Oxford Cambridge and RSA

GCE

Physics B (Advancing Physics)

Advanced GCE **H559**

Advanced Subsidiary GCE **H159**

OCR Report to Centres June 2015

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.

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OCR REPORT TO CENTRES

G491 Physics in Action

General Comments:

In general, this was a straightforward paper. The overall performance of the candidates seems similar to other sessions, with a mean mark of over half marks and a satisfactory spread.
Most of the questions were not over-wordy, which meant candidates should have had sufficient time to process the information in the question. There was some evidence of candidates not having time to complete the paper, with substantial No Response to the last parts of question 10. There was a lot of information to process for Q10, when some candidates were pushed for time

The candidates' explanations tended to be poor e.g. the applications of metal alloys (Q9c), many identified an inappropriate alloy, or failed to explain its choice for the application or explain at a micro-structural level why it behaved this way. Sadly many candidates had underlined the words in the question that required answering, but then failed to deliver a response to each part.

There were some POT errors as usual and generally unclear methods / working shown in multistep calculations.

Sadly Q8 b) (ii) was misinterpreted by many. Quite a few candidates interpreted the question as a request to explain from the graph why the filament is not obeying Ohm's Law, i.e. they elaborated on their answer to 8a) 'It's not a straight line through the origin and Ohm's Law says it should be'. Rather candidates should have explained the behaviour by heating of filament and rise in resistance / resistivity of the metal.

Comments on Individual Questions: Section A (21 marks)

Q1 The introductory question on units was well answered: candidates were well prepared, full marks were common and a score of zero was rare; there was some differentiation for weaker candidates. Units of power AV were nearly always given correctly, then conductance A V^{-1} ; charge as As was the least well remembered.

Q2 The calculation of speed of light in a material: in general most candidates applied the correct equation and did this well. There were a few who got the equation inverted and some SF errors (despite the request in question to quote to appropriate SF) and a few Rounding Errors.

Q3 Most candidates could correctly analyse a potential divider, which was pleasing. The most common error was to take the resistor ratio 40/240 = 1/6 and then 1/6 x 4.5 = 0.75 V i.e. not to take the ratio including the total resistance 40/(240 + 40) = 0.64(3). Candidates tended to score both marks or none.

Q4 a) This was marked with only **one** correct point being required for the mark, incorrect estimates were ignored. Most got the mark somewhere. Students who did not score tended to be insufficiently precise about values read from the graph e.g. frequency ranges from 2 to 4 kHz.
b) Weak candidates tried to count the “warble” peaks on Fig 4.1, and gave an answer around 14, or just counted the down / up frequency shift over 0.5 s and gave the answer 2. Better candidates took a mean frequency x time approach and could get a method mark even if their frequency estimate was out of range

Q5 Involved interpreting a loudness / frequency plot for speech and music plotted on a log scale.
a) Most correctly explained how to recognise a log scale. The most common mistake amongst weaker candidates was only to record that the gaps in the scale are not equal.

b) They were asked to identify the frequency of the loudest orchestral sound. Wrong answers were often the highest frequency of music, i.e. around 17 kHz rather than 320 Hz.
c) Most seemed able to apply their understanding of scales and bandwidth to an unfamiliar context, which was pleasing. Wrong answers included using the music boundary line rather than speech, or estimating the highest frequency as 11 kHz.

Q6 This question concerned wavefront curvatures being changed by a lens.
a) Most seemed to be able apply the reciprocal rule 1/*u* to get the wave curvature with minimum fuss. A few did not evaluate the fraction (expected), and many did not see the minus sign (Cartesian convention), printed at the beginning of the answer line (this was not penalised).
b) Answers suggested that many candidates were not familiar with the idea of being able to add curvature to wavefronts using lens power, to obtain a smaller negative curvature than you start with. There were many examples of confused working out, or incorrect application of the lens formula ending up with either + 4.8 D or - 3.2D. This part differentiated the better candidates.

Q7 This question involved the p.d. against time graphs for a battery discharging at two different temperatures.
a) Candidates had to notice two effects of changing temperature: this was mostly well answered, relating the lower level of voltage or shorter duration at the lower temperature. Some lost a mark(s) because they did not relate their comments to the sense of temperature change.
b) 1. To find the average current many candidates did not estimate $V_{average}$, but took V_{max} / *R* i.e. 3.1 / 5 = 0.62 A hence getting an over-estimate, which lost a mark.
b) 2. In estimating the charge delivered ecf was allowed on their current value. There were many penalties (one mark only) for a variety of incorrect conversion of 10 hours to (36 000) seconds. Some candidates used area under graph / *R*, which could gain full marks.

Section B (39 marks)

Q8 This question concerned the current against p.d. characteristic of a tungsten filament lamp.
a) Most could state how the curved characteristic did not obey Ohm's law. Some weaker candidates referred to Hooke's Law despite the mention in the root of the question? A common mistake was to state "line does not go through the origin" which was insufficient for a mark.
b) i) Involved reading from the lowest and highest readings recorded on the graph and completing a table for calculated values of resistance and power. It was well answered for 3/3 marks by most candidates. Common errors were to misread the maximum current 284 ± 1 mA, or some POT errors misinterpreting the milli multiplier, or just miscalculating resistance or power at 6.0 V.
b) ii) Sadly there was too much evidence of candidates interpreting this part in the same way as Q8a), i.e. "It's not a straight line through the origin and Ohm's Law says it should be"; rather than to attribute the increase in resistance to the heating of the filament. Some candidates did not give the sense of the change for temperature or (more commonly) resistance, just opting for the weaker "it changes", which was not credited.
b) iii) Given tungsten resistivity at room temperature and filament cross-section, candidates had to calculate the length of wire required, stating any assumption made. This assumption mark (filament nearest to room temperature at lowest current or resistance value) was often lost, by omission, or by many in making up their own intermediate value for *R* between 21 and 3.1 Ω. This was a discriminating question with only top candidates getting 3/3 marks, but weaker ones picking up a mark by re-arranging for $L = RA / \rho$.
b) iv) This higher level question asked for the ratio of resistivities of tungsten for the filament when hot and cold. There were many NR (no response) to this difficult question. The best candidates realised it would be the same as the already calculated resistance ratio. Weaker ones gave many circular arguments assuming resistivity proportional to Centigrade temperature and ending up with a ratio of 150, which gained no credit.
c) Here candidates had to account for the good conduction in metals and suggest why it might alter with temperature. Most got two marks for "delocalised electrons that are free to move / carry charge". There was a good number of QoWC penalties applied for "atoms" instead of

"positive ions vibrating" and quite a few candidates think more electrons are liberated in metals at higher temperature which increases conductivity. A well answered but differentiating question.

Q9 This question concerned the stress against strain graphs for four metal alloys.
a) Over three-quarters of the candidates could correctly select which alloy has i) lowest Young modulus, and ii) highest tensile strength, and iii) greatest plastic region for 3/3 marks.
b) i) Here they were asked to calculate the Young modulus of one of the alloys. There were many POT errors, forgetting the GPa multiplier, and some estimates were out of range, due to poor selection of graph point to read from.
b) ii) This question to calculate the extension of a cable had the highest facility on the paper, with only a few incorrect rearrangements of the equation strain = extension / length.
c) This part concerned selecting alloys for a given purpose, giving reasons and microscopic explanations explaining their choice. Sadly this was poorly answered and organised by candidates. Many chose the wrong alloy for i) a lift cable or ii) a car crumple zone, having already recognised the correct alloy with the highest tensile strength, and with the largest plastic region respectively in 9a). Many did not link properties to the application and even more did not discuss the microstructure at all, or did so in very vague terms, or got it wrong. Many wrote about prolonging the collision time or absorbing the force or impact rather than energy. This was a disappointing response.

Q10 This question was about aspects of a movie "A boy with his atom" constructed using a scanning tunnelling microscope.
a) i) Nearly all candidates could explain that a 4 bit number codes for 16 different intensity levels.
a) ii) In finding the information in bytes per image, the most common error was to multiply the number of pixels by 16 levels instead of 4 bits per pixel and get 2 400 000 bits or 300 000 bytes for the final answer.
a) iii) Here to find the information in bytes for the whole movie, ecf was applied from their bytes in a) (ii) so the facility rose considerably as most realised that there were 450 images in 90 seconds.
b) Here they were asked to calculate the magnification of the atoms in the image (involving measuring the atoms in the image - many estimates were out of range e.g. 3mm). There were many POT errors, some candidates mixed up nano and pico multipliers. Although some good students gave clear, correct, concise solutions, there were also lots of blanks for this part.
c) In this part candidates were asked to estimate the resolution of the image and make their method clear. They were mostly very poor at showing their method, or gave part solutions that didn't get to the final answer at all. It was often hard to tell what their method was, or what size they thought an atom was on the paper. The top quarter of candidates managed to score both marks, indicating good differentiation.
d) i) Candidates had to calculate the sensitivity of the STM by drawing a tangent to the graph at height 0.25 nm above the surface. Many did not draw a sensible tangent, or misjudged the x axis scale and drew it at 3.0 nm. Many took y/x rather than dy/dx gradient 160 / 0.25 = 640 pA / nm which scored zero or had POT errors. Quite a few got 1 mark for an acceptable gradient or triangle drawn on the graph, but calculated it out of range.
d) ii) Candidates had to sketch an appropriate tunnelling current against distance on surface graph. There were now a substantial number of nil responses. Most 1 mark answers were for a correct single and double peak shape but drawn too low in current value i.e. not using all the information given.
d) iii) Candidates had to link the current from STM to the image. There were lots of vague answers along the lines of "increase in current shows presence of atom" as if the computer drew an atom when the current increased! About a quarter of candidates managed to correctly link the current value to a pixel greyscale value to explain image formation.

G492 Understanding Processes/Experimentation and Data Handling

General Comments:

The number sitting this examination was similar to that for June 2014, and the mean score slightly higher. There were relatively few candidates who were clearly 'out of their depth', and the standard of English and Maths is generally improving.

It was noticeable in this long examination that a number of candidates did not leave themselves enough time for Section C, based on the pre-release materials, although few ran out of time before completing the paper. A number of Examiners also felt that candidates had not prepared the pre-release materials adequately for the examination and did not do themselves credit in section C as a consequence.

One shortcoming in the longer questions commented on by Examiners this 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.

Once again this year, Examiners felt that many candidates did themselves a serious disservice in that their writing and presentation of calculations was so poor it was often impossible to discern what they had intended. It is in candidates' best interest to ensure that the Examiner can follow their work clearly: particularly praised by many markers was the clear way in which many candidates who needed to use the extra pages at the back of the paper signalled this clearly in the main answer space with (see page 22).

Comments on Individual Questions:

Section A (Questions 1 to 7)

This section proved accessible, as intended, with most candidates getting >15/21 and stronger candidates getting nearly all of the marks.
Few candidates were able in Q4 to sketch the effect of widening the slit on the diffraction pattern.

In Q6, many candidates did not state an assumption which needed to be made, and quite a few applied equations of uniformly accelerated motion without having different signs for *u* and *v*.

Section B (Questions 8 to 11)

Q8 (Standing waves)
This question was well answered on the whole. In part (a) a number of candidates used the word superimpose rather than superpose and many failed to understand that the standing wave was created as a result of two progressive waves rather than reflection of a progressive wave. Some seemingly concentrated so much on explaining the properties of a standing wave they forgot to mention the situation at X. In part (b), many gained only 1 mark for calculating λ and did not go on to halve it. In part (c)(i), most realised that the frequency had to have been doubled, but only the better candidates rationalised it correctly: if $\frac{1}{2}\lambda$ has been halved, then so has λ, so *f* must have been doubled. Part (c)(ii) was the hardest part, as many candidates concentrated on what happened at X and did not compare the waves leaving the two speakers. Those stating 'they are out of phase' rather than 'they are in anti-phase' or 'they are 180° out of phase' did not get the mark. Part (d) was generally well answered, even if not always clearly expressed.

Q9 (LED lamps)
In (a)(i), most candidates gained at least 2 of the 3 marks, with the commonest error being to use 5W as the power rather than 5 W/22. In part (a)(ii) most relied on the notion that the intensity depended only on number of photons, so assumed that the same number of photons transferring more power (50W) meant the filament lamp photons had more energy, while others confused the ejection of photons with the ejection of electrons by the photoelectric effect. Many candidates gained a mark for recognising that the filament lamp photons were of lower energy/frequency although their reasoning wasn't always clear.

In part (b), many calculate the purported mean wavelength to be 600 nm but did not make any meaningful comparison with the wavelength distribution in the spectrum. In part (c) most candidates realised that the LED lamp producing the second spectrum looked more red, although some thought it must be a filament lamp. Some interesting environments were suggested for its use; photographic dark rooms and traffic lights were popular.

Q10 (Baumgartner's fall)
It was disappointing in part (a)(i) that fewer than half the candidates drew a tangent at t = 30 s, and of these many then calculated the gradient using Δt < 20 s. In part (a)(ii), about half the candidates correctly related the resultant acceleration to the weight and the air resistance and gained all three marks. The description and explanation of the velocity changes in the graph between 30 s and 70 in part (b) was well done by most, although some provided explanations of what was happening before 30 s or following from 70s. In part (c) most candidates did show their method, and divided the area into trapezia, or rectangles and triangles, or counted squares, to obtain a result.

Q11 (Coaches vs cars)
Parts (a) and (b), involving fairly straight-forward algebra, were two of the questions most frequently left blank in this paper. In part (a) it was necessary to show that the volume of air was the cross-sectional area *A* multiplied by the distance moved in time *t* and this was often not clear. Some candidates attempted to use dimensional analysis to derive the equation, but that is not acceptable. 1A number of candidates put off by part (a) did not attempt (b), even though it was simpler. Part (c) was generally done well, although $\underline{P = E/t}$ was not evident in some responses. In part (d), a large number of candidates didn't refer to energy losses as directed in the question; at least one candidate wrote "this is not physics", rather missing the point and didn't score very highly. Many candidates wrote a great deal on the social/environmental issues but often did not give enough energy arguments to gain good marks.

Section C (Questions 12 to 14)

Most candidates were well prepared for these questions on the advance-notice material, but a number did not answer the questions set, probably reverting to what they had prepared against similar but slightly different questions. As always, some candidates had not adequately studied the advance notice material, even though their Centres will certainly have taken them through it in detail.

Q12 (Sensors)
Part (a) was well done by most; virtually all had (a)(i) correct, and most had (a)(ii) also correct. Part (b) was well done by most, although quite a few confused the sensitivity with the gradient of the *V-t* graph. Most scored well in part (c)(i), with less-successful candidates not linking the choice of sensor clearly to the application stated (an incubator for a baby). Most gained full marks in (c)(ii), and the quality of graph-sketching was consistently good.

Q13 (Energy saving houses)
In part (a), where extended writing was required, many answers were rambling and unclear. Despite the instructions in the question '…use data… ignore any changes in the number of people living in the house…', many candidates failed to do follow either of those instructions.

Part (b) was surprisingly poorly done: many candidates gained 1 mark for getting the energy reduction in kWh but then did not (or could not) convert to J, while others did not use the data in the table as instructed but read from the bar chart.

There were some good answers to (c)(i), (ii) and (iii), but weaker candidates did not see the underlying development (the 'story') in this part of the question. In part (c)(ii) many wrote that decreased energy use suggested that 2000 might have been warmer than 1996, which is an outcome that would have been expected from the use of heat pumps. In part (d), most spotted the negative correlation but better candidates realised that 3 marks required rather more and identified the poor fit to the regression line, and also the better fit in the summer months, while some months with very similar temperatures had very different energy use.

Q14 (Young's experiment)

Answers to (a)(i) were often superficial: Newton was often stated to be an authority, but without qualification, and religious beliefs often cited as a likely factor. Einstein and photoelectric effect sometimes appeared in responses. In (a)(ii), many thought the size of the hole should be about the size of one wavelength of light, and in (a)(iii) most referred to monochromaticity, coherence or brightness, while some felt a laser would have allowed Young to have done his experiment at night or during cloudy weather.

In part (b), many candidates had the right idea but could not express it clearly, often gaining one mark for 'easier to measure'.

Part (c)(i) was well done by many: a popular response was not simply to calculate the percentage uncertainties in *x* and *d* and to show that the latter was greater than the former, but to calculate all three percentage uncertainties and to add them, showing that this was considerably greater than the percentage uncertainty in *x*. This was acceptable. Part (c)(ii) had difficult units, and *Power-Of-Ten* errors lost marks here for many. If the same POT error were made in (c)(iii), it was treated as *error carried forward* and not penalised further.

Part (c)(iv) was difficult for many, and there were many interesting answers. Most candidates failed to follow the development in part (c) and compare the random uncertainty from parts (i) and (ii) with the systematic error from the 'book' value of 635 nm and relate it to misaligning the card. Many candidates realised that the tilted card would give a greatly increased value of *d*, but only the best realised that this greater *d* would give values of *x* which were smaller than expected, resulting in too small a value of *x* × (incorrect *d*)/*L*. A number of candidates ingeniously estimated the increase in *d* produced when the card is tilted though a chosen angle.

G493 Physics in practice

General comments

This was the final full year of the AS coursework unit of Advancing Physics. The moderation process for the vast majority of centres was straightforward as the overall quality of administration was high. Following the request for the sample most Centres responded promptly in submitting well-organised portfolios together with the associated documentation. The thorough checking of the addition and transcription of marks prior to submission was appreciated and there were few clerical errors. However, whilst evidence of internal standardisation was welcome, the inclusion by some Centres of more than one Coursework Assessment Form was potentially confusing for Moderators. In such cases the agreed definitive mark must be clearly indicated.

The work of candidates should be annotated to show where marks have been awarded, as this enables the moderator to easily check that the assessment criteria have been applied correctly. It was particularly useful to the Moderator when teachers indicated errors of physics or mathematics. Although the level of annotation for the Quality of Measurement task was generally high, there tended to be fewer comments to support the marking of the Physics in Use task. Many centres were allocated the same Moderator as in 2014 and some had clearly acted on the specific feedback given in their individual reports last year. However in other cases Moderators reported similar discrepancies relating to the awarding of marks to those noted previously. Common issues for each of the two tasks are summarised below.

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 lenses, sensors, materials and waves were other fruitful areas of the AS 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 sometimes lacking, even in cases where there were clear potential hazards with the experiment.

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 used, 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 that any suggested improvements to the experimental method had made to 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. A few candidates embarked on potentially interesting projects that did not lend themselves to drawing graphs. Although primarily assessed in strand C the relevant physics should be integrated into the report, rather than being dealt with in a separate ‘theory’ section near the start, or tacked on at the end.

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 for high marks to be awarded. However, the use of the Excel function that gives 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 it was difficult to judge the quality of the work produced in some cases 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 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. Aspects of both good and poor physics should be indicated; otherwise the Moderator may assume that any errors not noted have been overlooked when awarding marks.
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). It can be helpful to couch the title as a question, such as “Why is carbon fibre used for hockey sticks?” as this immediately focuses the candidate on the properties needed for that application. Other interesting topics chosen this year included:-

- Acrylonitrile Butadiene Styrene used in 3D printing
- Carbon nanotubes in bone tissue engineering
- Cellulose microfibrils in plant cell walls
- Copper in architecture
- Cupro-nickel in coins
- Germanium in telescope lenses
- Graphene in touchscreen displays
- How have developments in glass technology made road vehicles safer?
- How is concrete used successfully in the application of floating dock systems?
- Nickel in the turbine blades of jet engines
- Reinforced carbon-carbon in the nose cone of the space shuttle
- Self-healing asphalt concrete
- Stainless steel in stents
- Tungsten in fission reactors
- Why is Aramid Fibre Used in Boat Hulls?
- Why is fibreglass used in pole vaults?
- Why is galvanised steel good for making trampoline springs?
- Why is silicone rubber used for heart-lung machines?
- Will Graphene be an alternative to copper wires?
- Zirconium Dioxide in ceramic knives

In strand A(ii) of the assessment criteria most candidates clearly identified the information used, for example by quoting the full web address for internet-based sources. The use made of the information 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 was preferable to it being on the final slide of a PowerPoint presentation, where the resulting small text often proved rather difficult to read.

G494 Rise and Fall of the Clockwork Universe

General Comments:

This paper turned out to be similar in difficulty to its predecessors.

As ever, weaker candidates who can successfully calculate quantities with complex formulae, often flounder when those formulae have to be transposed or combined. A lack of formal and logical arrangement of steps in their working does not help Examiners in their quest to award marks.

Many candidates of all abilities still fail to give precise explanations and descriptions, often being content with vague statements of general rules.

Comments on Individual Questions:

Section A

As in previous years, this section contained a number of short, relatively easy questions covering the whole module.

Q.1 The vast majority of candidates correctly identified the unit for gravitational field strength, but weaker ones had some difficulty identifying a possible unit for gravitational potential.

Q.2 Although most candidates scored at least one mark for this question about evidence for the Big Bang, many failed to earn the second mark. Those who opted for background microwave radiation often didn't explain that this was red-shifted radiation from an earlier time in the universe. Others forgot to mention that the recessional velocity of galaxies was deduced from the red-shift of the light from them.

Q.3 This question discriminated well, with the majority of better candidates having no difficulty in using the data to calculate the speed of the particles. The few weaker candidates who could successfully calculate a value for γ were often unable to sort out the square root correctly.

Q.4 This question required candidates to show that momentum was conserved but kinetic energy was not. The few candidates who simply wrote out the calculations with no supporting words of explanation earned very few marks. The calculations were not difficult, but needed to be in a structure of words to explain what the candidate was trying to show. Many strong candidates lost a mark by failing to show why the final mass of the object was 400 kg. Although about half of the candidates were able to give a correct reason for the non-conservation of kinetic energy, very many forgot about the context and stated that the “missing” energy had become sound.

Q.5 The vast majority of candidates were able to identify the correct *p-T* graph for an ideal gas.

Q.6 This question was about an iterative calculation for an object in SHM. Although most candidates were able to complete the first two rows correctly, only a minority managed the calculation for the third row. Only a minority of strong candidates were able to explain why the values from the iterations were different from those obtained from a formula.

Q.7 Many weak candidates ignored the data and tried to justify the formula. Those who used the data often failed to use all of it to test the relationship. Only a minority of strong candidates used an appropriate number of s. f. in their calculations.

Q.8 Just under half of the candidates were able to describe a practical method for determining the decay constant. Too many assumed that N was the activity of the sample, and those that glibly said “measure the half-life” without explaining how to do it lost the mark.

Q.9 This question didn't discriminate at all, although most candidate were able to identify the correct equipotential curve around the binary star.

Section B

This section always contains four longer questions which test a candidate's understanding of selected parts of the module.

Q.10 This question about estimating a value for G proved to be very straightforward for most candidates. However, in part (a), a large proportion of weak candidates could not do the algebraic manipulation; those who started off with the correct relationships often erroneously included a minus sign which had to be quietly forgotten at a late stage. The two-part calculation of part (b), although involving complicated formulae, proved to be quite straightforward for the most candidates. Similarly, few candidates were unable to state one assumption behind the Earth-Moon distance calculation for part (c)(i), but only about half were able to give two. A common error was the assumption that the Moon had to be stationary for the method to work. Part (c)(ii) was another two-part calculation which was well answered by the majority of candidates. However, only a minority of strong candidates were able to identify the mass of the Earth as the source of the error for part (c)(iii).

Q.11 Part (a) of this question required candidates to explain how air molecules can provide a pressure on the Earth's surface. It was poorly answered. Although nearly all candidates mentioned that the molecules hit the surface, only some of them stated that this transferred momentum to the ground, and even fewer that the force on the ground was the rate at which momentum was being transferred to it. Very many candidates lost marks by quoting general rules about force and momentum transfer without mentioning the objects (molecule or surface) involved. The calculation of part (b)(i) proved to be very straightforward, with only a small minority of candidates being unable to convert degrees centigrade into kelvins. Part (b)(ii) was a stretch-and-challenge question which discriminated well. Although most candidates calculated the force correctly, many lost a mark by forgetting that the molecules bounce off the surface when they hit it, and omitting to state a relevant assumption.

Q.12 This question was about discharging a capacitor. Part (a)(i) proved to be straightforward for the vast majority of candidates, but part (a)(ii) caused them difficulty, usually because many of the candidates ignored the fact that discharge did not start when the time was zero. Although questions like this have been set many times before, most weaker candidates wanted to use $Q = CV$ to find the value of the capacitor instead of reading the half-life off the graph. Similarly, less than half of the candidates could calculate the leakage current for part (b)(i), mostly because they failed to distinguish between Q and ΔQ. Many candidates correctly identified ε as energy for an electron, most wrongly assumed that it was to force the electron across the capacitor rather than allow it to move freely through the dielectric. The calculation of part (b)(iii) was another stretch-and-challenge question, with only stronger candidates able to successfully solve the simultaneous equations with the help of logs.

Q.13 This question concerned forced vibrations of a lift. Although many candidates could satisfactorily explain the safety aspects of resonance in the system for part (a), many had difficulty with the synoptic element from G491 in part (b)(i). Many candidates were unable to do this, often confusing the length of the cable with its extension in their attempts to derive the required rule. The calculation of part (b)(ii) discriminated very well, with weaker candidates often selecting the wrong mass for the lift cage and confusing the period of the oscillation with its frequency. Part (c)(i) was very poorly answered, with most candidates unable to explain why damping was impractical for a lift, usually because they failed to mention a damping mechanism, such as friction. However, many were able to suggest and explain a practical modification which would improve the safety of the lift.

G495 Field and Particle Pictures

General Comments:

The marks on this paper ranged from 9 out of 100 up to 96 out of 100. The mean of 61% is the same as June 14 and similar to the sessions before. Once again, there was very little evidence of candidates running out of time and, most encouragingly, few questions were left blank. This suggests that the candidates generally had sufficient confidence to respond to questions on all areas of the specification.
There were only four 'show that' calculations across the whole paper so fewer marks could be gained through trial and error; this puts the mean mark in context and provides further evidence that the students were well prepared by the Centres. This was particularly evident in the questions based on the Advance Notice article, although even in this section there were some questions that proved surprisingly difficult for many. Once again, some of the work was difficult to read and some candidates lost marks in 'show that' questions through not giving their own values or presenting incomplete arguments – in such cases it was clear that the candidate had the knowledge to gain more marks.
Following the trend from last year, more care was shown with significant figures in this session but incorrectly rounding intermediate values remains a source of error. Once again, the best candidates show the ability to apply physics to novel situations and demonstrate their understanding through clear explanations.

Comments on Individual Questions: Section A (21 marks)

Q1 The opening question tested recall of terms. This was correctly answered by the majority of the candidates.

Q2 This question required careful drawing and many candidates lost a mark through insufficient care. A small minority of responses failed to gain marks as they drew trajectories which did not take the same path as the original track. The explanation for the difference in tracks proved more challenging. A common error was to state that the slower particle had 'more' force on it.

Q3 This proved accessible to most of the candidates who easily linked the straight line to a uniform field and then calculated the field strength from the gradient. A sizeable proportion of the candidates lost marks through not including units in their answer.

Q4 Another accessible question. The majority of candidates recalled basic facts about alpha particles and used their understanding to explain a possibly unfamiliar situation.

Q5 This was intended to be a very accessible question but a surprising proportion of the candidates failed to gain the mark.

Q6 This question, on flux and flux density, proved challenging to many. Whilst the majority of the candidates stated that the flux remains constant throughout the core, a sizeable proportion failed to state that the flux density is double in the part of the core of half the cross-sectional area, merely writing that the flux density would increase was not enough to gain the mark. The second part of the question was also challenging; many candidates lost marks through confusing the terms 'permeance' and 'permeability'.

Q7 This was one of the most accessible questions on the paper.

Q8 Although the majority of responses gained full marks for the calculation in part (a), far fewer candidates gained the mark in the second part of the question. A common error was to cite 'high activation energy' as the reason for the need for high temperatures without making the link between high temperatures and the energy of the nuclei. A sizeable minority of the candidates suggested that high temperatures are required to overcome the strong nuclear force.

Section B (total 39)

Q9 This question concerns electric fields near point charges. Parts of the question proved challenging and showed that many candidates don't have a confident grasp of the concepts of field strength and, in particular, potential. This is one of the more conceptually stretching parts of the course so it is unsurprising that the question caused candidates problems.
(a) The opening was well-answered by the majority.
(b) The second part of the question, involving calculating the potential and field strength, was differentiating. Candidates who scored well on the paper overall tackled these calculations with ease whereas weaker candidates failed to use inverse and inverse-square relationships correctly.
(c) (i) Candidates scoring well over the whole paper scored 2 or 3 marks on this question and gave a good explanation of the equal and opposing fields in the first case and successfully calculated the field strength in the second case. Some candidates reached the desired value of 6.3×10^{7} N C^{-1} through using an incorrect separation of 2×10^{-3} m. This showed a lack of understanding of the physics of the situation.
(d) (ii) This was a challenging question for many and revealed common misconceptions. Common errors included considering potentials to have opposite directions and reference to the force at the centre point. Many candidates talked about the potential of (or at) the charges rather than the potential at the midpoint. This may be a helpful question to discuss in class.

Q10 This question concerns a simple motor and touches on a number of concepts from electromagnetism. Candidates always find this topic challenging, and this year was no exception.
(a) (i) This simple calculation proved to be less accessible than expected. The majority of the candidates failed to gain the mark because they did not take into account the number of turns on the coil.
(ii) Most candidates gained the first mark here for stating that the force on the side of the coil would halve although some failed to give the factor by which the force changes, a similar error to that discussed in question 6. The second mark – that there are other factors affecting the rate of rotation of the coil so it will not simply double – was not gained by many.
(b) (i) and (ii) A return to relatively straightforward calculations allowed many candidates to pick up marks.
(iii) This question was designed to stretch the candidates. The majority of responses gained marks for successfully describing the relationship between rate of change of flux and emf. However, significant misunderstandings were also evident. Many candidates wrote of an induced current opposing the supply current. Some responses suggested that the induced emf produces the current in the coil and the emf will be greatest when the flux linkage is greatest.

Q11 This question is about the deflection of particles in a magnetic field and requires the candidates to think critically about a well-known representation of particle deflection.
(a) (i) and (ii). These questions were answered correctly by the majority of the candidates. Some candidates missed out on the first mark by simply stating that the motion of the alpha particle was 'centripetal' rather than stating why the motion was of this form.
(b) Although the better candidates gave clear answers, there were some quite common misunderstandings revealed. Weaker answers considered 'weight' to be a factor and suggested that the zero deflection of the gamma ray was due to its lack of mass (even though they had successfully derived the explanatory equation in part (a) (ii)).
(c) This is a challenging question and it was encouraging to see many high-scoring responses to a context the candidates are unlikely to have considered. This shows a good understanding of basic physics and the ability to apply such understanding to unfamiliar situations. The best responses explicitly stated that B is a constant so cancels when considering

the ratio of radii of paths. Many correctly calculated such a ratio and used their value to discuss the inaccuracy of the well-known representation.

Q 12 This question is about using iodine-131 as a tracer.
(a) The first part of the question is the familiar challenge to show that lepton number has been conserved. Although there was some evidence of a lack of understanding of the term 'lepton number' (typically confusing it with the proton numbers of the nuclei shown), most marks were lost through giving incomplete explanations. Many candidates failed to state that the lepton number on the left hand side of the equation is zero, so correctly showing a zero value for the right hand side can only gain one out of two marks.
(b) (i) This 'show that' question proved straightforward for the majority of the candidates.
(ii) Most candidates performed this calculation with confidence. Some candidates realised that the 12 weeks represents 10.5 half-lives and so divided the original activity by $2^{10.5}$ whilst others used the exponential decay equation.
(c) Many candidates gained the two marks available for the calculation but did not make a comment about the assumption or merely restated the stem of the question through stating that the assumption is that all the iodine decayed in the gland. The only common error in the calculation was to use the value for activity rather than the number of particles.
(d) Although the majority of candidates gained some credit here, only a minority gained all three marks. Once again there were errors of omission such as not clearly stating that iodine-131 emits beta particles. Some candidates suggested that gamma emitters are used because gamma radiation can pass through skin; whilst this statement is correct it is not markworthy as the radiation must pass through a greater thickness of absorber than a layer of skin.

Section C (total 40 marks)

This section was based on the Advance Notice article concerning optical microscopes and electron microscopes. Many candidates answered the questions with the confidence of the well-prepared and it is clear that many Centres have discussed the article with students and explored possible areas for questions and calculations. Nevertheless, some of the questions will have tested the candidates' ability to think under pressure. There were very few questions left blank so it is unlikely that candidates have been disadvantaged by not having time to attempt questions for which they may have been prepared.

Q 13 (a) and (b) The first part of this question proved straightforward. The (b) part was expected to be equally accessible, but this was not the case; only about half the candidates reached the correct value. This is an area of the course they meet early in the AS year and it was clear that many candidates had forgotten that object distances are negative in the Cartesian convention. If a candidate chose to use a different convention full marks could still be gained for a correct answer.

Q 14 (a) This is a straightforward calculation and the majority of candidates gained both marks. (b) This calculation is less straightforward and many candidates lost marks through confusing units and inaccurately calculating the area of a single lens.

Q15 This long question is about accelerating electrons in an evacuated tube.
(a) This simple calculation was correctly answered by all but a few candidates.
(b) This was a rather greater challenge. The better candidates correctly converted 1 cm^3 into m^3 and reached the correct value. Candidates scoring two out of three marks realised that a conversion was required but showed a power of ten error. Weaker candidates only gained one mark as they simply ignored the volume factor.
(c) (i) This was generally well-answered with many candidates producing very clear arguments. Weaker responses described the Boltzmann factor in general terms rather than applying it to the specific situation.

(c) (ii) This challenging calculation was performed correctly by more than half the candidates, even though their working was sometimes labyrinthine and difficult to follow. Weaker candidates simply multiplied 2200 by 3 to gain 6600.

Q 16 This long question focuses on the acceleration of electrons.
(a) (i) and (ii) These proved to be straightforward calculations.
(b) Another straightforward calculation that was answered correctly by the majority of candidates although there was some (mis)use of $E = hf$ by weaker candidates.
(c) As with the other parts to this question, most candidates reached the correct answer.

Q 17 This question proved more challenging than many in this section even though the physics involved is straightforward. Although the majority gained the marks for part (a), the simple calculation of resistance given the resistivity and the data required to calculate the resistance proved more difficult than expected. Many candidates simply assumed that the resistance was 1.6 ohm. The poor performance on this question may be due to this area of physics being covered early in the AS year, similar to question 13.

Q 18 This question is about the deflection of electron beams.
(a) A straightforward 'show that' question.
(b) This question proved to be highly discriminating. Weaker responses tried to calculate the force on the electron using $F = qvB$. This error did not stop candidates gaining credit for a correct use of an incorrect value for force, but most responses that confused electric and magnetic effects failed to get beyond a force calculation. The markscheme allowed for the possibility of a candidate using relativistic effects but none of the markers reported any examples of this. The best candidates produced clear calculations that showed complete confidence in using ideas from different parts of the course to reach an answer.
(c) Just under half the responses gained both marks for this question. Candidates who could not see the simple reasoning tended to fill the answer space with a description of varying forces somehow balancing out.

Q 19 The last question on the paper was a calculation of the gamma factor for an electron leading to a calculation of its velocity. In the past such a question may have been split into two to make the route to the answer more obvious. It is encouraging that around half the candidates gained full marks for this extended calculation at the end of a two hour paper. A few of the weaker candidates gained two marks for correct use of an incorrectly calculated gamma factor, but most of the answers which showed an incorrect gamma factor showed further errors.

G496 Researching physics (A2)

General Comments:

The Researching Physics component remains the highlight of the Advancing Physics course for many Centres. Candidates continue to generate a wide range of interesting portfolios and the skill their teachers employ in guiding them towards fruitful areas of research remains impressive. Where the assessment of the coursework at a Centre is undertaken by more than one person, there is a requirement for an internal Moderation process. At Centres where such a process has taken place it is important that an unambiguous single mark total for each portfolio is clearly indicated. The best Centres are able to elicit well written, compelling Research Briefings and encourage their charges to carry out rewarding and successful Practical Investigations.

Practical Investigation

Moderators reported that the Practical Investigation was the component most likely to reveal a discrepancy between their marking and the Centre's own assessment. Strand A assesses the way that the candidates approach their projects and Strand B how well the relevant Physics has been used to make progress. Moderators reported that some centres had been generous in their marking of these Strands. Candidates that scored highly generally investigated topics firmly rooted in the Advancing Physics course and chose one or more continuous variables to focus on. They were also able to provide evidence that their Investigation had developed beyond the initial plan. These candidates also realised that the physics they included should be appreciably of 'A' level standard.

In Strand C the way the evidence is gathered and displayed is assessed. The data gathered during the Investigation needs to be reported clearly in tables headed with quantity and unit and recorded to an appropriate and consistent number of significant figures. Any graphs plotted should be relevant, have explanatory titles, major and minor gridlines have clearly labelled axes, best fit lines and neatly plotted points. Centres are becoming much more insistent that where graphs play an important role in the narrative they must be displayed as full pages rather than thumbnails surrounded by text.

Strand D of the assessment requires candidates to draw some conclusions and link the data they have gleaned from their experiment to a conclusion. This continues to present challenges for even the most able making it all the more pleasing when this aspect is well tackled. Some of the more mathematically inclined candidates embarked on long unnecessarily detailed analyses of the errors in their measurements eclipsing the more interesting experimental anomalies that if investigated might have revealed some more interesting physics. Clearly stated mathematical relationships between the variables supported by graphs relating suitably derived quantities marked out the very best candidates in this year's cohort.

Popular topics for this year's Investigations ranged from the behaviour of viscous liquids as their temperature changed to the relationship between the input and output voltages/powers/energies of transformers constructed in ways too numerous to list.

Research Briefing

Centres have made clear to their candidates that they must select a topic for research that gives scope to demonstrate their level of understanding of the physics underpinning their choice. Most candidates understand the need for a comprehensive bibliography linked to their writing, illustrations that assist in explaining the details and the need to include plenty of relevant 'A' level physics as they construct their reports. Centres have developed their own techniques for assessing their candidates' understanding of the material they have researched; some use an individual interview, others prefer a class presentation followed by a Q&A session. Most centres provide a single sheet of notes taken during this process as evidence for the Moderator rather than using the rather small box provided on the assessment grid. Moderators reported that their assessment of the Research Briefings rarely differed by more than one mark from the centres own score for this component of the portfolio.

Space topics remain most popular with the very best reports giving impressive summaries of the latest research in the field.

Comments on Individual Questions:

N/A

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