External Assessment Report 2014

Subject(s)	Physics
Level(s)	AH - Revised

The statistics used in this report are prior to the outcome of any Post Results Services requests

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:

2013: 62
2014: 133

Examination

The paper was accessible to candidates, although the last two questions required quite a lot of reading. Some candidates found time an issue with these questions.

Open-ended questions were included, and the balance of the paper tended to be more skills-based compared with the traditional paper.

There were 49 marks of common questions in the revised and traditional papers. Detailed analysis of performance in common questions allowed some comparison of cohorts.

Investigation

The traditional and revised Investigation requirements are identical, with markers going through the same training.

The mean mark for the Investigation decreased from 15.23 to 13.36. This was disappointing since the mean mark for the traditional candidates had increased from 13.7 in 2013 to 14.5 in 2014, although this must be considered alongside the fact that it is still a small cohort.

2014 AH Physics Investigation mean mark per category

Category	Max Mark	Mean Score 2013	Mean Score 2014
Introduction Summary	1	**0.8**	**0.6**
***Underlying Physics**	**3**	**1.3**	**1.2**
Procedure Diagrams	2	**1.2**	**1.1**
Description	2	**1.3**	**1.1**
***Level of Demand**	**2**	**1.4**	**1.0**
Results Data	1	**1.0**	**0.9**
***Uncertainties**	**3**	**1.5**	**1.3**
Analysis	2	**1.2**	**1.0**
Discussion Conclusion	1	**0.8**	**0.8**
***Evaluation procedures**	**3**	**1.5**	**1.3**
***Investigation as a whole**	**2**	**0.7**	**0.7**
Presentation Title	1	**1.0**	**1.0**
Clarity	1	**1.0**	**0.9**
References	1	**0.7**	**0.5**
Mean Mark		**15.2**	**13.4**

For the following advice, you should refer to the examination paper and marking instructions which can be downloaded from: http://www.sqa.org.uk/sqa/48232.html

Areas in which candidates performed well

Examination

3(a)(iii) Good response, candidates remembered to calculate the radius of the exoplanet for 1 mark.

3(b) Candidates did well with this question testing unfamiliar physics.

4(a)(ii) Calculating the Schwarzchild radius was well done by candidates.

4(b) Good understanding of Hertzsprung-Russell diagram.

4(c)(i) Candidates did well in the handling of the equation for luminosity.

6(a) Wave particle duality or equivalent was often quoted correctly.

8(b) Most candidates remembered to halve the 0.14 m.

9(a) This was an easy question with 50:50 chance of correct answer.

9(b)(ii) Candidates had a good grasp of uncertainties.

11(a)(ii) Candidates demonstrated a good understanding of polarisation.

13(a) Mostly done well with the correct shape – some dropped ½ mark for omitting the origin.

Open-ended questions mean marks:

No 5	1.49
No 14	1.59

Investigation

Results

Uncertainties: Improvement in use of calibration, reading, random uncertainties and their combination.

Analysis: Spreadsheet use increasing, good use of LINEST function to calculate the uncertainty in the gradient of a straight line. It would be beneficial if candidates explained or highlighted the LINEST data.

Discussion

Conclusion: most gained a mark for this with clear links to the aim of the investigation.

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, description and results. This caused a lack of 'flow' for the reader.

- Contents and page numbers — excellent.
- Clear and concise — almost all candidates produced clear and concise reports.
- References — most were at the end **and** also cited in the text — mainly in 'Underlying Physics'.

Areas which candidates found demanding

Examination

1(a) A 'show' question – many candidates chose a poor starting point. Each calculus step should be clearly stated – the marking instructions demonstrate this.

2(a) An incorrect formula for the moment of inertia was often selected.

2(b) Good question but many failed to realise that potential energy was converted to rotational **and** linear kinetic energy.

6(d)(i) Description of the Bohr model of the atom was poor.

7(b)(ii) Candidates often omitted the vertical component, v**sinθ.**

10(a) & (c) Candidates demonstrated a poor understanding in basic optical phenomena.

12(b) This part was very badly attempted. It would appear, from the responses, that many candidates had not covered this in the syllabus.

Investigation

Introduction

Underlying Physics: again very few candidates scored full marks — derivation of formulae was often not given. No cross-referencing given linked to references at the back of the report. Symbols were often not defined.

Procedures

Diagrams: the image quality of photographs was often poor — perhaps because they were taken with a mobile phone. Care should be taken to label photographs and include normal diagrams for clarity. Several diagrams were still disappointing this year — lacking clarity and labelling. Circuit diagrams were often not included. Some candidates used snapshots from a Smartboard of hand drawn diagrams / theory. This is not advisable since the final product was very poor quality.

Descriptions: these were often not clear and to the point. A marker should be able to replicate the experiment **exactly** by following the description. The range of the variables was often omitted. No mention of how each quantity is measured and what equipment was used.

Level of demand: some candidates had attempted just two experiments, plus another that was only at Higher standard.

Uncertainties: significant figures are still a problem, also inappropriate averaging is still being used.

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, grid lines too large or missing and units missing or incorrect.

Graphs should not be forced through the origin and trendlines should be checked. The use of LINEST will see a drop in time spent on estimating the uncertainty in a gradient. Some candidates using LINEST do not seem to know the significance of its use.

Discussion (Quality areas)

Evaluation of experimental procedures: there was a lack of reference to and discussion of uncertainties quoted in the experiment.

Evaluation of discussion as a whole: students still find this difficult – it could cover further work, frustrations, physics points, modifications, lost time, etc. There is little evidence of reflection on procedures and findings.

Advice to centres for preparation of future candidates

Examination

Mark allocation

- **3 or 4 marks** will generally involve more than one step or several points of coverage.
- **2 marks** will involve just one use of an equation or a couple of descriptive points.

Use of data sheet

- Clearly show the substitution of a value from the data sheet. For example, do not leave μ_o in an equation, show the substitution $4\pi \times 10^{-7}$ in your equation.
- Rounding – do not round the given data sheet values, eg mass of a proton = $1{\cdot}673 \times 10^{-27}$ kg **not** $1{\cdot}67 \times 10^{-27}$ kg.

'Show' questions

- Generally **all steps** for these must be given, including the final answer, even although they might seem obvious. Do not assume that substitutions are obvious to the marker.
- All equations used must be stated separately and then clearly substituted if required. Many candidates will look at the end product and somehow end up with the required answer. The marker has to ensure that the path to the solution is clear. It is good practice to state why certain equations are used, explaining the Physics behind them eg derivation of escape velocity - $E_k + E_p = 0$ as a starting point.

Calculus — equations of motion

- $s = f(t)$
  Be clear that differentiating once gives the velocity, differentiating twice gives the acceleration.
- $a = f(t)$
  Integrating once gives the velocity, integrating twice gives the displacement. Remember to take into account the constant of integration each time by considering the limits.

Definitions

Know and understand definitions given in the course. Definitions often come from the interpretation of an equation.

Diagrams

Use a ruler and use appropriate labels. Angles will be important in certain diagrams. On no account should ray diagrams be drawn freehand.

Graphs

- Read the question and ensure you know what is being asked. Label graph axes correctly (quantities and units) and do not forget to label the origin.
- Rearranging equations in the form of $y = mx + c$ so a suitable graph can be plotted to obtain the gradient is an essential mathematical skill in AH physics.

Explain / Descriptive questions

- These tend to be done poorly. Ensure you have covered all points and read over it again to check there are no mistakes. Try to be clear and to the point.

Uncertainties

Ensure you are comfortable with those listed below:

- Systematic, scale reading (analogue and digital) and random uncertainties.
- Percentage / Fractional uncertainties
- Combinations - Pythagorean relationship
- Absolute uncertainty in final answer (give to one significant figure)

Uncertainties booklet is available at:
http://www.ltscotland.org.uk/resources/u/nqresource_tcm4229401.asp

Experiment Descriptions

- 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.

Unfamiliar Questions

- You might be given a relationship that you have not seen before. Don't panic; use your problem solving skills to attempt the question.

Incorrect units

- Marks were regularly dropped this year for incorrect units for **torque, moment of inertia, angular acceleration, linear acceleration** and **angular momentum**.
- Units should be checked, if there is time, at the end of the exam.

Prefixes

- Candidates will be penalised for incorrect conversions of units. It is also better not to make a final step of say, converting an answer from m to nm, unless of course this is a requirement. Candidates will be penalised for the incorrect final line.

Open-ended questions

- Candidates improve in performance with practice. It is very easy to spend too much time on these (worth 3 marks). Examiners are not looking for an essay.

Investigation

Guidance for both candidates and teachers / lecturers can be accessed at http://www.sqa.org.uk/sqa/3206.html

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

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 should only be necessary to have candidates carrying out the same or similar Investigations where the centre has a large cohort.

- **It is important not to just hand out old 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 which duplicate procedures tend 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 quick fix so that the Investigation can be completed with one or two afternoons' lab work. Some are well beyond the ability of the candidates and their reports have demonstrated a lack of understanding. Quite often candidates are just following instructions from worksheets prepared by the University.

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 out pupils to universities and the pupils are attempting 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

http://www.sqa.org.uk/sqa/files_ccc/PhysicsAHRevised.pdf Pages 54 -60

For the candidate to pass the Unit award, the teacher/lecturer 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.

AH Physics Investigation Advice

Every year candidates throw away what should be ‘easy’ marks by being careless in their report. The advice below can be used as a checklist to ensure maximum marks in the Investigation.

Introduction (4 marks)

Summary (1 mark)

The **purpose** and **findings** should be clearly set out so that someone reading the report clearly sees what lies ahead.

The experiments attempted should be clearly listed and the numerical results, including uncertainties, given where appropriate.

Underlying Physics (3 marks)

Here the candidate must demonstrate a good understanding of the theory. The theory must be relevant to the experiments that follow. All terms used should be clearly defined. Derivations should be shown and **cross referenced** linking to the reference list at the back. Equations should not be plucked out of thin air. Care should be taken not to cut and paste from references. It is also better to cover the theory for all experiments in this section. This area gives the markers an opportunity to reward quality.

Procedures (6 marks)

It is surprising how many students drop marks needlessly in the next two sections. With a bit of care all should attain 4 marks for the diagrams and descriptions of how the apparatus is used. Anyone reading the next two sections should be able to repeat the experiments with the detail given. References should be given for any specialised equipment.

Diagrams (2 marks)

There is an increase in the number of digital photographs, but unfortunately, in many cases, they add nothing to the description of the experiment. **Do not include a photograph if it is not good quality.**

The background should be uncluttered. It might be an idea to illuminate the apparatus to aid clarity. A satisfactory photograph showing clear detail **should be labelled**.

Labelled circuit diagrams should be also be drawn where appropriate.

A labelled schematic diagram will also help clarify the set up.

Description (2 marks)

A clear account of the procedures should be given. Many candidates omitted the range of readings used, the number of repetitions made and the apparatus used to take measurements.

Someone reading the description should be able to replicate the experiment **exactly**.

Although not penalised, the confusion in the use of meter and metre was widespread!

Level of Demand (2 marks)

There should be three or four experiments attempted corresponding to 10 -15 hours labwork.

Results (6 marks)

Data (1 mark)

Candidates must show all readings and not just the mean values.

Uncertainties (3 marks)

Although the manipulation of uncertainties seems arduous, it is important. All experimental Physicists must quote the confidence in their measured values.

Candidates must quote, where appropriate, **calibration, scale reading and random uncertainty** for measurements taken. They should then be combined appropriately.

An example showing how one set of results is combined will be sufficient.

Final absolute values in uncertainties should be clearly stated and shown on a graph as error bars, if possible.

Analysis of Data (2 marks)

Advantage should be taken of spreadsheet packages to analyse and present data.

All candidates should be familiar with the use of Excel and the LINEST function (or equivalent). LINEST provides a quick method of finding the gradient of a straight line and its uncertainty.

Candidates should show the process of using LINEST using selected cells.

Major and minor gridlines should be shown and graphs should be half page size minimum. The points should be small and error bars should be drawn if possible. The origin should be shown where appropriate.

Straight lines should not be forced through the origin.

All teachers should become familiar with Excel and the LINEST function in plotting and analysing graphs.

Discussion (6 marks)

Conclusion (1 mark)

This must relate to the overall aim of the investigation.

Evaluation of Procedures (3 marks)

This is probably better given at the end of each experiment. The candidate should look at the individual uncertainties and decide on the factor that has had the greatest effect on the readings. They should then suggest improvements. Account should be taken of the plotted graphs and any rogue points should be highlighted.

This is a quality area and candidates should take into account as many factors as possible and suggest improvements to the procedure. It might be that the experiment has systematic uncertainties or indeed is flawed.

Alternatively, the experiment might be successful, but the candidate should highlight the reason(s) for this.

Candidates should refer to graphs, percentage uncertainties and comment on what they show.

Evaluation of Investigation (2 marks)

This should be at the end of the report.

Candidates have difficulty with this section. An overall evaluation of the report should be given here.

Any frustrations / difficulties encountered should be given. How these were overcome – what improvements / modifications were made? What was gained from carrying out the Investigation?

Try not to repeat anything that was included in the evaluation of procedures.

State any further work that might be investigated.

Presentation (3 marks)

Title, contents and page numbers must be given. (1 mark)

Readability (1 mark)

Experiments should be written up sequentially. Diagrams and descriptions **should NOT be grouped together.** Avoid using appendices if possible.

References (1 mark)

These must be cross referenced in the text — normally in the Underlying Physics section.

Books: The book title, edition, author and page number should be given eg [1]Tom Duncan, A Textbook for Advanced Level Students, 2nd Edition, pages 228 - 229.

Websites: The full URL of the actual page which contains the information should be given and not simply the homepage of the website. Include the date you accessed the material eg [2]http://en.wikipedia.org/wiki/Young's_modulus accessed on 10/12/2013

Investigation Selection

Candidates tended not to attain a high Investigation mark if any of the following were chosen as a main experiment:

- Wind turbines – plastic vanes, adjustable angle, vary number of vanes etc.
- Snell's Law
- Measurement of g using a falling ball
- Speed of sound using two microphones
- Clap – echo method to measure the speed of sound.
- Focal length of a lens using light from a window and screen.

The level of demand for these is not AH level and these experiments should only be used as 'additions' to demonstrate handling of uncertainties**.** It would seem acceptable to include these, **with a good uncertainty treatment**, if the other three experiments are of the appropriate standard.

Statistical information: update on Courses

Number of resulted entries in 2013	62

Number of resulted entries in 2014	133

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	29.3%	29.3%	39	87
B	23.3%	52.6%	31	74
C	15.8%	68.4%	21	62
D	7.5%	75.9%	10	56
No award	24.1%	-	32	-

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.