External Assessment Report 2012

Subject(s)	**Physics**
Level(s)	**Advanced 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

There was another increase in numbers this year.

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012
Number of candidates	1,391	1,401	1,422	1,370	1,396	1,525	1,730	1,748	1,905

Credit must go to the Physics teaching staff who run these classes, quite often with a reduced time allocation.

Examination

The paper was seen as more demanding than previous years. However, the vast majority of candidates made a good attempt at the paper. There was no evidence of lack of time.

Investigation

The mean mark held at 13·7. Many candidates failed to pick up relatively easy marks, such as references, titles contents and page numbers, diagrams and descriptions.

Areas in which candidates performed well

Examination

Question 1 (a) (i): Candidates are confident in using the relativity equation, although some did not realise a beta particle is an electron.

Question 1 (a) (iii): Weak force.

Question 2 (a) (i): Candidates are gaining confidence in calculus methods.

Question 2 (b) (i): Straightforward calculation of acceleration.

Question 3 (a) (i): SHM equation for displacement.

Question 3 (b) (iii): Conservation of angular momentum question.

Question 7 (a) (i): Calculation of wavelength of a photon.

Question 8 (a): Application of equation for the magnetic induction.

Question 9 (a) (i) – (iii) (b), (c): Good performance.

Question 10 (b): Applying the correct Doppler equation.

Areas which candidates found demanding

Question 2 (a) (ii): Higher proof — many poor attempts.

Question 2 (b) (ii): Difficulty in relating angular and tangential acceleration.

Question 2 (c) (i): Many failed to realise the significance of the horizontal component of F to provide the central force.

Question 3 (a) (ii): More practice in this type of problem required.

Question 3 (c) (ii): Looking for input of energy from diver. Work done in pulling his body inwards.

Question 4 (b) (ii): Many missed out the negative sign.

Question 4 (c): Many became bogged down with the maths. Candidates would benefit from more practice of this type of problem. This type of problem can also be applied to a point between two electric charges.

Question 5 (c): Disappointingly low marks — constant field between plates.

Question 6 (a) (v): To attain full marks, candidates must state that if v doubles, r doubles — or they are in direct proportion.

Question 7 (a) (ii): Definition of inductance poorly attempted.

Question 7 (b) (i): Many stated that the magnetic field strength increases but missed out that it levels off.

Question 7 (b) (iii): Poor attempts at graph — wrong trend scored zero marks.

Question 7 (c): Current changes OK — no mention of dependence on capacitive and inductive reactance.

Question 8 (b) (i): Many did not understand the interaction of the magnetic fields **between** the wires.

Question 8 (b) (iii): Many forgot to calculate the **weight per metre** of the wire.

Question 10 (a) (ii): Frequency increases **continually**, due to 'bunching up' of wavefronts. Many just gave the frequency increase due to the wavelength becoming less. No mention of continual decrease in wavelength.

Question 11 (b) (iii): Must name the measuring instrument to give the improvement. Improvement only required for Δx, not D.

Advice to centres for preparation of future candidates

Examination

- For questions where the numerical answer is given, or the derivation of a formula is required, the candidate must **show understanding by demonstrating all the required steps**. This might include quoting the required formula then showing the correct substitution or re-arrangement before leading to the required answer. This might also include retrieving the value of any physical constants, eg substituting the value of ε_0.

- Candidates would benefit from more practice of questions on null points between planets or charges. For example, there is no need to expand into a quadratic — just take the square root of both sides.

- Remind candidates that they should be careful how they answer 'explain' or 'describe' questions.

- Definitions should be committed to memory — with understanding.

Use of Data Booklet

Candidates should now be familiar with the use of the periodic table in the Data Booklet.

- **Candidates should not round off the data given until the last line of a calculation**, eg the mass of proton and neutron would be identical if rounded off to two decimal places.

- Remember to point out to candidates that moments of inertia and other information is on the page that follows the main equations in the Data Booklet.

- Remind candidates to take care when labelling graphs — **origin, quantities, units**.

- Know that the path of a charged particle in a magnetic field is dependent on the size of the charge and the mass of the particle.

- Care should be taken when substituting given quantities eg if $2{\cdot}29 \times 10^6$ m s^{-1} is substituted as $2{\cdot}92 \times 10^6$ m s^{-1} then this is not taken as a slip but is incorrect substitution.

- Hump-back bridge, diver on a springboard, trampolinist leaving surface, grain of sand on loudspeaker surface, etc can all be used as examples of problems related to conditions when 'the object just leaves the surface of contact'.

- Conservation of angular momentum problems — increase in rotational energy is due to the work done by skater, diver, trampolinist, etc.

- Candidates should know the significance of the terms 'capacitive reactance' and 'inductive reactance'.

- Avoid fractions in final answer. Candidates are advised to change calculator settings to give decimals.

- Ensure that the symbols used are those in the Data Booklet.

- **Question 10 (a) (ii) becomes an excellent teaching point question for the true understanding of Doppler. Care must be taken with the language used.**

Investigation

AH Physics Investigation comparison (2009–12)

Category		**Average mark per category**				
		Max mark	**Average score 2009**	**Average score 2010**	**Average score 2011**	**Average score 2012**
Introduction	Summary	1	0·7	0·7	0·8	0·7
	*Underlying physics	3	1·3	1·2	1·2	1·2
Procedure	Diagrams	2	1·3	1·2	1·1	1·1
	Description	2	1·3	1·2	1·2	1·1
***Level of demand**		2	1·1	1·0	1·0	1·0
Results	Data	1	0·9	0·9	1·0	1·0
	*Uncertainties	3	1·3	1·3	1·3	1·3
	Analysis	2	1·1	1·1	1·0	1·0
Discussion	Conclusion	1	0·8	0·9	0·8	0·8
	*Evaluation procedures	3	1.3	1·2	1·2	1·2
	*Investigation as a whole	2	0·8	0·7	0.6	0·7
Presentation	Title	1	1·0	1·0	1·0	1·0
	Clarity	1	0·9	0·9	0·9	0·8
	References	1	0.6	0·7	0.6	0.6
Mean mark		25	**14·4**	**13·8**	**13.7**	**13·7**

* Denotes quality (subjective) areas

Areas in which candidates performed well

Results

Uncertainties: Improvement in use of calibration, reading, random uncertainties and their combination, but for many candidates there is still significant room for improvement.

Analysis: Spreadsheet use increasing, good use of LINEST function to calculate the uncertainty in the gradient of a straight line.

Discussion

Conclusion: Most gained a mark for this.

Presentation

The majority of candidates gained two marks for the first two areas, although **some made it difficult for the Marker by grouping the diagrams, descriptions and results**. This caused a lack of ‘flow’ for the reader. It is better to follow the Outcome 3 structure for each of the experiments.

Areas which candidates found demanding

Investigation report (see page 9 for advice).

Introduction

Underlying physics: Again very few candidates scored full marks — justification of formulae required. Where possible, candidates should use their own language to describe/explain the theory. They should not just copy verbatim from textbooks/websites. This is an area where quality is rewarded.

Procedures

Diagrams: The image quality of photographs was often poor. Care should be taken to label photographs and **include normal diagrams for clarity**. **More care should be taken with photographs, especially with organising the background to ensure maximum clarity**. Circuit diagrams should be included where possible. Many diagrams were still disappointing this year, often lacking clarity and labelling.

Descriptions: Should be clear and to the point. The Marker should be able to replicate the experiment **exactly** by following the description. Values of variables were often omitted and how the variables were altered left to the imagination of the Marker.

Level of demand

In most cases, there should be three to four experiments attempted and **not just Coursework**.

Results

All relevant raw data should be recorded in the report, not just averages.

Uncertainties: Significant figures are still a problem, also inappropriate averaging used (see later). It is acceptable to use software to find the uncertainty in the gradient of a line.

A booklet on uncertainties is available at:
http://www.educationscotland.gov.uk/resources/nq/u/nqresource_tcm4229401.asp

Analysis: There has been an increase in the use of spreadsheet packages to produce graphs. **Although improving, there are still some issues with size, zero not shown, scaling, and grid lines too large or missing**. Spreadsheet packages will give dot-to-dot lines if not used properly. Hand-drawn graphs are better copied rather than scanned-in as these are often too small to read and analyse. Graphs should occupy a whole page and if drawn using software packages, should have major and minor gridlines for each axis. Lines should not be forced through the origin and trend lines should be checked.

Discussion

Evaluation of experimental procedures: There was a lack of reference to, and discussion of, uncertainties quoted in the experiment. Too much emphasis on 'better equipment' rather than considering procedures. Candidates should refer to their graphs and comment on what they show. There is usually little comment on which of the apparatus caused the poor results.

Evaluation of discussion as a whole: Candidates still find this difficult. Further work, frustrations, physics points, modifications, lost time, etc. Little evidence of reflection on procedures and findings. Too many candidates quoting a 'lack of time' as a reason why more readings were not taken.
(Quality areas)

Presentation

References: Cross-referencing is improving but a significant number of candidates are still failing to cite their references in the appropriate places within the body of the report. **References must be listed** at the end of the report. It is not enough to have the reference only quoted in a footnote at the bottom of the page. In addition, **book page numbers must be stated**, for example:

Duncan, Tom (1987) *A Textbook for Advanced Level Students* 2nd edition: John Murray.
page numbers (189–191).

Advice to centres for preparation of future candidates

Investigation

Guidance for both candidates and teachers/lecturers can be accessed through www.sqa.org.uk.

Each candidate should be given a copy of the Guidance to Candidates document.

Included in the Guidance to Teachers/Lecturers is the Markers' form AH6 which will allow staff to allocate marks for particular sections. This will assist candidates to improve the early draft of their report. Too many candidates fail to gain what should be 'easy marks' due to not having followed the advice.

Some centres had duplicate investigations (results different) despite having a small number of candidates. It is advised that, unless centres have a large number of candidates, duplicate investigations should be avoided. **There is a fair chance that the Investigation Unit from these centres will be verified next session.**

It is important not to just hand out old projects/investigations for viewing or triggering ideas, without ensuring that they are collected afterwards. It is better to use brief accounts of possible investigations so the candidates can research/plan these using appropriate references.

The investigation should normally comprise three to four related experiments. Only in exceptional circumstances will one or two be sufficient to cover the recommended time of 10–15 hours of experimental work.

Investigations that carried out the same procedures several times tended to score low marks, eg finding Young's modulus for five different materials using the same approach.

Data must be collected and not simulated.

Use of university facilities

It is pleasing to see schools using university support where possible. This not only gives the candidates experience of working in another environment, but also creates an opportunity for the universities to demonstrate the facilities available.

However, it must be said that if using these facilities for an investigation, this should not be seen as a quick fix so that the investigation can be completed with one or two afternoons of lab work. Some investigations have been well beyond the ability of the candidates and their reports have demonstrated a lack of understanding.

The high scoring 'university investigations' are clearly well planned in advance and have either introductory experiments done in school or a more specialised experiment attempted at university to round off the investigation.

There was some evidence of centres treating the candidates' visits to universities as a lab afternoon with technicians on hand to aid the students. Some experiments had tenuous links, which highlighted poor planning.

Some schools are sending out candidates to universities where the candidates then attempt identical investigations. This is not recommended and these cases may be considered under suspected malpractice. Centres are reminded that the Investigation must be the work of the individual candidate.

Investigation Unit Award

To pass the Unit award, the teacher must be satisfied that the candidates have passed Outcomes 1 and 2.

Centres should ensure that evidence for Outcomes 1 and 2 is kept in an investigation record. This record could well be required for verification. **Again, refer to latest guidance for teachers/lecturers**.

It is recommended that the following information on how the marking scheme is applied should be photocopied and distributed to the candidates.

Notes on Marking of Investigation		**Advice for Candidates**
No **half marks** are awarded throughout.		
Introduction		
Summary:	purpose	**Must** be at the beginning of the report, immediately following the content page.
	findings	Findings were often omitted. Findings should be consistent with purpose, eg comparison of different methods of measurement or stating numerical values with their uncertainties. **(1,0)**
Underlying physics:		**Not good enough to just give equations.** Physics behind the equations should be explained. Opportunity for Markers to reward commensurate/good investigations. Physics explained should be relevant to experimental procedures. **(3,2,1,0)**
Procedures		
Diagrams / descriptions		Generally well done. Increase in use of digital photographs. These must be clear and labelled. Apparatus/circuit diagrams should also accompany these. **(2,1,0)**
Apparatus use		Should include a detailed account of how all measurements were taken. Description should be clear enough to allow replication of experimental work. **(2,1,0)**
Level of demand		Centres should ensure that the Investigation is at an appropriate level. Basic Outcome 3 experiments alone are unacceptable. One might be used as an introductory experiment. Minimum of three to four procedures required – **in exceptional cases** one or two can be acceptable provided 10 to 15 hours experimental work is carried out. **(2,1,0)**
Results		
Data Most candidates awarded a mark here. *sufficient/relevant*		(Must show all readings taken — no short cuts to average). **(1,0)**
Uncertainties		Candidates should quote, where appropriate, calibration, scale reading and random uncertainty for each measurement made and combine these appropriately. Candidates were penalised for inappropriate use of random uncertainty (eg applied to different methods of finding refractive index) and for not finding the uncertainty in the gradient of a straight line graph, where required. (It is sufficient to show one example of each type of calculation involving data and the combination of uncertainties.) **(3,2,1,0)**
Analysis of data		Improvement in use of spreadsheet packages. Excel — use of LINEST good, but care should be taken with size of points. Still some problems — **lack of grid lines** for graphs, size of graphs, origin omitted, error bars missing where appropriate. Spreadsheets packages may be used to establish the equation of a straight line plus the uncertainty in the gradient and intercept. **Lines should not be forced through the origin.** **(2,1,0)**

Discussion		
Conclusion	**Must** relate to the purpose of the investigation.	**(1,0)**
Evaluation of Procedures	Not specific/detailed enough. Sometimes better to break down into [1]assessment criteria where applicable. Sources uncertainties ignored; no mention of limitations of equipment. Compare percentage uncertainties — comment on reduction of these. **Better at the end of each experiment.**	**(3,2,1,0)**
Evaluation of Investigation	Candidates had difficulty with this section. Very little mention of Investigation modifications and further improvements in sufficient detail. Describe difficulties, frustrations with problems encountered. **Should be at the end of the report.**	**(2,1,0)**
Presentation		
Title, contents, page numbers	Any one omitted — (0)	**(1,0)**
Readability	Write up experiments sequentially.	**(1,0)**
References	**Must** be cited in text, eg ref 1, ref 2, etc. Reference at back should not only list the book or website, but also the appropriate page number or date accessed so the Marker can easily check on these. References for diagrams alone not sufficient.	**(1,0)**

[1]See assessment criteria in Guidance on Course Assessment for Candidates, **available from SQA's website and should be issued to all candidates.**

Incorrect application of random uncertainty

For example: finding g using a pendulum.
Varying the length l and measuring the period T of the pendulum.
Different values of g were calculated for each l and T.
A mean value of g was calculated with associated random uncertainty. This is incorrect.
Allowance for random uncertainty in the measurement of time is made when measurements are repeated for one value of length.
A better way of finding g is to plot a graph of T^2 against l and then calculate the gradient of the line.

Investigations frequently classed as non-commensurate with AH

Output of a solar cell
Golf ball — basic bouncing experiments, Standard Grade angle of launch
Specific heat capacity — simple Standard Grade experiments with uncertainties included.
Efficiency of electric motor
Efficiency of a transformer
Investigations where no measurements were taken, eg making a hologram, construction of an electronic device
Impulse experiments
(Those listed were Higher or Standard Grade level with no real attempt at extension work.)

Popular investigations

Comparisons of different methods of measuring *g*
Comparisons of different methods of measuring refractive index
LCR circuits — factors affecting capacitance; factors affecting inductance
Measurement of magnetic field strength using a Hall probe
Stretched strings
Interference of light
e/m for an electron
Young's modulus
Surface tension, viscosity
Focal length of lenses
Speed of sound — comparison of different methods
Measurement of Planck's constant
Aerofoil lift

Statistical information: update on Courses

Number of resulted entries in 2011	1,757

Number of resulted entries in 2012	1,917

Statistical information: performance of candidates

Distribution of Course awards including grade boundaries

Distribution of Course awards	%	Cum. %	Number of candidates	Lowest mark
Maximum Mark 125				
A	35.3%	35.3%	676	81
B	23.4%	58.7%	449	69
C	20.5%	79.2%	393	58
D	7.8%	87.0%	149	52
No award	13.0%	100.0%	250	-

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.