External Assessment Report 2010

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

Number of candidates

- 2003: 1374
- 2004: 1391
- 2005: 1401
- 2006: 1422
- 2007: 1370
- 2008: 1396
- 2009: 1525

2010: 1730

2010 has therefore seen yet another increase in AH Physics numbers. Credit must go to the Physics teaching staff who run these classes, quite often with a reduced time allocation.

Comments on candidate performance

General comments

Examination

The paper was seen as fair, with the vast majority of candidates making a good attempt at the paper. There was no evidence of lack of time. Excellent performances in the Grade A questions indicated a strong cohort.

Investigation

The mean mark decreased from 14.4 to 13.8, which was slightly disappointing.

Areas in which candidates performed well

Examination

- Question 1 (b): good start to the paper — uncertainties were well done.
- Questions 2 (a), (c): centripetal force handled well.
- Questions 3(a), (b): no great difficulty with finding angular acceleration from the graph.
- Question 4: good grasp of application of conservation of angular momentum.
- Questions 6 (a), (b): well done, despite being an unfamiliar style of question.
- Questions 7 (b), (c): good understanding shown.
- Questions 8 (c)(i), (ii): although problem solving, both of these were tackled very well.
- Question 8 (d): good question, good response.
- Questions 9 (a), (b): no great difficulty here.
- Question 10 (d)(i): candidates called on their previous knowledge to tackle this well.
- Question 11 (b): no difficulty here.

Areas which candidates found demanding

- Question 1 (a): to achieve full marks in derivations or 'show' questions, each step must be shown explicitly. Candidates are missing out basic steps that they probably know but do not write down.
- Question 2 (b): many did not know, or were unable to derive, the tan θ expression in relation to the model aircraft.
- Question 3 (c): the kinetic energy of the falling mass was often omitted. The average score for this question was 0.7 out of 4.
- Question 4 (a): definition of conservation of angular momentum — poor attempts.
- Question 5 (a): $a = -\omega^2 y$ — the negative sign was often missing.
- Question 5 (c): to obtain full marks, the candidate had to state $v = dy/dt$ and then differentiate the cos or sin term successfully.
- Question 6 (c)(ii): many mixed up their sin and cos depending on the angle chosen to attain the vertical component.
- Question 7 (a): many gave the wrong direction in what should have been a 50:50 choice.
- Question 7 (d)(ii): care should be taken with squaring in a formula — this was quite often omitted.
- Question 7 (e): candidates did not read the question in relation to changes that must be made to the magnetic field.
- Question 8 (a): a surprising number came up short on this one — these are basic Higher equations.
- Question 8 (b)(i): the curved path is produced by two components — the vertical and the horizontal velocities. The majority of candidates missed out any reference to the horizontal component.
- Question 8 (c)(ii): many took the wrong distance (10.0 mm) to find the time between the plates.
- Question 9 (c): still difficulties with $I \propto A^2$.
- Questions 10 (a), (b): very few attained full marks in these explanation/derivation questions. Candidates should not expect the Marker to read minds and plug gaps in the answers given.
- Question 10 (c): poor response on this one — a good question to find the 'next thinnest coating'.
- Question 11 (a): there are still many dropping silly marks here.
- Question 11 (b)(ii): some only gave 'take one reading of I, I_0 and θ'. Many decided to substitute into the equation to 'see if it works'. Incorrect graphs of I vs θ, I vs Cos θ were suggested.

Investigation report

Introduction

- Underlying Physics: again very few candidates scored full marks — justification of formulae is 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.
- Several diagrams were disappointing this year, lacking clarity and labelling, and this is reflected in the drop in average marks.
- Descriptions should be clear and to the point. Markers should be able to replicate the experiment **exactly** by following the description. Values of variables were often omitted, and how the variables were altered was left to the imagination of the Marker.
- Level of demand: there should be three or four experiments attempted and not just Course work. Several candidates included too many that can be considered Course work.

Results

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

- Uncertainties: significant figures are still a problem, with inappropriate averaging used (see below).
- It is acceptable to use software to find the uncertainty in the gradient of a line. The uncertainties booklet is available at: 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.

Discussion

- Conclusion: most gained a mark for this.
- Evaluation of experimental procedures — lack of reference to and discussion of uncertainties quoted in the experiment.
- Evaluation of discussion as a **whole** — students still find this difficult. Further work, frustrations, physics points, modifications, lost time, etc.

Presentation

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

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 also include retrieving the value of any physical constants, eg substituting the value of ε_0.
- More practice on conical pendulum, banked track for cars, bicycles and aircraft banking.
- Practice problems on involving the conversion of potential energy to linear and rotational kinetic energy, eg cylinder rolling down a slope, flywheel.
- Definitions should be committed to memory — with understanding.
- Use of data booklet: (a) candidates should now be familiar with the use of the periodic table in the data booklet; (b) they should not round off the data given until the last line of the 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.
- Care should be taken over 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 — realise which has the greatest effect.
- Care is required over the understanding of interference by division of amplitude with regard to thin films.
- Procedures describing unfamiliar experiments can still be attempted using basic rules of experimental technique, eg identifying and stating how the variables are measured. There should be at least five data points with adequate repetition of each one.
- Relationships between the variables can be verified by plotting the appropriate graph.

Investigation

2009–10 AH Physics Investigation: comparison of average marks per category

Category	Maximum mark	Average score (2009)	Average score (2010)
Introduction			
Summary	1	0.7	0.7
***Underlying Physics**	3	1.3	1.2
Procedure			
Diagrams	2	1.3	1.2
Description	2	1.3	1.2
***Level of Demand**	2	1.1	1.0
Results			
Data	1	0.9	0.9
***Uncertainties**	3	1.3	1.3
Analysis	2	1.1	1.1
Discussion			
Conclusion	1	0.8	0.9
***Evaluation procedures**	3	1.3	1.2
***Investigation as a whole**	2	0.8	0.7
Presentation			
Title	1	1.0	1.0
Clarity	1	0.9	0.9
References	1	0.6	0.7
Mean mark		**14.4**	**13.8**

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 for candidates.
- Included in the guidance to teachers/lecturers is the Markers' form AH6 which will allow staff to allocate marks for particular sections. This will help candidates 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 (with different results) despite having a small number of candidates. Given the range of possible investigation topics, duplicate investigations should only be necessary in centres with large cohorts. There is a fair chance that the investigation Unit from centres with small cohorts using duplicate investigations 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.
- Markers commented that several investigations involved carrying out only one or two experiments — the majority of these investigations attained a very low mark.
- The investigation should comprise three or 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 using these facilities for an investigation should not be seen as a quick fix, so that the investigation can be completed with one or two afternoons of lab work.

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 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 out pupils to universities and the pupils are attempting identical investigations. This is not recommended, and these cases may well be referred 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.

Summary: 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 3 to 4 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 assessment criteria[1] 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 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 — zero marks if any one omitted. **(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 *Course Guidance for Candidates*, which is available from the SQA website and should be issued to all candidates.

Incorrect application of random uncertainty

- Eg 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 2009	1550
Number of resulted entries in 2010	1736

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	34.9%	34.9%	605	87
B	22.3%	57.1%	387	74
C	20.7%	77.8%	359	61
D	8.5%	86.3%	148	54
No award	13.7%	100.0%	237	–

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.