Course report 2019

Subject	Physics
Level	Advanced Higher

This report provides information on candidates' performance. Teachers, lecturers and assessors may find it useful when preparing candidates for future assessment. The report 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 assessment documents and marking instructions.

The statistics used in this report have been compiled before the completion of any post-results services.

Section 1: comments on the assessment

Question paper

The majority of questions performed as expected, although two questions proved more difficult than anticipated.

Question 3(b)(i)	It was expected that candidates would be able to explain that the decrease in the moment of inertia of the gymnast when making a pike position is due to the redistribution of the gymnast's mass closer to the axis of rotation. The explanation of many candidates, however, was based upon a reduction in l, from the relationship $I = \frac{1}{3}ml^2$ used in question 3(a), when the gymnast was in a straight position and could be approximated as a uniform rod. This resulted in many candidates not being awarded the mark for this question.
Question 11(b)(ii)	It was expected that candidates would be able to determine the displacement of the tin at the point the coin just loses contact with the lid by substituting the value they stated in response to question 11(b)(i) into the relationship $a = -\omega^2 y$. Many candidates, however, did not select the appropriate relationship. In addition, a number of candidates did not state a value in response to question 11(b)(i), which could have been carried forward to question 11(b)(ii).

Grade boundary marks were adjusted to take account of the above points.

Project

The project performed as expected.

Section 2: comments on candidate performance

Areas that candidates performed well in

Question paper

Question 1	Many candidates were able to differentiate and to integrate the given relationship for the velocity of the rocket, and to substitute values to determine the required time and distance.
Question 2(a)(i)	Almost all candidates were able to calculate the centripetal force acting on the pod.
Question 2(b)(ii)	Many candidates correctly stated and justified the effect of the given change on the angle θ.
Questions 3(a), (b)(ii)	Almost all candidates were able to show the value of the moment of inertia of the gymnast, and to use the principle of conservation of angular momentum to determine angular velocity.
Question 5(b)	Many candidates were able to correctly calculate the value of gravitational potential.
Questions 6(b)(i), (ii)	Almost all candidates were able to use the given spacetime diagram to identify the accelerating object, and to draw a world line representing a stationary object.
Questions 6(c)(i), (ii)A	Many candidates were able to substitute the correct values into the given relationships to determine the mass of the black hole and to calculate the angle of deflection of a ray of light.
Question 7(a)(i)	Almost all candidates were able to identify a red giant on a Hertzsprung-Russell diagram.
Questions 7(b)(i), (ii)	Many candidates were able to correctly calculate the luminosity and the surface temperature of Betelgeuse.
Questions 10(a)(i)A, B	Many candidates were able to correctly calculate the magnitude of the magnetic force acting on the alpha particle and the radius of its circular path.
Question 11(a)(ii)	Many candidates were able to correctly calculate the maximum kinetic energy of the tin.
Question 12(b)(i)	Almost all candidates were able to substitute the correct values into the given relationship to calculate a value for the speed of sound.
Question 13(b)	Many candidates correctly stated and justified the effect of change of colour on the fringe separation.

Question 14(a)(i)	Many candidates were able to show the value for electrical potential.
Question 14(b)	Many candidates correctly stated and justified the effect of the movement of the iris on electrical potential at the electrode.
Question 15(b)(ii)	Almost all candidates were able to substitute the correct values into the given relationship to calculate a value for the drift velocity.

Project

Abstract	A large number of candidates clearly stated the aim(s) and findings of their project.
Procedures	Most candidates were able to describe the apparatus and procedures they used in their project. A number, however, did not include labelled diagrams and/or photographs of sufficient clarity, and did not describe their procedures in past tense passive voice.
Results	Almost all candidates produced raw data, which was sufficient and relevant to the aim(s) of their project. Many candidates showed an awareness of scale reading, random and calibration uncertainties, and an ability to combine them to estimate the uncertainty in a measured value. The combination of uncertainties in measured values to find the uncertainty in a derived value was also well done.
Discussion:	A large number of candidates were able to write a conclusion that was valid and related to the aim(s) of their project. An encouraging number of candidates gained the mark for the quality of the project. This mark is intended for a report that indicates a good, competent project, well-worked through.
Presentation	Most candidates' project reports were structured appropriately, with title, contents page and page numbers. Only a very small number of candidates were penalised for exceeding the maximum word count. Many candidates produced a high-scoring report, with a word count substantially less than the maximum allowed.

Areas that candidates found demanding

Question paper

Question 5(a)	Only a small number of candidates were able to state the meaning of a gravitational potential of -1·70 × 10^9 J kg^{-1}.
Question 5(c)	A number of candidates incorrectly determined the change in potential energy by calculating $E_{p(A)} - E_{p(B)}$, rather than $E_{p(B)} - E_{p(A)}$.
Question 6(c)(ii)B	Only a small number of candidates were able to sketch a line showing the variation of the angle of deflection with distance from the centre of the Sun.
Questions 7(a)(ii)A, B	Many candidates were unable to state the change in fusion reactions, and explain the increase in diameter, when the Sun leaves the main sequence.
Question 10(b)	Many candidates were unable to explain the reasons for the helical path followed by charged particles travelling in a magnetic field.
Question 11(b)(i)	Only a small number of candidates were able to state the magnitude and direction of the acceleration of the tin when the coin loses contact with the lid.
Question 12(a)(ii)	Many candidates were unable to describe the effect of increasing its frequency on the loudness of the sound.
Question 12(c)(iii)	Only a small number of candidates were able to suggest a possible source of a systematic uncertainty.
Questions 13(c)(i), (ii)	Many candidates did not select the relationship $\textit{optical path difference} = n \times \textit{geometrical path difference}$ In addition, only a small number of candidates were able to determine the optical path difference between rays at the given point of destructive interference.
Question 15(b)(iii)	Many candidates were unable to fully explain why the drift velocity remains constant when the magnetic induction is increased.
Question 16(b)(ii)	Many candidates were unable to correctly state and justify which ammeter shows the greater reading.

Project

Introduction	Although an improvement on previous years, a number of candidates did not give an account of the physics behind their project in sufficient depth or at the appropriate level. To score well in this section, candidates are required to demonstrate an understanding of the physics behind their project. In a number of cases, relationships were stated with symbols not defined, or relationships were used without an attempt at justification. A smaller number of candidates attempted to reproduce justifications from referenced sources, but made a number of errors when doing so.
Procedures	Only a minority of candidates gained full marks in the 'level of demand' section. In some cases, the experimental procedure was not at a level appropriate for Advanced Higher. Some candidates' procedures involved the use of the same experimental arrangements to measure different variables with a limited range of variables and a small number of repetitions. The experimental phase of such projects did not have an appropriate level of demand.
Results	Only a small number of candidates gained full credit in the 'analysis' section. To score well in this section, candidates are required to show an analysis of their raw data that is appropriate to their project. A small number of candidates did not include their raw data, showing mean values only. To gain credit, all data should be included in the report. Some candidates did not use a graphical analysis where it would be appropriate to do so, but produced a final value by averaging a number of results, which had been obtained using different values of the independent variable. Such analysis is incorrect. A number of candidates produced graphs using Excel or similar software packages, which were not of an appropriate size, did not include both major and minor gridlines, and used symbols to mark data points that were excessively large. Any graphs included in project reports should have sufficient clarity to allow the reader to check that data points are plotted accurately. A number of candidates did not lay out their analysis clearly. Including sample calculations can clarify for the reader how the data is being analysed.
Discussion	A number of candidates did not evaluate their experimental procedures in sufficient depth to score well, focusing rather on superficial 'the experiments went well' or 'could have used better equipment' evaluation. Candidates should identify the dominant sources of uncertainty and suggest how these uncertainties may be reduced; or comment on the adequacy of repeated readings, or on the range over which independent variables were altered.

Similarly, in many cases the discussion and evaluation of the project as a whole lacked any depth, and in some instances included repetitions of points made in previous evaluations of procedures.

Presentation	Only a minority of candidates listed and cited references to at least three sources of information in either Vancouver or Harvard style.

Section 3: preparing candidates for future assessment

Question paper

Candidates were, in general, well prepared for the question paper, and showed a good understanding of the majority of the concepts tested. Questions assessing candidates' ability to use relationships to determine values were well done, as were 'must justify' type questions, in which candidates must make and justify a statement using relevant and correct physics. 'Show' type questions — both those requiring candidates to select an appropriate relationship, substitute values and state the final answer, and those requiring an equation to be derived — were also done well. Candidates should be reminded, however, that in 'show' type questions, an appropriate relationship, usually selected from the relationships sheet, must be explicitly stated.

In answering numerical questions, candidates should be discouraged from rounding numbers prior to the final answer (intermediate rounding). Candidates should also be strongly discouraged from including a penultimate line to their working, showing an unrounded or truncated final value. A number of candidates rounded incorrectly, or truncated the number, leading to errors in the final answer, resulting in the mark for the final answer not being awarded. The final answer should be in decimal form, rounded to the appropriate number of significant figures. Candidates should be strongly encouraged to show only the selected relationship, the substitution of values, and then the final answer, including units, with the appropriate number of significant figures.

In class, candidates should be given opportunities, either verbally or in writing, to practise **explaining** concepts and ideas from the course, such as the forces producing the centripetal force on an object moving in a circular path, the equivalence principle, quantum tunnelling, wave-particle duality, or the path followed by a charged particle in a magnetic field.

Open-ended questions from past SQA question papers could provide suitable prompts for candidates to practise explaining some of the more challenging concepts in the course.

Opportunities to practise experimental skills, as part of the project as well as during classwork, should enable candidates to answer questions assessing aspects of experimental technique, analysis of experimental data, and sources of uncertainty.

Candidates should be encouraged to take care with the language used when answering questions assessing the knowledge of definitions. While some variation in wording may be acceptable in response to descriptive questions, there is less scope for such variation when answering 'What is meant by...' questions. For example, a number of candidates were unclear on what is meant by 'a gravitational potential of $-1{\cdot}70\times10^{9}$ J kg^{-1}'.

In some questions, the final answer from an earlier part is 'carried forward' for substitution into a relationship. Candidates should be advised that their stated **final answer** should be substituted, and not an unrounded value, which may have been stored in a calculator. This is particularly the case in 'show' type questions, where the final answer is given.

Candidates should be encouraged to make handwriting as clear as possible, especially symbols and letters used in relationships, and numbers used in substitutions and final answers.

In the examination, candidates should also be encouraged to refer to the data sheet and to the relationships sheet, rather than trying to remember data and relationships.

The document *Physics: general marking principles* outlines the principles used in the marking of physics question papers. Centres are advised to adopt these general instructions for the marking of prelim examinations and centre-devised assessments for any SQA Physics courses.

Project

Almost all candidates were aware of the requirements of the project, and of the information in the instructions for candidates, which is appendix 1 of the coursework assessment task for Advanced Higher Physics. From session 2019−20, the instructions for candidates is included as a section in the *Advanced Higher Physics Project Assessment task*.

Topic choice

Centres are reminded that, unless they are presenting a large number of candidates (more than 10), candidates should not be allowed to choose a topic that may lead to experimental procedures similar to those being carried out by another candidate in the centre. Centres presenting a larger number of candidates must minimise the number of candidates investigating the same topic. There should be no need for candidates in a small class or group to be investigating the same topic. If two candidates in a centre are following the same experimental procedures, the teacher or lecturer must ensure that each candidate carries out research, including experimental work, individually. There should be no situations where a whole class, irrespective of class size, is investigating the same topic. Centres are also reminded that candidates must work individually and group work is not allowed.

To score well in the project, each candidate should be encouraged to choose a topic for which the underlying physics and experimental procedures present an appropriate level of challenge, and the opportunity to access marks for the introduction, procedures, results and discussion.

Abstract

Candidates should state a clear aim(s) for their project and state findings clearly.

If the aim is to measure a physical constant using a number of procedures, candidates should name, or briefly describe, each procedure, stating the value obtained for the constant, complete with unit and uncertainty, for each procedure.

If the aim is to compare methods, candidates should be clear which aspects are being compared, for example accuracy, precision, ease of measurement, number of uncertainties rather than stating ‘method A was better than method B’.

If the aim is to confirm a relationship between variables, candidates should be wary of stating that a relationship shows direct proportionality in their findings if the line of best fit does not pass through the origin.

Introduction

To score well in this section, candidates should demonstrate an understanding of the physics of their chosen topic. Simply stating a number of relationships without any justification, or reproducing information from sources without input from the candidate, would not demonstrate full understanding.

The inclusion of historical, socio-economic or other non-physics information may be of interest, but does not contribute towards demonstrating an understanding of physics, and is likely to be given no credit.

Procedures

Candidates should include clear, uncluttered, labelled diagrams or photographs to help describe the apparatus. Many of the candidates who attempted to sketch their apparatus electronically using drawing packages produced diagrams lacking the clarity necessary for replication. It may have been quicker and clearer to produce a sketch using pencil and paper and scan it into the report. A circuit diagram should support the description of apparatus used in a procedure involving an electrical circuit.

Candidates should describe their procedures, using past tense passive voice, in sufficient detail to allow replication. This includes details, such as the number of repeats, together with the range and interval of the independent variable.

The number of experiments will depend on the chosen topic, but the experimental phase of the project normally consists of three or four related experiments. In any event, candidates should be advised to spend approximately 10 to 15 hours in the laboratory obtaining their experimental data.

Results

For data to be considered sufficient, candidates should ensure the number of repeats, and the range and interval of the independent variable, are appropriate for the experiments. Candidates should include all their data in the report, not just mean values. If the volume of raw data is large, it should be included in appendices.

Additional opportunities to practise graphical analysis and the estimation and combination of uncertainties as part of classwork may support appropriate analysis of raw data, including uncertainties.

Discussion

In their evaluations of experimental procedures, candidates should be encouraged, as appropriate, to comment on the accuracy and precision of their measurements, the adequacy of repeated readings, the adequacy of the range over which variables are altered, the adequacy of control of variables, any limitations of their equipment, the reliability of their methods, and on sources of uncertainties.

In their discussion and critical evaluation of the project as a whole, candidates should be encouraged, as appropriate, to comment on the reasons for selection of procedures, problems encountered during planning, modifications to planned procedures, interpretation and significance of findings, suggestions for further improvements, and suggestions for further work.

Presentation

References to at least three sources of information, listed at the end of the report, should also be cited in the report where information is quoted from the sources. Both the listing and citing of references should be in either Vancouver or Harvard style. In addition to support in the instructions for candidates, many internet sites offer guidance and support in referencing in Vancouver or Harvard style.

Maximum word count

The project report should be between 2500 and 4500 words in length — excluding the title page, contents page, tables of data, graphs, diagrams, calculations, references, and acknowledgements. It is possible to produce a high-scoring report using considerably fewer words than the maximum permitted.

Grade boundary and statistical information:

Statistical information: update on courses

Number of resulted entries in 2018	1891

Number of resulted entries in 2019	1646

Statistical information: performance of candidates

Distribution of course awards including grade boundaries

Distribution of course awards	Percentage	Cumulative %	Number of candidates	Lowest mark
Maximum mark				
A	31.5%	31.5%	518	90
B	26.8%	58.3%	441	77
C	20.3%	78.6%	334	64
D	9.2%	87.8%	152	57
No award	12.2%	-	201	-

General commentary on grade boundaries

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.

SQA aims to set examinations and create marking instructions that allow:

- a competent candidate to score a minimum of 50% of the available marks (the notional C boundary)
- 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.

Therefore, SQA holds a grade boundary meeting every year for each subject at each level to bring 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. Members of the SQA management team chair these meetings. SQA can adjust the grade boundaries as a result of the meetings. This allows the pass rate to be unaffected in circumstances where there is evidence that the question paper has been more, or less, challenging than usual.

- The grade boundaries can be adjusted downwards if there is evidence that the question paper is more challenging than usual.
- The grade boundaries can be adjusted upwards if there is evidence that the exam is less challenging than usual.
- Where standards are comparable to previous years, similar grade boundaries are maintained.

Grade boundaries from question papers in the same subject at the same level tend to be marginally different year to year. This is because the particular questions, and the mix of questions, are different. This is also the case for question papers set by centres. If SQA alters a boundary, this does not mean that centres should necessarily alter their boundary in the question papers that they set themselves.