RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE **A2 H559**

Advanced Subsidiary GCE **AS H159**

OCR Report to Centres

June 2012

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

Overview

Once again, the four papers taken in this session have shown the best candidates performing to very high standards. It is particularly pleasing to see that the new approach of G491, limiting Section B to three longer questions, has retained the more appropriate marks of recent sessions. The mean mark for G491 this June is 34.3 out of 60 which compares well to the mean mark of 35.5 last June. There was very little evidence of candidates running out of time on this or any of the other papers. The longer paper at AS level, G492, produced a mean mark of 55.5 out of 100, compared with 55.9 from June 2011.

The two A2 papers seem to have been a little more accessible than in the previous June. G494 produced a mean mark of around 36 out of 60 compared with around 32 in the previous year. The mean mark on G495 was 62.7 out of 100 compared with 56.2 in the previous June.

The comments on the individual papers will give more detail of candidates' performance but there are certain areas that can be highlighted. In particular, mid-range candidates lost marks in a number of key areas. These are: rounding errors, incomplete algebraic arguments, incomplete or imprecise arguments in explanatory questions and lack of care in graphical questions and diagrams. It is also apparent that some candidates do not read the longer questions thoroughly before attempting to answer the earlier parts of the question. This means that the candidates do not always construct clear arguments in the latter parts of a long question.

The coursework boundaries remained the same as in 2011. This shows that Centres are generally correctly applying the criteria for assessment. Detailed comments given by the principal moderators will help Centres in future sessions.

News round-up for GCE Physics B

A level reform
Over the last year, the future of A levels has received extensive interest. Ofqual is currently running a consultation to seek views from higher education, employers, learned societies, colleges, schools and others.
There is a link to all the relevant consultations, debates and reports at
http://social.ocr.org.uk/groups/science/conversations/level-questionnaire-and-level-reform
(also see http://social.ocr.org.uk/groups/science/conversations/level-timelines). We would strongly encourage teachers to contribute to the consultation (11 September deadline).
Additionally, if you have suggestions of content you would like to see in any revised GCE Physics qualifications please e-mail your comments to GCEScienceTasks@ocr.org.uk, we would be very happy to hear from you.

Keep up-to-date with developments in GCE Physics
The OCR community, www.social.ocr.org.uk/groups/science, is a useful reference point to help keep teachers up-to-date with GCE Physics (and science). I would strongly recommend visiting the site and registering.

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G491 Physics in Action

General Comments

For candidates this appeared a very accessible paper. The new style with a reduced amount of reading (with three rather than four questions in section B) helped all the candidates and the vast majority were able to complete their papers in the hour available. The mean mark was over half the total with a satisfactory spread.

Comments on Individual Questions

Section A

In questions 1 and 2 candidates scored well, having to match electrical units to some equivalents and mechanical properties to some definitions. The starter questions were accessible to most candidates as planned. The most common unit errors made were equating: 1V to 1V A^{-1} and 1 Ω to 1 J C^{-1}. In mechanical properties, mixing up the definitions of hard and tough was common.

Question 3 was a straightforward potential divider application but successfully differentiated weaker candidates. In part (a) many of these tried to use voltage ratio and resistance ratio but made the mistake of using the ratio 1:4 to split the 6 V p.d into 4 rather than 5 parts ending with the incorrect answer 1.5 V rather than 1.2 V for the p.d. across the smaller resistance. In part (b) to calculate the power in one part of the divider the differentiation was greater. Few candidates used the most direct method of V^2 / R or if they did, used the wrong p.d. (usually total of 6 V) or got confused by extended working. The marks were available by ecf from an incorrect voltage in (a).

Question 4 was about calculating and describing the variation in sensitivity of a resistance thermometer from graphical data. It was a good differentiator, only about a quarter of candidates could calculate the sensitivity as the *gradient* ΔR / ΔT. The most common errors were: power of ten errors, with candidates missing the fact that R was given in kΩ ; and many evaluated only R / T getting 8.8 Ω $^{o}C^{-1}$ which scored zero. In describing the change in sensitivity in part (b) about half noted the decrease at higher temperatures for an easy mark but suggested the limit of constancy was above 500 ºC, and so missed the second harder mark. To judge linearity of data candidates could be encouraged to compare to a ruler (straight edge) or to look obliquely along a line to better judge where it starts to curve. Another common error was to suggest sensitivity was rising and then levelling off, i.e. they were discussing *R* the y-variable and not gradient (sensitivity).

Question 5 was about a lens forming a tiny image of a microcircuit. In part (a) many candidates seemed unfamiliar with the magnification (10^{-3}) of less than 1 where the image is smaller than the object. They could still get a straightforward first mark for recalling: magnification = *v* / *u* but many confused *u* and *v* and did not get the second mark.
In part (b) there was as usual a good range of responses for the lens formula calculation. Many continued to confuse *u* the object distance with *v* the image distance, although these are defined on the data and formulae sheet, and scored a maximum of 1 mark for defining lens power correctly. Examiners had to be very careful not to award full marks for a correct value on the answer line when the method was totally flawed containing multiple errors.

Question 6 was about scaling a galactic nucleus on an astronomical image from the Hubble Space Telescope, it was pleasingly well done compared to similar questions from previous seasons. There were many ways to get to an answer within an acceptable range (narrow scoring 3/3 and wider scoring 2/3). Weak candidates got a first mark for starting to measure the pixels per cm of image. Several candidates calculated the number of pixels across the nucleus and gave that as the answer, and could score 2/3. Benefit of doubt was applied to candidates getting $33 \times 10^3 \pm 3 \times 10^3$ light-years, even if their method was not totally clear and they scored full marks. Those that did something involving total number of pixels in the image tended to tie themselves in knots and score zero.

Question 7 was a rather novel type for this paper. It involved two simple Fermi-type questions where candidates had to estimate quantities (breaking strain in a rubber band and the power of a 'one cup' kettle in kW) given five different orders of magnitude to select from. There was a wide range of answers, but the question was reasonably well answered with fair differentiation.

Section B

Question 8 was about plastic materials. In part (a) most knew how to calculate the Young modulus, but power of ten error or unit errors (Pa / m) sometimes cost candidates the last mark. The calculation of force in the sample at given stress and cross-sectional area in (aii) was straightforward for most but again a few made power of ten errors.

In part (bi) describing the behaviour of the sample from a stress versus strain graph many candidates gained a mark for mentioning plastic behaviour. But candidates then struggled to find the correct language to describe the behaviour of the material. The commonest errors were: stating that strain increases rapidly or that it undergoes a lot more strain than stress, or writing about the sample being hard or easy to stretch.

Most candidates used the correct method in (bii) for calculating the extension, but many struggled to pick the correct strain from the graph at the breaking point, and some felt they had to subtract the original length from a correctly calculated extension.

Part (c) was generally well answered for a question that required explanation of what happens to the long chain molecules as the plastic stretches. Many responses used technical vocabulary with confidence and there were lots of ways to get the marks. The commonest errors were answers giving metallic bonding explanations and discussion of macroscopic behaviour only.

Question 9 concerned a voltmeter calibration using a standard cell whose specifications were given. This question proved challenging and differentiated well. In part (a) most candidates recognised the number of significant figures in the standard emf correctly as four, but the most common error was to confuse with the number of decimal places and to quote three.

Part (b) asked for the uncertainty in the emf to be expressed as a percentage. The most common error was to be out by a factor of 100 by forgetting the %. There were also quite a few significant figure penalties here for candidates who expressed their final answer to more than 2 significant figures.

In part (ci) candidates were asked to calculate how long a student had to make a measurement before overloading the standard cell. This was well answered with nearly all candidates getting credit for their method by setting up $t = I / Q$. Some confused POT from the µ multiplier.

Part (cii) was challenging but reasonably well answered by various routes. Candidates had to calculate the internal resistance of the voltmeter from data given, many got 2/3 marks because they didn't subtract the internal resistance of the cell from the total resistance they had calculated. Some used the wrong current of 2.8 µA, but could still gain some credit, and there was one mark for those that got as far as calculating the new p.d. across the voltmeter.

Part (ciii) asked for the voltage drop across the internal resistance of the cell. This was a straightforward $V = I R$ calculation, but only the better candidates had enough conceptual grasp to use the correct current and resistance values. Many had calculated this p.d. earlier in the question, but did not realise it was being asked for here. Weak candidates tended to give up at this stage of the question and move on.

In part (d) candidates were guided to see that if too much charge or current was drawn from the standard cell its standard p.d. would drop, but few followed the full story and most scored zero. Some managed a mark for the idea that the current was too high, but only a few went on to relate this to the effect on the standard voltage.

Question 10 was about a 3-D television system. Part (ai) asked for the number of light intensities that could be coded by a 12 bit number and most correctly calculated out 2^{12}.

Part (aii) asked candidates to show that the number of bits in one uncompressed image is about 75 Mbits and over the candidates reached this point, remembering to show their calculation by quoting a third significant figure. Many got stuck at 6 220 800 the number of sub-pixels, but forgot to multiply by 12 bits per sub-pixel.

In part (aiii) candidates were asked to estimate the bandwidth of the transmission system to support 120 frames per second. About half realised it could be estimated as bits per frame x frames per second, and using the approximation that

frequency ≈ bit rate (≈ bit rate / 2 is also acceptable). Some incorrectly multiplied by 2 here rather than divided (perhaps thinking of Nyquist sampling). Some incorrectly subtracted a minimum frequency to obtain a bandwidth or tried to use $f = 1 / T$.

Part (b) thoroughly tested candidates' knowledge and understanding of polarisation, and was reasonably well answered by the better candidates, but provided good differentiation. Part (bi) required candidates to explain the difference between polarised and unpolarised light. Weaker candidates tended to refer to the direction or plane of travel of a wave rather than its direction of oscillation, and forgot to mention that polarisation can only occur for transverse waves. Diagrams of transverse waves were poorly labelled and did not usually score marks, as the directions of propagation and oscillation were missing. Many responses stated that unpolarised waves travel in all directions. Many weak candidates thought that unpolarised electro-magnetic waves have perpendicular electric and magnetic components, one of which is removed by a polarising filter. Many unnecessarily talked about the action of a polarising filter here.

Part (bii) required candidates to complete the explanation of how polarising filters could be used to allow images to pass alternately to the left and right eyes. This proved to be highly differentiating. However, most candidates made a reasonable attempt, but many explanations lacked clarity and or detail (for example many just said use the second filter in opposite direction – rather than perpendicular) Many candidates also thought that one lens of the 3-D glasses had a fixed filter and the other the switchable LCD filter.

G492 Understanding Processes/Experimentation and Data Handling

General Comments

The entry for this paper was similar to June 2011. All Examiners reported that the level of difficulty of the paper was appropriate. There was no evidence of candidates suffering from shortage of time in this paper.

Candidates continue to handicap themselves by a lack of organisation in laying out their work: many examiners reported poor drawing in 6, sub-standard graph work in 14, illegible and incoherent answers wherever continuous prose was needed, and poorly laid-out calculations Although an excessive number of significant figures was penalised only in 12(d), marks were lost though rounding errors in a number of places through the paper.

Comments on Individual Questions

Section A

Section A proved accessible, with good candidates scoring 17+/21.

Question 1 was done well, with most getting at least 2/3 marks. The commonest error was in estimating the length of the forearm rather than its width.

Question 2 proved surprisingly difficult with few candidates demonstrating an understanding of units and many interchanging parts (b) and (c).

Question 3 was answered well by most, although most probably had 2/3 here. Successful candidates often wrote down the equation that they were attempting to model in order to see which of the given equations was equivalent.

In Question 4, most could do the calculation in (a), but in (b) it was sometimes hard to follow the approach taken by the candidate – this is essential if the candidate is to get 1/2 for use of a correct method if the answer should not prove to be correct.

Question 5 was well done despite the occasional rounding error and some calculator confusion between radian mode and degrees mode.

In Question 6, examiners all commented on the general poor standard of drawing: one such comment is typical: 'Once again the poor quality of drawing and apparent lack of pride in their work cost many students marks. This was obvious when marking candidates from a Centre that had taught and drilled their candidates how to draw wave patterns accurately.'

Question 7 was mostly well answered, although some of the phasor additions in part (a) were difficult to interpret.

Section B

As usual, this section was the most demanding part of the paper, as the contexts are new. Candidates showed good mathematical fluency, but did not always lay out their work clearly. Explaining themselves in continuous prose is also a skill that many lack. In most questions in this section candidates gained high marks on the earlier parts, but found the latter parts more demanding.

Question 8 (Interference of microwaves)

Part (a) was well done, but in (b) many candidates did not realise that the situation was not a simple standing-wave arrangement. The weakest candidates did not seem aware that superposition featured at all in this question.

In (c), better answers identified aspects of the results that would change and would remain the same and explained both. Weaker answers often just found aspects of the apparatus which would be the same, such as the frequency of the microwaves used, which did not address the question.

Question 9 (Solar panel and led lamp)
This mathematical parts of the question were tackled well by most, but the last two parts, which required a coherent written answer (some of it very straightforward common sense) were poorly answered or lacked precision. Candidates who scored well on this part of the question showed an understanding of the context/practical application. A number felt that the solar panel would not be able to provide enough energy for the lamp (despite having correctly calculated those values earlier); other, more consistent perhaps, were afraid the powerful solar panel would cause the lamps to explode.

Question 10 (Vector nature of velocity, displacement and acceleration)
This question proved the hardest on the paper. Part (a) was often done well, although a surprising number had difficulty with the velocity components in (a)(ii) despite going on to get (a)(iii) completely correct, suggesting that they had not correctly read the question and understood the context described at the start. Part (b), aimed at the very best candidates, discriminated well, with only the very best being able to visualise the situation, distinguish u from v or allow for the minus sign.

Question 11 (Pile driver)
While most candidates could answer parts (a) and (b)(i) well, parts (b)(ii) and (iii) were often poor, with many in (iii) quoting $F = ma$ and stating that increased m therefore implied increased F. There were a number of possible approaches to the question, but that does not constitute one: if the candidate had written 'the pile decelerates with approximately the same deceleration' first, then quoting $F = ma$ would have been valid. Successful candidates were those who had scanned the question and seen the structure implied in the division into (a)(i), (ii) and (iii) and seen that this division did indicate the approach which should be taken.

Part (c) was usually done well with thankfully very few candidates suggesting drawing a graph or doing an experiment to confirm the suggested relationship. The final answer was deliberately ambiguous, requiring the candidate to explain why 'yes', 'no' or 'can't tell' was the correct classification for the relationship – all three could legitimately be argued for, and gain marks thereby.

Section C

Most candidates had prepared well for this section which was between sections A and B in difficulty. As always, some did not seem to have worked through the advance notice material adequately and consequently had difficulty in finishing the paper in the time allowed.

Question 12 (Digital and analogue ammeters)
This was well answered by most. In part (b), the resolution of the digital and analogue meters depicted was asked for, but the answer line in (b)(i) started with ±, implying that the uncertainty in a measurement from the instrument concerned was required. As the resolution of the digital instrument is 0.01 A, with uncertainty ± 0.005 A, both were allowed. (b)(ii), using the value from (b)(i), naturally applied 'error carried forward'. The Principal Examiner regrets the error in (b)(i), but it does not seem to have confused candidates. Of more concern is the fact that, having correctly suggested suitable values for each instrument, a significant number of candidates were unable to explain why they had chosen that value, and so lost marks.

Part (c) was generally answered well, although some failed to gain marks by giving an answer which was vague or ambiguous, when the question was actually quite specific.
Part (d) was answered well, although some lost marks for incorrect significant figures or rounding.

Part (e) and (f) were also answered well although some candidates did not gain the mark in (f) by giving a vague answer such as 'it might affect the circuit' rather than, for example 'it would resulting the current being smaller than it should be'.

Question 13 (Planck constant with LEDs)
Part (a)(i) was intended to be straightforward, but many candidates lost marks for mis-plotting points (some did not plot points at all). Calculations of the gradient were often difficult to interpret due to lack of systematic working, and many candidates assumed that the graph went through (0,0) and so just used a single point to calculate the gradient, which was not acceptable.

Part (a)(ii) was rarely answered well - few could work logically and present their reasoning clearly even if they were on the right lines and many just tried putting numbers in, although (a)(iii) was mostly answered well.

In (b)(i) most were able to give evidence for not fitting trend (though many tried invalid calculations of *h* or mistakenly plotted wavelength on the frequency axis), but few suggested a practical reason why the value was too high so lost the third mark; many appeared not even to notice this part of the question.

In (b)(ii) many didn't seem to have a clue what to do, and of those that did very few calculated the correct percentage uncertainty, using the ± 0.2 V with the largest p.d. value of 3.02 V to obtain the smallest possible percentage error in p.d., which is still an order of magnitude greater than the quoted ± 0.5% for wavelength.

Question 14 (Cavendish's experiment)
This question rewarded candidates who were familiar with the article: it was very obvious who had spent time on this, as they scored well on this question. There were much better longer prose answers to this question than in any other part of the paper. The responses to part (c) were really positive.

Part (a) was usually done almost completely correctly, although only the very best scored 3/3 in part (iii) as few candidates realised that they should not only calculate the mean for the first data set but use the spread of those data to compare that mean with the 5480 kg m^{-3} for the second set.

Part (b) was well done by most, although some candidates failed to match up each example of Cavendish's attention to its justification. It was surprising how many candidates recognised that enclosing the smaller masses in a draught-proof box was an example of Cavendish's improvements but could not suggest a possible function to this box (it's in the name).
There were many excellent answers to (c)(i). Those candidates who sequenced their answers properly were more successful. A large minority did not know how to tackle the question, with many failing to use the average from the earlier part of the question and so wasting a lot of time working out the average for themselves, often getting it wrong. In (c)(ii) the most successful approach involved comparison of the range of values with the modern value.

G493 Physics in Practice (Coursework)

General comments

The moderation process for the vast majority of Centres was straightforward this year 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. However the use of plastic wallets and cardboard folders is not recommended as this can provide unnecessary work for moderators; it is sufficient for candidate work to be securely fastened together. The thorough checking of the addition and transcription of marks prior to submission was appreciated and there were few clerical errors this year. However, whilst evidence of internal standardisation is welcome, the inclusion of more than one Coursework Assessment Form can be confusing and the definitive mark must be clearly indicated.

It is expected that 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 correctly applied. It is particularly useful to the moderator when teachers indicate 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.

The majority of centres were allocated the same Moderator as in 2011 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 last year. Common issues for each of the two tasks are summarised below.

Quality of Measurement task

Candidates appear to have been encouraged to undertake a wider variety of experiments for the Quality of Measurement task this year, the vast majority being appropriate and covering a good range of physics from the course. Experiments to measure '*g*' were a popular choice, but it is not intended that methods based on timing the period of oscillation of a pendulum are undertaken as the theory lies outside the AS level specification. Guidance on suitable methods for measuring '*g*' is provided in the activities section of chapter 9 of the Advancing Physics CD-ROM. The properties of lenses (chapter 1), sensors (chapter 2), materials (chapter 4) and waves (chapter 6) are other fruitful areas of the AS course. There were some interesting variations on common tasks undertaken this year, such as the resistivity of carbon putty and the Young modulus of confectionery e.g. the "jelly snake". Giving candidates the opportunity to choose from a range of possible experiments also provides a better 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. A short risk assessment (which may find no substantial risks) is a simple solution.

In general, candidates demonstrated a greater understanding of uncertainties and systematic errors this year and moderators were in closer agreement with the marking of strand B. However some candidates tended to focus solely on the resolution of the measuring instruments used, rather than considering the (often larger) range of repeated measurements. There are a number of experiments on the CD which may help to develop an appreciation of this aspect of uncertainty at an early stage of the course. For example, ideas of '*Plot and look'* can be introduced through Activity 110E: '*Using a digital multimeter to measure resistance*' in Chapter 2 or Activity 100E: '*Measuring breaking stress of materials*' in chapter 4. 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. This idea of progression in experimental work can be addressed through, for example, Activities 250E-253E '*Measuring wavelength better and better*' in Chapter 6.

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. Although primarily assessed here 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. This should be qualified with reference to uncertainties and possible systematic errors; for example the gradient of a graph might have +/- values associated with it. The analysis should demonstrate an understanding of the physics involved; for example why a graph of 's *against* t^2' might be expected to produce a straight line in a '*g by free-fall*' experiment.

Physics in Use task

The vast majority of candidates now use 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 be read easily. Candidates must produce a clear record of their presentation to be awarded high marks in strand A(iii). There also tended to be less teacher annotation for this task, either on the Coursework Assessment Forms or on the work itself, and this made the moderation process more difficult. Teachers can assist the moderator by commenting on the oral aspects of the presentation and by annotating printouts to highlight aspects of both good and poor physics. 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 silicon nitride used in ball bearings?", as this immediately focuses the candidate on the properties needed for that application. Other interesting topics chosen this year included ceramics in joint replacement, metal foams in medicine, silica aerogel as an insulator, percuflex in urology stents, nomex in flame-resistant suits, silicon carbide in telescope mirrors and graphite-epoxy in martial arts weapons.

Moderators noted an improvement this year in strand A(ii) of the assessment criteria, dealing with 'sources'. Here candidates more clearly identified the origin of the information used by, for example, quoting the full web address for internet-based sources. There were also improvements in the subsequent linking of the information sources to the presentation itself, often achieved by simply linking the name of the source to the slide number concerned. Print-outs of the source material itself should not be sent to the moderator. It is preferable to provide the bibliography as a separate Word document rather than as the final slide of a PowerPoint presentation, as the resulting small text can then be particularly difficult to read.

G494 Clockwork Universe

General Comments

Section A of this paper proved to be somewhat easier than its predecessors, giving the paper a higher mean mark than in previous sessions. The questions in context of Section B worked well to separate the able from their less able brethren, usually because the latter were often unable to keep the context in mind and treated each subsection as a separate question, totally unrelated to the previous parts of the question.

As always, candidates for this paper do best when presented with straightforward calculations based on relationships supplied on the data sheet. Their Achilles heels are either calculations which require them to remember a relationship (E = kT, $GPE = mV_g$...), free response explanations of phenomena or the use of exponentials and logarithms. In particular, answers to free response questions often lacked enough precision to earn the marks. For example, too many explanations involving kinetic theory suggest that their author's have barely made any progress since GCSE.

Weak candidates continue to lose marks for calculations through incorrect rounding during a complex calculation. Many calculations in this paper involved more than one step, so it was important that enough significant figures were carried over from one calculation to the next.

Comments on Individual Questions

Section A

Q1 The first part of this unit's question proved to be harder than the second half. This was unexpected, as the second one required candidates to work something out, whereas the first one simply tested recall. In any case, the question proved to be an easy start to the paper for the vast majority of candidates.

Q2 Although the vast majority of candidates could correctly calculate the energy stored in the capacitor, only about half could identify the correct graph for the variation of energy with potential difference.

Q3 This question on the use of the gamma factor provided good discrimination. Many weak candidates did not even attempt to calculate the gamma factor, and attempted to answer the question in other ways - for no marks. It was good to find that so many candidates are now able to calculate the gamma factor and that most can use it correctly to calculate a time dilation.

Q4 The majority of candidates could pick out the correct definition of the decay constant, and most were able to complete the iterative calculation satisfactorily. Candidates who failed to round their calculations correctly lost a mark. The last part of the question provided the greatest discrimination -many weak candidates wanted to use a formula instead of the iteration, start off with more nuclei in the sample, keep more significant figures, have a more accurate value for the decay constant... However, the majority of strong candidates knew that only reducing the time interval would have the desired effect.

Q5 It was good to find that the vast majority of candidates had no difficulty in calculating the KE change of the brick. Too many candidates forgot to take the second step of the next calculation and only calculated the change of GPE instead of the work done. A number of weak candidates attempted to use GMm/r instead of mgh to calculate the GPE.

Q6 Candidates have clearly had a lot of practice at calculations involving momentum. A few candidates lost a mark by omitting the sign of the final velocity, but the vast majority earned full marks for this question.

Q7 This question on the Boltzmann factor discriminated well, with many candidates opting for the incorrect definition of the quantity □.

Q8 Less than half of the candidates earned the mark by drawing three circles concentric on the star, with a greater distance between the outer circles than the inner ones. Many candidates clearly used a compass to draw their circles, although freehand circles were perfectly acceptable. Unfortunately, most took great pains to make sure that their equipotentials were evenly spaced, often writing a sentence to assure their examiner that this was intentional.

Q9 The first part of this question about SHM proved to be the easiest one of Section A. The second part was more challenging.

Section B

Q10 Only a small minority of candidates were able to give a complete definition of the quantities *v* and *r* in the Hubble law. A disturbing number of weak candidates thought that *r* was the radius of the Universe, and many others neglected to state that the objects in question were galaxies. However, almost all of the candidates were able to convince their examiners that the constant H_0 has the units of s^{-1}, Although the majority of candidates successfully negotiated the scale and units of the graph to get an acceptable value for the Hubble constant, it was disappointing to find so many who did so without drawing a best straight line through the points; many obviously picked one point and used it for the calculation. Although most candidates knew that the Big Bang theory says that all matter was at one point some time in the past, only a minority of candidates could persuasively relate this to the Hubble law. Too many candidates think that the Universe has a centre (usually the Earth) and that the Big Bang was an explosion which ejected matter into a pre-existing and immutable space. Very few candidates could explain why the reciprocal of the Hubble constant is a measure of the age of the Universe - most assumed that since this quantity had the dimensions of time, it could be nothing else than the existence of time. The final calculation of the age of the Universe was correctly done by the vast majority of candidates, despite their having to convert seconds into years without any reminders.

Q11 This question was about the kinetic theory of gases. The first calculation with the Ideal Gas Law proved to be very straightforward, with very few candidates being unable to recall that absolute zero is -273□C. The second calculation required candidates to recall the formula linking the energy of a particle to its temperature as well as how to apply it to an ensemble of particles. Weak candidates tried to use $E = mc\theta$ and earned no marks. Average candidates used $E = kT$ to calculate the energy change of a single particle, but only strong candidates worked out the energy change of all the particles involved. Only a minority of candidates earned full marks for their explanation of the drop in pressure caused by the drop in temperature. This was usually because of insufficient detail or imprecise writing. For example, **less frequent** collisions with the wall earned a mark, whereas **fewer** collisions did not. Candidates fared much better with the next calculation, with most of them earning both marks. The last part was a stretch-and-challenge question, designed so that only the best candidates could earn all the marks. As always, most candidates lack fluency in their handling of functions involving exponentials, and only a small minority has the skills to take logarithms of them.

Q12 This question was about SHM in the context of a bike ride. The calculations of force constant and resonant frequency proved to be straightforward for most candidates. Only a small minority earned full marks for their explanation of the need for damping when the bike was ridden over bumpy ground - too many got carried away with the context and focussed on the dangers to the rider rather than the physics. Too many candidates stated that damping significantly alters the resonant frequency of a system and few were aware of the role of energy dissipation. Although about half of the candidates could sketch the correct curve for the kinetic energy of the system, only a small minority bothered to calculate its amplitude and plot it accordingly.

Q13 This question was about the orbits of satellites around planets. Many weak candidates lacked skills in algebra, unable to convince their examiners of the truth of the two equations presented at the start of the question. Too often, they would write down the correct initial relationships and then magically go straight to the final equation, without showing required intermediate steps. Weak candidates were often unable to sketch the variation of total energy with radius of orbit. Only half of the candidates, regardless of ability, could give the correct direction of the force needed to slow down a satellite in orbit, but more realised that the gas ejected by the rockets had to go in the opposite direction to the force. The last part of the question was incorrectly answered by the majority of candidates, usually because they had forgotten that the first part of the question had been about an equation for the total energy of the satellite, or did not know that work done is equal to change in total energy. Many candidates tried to calculate the work done from force and distance, or just calculated the change of GPE.

G495 Field and Particle Pictures

General Comments

This paper proved accessible for many candidates. The mean mark was more than sixty per cent. There was very little evidence of candidates running out of time and most candidates attempted all the questions. As in previous years, it is clear that many Centres prepare their candidates well for this examination, paying particular attention to section C.

Once again, routine calculations produced a dependable source of marks for most of the candidates whilst questions requiring descriptive or explanatory answers proved much more testing. There were many questions in which a candidate may have assumed that he or she had written enough to gain the marks whereas the answer was too vague to reach the marking point. Some of these are mentioned below. This paper will prove very useful in preparing future candidates for this style of question.

Comments on Individual Questions

Section A

This section was generally well answered and showed, once again, that many Centres had carefully prepared candidates for the examination. However, there were a few questions that revealed weaknesses in a significant proportion of the responses. For example, in question 2 (b) many candidates considered a photon to have the highest rest energy, a rather surprising choice. Question 3, involving unit manipulation, also presented problems for some candidates as many lost the mark because their work was not clear enough or they mixed together symbols and units. It is worthwhile practising and discussing similar questions in class to ensure that candidates understand the process involved. Question 5 was quite discriminating for Section A as the second and third parts were quite novel for this examination and tested understanding of the vector nature of field strength and the scalar nature of potential. It will be a useful question to discuss in class.

Question 7 was notably clearly answered by many candidates, the best of whom gained the answer through the elegant method of raising 0.5 by the number of half lives passed.

Section B

Question 9 was about an electron scattering experiment. In the first part candidates were asked to explain the path of an electron as it passes a nucleus. Part (a) required candidates to explain the path of an electron as it passed the nucleus. Although the majority of responses gained 1 or 2 marks the third marking point, linking curvature to force, proved elusive. Some misunderstanding was evident in responses which considered centripetal effects. Part (b)(i) proved discriminating with the better candidates showing clear working whilst weaker candidates gave muddled responses or confused symbols with units. Part (b)(ii) was generally well answered although some responses calculated spurious electron ‘frequencies’ through the use of $E = hf$. Part (c) proved accessible to the majority of the cohort.

Question 10 concerned using accelerated protons in medicine. The first part of the question, requiring an explanation of the term ‘rest energy’ was not well answered – it is quite possible that candidates have never been asked to explain this term before. In contrast, the calculations involving the gamma factor and the speed of the protons were well answered with only the weakest candidates using the non-relativistic kinetic energy equation in an attempt to find the speed of the protons. Part (b) asked candidates to estimate the number of protons required to give a quoted effective dose equivalent. Many managed this task but a high proportion of the responses required considerable decoding by the examiner to follow the sometimes tortuous chain of reasoning. Most candidates gained some of the three marks available for part (c)(i) but only the best provided a complete explanation to gain all the marks. It is as if the candidates move on from the question before reading their answers to check they have made a complete argument.

Question 11 was about deflecting particles in a uniform electric field. Unfortunately many candidates lost marks in part (a) through not taking sufficient care with their diagrams. Similarly, candidates lost marks in (c) (i) through not equating magnitude of drag force to magnitude of weight in terminal velocity. The rest of the question was well answered by the majority of the higher ranked candidates who tackled the calculations with ease.

Question 12 was about permeance and permeability. Once again the calculations proved accessible to most candidates and difficulties did not arise until the latter two parts of the question in which much confusion between permeability and permeance was evident. In (d) many students chose to believe that the permeability of the iron would decrease as that is what the equation suggests.

Section C

The Advance Notice was about earthquakes and their detection. Once again it was clear that many Centres spent considerable efforts preparing their candidates for this section of the paper.

Question 13 was not a particularly accessible opener to section C. This may be because it relies on work met in the early part of the AS course. Whatever the reason, many responses showed little understanding of brittle fracture and gave incomplete answers such as ‘fractures after the elastic limit has been reached’ which may or may not mean that there is no plastic flow. This uncertainty of meaning lost the candidates marks.

Question 14 was much more accessible and allowed even the weakest candidates to gain marks. However, question 15 proved to be one of the most challenging in the section with answers once again riddled with incomplete or vague statements. For example ‘vibrating at right angles to wave motion’ is not sufficiently precise to gain the mark for describing a transverse wave because the term ‘wave motion’ is not clearly defined. Similarly, diagrams of sinusoidal waves without clear annotations do not reach the marking point.

Question 16 was generally well answered although some students transposed the angles to give an angle of incidence of 21 degrees and an angle of refraction of 30 degrees.

Question 17 was about the pendulum used in a Milne seismometer. Most candidates recognised the problems of resonance in part (a) and the calculations proved accessible to the majority.

Question 18 caused more difficulties. Better candidates correctly linked low acceleration (via F = ma) to little motion whereas some chose to attempt to describe the situation using the concept of inertia. Such attempts were muddled and unsuccessful. Part (b) was the most challenging question on the paper and only the very best candidates linked the situation with a small angular displacement. In contrast, question 19 was accessible to the majority.

Questions 20 and 21 concerned electromagnetism – a tricky subject for many. However, many of the responses to question 20 showed real understanding and the biggest concern in 19(b) (i) was converting 4 centimetres squared into SI units. The responses to the last question did sometimes show a little weariness at the end of a long paper and responses were often muddled. For example, it was not unusual to see discussions of emfs creating magnetic fields. Candidates used the phrase ‘Lenz’s Law’ as an explanation in itself and so, once again, missed out on marks.

G496 Researching Physics

A very large proportion of the Centres moderated this year sent all of the requisite paperwork for the Researching Physics Module, G496 completed correctly with very few exceptions. It should be noted that plastic wallets or binders should not be used to secure the candidates' work. A staple at the top left hand corner is all that is required.

The automated request for sample portfolios sent out by the OCR Computer system seems to have saved a lot of unnecessary bureaucracy for which Centre assessors and moderators alike are very grateful. Fewer clerical errors were reported by the moderating team than was the case last year and more Centre assessors now seem aware of our requirement to provide detailed supporting annotation as they mark their reports. The need to identify the evidence used to arrive at the overall internal assessment was made clear by the most experienced Centres although there remains a significant few who did not provide any information at all about the questions asked and the answers offered in support of Research Briefing Strand Biii (Understanding). The most recently published assessment grid for this component includes a box for brief notes about the candidates' performance during interview. Very large Centres realised the need to explain their internal moderation procedures to their moderator although sometimes the different teachers involved did not always finalise the marking grid clearly making it difficult to work out what the final mark was supposed to be. Where more than one set and one assessor are involved it is essential to ensure that all of the teachers within the Centre have a common understanding of the criteria for assessment.

Practical Investigations

There was the usual impressive range of original, suitable ideas chosen by candidates across the whole ability range. Encouraging their candidates to select topic areas and suitable titles is a skill where the most experienced Centres continue to excel. Although setting the same experiment for the whole class may sometimes be appropriate for the AS Quality of Measurement coursework task, this is never an acceptable strategy for the A2 Practical Investigation. It is impossible to assess the candidate's own individual contribution to the work of a group experiment and as such these **must not** be offered. Obviously candidates do not work in isolation and will benefit from their shared experience but collaboration should only manifest itself in shared measurement techniques not identical data. Moderators reported a disappointing tendency for Centres to 'play safe', sometimes allowing their candidates to carry out routine course experiments where there was little opportunity for the candidates' own ideas to make a contribution. A Simple Pendulum or a Bouncing Mass on a Spring will of course generate plenty of data easily and both can be analysed to give all of the usual power relationships and reliable graphs but a candidate embarking on either of these cannot be said to have 'used sound knowledge of physics to make decisions about the progress of the investigation'. What the candidate will have done is followed the tried and tested path, trodden many times before to repeat someone else's plan and eventually to have reproduced somebody else's analysis. Starting out on an investigation where the outcomes are not known is, of course, a little scary, even the supervising teacher may feel a little uneasy but it is also an extremely exciting journey and puts the teacher and the candidate on a level footing for once, both finding out where it might lead together.

Some Centres allowed candidates to pursue some really imaginative ideas which meant that gathering enough data became an issue on occasions. Problems of this kind often arose where the major variable was not continuous and the only quantities being adjusted were categoric, e.g. different surfaces that did not have an obvious link - whereas using something like different grades of sandpaper would have at least allowed a comparison with grain sizes and some kind of sensible graph be drawn – unlike using several distinctly different surfaces leading to a bar chart and little of any sense to write by way of a conclusion.

Where moderators disagreed most with the Centres marking of this component it was generally in the rather generous assessment of Strand A (Approach) and Strand B (Progress and Use of Physics). The hallmark of a top candidate is in their ability to develop their investigation by using the underlying physics to guide progress, not simply to jump from idea to idea and hope for the best. High marks awarded in Strand A & B should be reserved for those candidates who have identified a clear strategy to gather data and have been guided by their finding to the next stages which follow on logically. The assessment of Strand C (Presentation) and Strand D (Conclusions) seemed well understood although some Centres were very harsh on their candidates if they failed to analyse uncertainty in enough detail, whereas others judged this adequate if there was simply an appreciation of the source of any errors identified. What moderators are expecting here is an understanding that all of the measurements made by the candidates are subject to uncertainty and that a quantitative assessment of the impact these uncertainties have on their conclusions will have been made. Graphs continue to vary considerably from Centre to Centre. At A2 level the minimum requirement should be a heading, major and minor gridlines, appropriate scales with labels and unit and a best fit line that is within any uncertainty bars that have been added.

Even the lowest scoring candidates for this component were able to gain marks either by pursuing an idea of limited scope thoroughly or by tackling one of greater demand and simply running out of steam. Some traditional ideas for Investigations that have not always been wholly successful in the past were developed in some intriguing ways this year. Parachute investigations have usually led to rather dubious, somewhat limited results but one candidate this year hit on the idea of tethering it and using an air blower to hold it steadily in a vertical air flow allowing some really good data to be recorded– another candidate was able to develop the Liedenfrost effect of drops dancing on a hot plate away from the usual ‘time to evaporate’ experiment to a rather more interesting one to do with the standing waves that develop on the surface of the drops.

Research Briefing

This continues to be a task that is well understood by most candidates and accurately assessed by the centres. The work submitted for moderation was almost always of appropriate extent and choice of topic. Centres have successfully trained their candidates to embed references in the text of their report and to have explained what is required in terms of the evaluation of the information that they have gathered. Teachers are understandably supportive of the candidates they examine and so moderators do make a point of comparing the level of physics used in the Briefing compared to that used by the same candidate in the Practical Investigation in order to verify the mark awarded for Strand Biii (Understanding). There isn’t always a good match here which suggests that some candidates are leaning too heavily on their Internet sources for content. This is of course, to be expected, but the marks awarded must reflect the amount of reworking of the source material that has been done by the candidate. Candidates are now much better at remembering to include references for the images they use and good candidates are better at integrating the illustrations they select into their arguments than has been the case in the past. Some moderators expressed surprise that smallish Centres allowed several candidates to tackle almost identical topics when they have an entirely free choice of title and the whole specification from which to choose. This kind of unnecessary overlap should be discouraged whenever possible.

The preparation of the candidates for this coursework and its subsequent assessment makes considerable demands on teachers and the work that goes into producing these Researching Physics portfolios is extensive. The obvious enthusiasm with which some of the reports are written is a great credit to the Centres they represent and teachers are to be congratulated on the quality of the work they elicit from their candidates.

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