candidates appearing to believe that the incident and reflected rays should always be at right angles to each other.

Question 30: Areas of weakness were:

Part (a)

A surprisingly high proportion of candidates were unable to state that the given relationship is confirmed because 'the graph is a straight line *through the origin*'. The mean score for this part was only 12%. Some candidates did state that the relationship is confirmed because 'the graph is a straight line'. This answer is insufficient as any straight line that intersects the axis away from the origin would require an additional constant to be added into the relationship.

Part (c)

The effect of repeating the experiment with the lights on would produce a graph line which is parallel to the original line and displaced up the irradiance axis. It was therefore essential that the candidate redrew the original line in order for the Marker to be sure that the two lines were parallel. Despite being instructed to 'Copy the graph shown …', a significant number of candidates failed to redraw the initial graph line and so made it impossible to access the mark.

Many candidates were careless in their graph drawing, for example, by drawing a 'straight' line freehand. Many candidates' graphs were too imprecise to be awarded the mark.

Question 31: Areas of weakness were:

Part (a) (i)

Most candidates answered this part well. However, there were some who failed to add the internal resistance of the power supply to the lamp's resistance in order to find the total circuit resistance in their calculations to find the current.

Part (a) (ii)

Most candidates also answered this part well. However, there were some who failed to give any units after calculating their value for the 'lost volts'. This was perhaps because of the terminology 'lost volts'. However, candidates must understand that answers could be given in terms of millivolts, kilovolts, etc and so they must clearly state the units that they have decided to use in their answer.

Part (a) (iii)

Again, this part of the question was answered very well by most candidates. However, there was a significant minority who used either the total circuit resistance or the e.m.f. in their calculation to find power. This finds the value of the *total* power output in this circuit and not the power output of the lamp.

Part (b)

Candidates were asked whether the internal resistance of the different power supply is less than, equal to, or greater than that of the first power supply, and then to justify their answer.

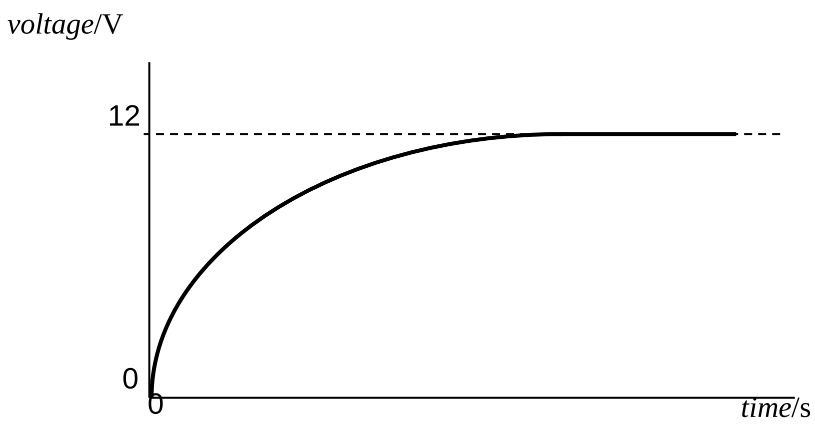
A small percentage of candidates used up (↑) and down (↓) arrows in their answers. This approach is inappropriate and should be avoided.

Many answers were not rigorously argued. For this type of question, a complete answer is likely to require the (re)statement of a relevant formula followed by discussion of what happens to each of the variables, leading to a conclusion about the effect on the dependent variable. Markers often saw answers like '$P = VI$. The power increases, so the current must increase ...' This answer has failed to discuss the possibility that the power increase is due to an increase in 'V'.

Question 32: Areas of weakness were:

Part (a)

Candidates were asked to *sketch* a graph of voltage/time for a charging capacitor. It appears that many candidates are misinterpreting 'sketch' as meaning 'rough' or 'inaccurate'. A sketched graph is one which is *not drawn to scale*, ie there is no need to ensure that values are positioned in proportion along the axes. However, appropriate values still need to be shown on the axes and the graph line should be drawn neatly in correct relation to these important values. It would also be good practice to link any important values to the graph line with a dotted reference line. Axes need to be labelled with the names and units of the quantities. The origin needs to be labelled. A fully correct answer to this part could be,



Errors seen by Markers included:

- unlabelled axes
- unlabelled origin
- freehand lines curving the wrong way (ie upwards)
- carelessly drawn freehand lines which did not stay at a steady level
- graph line flattening out above (or below) the 12 V value
- graph line stopped, but *still on a rising trend*, when the 12 V value is reached
- the value of '12' shown, but no unit indicated anywhere on the voltage axis
- a gap between the start of the graph line and the origin

Some candidates produced two *conflicting* answers to this question: one in their booklet and another on separate graph paper. Markers need to be clear which version the candidate wishes to be marked. Candidates should delete any draft answer(s).

Part (b)

Many candidates correctly read the starting current value from the graph as ‘2’, but failed to notice that the units were milliamperes, not amperes.

Some candidates wrongly used the highest value shown on the scale of the vertical axis (‘2.5’) as the starting current.

Part (c) (i)

Many candidates stated that the initial discharge current remains the same because ‘it does not depend on capacitance’. This fails to get to the heart of the reason, which is that the initial discharge current depends only on the voltage and the resistance, neither of which have been changed.

Part (c) (ii)

Candidates were asked how the capacitance of the new capacitor compared with that of the original 220 µF capacitor. They were told that they ‘must justify’ their answer. Any answer that made no attempt at a justification could not be awarded any marks.

Some candidates wrote ‘the new capacit*or* is smaller’. This shows a lack of precision in the use of language since it refers to the physical size of the capacitor, which bears no relationship to its capacitance.

The question shows graphs for the two capacitors discharging. Some candidates discussed how the capacitors were *charging*: this could not be accepted as appropriate.

There were frequent other examples of candidates using wrong/inappropriate terminology in their answers. Examples are: ‘current is being lost quicker with the second capacitor’ and ‘the original capacitance was better’.

Some candidates made a correct statement such as ‘the second capacitor discharges quicker than the first’, but they failed to answer the question as they did not say how the two capacitances compared to each other.

Some candidates attempted to answer this question using the relationship $Q = It$, stating that ‘the current is constant’. This statement is wrong physics. Although the initial value of the discharging current is the same in both cases, at all other times the discharge current for the second capacitor is less than that for the first capacitor and, of course, both currents decrease to zero.

Question 33: Parts (a), (b) and (c) were answered reasonably well. However, there were some significant weaknesses.

Part (a)

Candidates were asked to use square ruled paper and draw a graph of the given experimental results. Issues and errors noted by Markers include:

- Too small a scale used for the graph
- Chosen scale difficult to work with (eg making it difficult for them to plot points correctly)
- No graph line drawn through the plotted points at all
- Inappropriate line drawn through the points (eg straight line rather than a curve)
- A series of straight lines drawn from dot-to-dot through the plotted points
- Multiple, overlapping lines drawn through the points
- Line drawn in ink rather than pencil, thus preventing easy correction
- Axes not labelled with both the name of the quantity and its units

Part (c)

Candidates were asked to suggest two improvements to the experimental procedure.

It should be noted that vague, imprecise answers such as ‘use more accurate apparatus’ and ‘take measurements to more significant figures’ are not satisfactory at this level.

Part (d):

Candidates were asked to describe further experimental work that could be carried out to investigate a different factor that might affect the horizontal range of a projectile. Again, many answers were vague and lacked detail.

It should be noted that an answer to this type of question should include something about each of the following:

- Identification of a suitable variable to investigate
- Identification of variable(s) to be kept constant
- Detail of how to change and measure the chosen independent variable

Other general issues

Markers commented about the difficulty they had in reading the answers from a few candidates due to unclear handwriting.

Markers reported that the structure of numerical calculations were sometimes of a poor standard and difficult to follow.

Markers reported that candidates’ diagrams were often carelessly drawn and unclear or inaccurate.

Markers questioned whether many candidates had had sufficient experience in presenting their answers on blank paper prior to sitting the examination.

Advice to centres for preparation of future candidates

General

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 practice could reduce the frequency of inappropriate or incomplete answers.

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 candidates' answers.

Candidates must be prepared to present their answers on blank paper. It should be ensured that they have had sufficient practice in presenting written paragraphs, clearly structured calculations and neat diagrams on unlined paper prior to sitting this examination paper.

As well as for plotted graphs, candidates should consider using square-ruled paper for some of their other answers. Answers which might be improved by using this paper include vector diagrams, sketched graphs and other diagrams such as those showing the path(s) taken by rays of light.

Candidates should use a ruler when drawing straight lines. For example, when drawing the axes of graphs and the path(s) taken by rays of light.

When a candidate makes two (or more) attempts for the same part of a question, they must score through the part(s) that they do not wish to be considered by the Marker. They must not leave alternative answers for the Marker.

Candidates should not use up (↑) and down (↓) arrows in their answers rather than using words. This may be acceptable 'shorthand' for use when making their own notes, but candidates should not use this symbolism when attempting to communicate physics to others — as in examination answers.

Candidates must start their answers to 'show' questions by quoting an appropriate formula before any numbers/values are used. The substitution of numbers should then use the data given in the question without 'mental arithmetic' having been performed.

Candidates must be aware that, in a 'must justify' question, no marks can be awarded if the candidate makes no attempt at a justification.

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.

Candidates would benefit from spending more time learning correct technical terminology (for example: total internal reflection occurs whenever the incident angle is greater than the critical angle; 'capacitor' refers to the circuit component while 'capacitance' is the measure of its value).

Candidates must understand that to ‘sketch’ a graph does not mean that the graph can be untidy or inaccurate. The instruction to ‘sketch’ a graph only means that it does not have to be drawn to scale. Care should still be taken to present these sketches as neatly as possible. For example, a ruler should be used to draw the axes and any straight sections of the graph line. The origin and axes on sketch graphs must be labelled and any important values carefully shown. It is useful to link these important values to the relevant parts of the graph line using dotted reference lines. It is wise to use a pencil when attempting to draw the graph line — any wrong line(s) can then be erased to leave a neat, clear, single line as the final answer.

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 must ensure that they know all the prefixes required for the Course and that they practise using the correct power of ten for each prefix.

When asked to draw a graph using square ruled paper, candidates should use suitable scales on the axes in order to produce a graph that is not too small. However, they should also ensure that their scale is ‘easy to work with’. Candidates should ensure that each axis is labelled with both the name of the quantity and its units. Points must be plotted clearly and accurately. A best-fitting line (straight or curved as appropriate) should be drawn through their plotted points. However, this graph line should not be ‘forced’ to touch each point. Again, it is wise to use a pencil when attempting to draw the graph line — any wrong line(s) can then be erased to leave a neat, clear, single line as the final answer.

Statistical information: update on Courses

Number of resulted entries in 2011	-

Number of resulted entries in 2012	457

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	37.9%	37.9%	173	63
B	24.1%	61.9%	110	53
C	18.6%	80.5%	85	43
D	5.5%	86.0%	25	38
No award	14.0%	100.0%	64	-

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.