GCE

Physics B (Advancing Physics)

Advanced GCE **H559**

Advanced Subsidiary GCE **H159**

OCR Report to Centres June 2016

OCR (Oxford Cambridge and RSA) is a leading UK awarding body, providing a wide range of qualifications to meet the needs of candidates of all ages and abilities. OCR qualifications include AS/A Levels, Diplomas, GCSEs, Cambridge Nationals, Cambridge Technicals, Functional Skills, Key Skills, Entry Level qualifications, NVQs and vocational qualifications in areas such as IT, business, languages, teaching/training, administration and secretarial skills.

It is also responsible for developing new specifications to meet national requirements and the needs of students and teachers. OCR is a not-for-profit organisation; any surplus made is invested back into the establishment to help towards the development of qualifications and support, which keep pace with the changing needs of today's society.

This report on the examination provides information on the performance of candidates which it is hoped will be useful to teachers in their preparation of candidates for future examinations. It is intended to be constructive and informative and to promote better understanding of the specification content, of the operation of the scheme of assessment and of the application of assessment criteria.

Reports should be read in conjunction with the published question papers and mark schemes for the examination.

OCR will not enter into any discussion or correspondence in connection with this report.

CONTENTS

Advanced GCE Physics B (Advancing Physics) (H559)

Advanced Subsidiary GCE Physics B (Advancing Physics) (H159)

OCR REPORT TO CENTRES

G491 Physics in Action

General Comments:

This is was legacy specification, so had a smaller entry than usual. The paper worked well to differentiate the candidates entered and produced a mean mark well over half of the paper maximum as usual. The spread of marks was rather narrower than usual with a lower proportion of candidates near the paper maximum and zero marks.

There was little evidence of candidates running out of time, and in Q11, the hardest question on the paper, most candidates made an attempt at most parts.

Comments on Individual Questions:

Section A

1 Candidates coped well with an introductory question on units with over three-quarters scoring the maximum three marks.

2 This question got candidates to link named material properties to their definitions and was generally well answered. The most common error was to describe soft as having a low Young modulus, rather than easy to scratch or indent.

3 This question showed more differentiation, most candidates recognised the smallest bandwidth on the diagram (peak D) but forgot the inverse relationship between frequency and wavelength to select the smallest wavelength, (highest frequency – also peak D). In estimating the bandwidth of the widest peak B, the most common error was to miss the Mega multiplier and lose a mark to POT (Power of Ten error).

4 Nearly all could calculate the width of the nano-conductor given the atomic diameter, there were very few POT errors here which was pleasing. The second part was a show that on the conductance of the nano-conductor at about 25 μS. This was more demanding and only the better candidates correctly worked out the orientation of the conductor and the appropriate values for the length and cross-sectional area. One mark from the last two was available for those that got as far as length is 7.6 nm or 5.8×10^{-19} m^2.

5 Candidates were invited to explain the approximation $f \approx v$ for the case of a distant object and a convex lens. Many reasoned correctly that $1/u \approx 0$ or tends to zero for the first mark. For the application of the lens formula students had to apply the correct sign convention and obtain 285.8 D or appropriately rounded. Those with a sign error were penalised the mark. The last part on magnification was pleasingly well answered, but tended to produce 2 or 0/2 marks. Candidates used ratio or similar triangles correctly and got both marks, showing their method clearly, which was pleasing, or couldn't start this part.

6 This question about temperature sensors was more differentiating, candidates found it hard to suggest a physical reason for the sensor A having the longest response time on the graph. Sadly many just suggested it takes longer to heat up, which was not credited. The best candidates talked about thermal conductivity, thermal capacity or shape factors to get the mark. In the next part, weaker candidates incorrectly interpreted the sensitivity of the sensor as the gradient of the p.d. against time graph, and chose sensor B with the greatest gradient. Only those thinking carefully selected A which showed the largest voltage rise for the same temperature increase. The last two marks were for calculating the sensitivity of sensor B, here candidates tended to score either 2 or 0/2 marks available and the facility was just over 0.5. Allowance was made for those candidates who estimated a sensible value for room temperature, (although the question said the water bath was 70 °C above room temperature) and they gained full marks if they made no arithmetic error.

7 Most candidates scored 2/4 marks available for this question on the number of bits worth ascribing to a digital sample of a noisy signal. Either by arguing that $2^{10} = 1024$ (> 1000), or $\log_2(1000) = 9.97$ so take 10 bits. In the last part they were asked to explain why ascribing more bits per sample was not worthwhile. Sadly most candidates revealed misconceptions about the nature of sampling signals with noise. Most believe that using fewer bits “filters out” the noise, rather than signal and noise being sampled each time. So there were many statements like “using more bits would start to sample the noise”. It is a complex concept but students must choose their words carefully enough to represent the physics situation to score credit.

8 This was a well answered question on the application of electrical power $P = V^2 /R$ dissipated in a resistance, which was pleasing as it involved reasoning by direct and inverse proportion.

Section B

9 This question was about the stress against strain graphs for glass and epoxy resin, leading to the idea of a composite material.

(a) Candidates were asked to *describe features from the graph* that indicate that epoxy is a plastic material, and that glass is elastic and stiffer than epoxy resin. Many weaker candidates chose to give their own definition of these terms rather than relating to evidence from the graphs, and scored no credit. The better candidates referred to graph features such as the flattening at 0.008 strain for the plastic, and the proportionality up to breaking for glass, and its larger intial gradient (Young modulus). Surprisingly the facility was under ½ and candidates should be encouraged to underline or highlight action words on the question paper, so as not to miss the point of a question.

(b) Candidates were asked to find the ratio strength of glass : strength of resin. They had to choose the correct graph feature (breaking stress), take two measurements (100 / 22 in MPa) and find the ratio. Some dropped out at each stage of the process and lost the mark available for the correct answer 4.5. The most common error was to misread the graph for epoxy breaking strength at 21 MPa.

(c)(i) This was the first part of this question to be well answered – find the Young modulus for the epoxy resin. The facility was near ¾ which was pleasing, the most common error which lost 1 of the 2 marks available was a POT error on reading stress from the graph, so about a fifth of answers were a factor of *x* million out.

(c)(ii) Candidates had to use their knowledge of plastic materials to suggest how long chain molecules can show plastic behaviour, which is limited by cross-linking between the chains. This was a QoWC question so candidates had to structure their answers and use appropriate technical terms. This differentiated well with only the top 10% getting 3/3 of marks and an even spread for the other marks. The weaker candidates have a poor sense of what constitutes a good physical explanation e.g. just “cross-links prevent slip”, whereas the best wrote answers better than the mark scheme!

(d) This was about the composite material aspects of the question.

(i) This asked candidates to consider the problems due to material properties of a canoe made only from glass or of epoxy resin. It was well answered with a high facility, most candidates realising that a glass canoe would easily shatter or fracture on impacts, whereas an epoxy one would not be stiff enough and hold its shape or deform permanently.

(ii) This asked them to consider the mechanism of how a composite material combines useful properties of its two component materials. It was apparent that many had not been taught anything about this and some made over-simplistic assertions e.g. “the best properties are combined”. Few candidates talked about the bonding of the resin to the fibres and the transfer of force or stress from the resin to the stiffer glass; or the protection from crack propagation which the flexible resin affords to the brittle fibres.

(iii) This asked about why the fibres should be randomly oriented within the composite. This question was well answered and better candidates spoke well about the composite bearing stress or resisting crack propagation in *every* direction.

10 This question was a novel one about the use of the internet and the cost of electrical energy to run hand held devices as well as to build and maintain server farms to service “the cloud”. Considering some familiar concepts were in a very novel context this question was pleasingly well answered by many candidates.

(a) From a graph of the number of people with worldwide internet access against date (showing exponential growth), and the world population in 2012 candidates had to work out the % of the population that could access the internet. This was well answered. The combined power to run all the laptops of world users was then well estimated.

(b) A graph showing how the number of computations per Joule of energy (on a $\log_{10}$ scale) has grown with time from 1980 was presented. Candidates had to describe the exponential growth, or linear graph on a log scale for the first mark. The weaker candidate just said linear growth, missing the log scale. The candidates then had to calculate the number of computations per second of a typical hand held device in 2014. This involved reading the computations per joule for 2014 and multiplying by the typical power 5 joules per second to get the computations per second. Just under ¼ of candidates scored all of the 3 marks available for this novel calculation, where they had to keep a close tab on their units. A common error was to misread the logarithmic scale as if it were linear, but these candidates could still score one follow through mark if they multiplied by 5 J per second.

(c) This was the second QoWC question and candidates had to organise and present calculations and estimates clearly and coherently, to answer the question “is access to the internet and its vast resources essentially free?”. They were given some data on the power to run a typical “server farm” or data centre, and the annual cost to build and maintain the farm. That nearly half the candidates coped with this was a tribute to these candidates’ abilities to handle numbers well in unfamiliar circumstances. The fact that a typical server farm uses 180 MW of power, and that there are now 1000’s of these around the world serving the internet and cloud is quite startling! Many concluded correctly that even when spread over the billions of world users, the cost per user is not negligible. Weaker students scored 2/4 marks for dealing with the energy costs across the year correctly, but only the best added in the capital and maintenance costs and went on to score the full four marks. Nevertheless answers were well presented and Centres can feel candidates were well prepared to tackle innovative questions, which is pleasing.

11 This question was about a battery with internal resistance running a single resistive circuit, and then two parallel circuit branches of equal resistance. So a deliberately easy start using the familiar equation $\varepsilon = V + IR$ and then a parallel circuit where only the better candidates could make sense of what was internal and what was external resistance to the battery.

(a) The first part was a show that, given the external p.d. $V = 2.6\,\text{V}$ that the e.m.f. is near $3\,\text{V}$. Nearly all candidates achieved these first two marks, using the familiar equation correctly after rearrangement.

(b)(i) Now the second resistive branch was added, weaker candidates thought the current should double, as resistance had halved, but they forgot to add in the internal resistance in series, and scored 0/3 for part (i). The first mark was for getting as far as: the total resistance = 4.7/2 + 0.9 = 3.25 Ω. They continued to find the new current (0.95 A) using the e.m.f. from (a). Error carried forward (ecf) was allowed from part (a).

(ii) Candidates then had to find the new external voltage, and could do this using their new current × external resistance. They had to think carefully about which current and resistance values to employ. Weaker candidates had now dropped out or been baffled , but about ⅓ got both marks here.

(iii) Finally they had to compare the external powers delivered in the two example circuits, and show that the ratio was about × 1.5. Because of ecf the facility actually rose to about 0.4 for this last part, where incorrect values for current and p.d. correctly used gained full credit. This kept the markers calculators busy!

G492 Understanding Processes/Experimentation and Data Handling

General Comments:

Although this is a legacy paper, with a reduced overall entry, the standard from previous years has been maintained. The mean score for the paper was very similar to that for June 2015. There were relatively few candidates who were clearly 'out of their depth', and the standard of English and Maths is generally improving. Where it was obvious that candidates had prepared thoroughly on the pre-release materials their marks for Section C were deservedly high as a consequence.

One shortcoming in the longer questions commented on by Examiners last year was that many candidates did not read the question through before plunging in, and did not see the 'story' in each question and the way the parts (a), (b), etc. related to each other. This was not the case this year and this enabled candidates to follow through questions with more success.

Comments on Individual Questions:

Section A

This section proved accessible, as intended, with most candidates getting more than 14/21 and stronger candidates getting nearly all of the marks.

Q1 A familiar format and generally well answered. Q2 More difficult than question 1, with fewer fully correct answers. Q3 Very few correct answers to 3a, where candidates have to select from the list the order of magnitude of the wavelength of microwaves. 3b was very successfully answered with candidates having a clearer feel for the dimensions of the thickness of paper. Q4 There was some misinterpretation of 4a and wavelet diagrams were incorrectly drawn but 4b was well answered. Both parts of Q5 were confidently answered. On Q6 A few candidates thought that red light was absorbed by the filter and some thought that it had a lower wavelength. Weaker answers were not able to give an explanation of why there should be more clarity with respect to the fringes.

Q7a was well answered for the first mark but there were limited correct responses that made a quantitative response to the main algebraic term. Many candidates for Q7b were able to relate larger wavelengths to waves travelling faster but responses qualifying this by stating that velocity is proportional to wavelength for the second mark were less frequent. Both parts of Q7 were successfully answered by some candidates through sensible use of calculations.

Section B

Question 8
8ai was generally well answered, common mistakes included not reading the mm in the answer line. 8aii there were few answers gaining full marks, the idea of the maximum angle of 90^o is known but many candidates struggle to put this into words. Clarity in 8b came from the use of correct diagrams; a misunderstanding of basic geometry was the undoing of some candidates. On 8c a lack of coherence and clarity of explanation meant that very few candidates scored two marks. A simple answer of linking slit spacing 'd' to wavelength was the easiest way of attaining the first mark.

Question 9
9a was answered well by most candidates; quoting to 3 or 2 significant figures was the most common mistake, and could be remedied by reading the question more thoroughly. 9bi, ii were familiar questions for this paper and well answered, mistakes were primarily few and far between but based around arithmetical errors. For 9ci most candidates were able to describe the halving of the wavelengths but only a certain number were able to relate this more directly to frequency doubling by clearly demonstrating the relationship between the physical quantities rather than just stating an equation. The best answers for 9cii were concise and related energy to $E=hf$ followed by a statement of energy conservation. The most common answers scored just the 1 mark for stating the higher energy associated with green photons. There were many some good suggestions for 9ciii, common answers including use as a pointer and for classroom based experiments.

Question 10
Unfortunately for Q10a there were too many answers that were without any reference to 'forces' as required by the question, and therefore failed to score and what was expected to be a more straightforward question. For 10b most candidates correctly recognised the need to find the area under the graph but there were very few accurate techniques with most candidates losing the final mark for an accurate assessment within the acceptable range. The most straightforward and successful approach involved simply counting squares. Q10c required candidates to draw a tangent, whilst most candidates did this, many were inaccurate and therefore lost the second mark; a small number drew a line tangential to the *s-t* curve. There was a better range of answers for Q10d compared to Q10a. However, some candidates did not know what a pellet was. The higher scoring answers were able to describe the scenario of increased acceleration for a longer period of time resulting in a higher terminal velocity.

Question 11
For part 11a there were some inaccurate estimates of centre of mass difference but this didn't stop most candidates following through with correct calculations using *mgh*. Interestingly very few just used the height difference and the mass to carry out a simpler calculation, most opting for calculating both old and new values before subtracting one from the other. 11b was generally well answered and 11ci presented very few problems. Part 11cii was a very difficult question; a very small number answered the question by drawing an appropriate vector diagram. There were other 'vector' diagrams, but not appropriate! It was conceptually and mathematically tricky. Due to the previous question not being answered correctly by the majority of candidates there were a lot of error carried forward marks for 11ciii for a relatively straightforward calculation.

Section C

Overall candidates seemed well prepared for Section C and demonstrated a good understanding of the pre-release material, however the use of the accrual article in the exam appeared to be more limited – see 13ai for example.

Question 12
Q12a generally well answered, most marks were lost to incorrect use of significant figures.12bi required a straight forward answer, instead lots of - "*Mass is not part of the equation"* answers meant candidates scored zero marks.12bii similar to 12a, well answered with most lost marks relating to incorrect uncertainty calculations. A minority of candidates ignored any changes to the uncertainty and simply quoted the vale from 12a. Q12c was very well answered with candidates able to test the limits of the uncertainty and demonstrate that there was a risk of failure.

Question 13

13ai not enough candidates referred back to the article where there were very clear descriptions for systematic errors and random uncertainties. A common answer was to simply quote examples of systematic and random errors, without actually saying what they are and the key differences. For 13aii there were generally better quality of answers that correctly identified the repeated error in every reading. In 13b the precision of the language used was a major factor in whether candidates were able to correctly describe and subsequently explain the impact of the stretched measuring tape. Most candidates consistently produced correct graphs for part 13c but a limited number were able to explain which particular features demonstrated the systematic error.

Question 14

Q14ai was straight forward and well answered. For part 14aii a small but surprising number of candidates drew unusual wave patterns and lost up to three marks. For part 14aiii it was generally the best set of answers of the qwc style questions. Most candidates were able to describe the process of a standing wave forming. 14bi/bii were straightforward and well answered. For part 14ci good explanations defeated most candidates. The subtleties of the quieter resonance were not picked up by most candidates. The subtleties of the higher percentage error were lost on most candidates for part 14cii and those who did, forgot to answer the question, which was how is '***v***' affected, and tended to lose the second mark. Part ciii was mostly well answered for one mark, with most candidates able to explain why presenting data in a graph led to better quality outcomes. 14di had some high quality answers and much improved on previous years; there was a genuine understanding or attempt to explain the gradient. For 14dii too many candidates forgot the ms conversion, or the ×2, or tried to invert the *x* axis reading, presumably because it was labelled 1/*f*. It was very encouraging that for part 14diii response showed a more detailed analysis of errors/uncertainty than previous papers with scope for more able candidates to explore good physics and good logic. The best answers used the uncertainty bars and/or minimum and maximum lines/gradients. 14e was often interpreted as being asked to explain why the speed of sound might increase at higher temperatures, rather than the simple answer required.

G493 Physics in practice

General comments

There were fewer than 100 candidates submitting work for the AS coursework unit of Advancing Physics this year. Many of these were in the second year of the course and re-sitting this first year unit. There were few clerical errors or other issues with the quality of administration and so the moderation process was relatively straightforward. However, whilst evidence of internal standardisation was welcome, having more than one mark on some of the Coursework Assessment Forms was potentially confusing for moderators. In such cases the agreed definitive mark should be clearly indicated.

The work of candidates was, in general, well-annotated to show why marks had been awarded, enabling the moderator to easily check that the assessment criteria had been applied correctly. It was particularly useful to the moderator when teachers indicated errors of physics or mathematics.

Quality of Measurement task

The vast majority of experiments chosen for this task were appropriate and covered a good range of physics from the course. Experiments to measure '*g*' were a popular choice, but methods based on timing the period of oscillation of a pendulum lie outside the AS level specification. The properties of sensors, materials and waves were other fruitful areas of the course for practical work. Giving candidates the opportunity to choose from a range of possible experiments provides a good preparation for the Practical Investigation component of the A2 course.

In strand A '*Quality of practical work in the laboratory*' candidates are required to provide written evidence that they have addressed relevant safety issues to satisfy the descriptor dealing with '*careful methodical work*'. This was generally well done, candidates clearly indicating any potential hazards with their experiment and the appropriate steps taken to limit the risks.

In general, candidates demonstrated a good understanding of uncertainties and systematic errors in strand B. However some candidates tended to focus solely on the resolution of the measuring instruments, or on the range of repeated measurements. It is the larger of these that should be considered. A common shortcoming in strand B was the lack of an appropriate evaluation of the effect of any suggested improvements to the experimental method on its outcome.

In strand C '*Quality of communication of physics in the report*' errors in the recording and presentation of data such as missing/incorrect units or the inconsistent/inappropriate use of significant figures in tables of results were sometimes overlooked by the centre assessor. Candidates should be penalised for graphical plots which lack clear labels, uncertainty bars or appropriate best fit lines. In general, candidates electing to produce computer-generated graphs using Excel were less successful than those who drew them by hand. A common fault was in the choice of a 'line' graph, rather than the more appropriate 'scatter' one.

In strand D '*Quality of handling and analysis of data*' candidates often placed too much reliance on tabulated data. Information should be extracted from the gradients, intercepts or other features of graphs in order to satisfy the criteria for high marks. The use of the Excel function to give the equation of the best fit line led some candidates to propose purely mathematical relationships, rather than ones based on a knowledge and understanding of physics. Final values of measured quantities should be qualified with reference to uncertainties and possible systematic errors; for example the gradient of a graph might have +/- values associated with it.

Physics in Use task

The vast majority of candidates used PowerPoint as their chosen medium for the Physics in Use presentation. However, in some cases, it was difficult to judge the quality of the work produced as the printout of the slides was too small to read easily. Candidates must produce a clear record of their presentation to be awarded high marks in strand A(iii). Comments by the centre assessor on the oral aspects of the presentation, and the quality of candidate responses under questioning, were appreciated. However there tended to be little annotation on the printouts of the slides.

In strand A(i) some candidates did not appreciate the requirement to place their chosen material in a clear context, tending to list its general properties rather than those related to a specific use. A clear context for the material also enables candidates to focus on the relevant macroscopic and microscopic properties in strands B(ii) and B(iii). Candidates who presented the title as a question, such as “Why is carbon fibre used for hockey sticks?” tended to do this more successfully as it immediately focuses the candidate on the properties needed for that application.

In strand A(ii) of the assessment criteria most candidates clearly identified the information sources used, for example by quoting the full web address for internet-based sources. The use made of the sources in the presentation was often achieved by simply linking the name of the source to the slide number concerned. Providing the bibliography as a separate Word document is preferable to it being on the final slide of a PowerPoint presentation, where the resulting small text sometimes proved rather difficult to read.

G494 Rise and Fall of the Clockwork Universe

General Comments

Very few candidates scored poorly and the paper did challenge at the top – discrimination was good.

In general, there was significant evidence that the underlying principles associated with the physics of particles (e.g. the link to pressure and temperature) are not well understood. Also there were many examples where the candidates' knowledge of basic geometry was poor (e.g. not knowing how to calculate an area of a circle when given the diameter, not knowing the equation for the circumference of a circle).

Qu1. This first question was generally well done. Most candidates correctly identified the units for (a) and a smaller majority for (b). It was noted that a small number of candidates used lowercase 'N' while others might use '/' instead of the negative power – both should be avoided – the 'n' is of course symbolic of a prefix and the '/' could indicate that the candidate knows the units but is unaware of the mathematical formalism using the negative sign, so is simply stating the units they recall, not selecting from the list.

Qu2. This question seemed to discriminate well. Weaker candidates often did not get the mark and if the answer was wrong, '*C*' seemed to be the common mistake.

Qu3. These two questions were generally well done. For the candidates that made mistakes on (a), it was surprising to see how many felt that the Boltzmann factor would be greater than 1.

Qu4. Many candidates did well on this question, achieving 2 of the 3 available marks. The range of different values calculated was quite large with PV/T, PV/NT (with an incorrect value for N) and the inverse of these two options. The cohort also used 1.38 or 1.4 for k.

A minority of candidates achieved all 3 marks – most failed to obtain the final mark because, although answers were often expressed to 2 SF, there was no justification given, even though the question referenced the precision of the data. Very few commented on the 2 SF for V.

Qu5. This question produced a wide variety of answers but usually, gave the right answer if it was started correctly. Many incorrect answers were indicated by the candidate creating a mess of formulas and then (almost) randomly calculating anything. This question is a good example of a 'multistage problem' that was not approached as such by many candidates.

Qu6. This aspect of graphical analysis, where the link between the diagrams is a differential is quite common, yet many candidates find it difficult. It was clear that for many, the link between d, v and a is not clear. Beyond the problem of getting the phase right, candidates were generally quite poor at drawing curves that look like sinusoids – frequently, the answer bordered on a triangular wave, which is not good – more practice with this kind of question is clearly needed.

It was also interesting to note that a large number of candidates chose to have their amplitudes at values 'between' the x-gridlines, rather than use the major horizontal lines given. This increased the risk of losing a mark for an inconsistent amplitude.

Qu7. This question was generally not done well. Candidates often seemed to ignore the question and simply explain what is meant by redshift.

It was also disappointing to see the large number of candidates that refer to stars or planets rather than 'distant' galaxies, as discussed in the question. This was a very good example of a question where candidates needed to read the question carefully and answer what is requested, rather than answer the question they want it to be.

For the second marking point, many failed to include the 'at some time in the past' element, so that their descriptions could fit the steady state theory as well as the big bang theory. Again, many failed to tie this to galaxies.

Qu8. (a) was generally done well and the slightly unusual axis did not cause many problems.

(b) was tougher, than (a), with many candidates calculating gamma but then almost randomly either multiplying or dividing it with *t*. A minority of candidates lost the second mark for giving the answer with '$\times 10^{-9}$' without crossing out the 'ns' on the answer line. This is a typical error and candidates must watch out for the format of the answer line.

Qu9. Candidates generally fell into one of two camps with this question. They either focused on the half-life, showing that the two obvious half-lives (6 V to 3 V & 3 V to 1.5 V) are not the same, or they tried using some other, more complex method. Most candidates using the 'half-life' route scored both marks while more complicated methods were often flawed.

Qu10

(a)(i) This was generally done well but far too many candidates did not seem aware of the correct formula for the circumference of a circle.

(a)(ii) Well done. The major problem was when candidates started with a negative in Newton's law of gravitation and did not set this equal to a negative centripetal equation. Having the negative sign simple vanish along the way, would not be creditworthy.

It is important for candidates to be careful with their symbols for *M* and *m* – they should look different if subscripts are not used.

(a)(iii) Candidates should take care when using km to remember to × 1000 and typically, many forgot the square in the formula that they had just derived.

(b)(i) Jupiter was quite a wide target but regardless, many candidates were careless with their arrow and it was very disappointing to see the number of answers which clearly did not use a ruler. Common mistakes were directing the arrow to the centre of the orbit or directing it tangential to the orbit.

(b)(ii) This question seemed to discriminate well. Many answers had roughly the right shape with points of inflection but with the line a long way from being horizontal at A.

(b)(iii) Very few candidates answered this question well. The most worrying feature was in the discussion of the forces and/or energy changes in an elliptical orbit, which was poorly done.

It was disappointing to see so many candidates thinking that Io has more GPE when it is close to Jupiter. Many invoked Kepler's law about areas swept out not understanding that this was not an explanation but an empirical law and not amounting to the explanation that was required. They also demonstrated their poor understanding when they stated that Io does not accelerate at A.

A small number of answers seem to have confused velocity (v) with gravitational potential (V_g).

Qu11

(a) This was not well done. There were some excellent answers but most candidates did not start with the correct equation for GPE and had to contrive to get the right answer. Further, many kept their equations general with the use of '*r*', when '*R*' was required.

(b) This was generally well answered. A small number of candidates tried to use $P=h\rho g$ to calculate the reduction in atmospheric density but this did not lead to correct answers.

(c)(i) Many good answers and it was pleasing to see that very few candidates seemed confused with °C and K.

(c)(ii) There were many good answers to this question. However, too many poor answers were linked to the candidates ignoring the question when it asked that …

… answers should clearly link the variations in the energy of the helium atoms to the behaviour of particles …

Several answers were in terms of the energy changing with distance from the centre of the Earth, and ignored the request to discuss the *range* of energies.

It was not good to see so many answers which show that candidates had little real understanding of the concept of temperature and felt that they could discuss the temperature of an individual particle rather than the system.

(c)(iii) It was good to see that many candidates defined the Boltzmann factor, but did not do so within the context of this question, leaving it as a general statement about effectively, a 2-state system. Very few considered the huge number of collisions made by atoms and many complicated their argument by adding 'per second' to their definition of the Boltzmann factor.

Qu12

(a)(i) There were some good answers to this question but not as many as would have been indicated by the answers to Qu11(c)(iii) – the earlier good descriptions of kinetic theory did not seem to translate to this question.

It was disappointing to see the number of candidates that referred to the inside of the tube as being a vacuum, particularly when the questions stated that the pressure is simply reduced. Also, many arguments were based on outside molecules "… trying to move to the area of lower pressure" or "… being sucked towards the vacuum cleaner", suggesting a poor grasp of the underlying mechanisms.

Descriptions of how pressure arises due to the collision of particles was quite poor.

(a)(ii) Generally well answered although it was very disappointing to see a large number of candidates were unable to calculate the area of a circle given its diameter – this was another example of many candidates not having a grasp of basic geometry.

(b) This was very poorly answered. It was interesting to note that many answers to this question were descriptive when the question clearly instructed that a calculation of some sort was needed.

The candidates did not understand this question although some tried to translate 'precision' as 'uncertainty' and gave some sensible attempts. Remarks about the pressure in the hose being more uniform once the nozzle had been removed revealed some of their misconceptions about pressure and kinetic theory.

Qu13

(a) Answered well. Many candidates got the first 2 marks but seemed to forget to include any assumptions made. It does suggest that candidates answer the question as they see it, and then never spent the short time to just re-check that they have complete the question fully. Such discipline would potentially, raise the marks awarded.

(b) Well answered. A small number of candidates seemed confused about which mass(es) had which velocities and this led to some unlikely values for the velocity of the pellet and compounded problems when calculating its *KE* in (c).

(c)(i) Most candidates did not consider it necessary to state that *KE* was not conserved. The few that calculated a gain in *KE* during the collision expressed no concern. Some did not realise that they had already calculated the final energy in (a).

(c)(ii) This question was generally well answered but the level of response was low. There were too many references to energy lost "… as heat and sound", without any reference to where the energy was actually lost.

A small number of candidates did seem to misunderstand the question and discussed energy losses when the pellet was fired.

G495 Field and Particle Pictures

General Comments:

The marks on this paper ranged from around 10 out of 100 up to 95 out of 100. The mean of 66% is rather higher than previous years and shows that the paper was accessible to most of the candidates who were clearly well-prepared for the examination. There was little evidence of incomplete work, although a very small proportion missed the final part of the last question.

Once again, whereas many candidates presented their work with admirable clarity, some scripts were very difficult to decipher and an increasing number of candidates forget to show working. There was also an increasing tendency to simply state an answer to the first two or three significant figures without rounding.

As is often the case, candidates found the descriptive questions the most challenging and often fell back on ‘common sense’ ideas or rather than thinking through the physics of the situation. However, the best scripts once again showed clarity of thought, careful preparation and a good understanding of the physics being tested.

Comments on Individual Questions:

Section A (20 marks)

Q 1 The opening question relied on simple recall and nearly all candidates chose the correct answer. The most common incorrect answer was B.

Q2 This proved far more challenging. Many candidates confused potential difference and potential.

Q3 This question relied upon fairly simple calculations of dose and risk. The majority scored highly on the question.

Q4 Many candidates failed to gain the mark for part (a) due to lack of care. Field lines often did not meet the plate at right angles and the fields drawn were often unsymmetrical. Perhaps candidates were rushing through Section A to leave more time for the longer questions. It may be worthwhile to remind students of the need for careful drawing. Part (b), whilst answered correctly by the majority, did reveal some misunderstandings and a small but significant proportion of the candidates considered the field to be radial between the sphere and the plate.

Q5 Candidate always find questions on electromagnetism rather challenging and this was no exception. Common errors were to consider that a flux induces an emf, rather than a changing flux. Some candidates merely stated that a changing flux induces a current (ignoring the role of emf). Candidates were familiar with the idea of laminating the core but often did not explain how laminations help in this situation.

Q6 Although the majority gained both marks here, a relatively common error was to assume that the total energy (2345 MeV) was the kinetic energy of the proton.

Q7 This proved accessible to the large majority of the candidates.

Q8 Many candidates incorrectly assumed that the protons physically collide with the nuclei and hence framed their responses in terms of greater nuclear radius leading to more collisions. Another source of error was to consider the properties of the gold atom rather than the gold nucleus.

Section B (43 marks)

Q 9 This question is about estimating the size of a hydrogen atom.

All sections of parts (a) and (b) were well answered by the majority of candidates.

Part (c) was also well answered with only a small proportion not gaining full marks.

Part (d) was less-confidently answered. Many candidates repeated the stem of the question, stating that kinetic energy plus potential is greater than zero without stating that the magnitude of the kinetic energy is greater than that of the potential energy for radii less than the minimum. Only the best responses clearly compared the $1/r^2$ variation of kinetic energy with the $1/r$ variation of potential energy even though this was clearly flagged in the earlier parts of the question.

Q 10 This question is about pions. Candidates were not expected to recall any factual material about pions but use data given to reach conclusions about pion – anti-pion annihilation.

(a) Nearly all the responses gained both marks here

(b) (i) This proved more challenging with candidates confusing energy conservation and momentum conservation. It was clear that a significant proportion of the candidates did not really have an understanding of photon momentum.

(ii) Other than some spurious working using the de Broglie relationship, most scored well in this calculation of minimum frequency and realised that the calculation involved two pions and two photons.

(c) (i) This calculation was straightforward.

(d) (ii) This calculation proved more challenging. A common error was to calculate the velocity for a pion of kinetic energy 1×10^{-17} J and then add this value to the original velocity. However, it was encouraging to see that most candidates avoided this trap.

Q 11 This question is about uranium-235 fission. It begins by requiring candidates to explain the term ‘binding energy per nucleon’ and to describe how this can be found from given data. Many candidates showed a lack of understanding of binding energy – commonly describing it as the energy needed to bind a nucleus together. They were more confident in describing the calculation but weaker responses were characterised by a lack of clarity that suggested a hazy grasp of the process.
Parts (b) and (c) were much more confidently answered and the standard calculations in part (d) proved accessible to all but the weakest candidates.

Q 12 This question was about the Hall Effect – although the candidates were not required or expected to know details of the effect and would not be disadvantaged if they did not.
Part (a) was an easy opener and proved accessible to nearly all.
Part (b) was straightforward but many candidates did not represent a uniform field in the region. The Examiners expected careful drawings showing equally-spaced lines throughout the region. Unfortunately, many drawings were rushed and suggested that an area of uniformity within the region rather than across the whole region.
Part (c) proved a straightforward calculation but only the best candidates gained all four marks for part (d) which required careful thinking and the use of the emboldened factor of 10^{-4}. It is always useful to remind candidates that if they see data in the stem of a question they should use it in their answer. Many candidates simply assumed that as metals are better conductors than semiconductors the drift speed of conduction electrons must be greater. The better answers used the logic of the preceding parts of the question to develop a coherent explanation of the differences in drift speed and number density of conduction electrons. The best answers were admirably clear.

Section C (37 marks)

This section was based on an Advance Notice article about electrical power for spacecraft. It was a wide-ranging article which touched many areas of physics. As usual, the majority of the candidates were well-prepared for this section of the paper but, as ever, there were a few surprises which revealed some misunderstandings.
Q 13 This question about the power supply of Sputnik 1 was a gentle opening question which most candidates found accessible.

Q 14 This question, about the Hubble solar panel proved a little more discriminating, with some candidates considering the power from one panel rather than the pair of panels. Part (d) was more challenging although it was clear that many Centres had discussed the inverse-square relationship mentioned in the article with the candidates during the preparation for the examination leading to confident and clear responses.

Q 15 This question, on radioisotope thermal generators (RTGs), was more challenging. Although it was based on standard calculations the context, though familiar through the article, increased the difficulty of the task. In particular, part (b) was difficult for the mathematically less-confident candidates. Part (c), which asked candidates to consider the dangers of launching RTGs and the possibility of using a shorter half-life isotope was not well-answered by many candidates. A large proportion of the responses confused or conflated the properties of the alpha emitters with the properties of alpha particles. Examiners saw many statements about the dangers of alpha particles entering the respiratory system having been released by the RTG, rather than alpha emitters being ingested and releasing alpha particles *in situ*. Whereas it was clear that many candidates understood why a short half-life source may not be suitable, they rarely explained this sufficiently clearly to gain maximum marks. Statements of the form ‘A short half-life source would not supply enough power’ were too vague to be worthy of marks.

Q 16 the last question on the paper was about electromagnetic tethers. Part (a) required candidates to suggest factors affecting the choice of a metal for the tether. Many candidates considered factors of a particular specimen rather than a material. (For example, the conductivity of the material is a possible factor in choosing the material, whereas conductance is not a property of a material but of a specimen.) Only the best responses clearly linked the factor with the reason. Once again, many candidates relied on common-sense thinking (e.g. the weight of the tether in space) in a situation where common-sense ideas are not necessarily applicable. Parts (b) and (c) were standard calculations. Part (c) which required candidates to show that the emf induced in the cable is a certain value was not well-answered; it was an easy calculation to reach the expected answer but only the best responses showed how they reached the answer. Part (d) returned to electromagnetic induction and once again the best responses showed clarity of thought and understanding whereas weaker responses did not set out the explanation in sufficient depth. For example, many responses suggested (correctly) that a force on the wire acted in opposition to the movement of the wire but did not explain the nature of the force or how it was generated.

G496 Researching physics (A2)

General comments

In the final full session for G496 there were around 3300 entries from just under 200 Centres. By this point it would appear that the majority of Centres who have stuck with the Advancing Physics specification have become adept at preparing their candidates for the two components of Researching Physics Coursework and for many this component is a compelling reason for choosing Advancing Physics. Conversations with Physics teachers often reveal that it is the unique flavour of the coursework tasks that require candidates to demonstrate genuine independence, think outside the box and engage in some ‘real’ science where the outcome is not always known in advance that appeals to them. By the same token there are many others who view the coursework component as a logistical nightmare and a good reason for not choosing this specification. Those of us who are experienced in delivering Advancing Physics know that this is not the case. With a little forward planning that involves getting candidates to start thinking about their topics well in advance and showing them good examples of portfolios from previous years, it is clear that the majority are prepared to take ownership of both tasks from an early stage and fully engage with them. The key to guiding candidates towards successful outcomes in both tasks is to have regular conversations with them as the work progresses, striking a balance between allowing them the space to make their own decisions and steering them away from potential blind alleys. Of course, many of the Centres who offer the course are well aware of this. Moderators have noted that Centres have developed a multitude of strategies of their own for ensuring successful and rewarding outcomes for their candidates.

As we move to the new specifications it is unfortunate that the opportunities to develop the wider skills of independence, research, planning and ownership as well as the more easily defined skills of tabulation, graphing and analysis are likely to be limited. It is often suggested that centres can still carry out a practical investigation and still set research tasks, but given the commitment of time and effort required from both the teachers and the candidates, this is unlikely to happen to the same extent that it does under the current specification. It is important, however, that as we move forward we remember that A Level Physics is more than a body of knowledge and a set of analytical skills, and that being able to think creatively about the subject rather than simply being told a ‘right’ answer is crucial for the next generation of scientists and engineers.

Practical Investigation

As stated previously, the majority of centres have become adept at delivering this component and moderators are seeing very few cases where large adjustments are required. Where Centres do drift out of tolerance it tends to be due to being slightly generous in several strands rather than significantly over-assessing one strand. There were only a small number of cases where moderators were regularly disagreeing with a Centre’s marks in a single strand by two marks. Unsurprisingly, this tended to be in strand B (progression) or strand D (analysis). There were fewer genuinely innovative investigations seen in this session, but many of the ‘old favourites’ were done very well.

Strand A: As always, this tends to be the strongest strand as candidates approach the task full of enthusiasm and good ideas. Very few candidates now fail to consider Safety – there is almost always at least a brief mention, and more often than not a reasonably comprehensive Risk Assessment. Where moderators disagree with a Centre’s mark it is likely to be either due to lack of demand of the task chosen or a lack of consideration of the variables and practical detail to support the judgement that a candidate has demonstrated skill and care.

Strand B: A minority of candidates demonstrate genuine progression but this is to be expected given that this is a very demanding hurdle for most A Level students. A candidate who makes good use of preliminary work to make decisions about how to proceed is moving beyond the three mark statement of carrying out a related set of experiments. The key to being able to achieve progression is to analyse data as it is collected and make decisions based on the outcomes. Many candidates still collect all their data for several variables before beginning any analysis and this is characteristic of a score of three marks in this strand.

Strand C: This should be the easiest strand in which to access the higher mark descriptors. Providing a candidate has collected data of sufficient range then simply using the assessment criteria as a checklist should ensure that four or five marks are justified for strand Ci. It is always surprising just how many candidates still do not include quantities, units and tolerances in table headers or allow Excel to dictate the number of significant figures that appear in the Average column. The same is true of computer generated graphs (which has been a feature of almost every report to centres since the course began). A useful discriminator for moderators is whether candidates have clearly justified their choice of values for uncertainty bars on graphs. We still occasionally see obvious and avoidable examples of poor practice such as splitting results tables between pages and failing to include diagrams or clear photographs of experimental set-ups which should be penalised under strand Ciii.

Strand D: As ever this tends to be the lowest scoring of the four strands, particularly for weaker candidates. Obvious pitfalls include candidates claiming that an inverse/exponential relationship exists with no attempt made to test it with an appropriate power law or logarithmic plot, and getting Excel to generate an equation for a line that has no physical significance. On the other hand the best candidates are often able to test proposed relationships appropriately and support them with detailed physics knowledge. We are seeing more candidates building on the good work on uncertainties from G493 and carrying out a clear analysis of the uncertainties in derived quantities.

Some of the particularly impressive investigations that were seen this year included Reactance in AC Circuits, Torsion Pendulum and Eddy Current Braking.

Research Briefing

It is clear that the large majority of Centres understand the criteria for this task well and are able to guide their candidates towards producing good quality reports on a variety of interesting topics. It is particularly apparent that very few low scoring reports are now submitted (it is quite unusual to see anything that scores less than six out of ten) and that the moderation team rarely disagreed with the marks awarded by Centres by more than one mark. The methods employed by Centres to assess strand Biii were varied. Some clearly insisted that candidates presented their reports formally and a few included Powerpoint slides – not the intention for this task. A less formal outline of the contents of the report to the group, with questions coming from the teacher and from the other candidates works well. However it is achieved there must be supporting evidence in the form of annotation to justify the mark given.

Strand A: Most reports had a clear focus, often phrased in the form of a question. Whilst the moderation team are not expected to count the number of words, a few reports were clearly much longer than the suggested limit of 2000 words and should be penalised for this. The main area where marks were awarded generously continues to be in strand Aii. The three mark descriptor describes exactly a report with a reasonable range of sources linked to the report using embedded referencing. The five mark statement also requires a serious attempt to evaluate and cross check the information. The best candidates achieved this either by adding a short commentary about the reliability of each source and the extent to which the information found agreed or disagreed with other sources, or by presenting the bibliography in the form of a table with a column designated for comments on reliability.

Strand B: Although the assessment statement for Scope of Physics suggests that the physics may go beyond the specification, there is no reason why a candidate who limits the physics to A2 cannot be given five marks providing they fully utilise the specification content, generally with a quantitative element to their analysis. An obvious area that often crops up is nuclear energy from fusion/fission. It is quite possible to undertake a thorough analysis including binding energy per nucleon calculations and considerations of nuclear stability without going beyond the specification. However, if a candidate has missed an opportunity to fully develop the analysis then this should be reflected in the mark awarded. It is unusual to see no evidence at all for strand Biii though some Centres provide an outline of the questions asked without giving an indication of the level of the responses. Moderators are looking increasingly critically at the evidence for this strand, particularly where the mark awarded is higher than the marks given in strand Bi and Bii.

Examples of interesting or novel topics that were developed particularly well included a variety of medical physics topics such as MRI/PET Scans and technological developments such as Magnetic Levitation and Gas Turbine Engines. The usual favourites on various aspects of Space and Nuclear Energy were also well represented.

OCR (Oxford Cambridge and RSA Examinations)
1 Hills Road
Cambridge
CB1 2EU

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

For staff training purposes and as part of our quality assurance programme your call may be recorded or monitored