External Assessment Report 2011

Subject	**Physics**
Level	**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 a small increase in numbers again this year.

Year	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Number of candidates	1,374	1,391	1,401	1,422	1,370	1,396	1,525	1,730	1,748

Again 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 fair with the vast majority of candidates making a good attempt at the paper. Some of the weaker candidates found the paper more demanding and struggled to complete all of the paper in the required time.

Excellent performances in the grade A questions indicates a strong cohort.

Investigation

The mean mark decreased from 13·8 to 13·7, which was slightly disappointing. There are still many candidates failing to pick up relatively easy marks.

Areas in which candidates performed well

Examination

On the whole, Unit 1 questions were well attempted by most candidates.

Question 1 (a)(i) — Very well done, although a few candidates quoted $E = m_o c^2$ and received no marks.

Question 1 (b)(i) — Most candidates attempted this ‘show’ question well, giving all the required steps. A few mixed-up the masses of the proton and neutron.

Question 6 (b) — Tackled well.

Questions 7 (b) (i) (ii) and (iii) are PS+ questions[1]. It was pleasing to see that candidates are now much more confident in the combination of uncertainties. This is a good problem to set for future classes.

Application of the Doppler equations was well attempted.

[1] ‘Problem Solving+’ questions

Areas which candidates found demanding

Question 1 (a)(ii) — Candidates selected the correct formula, but many failed to change the subject of the formula correctly. It is better to substitute first, including 3×10^8 m s^{-1} for *c*, and then change the subject.

Question 1 (c)(ii) — 10^{-14} m was often omitted.

Question 2 (a)(i) — incorrect formula for moment of inertia (I) often quoted from the Data Booklet.

Question 2 (a)(ii) — $I = mr^2$ was often omitted in this 'show' question.

Question 3 (a) — $\omega = 2\pi/T$ or equivalent must be given, otherwise no marks can be awarded.

Question 3 (c)(i) — $E_p = -GM_1M_2 /r$ must be given.

Question 3 (d) — Surprisingly, this part of the question was not done well. Lower ability candidates struggled here with the explanation in the change in frequencies.

Question 4 (a) — There was some confusion over the value of the amplitude.

Question 4 (e) — Many failed to realise that the period is unaffected.

Question 5 (a) — Charging by induction – 'Earth connection removed before the rod' was often not stated.

Question 5 (c) — More care required when drawing field lines. Most scored 1 out of 2 for the charge distribution.

Question 6 (a)(i) — Complete explanation required for full marks.

Question 6 (a)(ii) — $E = -12{\cdot}0$ V otherwise only a maximum of ½ mark was available for the equation.

Question 6 (a)(iii) — The definition of one henry was poorly done.

Question 6 (a)(iv) — Collapsing magnetic field produces large back emf. Key words often missing.

Question 6(c)(i) — Poor or no attempts made for the derivation of Doppler equation.

Question 7 (a)(i) — Some confusion over the explanation for this question — interaction of magnetic fields required for second mark.

Question 8 (a) — Derivation question — all steps are required. Individual equations must be stated.

Question 8 (b) — Poor understanding of helical motion and the components of velocity in relation to the magnetic field.

Question 8 (c) — Many did not understand the term ‘pitch’ of a helix.

Question 9 (a) — Failure to explain the 2D pattern resulted in many candidates scoring only 1 mark.

Advice to centres for preparation of future candidates

Examination

- For questions where the numerical answer is given or the derivation of a formula (show question) is required, the candidate must show understanding by demonstrating all the required steps. This might include quoting the required formula then making 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_o.
- Definitions — check those listed in the content statements. These should be committed to memory, with understanding.
- Candidates should realise that moments of inertia relationships, along with other information, are on page 8 of the Data Booklet, which is the page following the main equations.
- Data retrieval — ensure candidates do not mix-up the masses of a proton and neutron.
- Experimental descriptions — ensure all steps are given in the correct order, eg charging by induction.
- Field diagrams — more practice required and care taken over the shape.
- Full explanation of the production of a back emf needs revisited when both making and breaking a circuit.
- Doppler derivation not fully understood.
- Force between two conductors. Candidates should be able to explain why this force exists in terms of interaction of magnetic fields.
- Uncertainties — Question 7 (b)(i), (ii), (iii) may be given as practice when attempting an experimental report.

Investigation

AH Physics Investigation Comparison (2009, 2010 and 2011)

Average mark per category

Category	**Max mark**	**Average score 2009**	**Average score 2010**	**Average score 2011**
Introduction Summary	1	0·7	0·7	0·8
***Underlying physics**	3	1·3	1·2	1·2
Procedure Diagrams	2	1·3	1·2	1·1
Description	2	1·3	1·2	1·2
***Level of demand**	2	1·1	1·0	1·0
Results Data	1	0·9	0·9	1·0
***Uncertainties**	3	1·3	1·3	1·3
Analysis	2	1·1	1·1	1·0
Discussion Conclusion	1	0·8	0·9	0·8
***Evaluation procedures**	3	1·3	1·2	1·2
***Investigation as a whole**	2	0·8	0·7	0·6
Presentation Title	1	1·0	1·0	1·0
Clarity	1	0·9	0·9	0·9
References	1	0·6	0·7	0·6
Mean mark		**14·4**	**13·8**	**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 — there are still many candidates not quite achieving the standard.

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. Better to follow the Outcome 3 structure for each of the experiments in turn.

Areas which candidates found demanding

Investigation report (see page 7 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: Poor image quality photographs were produced — perhaps with mobile phone. Care should be taken to label photographs **and include normal diagrams for clarity**. Some diagrams were poorly drawn using the Word drawing package. Hand-drawn diagrams clearly labelled are acceptable. Several diagrams were disappointing this year — lacked clarity and labelling — reflected in drop in average mark.

Descriptions: Should be clear and to the point. 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: There should be three to four experiments attempted which are **not just coursework**.

Results

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

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

Uncertainties booklet available on:

http://www.ltscotland.org.uk/resources/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 not be forced through the origin and trend lines should be checked.

Discussion

Evaluation of experimental procedures: lack of reference to, and discussion of, uncertainties quoted in the experiment. Too much emphasis on saying 'better equipment', rather than considering procedures. Refer to graphs and comment on what they show. Little comment on which of the apparatus caused the poor results. Students often confuse accuracy and precision.

Evaluation of discussion as a **whole**: students still find this difficult. Further work, frustrations, physics points, modifications, lost time, etc. Little evidence of reflection on procedures and findings.

(Quality areas)

Presentation

References — cross-referencing improving. References must be listed at the end of the report. **Book page numbers must be stated**.

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. Centres are advised not to have duplicate investigations unless they have a large number of candidates, where duplication of topics may be necessary. **There is a fair**

chance that the investigation Unit from centres with low numbers of candidates and duplicate investigation topics will be verified next session.

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

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

Use of university facilities

It is pleasing to see schools using university support where possible. This not only gives the students 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 investigation topics are well beyond the abilities of the candidates and their reports demonstrated a lack of understanding.

The high-scoring 'university investigations' are clearly well planned 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 universities treating the students' visits 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 pupils to universities and the pupils are attempting identical investigations. This is not recommended and these cases may be considered under suspected malpractice.

Investigation Unit award

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

Centres should ensure that evidence of Outcomes 1 and 2 is kept in an investigation **record**.

This **record** could well be required for verification. **Again refer to the 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 sufficient/relevant		Most candidates awarded a mark here. (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 of 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

Advanced Higher

Number of resulted entries in 2010	1,736

Number of resulted entries in 2011	1,757

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	35·4%	35·4%	622	87
B	22·7%	58·1%	399	74
C	21·1%	79·2%	371	62
D	7·2%	86·5%	127	56
No award	13·5%	100·0%	238	-

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.