RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE **A2 H559**

Advanced Subsidiary GCE **AS H159**

Reports on the Units

June 2010

HX59/R/10

Oxford Cambridge and RSA Examinations

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REPORTS ON THE UNITS

Chief Examiner's Report

The candidates who took Advancing Physics A2 this summer were, of course, the first to experience the revised course and the new assessment structure. Although the changes to Advancing Physics may have looked relatively minor on paper it is clear that teachers, moderators and examiners have had much to consider. It is therefore very encouraging that the final results show that nearly all candidates gained a pass at Advanced Level, around one third gaining an A grade and one in ten reaching the new A* grade. However, it is also very important to consider how candidates feel leaving the examination room. The 100 mark papers seem to be performing as hoped – with very few blanks on the paper and plenty of evidence that candidates were well prepared for the Section C questions. The final paper (G495) gave an A grade boundary of 75 marks out of 100 and an E grade of 45 marks showing that all candidates had a fair go at the questions. The sixty mark papers are rather more challenging to candidates and the examiners. Year 13 students have the experience and maturity to manage their time and complete the G494 paper but G491 is still proving difficult for too many candidates. This is due to a combination of time pressure, lack of experience of the candidates and the contextual nature of the material in this Unit. The senior examining team is well aware of this issue which will be taken into account in the preparation of future papers.

There are some common threads in the reports on individual papers. For example, many candidates answer explanatory, descriptive questions rather poorly. It is useful to remember that examinations have to include questions involving extended writing in order to cover all the required Assessment Objectives. These objectives can be found in the specification available on the OCR website. As Physics teachers we may concentrate on giving our students plenty of practice in arithmetical techniques but it is also useful to include descriptive questions and structured discussion sessions in the delivery of the course. The other major area of weakness is that candidates do not always answer the question that is actually given to them. For example, the instruction 'show that' requires the candidate to demonstrate to the examiner how the result was reached – if the method is not clear the candidate may not gain all the marks. Similarly, there is considerable confusion between the unit of a quantity and the symbol for that quantity.

Centres are to be congratulated for their preparation of the Advance Notice material in G492 and G495. Similarly, the coursework was, at best, extremely impressive and showed that the teaching was supportive and imaginative – many candidates tackled topics that clearly showed independence and flair. It is worthwhile remembering that the best coursework can be nominated for a prize in each of the AS or A2 portfolio. The reports of the Principal Moderators highlight other areas of good practice.

G491 Physics in Action

This was a mostly accessible paper with most questions being successfully attempted by a large proportion of candidates. However, there were still a number of no responses appearing later, in the harder parts of section B questions and on the last question 11, suggesting that some candidates were struggling to complete the paper comfortably in the hour allowed. There was clear evidence that most candidates had at least read the whole paper and got to the end, even if some were pushed a little for time to complete; we will continue to strive to improve this aspect on future papers. There were many more high scoring candidates than in January which was encouraging, and the mean mark was considerably higher at just below half the paper marks, the spread and differentiation of candidates was also successful. The paper seemed to set a good balance of accessibility and interpretation of physics in context and challenge.

Section A

1 This was a high-scoring straightforward units starter question. In part (a) the most common errors for power were VC and Cs^{-1}. In (b) the most common errors for current were Cs and Js^{-1}. Several candidates chose the correct pair of units but reversed the order.

2 Also a high-scoring question to calculate stress in a wire and the maximum possible value given the uncertainties in force and cross sectional area measurements. In part (a) the most common error was missing out the factor of 10^{-6} in cross sectional area, here losing the mark. In (b) Most candidates got the method mark for attempting to find the largest force / smallest area, but a common error was in calculating smallest area i.e. $(0.86 – 0.10) \times 10^{-6} = 0.85$ rather than 0.76×10^{-6} m^2. Some also incurred rounding error penalty by giving 1.94×10^8 rather than 1.95×10^8 Pa. In c) Some lost the mark because they gave no reason for choosing cross sectional area as the measurement most worth improving. They were not specific enough in identifying its larger percentage uncertainty.

3 This question was about the resolution of an image of the Sun's corona and provided considerable differentiation. The number of candidates finding this difficult was surprising considering the number of similar questions on image resolution set previously. Answers ranged beyond 3600 km per pixel by many orders of magnitude. In part (a) many candidates lost both marks with calculations involving the total number of pixels (710 x 940). There was one method mark for showing a reasonable length / number of pixels. In (b) they were asked to estimate the height of a marked point on a solar prominence. Many candidates successfully used a ratio of measured distances in cm (height / Sun's diameter) method, but measured the distances so inaccurately it resulted in an answer outside the acceptable range. Some still got this right even though they had scored no marks on (a) for finding the resolution.

4 This question was about the power of the camera lens used to capture the image in question 3. It was generously interpreted as there was quite a bit of "fiddling" of +ve / -ve values due to incorrect application of lens equation and signs by some weaker candidates. This did not affect the calculation for some due to the negligible curvature of waves from the enormous object distance. Very few candidates explained this. Some candidates did not recognise that power of lens is 83.3 D, choosing to quote the answer as 1/83.3. Rounding errors to 83.4 were also penalised, as were candidates who quoted a final negative value -83.3 D.

5 This question was about interpreting diode response graphs at three different temperatures.

The question differentiated well as weaker candidates did not read the question carefully enough. In (a) they were asked to describe two features of the line at 25º C. There were some poor descriptions, e.g. '*The higher the voltage the higher the current*' or '*Not a straight line*', '*proportional after 1.4V*' which were too weak for credit. Many compared the 25°C graph to other temperatures, others got the threshold p.d. outside the acceptable range. In (b) they were asked to describe how the graphs changed with increasing temperature. Some clearly read -40°C as +40°C which confused their thinking; many found it hard to say in their own words that the diode turn on voltage decreased as temperature increased.

6 This question on charge was accessible to most candidates. Most candidates found the charge in part (a) correctly as $Q = I \times t = 1.5$ C. In (b) they were asked to calculate the number of electrons making up this charge. Very weak candidates got tiny inverse answers using $N = e / Q$. Others got 1 mark for the correct method $N = Q / e$ but with an order of magnitude error in their answer.

7 Candidates were asked to calculate the minimum number of bits required to code for specified characters on a mobile phone system. Some left their final answer at the number of characters, with 1/3 marks allowed for 74. Those that got this wrong could still gain 2/3 using ecf and solving 2^n = characters, many did this by inspection of 2^6 and 2^7, or by using logarithms. Most candidates remembered to round up the number of bits which must be an integer value.

Section B

8 This question concerned an LDR – light intensity response graph and a calculation based on a potential divider. In part (a)(i) there were lots of errors reading from the graph, usually not spotting /kΩ on the resistance scale, or careless reading of the scale (especially 600 Ω at 500 lux – where the graph clearly shows a value under 600 Ω). In (a)(ii) most candidates could explain in their own words the difference in confidence that arises from interpolation compared to extrapolation. In part (b) candidates were asked to draw a circuit diagram of an appropriate potential divider, sadly this was not well answered as many candidates are not confident with circuit symbols (especially LDR – many drew LED or photodiode symbols), or their positioning. Many voltmeters were placed over the LDR or battery, or even worse in series with the LDR and fixed resistor. Part (c) was a difficult calculation involving the potential divider and differentiated well, many weaker candidates skipped over this part. Some had potential divider equations inconsistent with their diagram, even although ecf on the placement of their voltmeter was allowed. A few got a mark for getting as far as calculating the correct current through the divider.

9 This question was about some properties and effects in a filament lamp, the early parts were accessible to most candidates, whilst the latter parts differentiated well as intended.

In part (a) most candidates could read the current from the graph correctly, and proceed to calculate the power of the lamp. A few got 1 mark for reading the current from graph correctly, but then using the wrong equation, (usually $P = I / V$). Others got 1 mark ecf for their current x 6.

In (b)(i) candidates had to calculate two missing resistance values from a current / p.d. table for the lamp. This was well done by almost all. In (b)(ii) these two points had to be added to a graph of resistance vs. current for the lamp. These were mostly correctly plotted, but drawing curves of best fit was more of a challenge, quite a few drew best fit straight lines or proportionalities (not appropriate since the resistance clearly has a finite value at zero current and then rises) and lost the mark.

In (b)(iii) candidates had to explain how the conductivity changes with temperature for the lamp filament, and about half managed this. Weaker candidates described the graph but did not refer to temperature or conductivity; or made irrelevant statements such as "*conductivity is constant as it is a material property*". There was some confusion of conductance and conductivity, so this provided good differentiation with a variety of plausible but unworthy attempts.

Part (c) was about a graph showing the transient surge current when a filament lamp is first switched on.

It was designed as a hard part-question but probably differentiated too much with few candidates gaining marks in (c)(iii).

In (c)(i) candidates had to link the low resistance of the cold filament from (b) to the expected peak surge current by performing a calculation. Many took the final, hot resistance of the filament rather than its room temperature value; and others gave only qualitative descriptions and gained no credit.

In (c)(ii) many attributed the lower peak value to 'internal resistance' without being specific where in the circuit this resistance was. Most correct marks were awarded for battery having internal resistance, or for filament heating up quickly and resistance rising. A few got the mark for response time/sampling interval of data logger leading to peak being missed. This was the first question part where a significant number of candidates did not attempt to answer the question.

In (c)(iii) candidates had to give an explanation of another quantitative feature of the graph, but found this very hard to achieve. Many answers had no quantitative feature referred to, or insufficient development of explanation, to generate any credit. Those that did get the mark mostly referred to the constancy of the current after 1.5 seconds due to the filament reaching its final working temperature and resistance.

10 In this question candidates were asked to contrast the structures and properties of a metal and a glass.

In part (a) candidates were asked to sketch labelled diagrams of metal and glass microstructures. There were some rather poor diagrams, quite a lot were not labelled, but could still score 2/3. Metal diagrams with regularity / symmetry tended to be better than those for glass, where randomness is harder to convey. Diagrams looking like rubber with sulphur cross-links were not given credit.

In (b) explanations of the ductility of metals and brittleness in glass were very poor. Better candidates approached the right idea but did not link their answers clearly to structure as requested, so marks were lost. Generally explanations were better for metal than glass. Not many could use the QWC terms correctly. Typically candidates mentioned slip / dislocations but were not able to correctly convey their mechanism.

In (c)(i) candidates had to identify a composite and its components, most chose reinforced-concrete correctly as an example, but less than half of the candidates gained marks in this question. Again many chose alloys, which was disappointing; centres not having picked this up from the previous session mark-scheme / report. Many candidates also remain confused about the nature of carbon fibre composite, often quoting as made of carbon and resin / fibre, rather than of carbon fibres bonded in resin.

In (c)(ii) candidates had to add a line to a stress / strain graph given data about Young modulus, yield strength and maximum tensile strain. The question was generously marked, for 2/3 correct features, ignoring any one incorrect feature; so the facility came out at well over a half. Most marks were awarded for correct initial gradient and the plastic region ending at 10% strain. There was a surprising number of no responses here, perhaps candidates missed the instruction above the graph or were starting to rush to finish.

In (c)(iii) candidates were asked to calculate a fracture area, given fracture energy and toughness. Many got the calculation inverted and scored 0/2, some forgot the 10^6 multiplier and were awarded 1 mark for a Power of Ten error. About a quarter of candidates did not attempt this part.

11 This question was about making sense of the digital audio Fourier compression that enables MP3 to store data about 20 times more efficiently than on a CD using waveform sampling.

Part (a)(i) asked about the information rate in the CD system. It had a high facility. The most common mistake was rounding errors. 1, 2, or 3 S.F. answers were acceptable but should be rounded appropriately. The 3 S.F. answer being 706 kbits per second.

In (a)(ii) candidates were asked for the resolution of the 16 bit sampling applied. The facility was unexpectedly low (time issue?) very few realising they should divide the voltage range by $(2^{16} – 1)$.

There were many strange attempts by weaker candidates e.g. voltage range / bit rate, or backwards working to "fiddle" the show that value. Nearly half the candidates did not attempt an answer here.

In part (b)(i) candidates had to interpret a 60 dB reading on a log scale stating the factor by which sound intensity had increased. There was a wide range of numerical and descriptive answers, quite a few candidates interpreted factor as a variable rather than a number and gave answers such as frequency.

Common errors were 10 or 6 rather than the factor of 10^6.

Very few candidates missed out part (b)(ii), but it was very poorly answered. Few candidates could interpret the response curve of the human ear and the logarithmic frequency scale, or select the inaudible frequencies that were too quiet to hear.

In part (c) candidates had to read a paragraph with information about the MP3 frequency sampling, and perform and explain a calculation to show the efficiency of coding compared to a CD sampling system. This was attempted by over 50% of candidates. The 2 quantitative marks seemed easier to gain than the QWC explanation mark. Some of the question's potential was realised, but perhaps it was a bit too "wordy" for a final question, leading to candidates rushing or missing this part question.

G492 Understanding Processes/Experimentation and Data Handling

1 General Comments

Following changes made to the examination time and also to the length of questions in this paper, as in January 2010, there was no evidence of candidates running out of time. Also, statistical data on performance in the questions revealed that section C was more accessible, and in fact (unlike May 2009) proved easier than section B. It was clear than candidates had generally been well prepared for section C by their centres.

2 Comments on Individual Questions

Question Nos 1–7 (Section A)

Section A was very accessible to all, with A grade candidates getting 18+/20 and E candidates about 12.

Q. 1 was intended to be an easy start to the paper, but a number had the answers transposed.

Q. 2 (a) & (b) proved straight-forward, but more candidates gave D than B for the answer in part (c).

Q. 3 was answered well by most.

In Q. 4 about half the candidates had 2/2, with the remainder having 1/2.

In Q.5, part (a) was correctly done by nearly all, but in part (b) all but the best candidates had one or the other part wrong.

Q.6 (a) was correctly done by most (even though no initial velocity was given, all assumed it was zero, although any quoted value would have had to be allowed) although the expression 0.86g baffled a number. Only the better candidates recognised the two-stage nature of part (b).

Q.7 (a) was done correctly by most, although a number got there by round-about methods. Part (b) proved more challenging, and many got just one mark for correctly identifying 24 cm as a quantity they needed to use.

Section B

Question No 8 (Helium balloon)

Parts (a) and (b)(i) were straightforward and well answered, but only the better candidates were able in (b)(ii) to apply the information about upthrust given at the question head to the data in the question.

(c)(i) produced a mixed response; those that took a common sense/logical approach to this often arrived at suitable answers. Those that took the formula and incorrectly worked backwards ended up with zero.

(c)(ii) was generally not very well answered, with many candidates not reading the question properly and missing the fact that they needed to explain two different features of the graph. Many of the explanations were vague, mentioning 'terminal velocity' without any explanation in terms of forces.

(c)(iii) proved a good discriminator; in this question it is possible to work forwards from F and v or backwards from k and v, but in either case it is essential to show that the value for k is consistent with that previously obtained for F.

Question No 9 (DVD as reflection grating)

(a)(i) was well answered, but the response to (a)(ii) was varied: most candidates were able to gain the first mark but the second mark proved inaccessible to most because of poorly worded explanations.

(b)(ii) highlighted again the fact that candidates do not always follow the 'story' developed in the question. The majority made answering this question more difficult by not referring back to part (i), but started afresh with the grating equation and obtained an impossible value for sin θ.

(c) did not receive many fully convincing answers but this was a challenging question; most gained partial credit for referring to destructive interference but few were able to explain the fact that visible wavelengths were constrained to the angle ranges shown and/or that the region indicated could have only first-order infrared or second-order ultraviolet, neither of which was present in the source.

Question No 10 (Earthquake waves)

Part (a) attracted answers which were very disappointing, below what one would expect of a GCSE candidate; candidates rarely related the oscillation direction in the wave to the direction in which the wave moved.

The algebra required in (b)(i) was not difficult, but few candidates worked through it systematically. Most attempted (b)(ii) despite its unfamiliar look (which was the intention of the question). Many gained partial credit for identifying the correct value of Δt from the graph (48 – 52s), while others gained a method mark for correctly evaluating (1/vs – 1/vp).

Part (c) was well done by many; measuring double the amplitude instead of the amplitude was overlooked here, as it made no difference to the result, but it was clear that many retained that GCSE misunderstanding.

In part (d), a simple clear statement about the range of values or its representation graphically would have gained the mark but this was rarely seen.

Overall, this question proved the hardest on the paper.

Question No 11 (Kitesurfer)

Part (a) was well, and clearly, answered by most.

Part (b)(i) discriminated well: most could calculate the weight of a 51 kg person, and better candidates were able to relate it to the vertical component of the combined tension in the kite strings.

Part (c) was disappointingly answered. As with similar questions of this type there was a poor response to explaining why objects travel at steady speeds. Very few candidates were able to use the correct terminology (often simple), and often ignored the instruction to answer in terms of components of forces.

Section C

Question No 12 (Breaking stress of wire)

In (a)(i) most gained a mark for recognising that the potential outlier was some way from the rest of the data, but few quantified it in a reasonable way to gain a second mark. It was hoped that the criterion that a reading separated from the mean by more than twice the spread should be considered suspect would be applied, but this was rarely seen. Any attempt to quantify the separation between that reading and the mean or minimum of the remainder in terms of the spread or range gained the second mark.

In part (b), 1 significant figure for both F and ΔF were required, and sometimes seen: in (c)(i) either 1 or 2 s.f. were allowed. Subsequently, there was no penalty for excessive significant figures. Even good candidates, who had gained full marks in (b) and (c)(i), routinely presented the results to part (d) as 81818181.8 ± 9090909.1 Pa (and got all 3 marks). Many lost the mark in (c)(ii) for not explicitly comparing the percentage error in diameter just obtained with that for force (which they did not need to calculate, as 1 part in 9 is clearly much, much more than 1%).

Question No 13 (Water rockets)

Parts (a)(i) & (ii) were well done by most, although some still use far too small a triangle when calculating a gradient. Most, in (a)(ii), used the values of height at 0 and 0.5 s to calculate the velocity; this was acceptable, as the graph is fairly straight in that region. A few used $v^2 = u^2 + 2as$ based on the final height to calculate u, which was allowed.

As with both 8(c)(ii) and 11(c), answers to (a)(iii) suffered from a lack of clear expression.

Parts (b) and (c) were reasonably well attempted but weaker candidates were inconsistent in taking (or unable to take) the relevant data from earlier parts of the question. In (c)(ii) it was expected that candidates would estimate the flight time from double the time to reach the highest point in Fig. 13.1, and many did; however, some just took the time of 4 s, as being the end of the graph, and this was given credit (presumably they assumed the rocket landed on a roof).

Question No 14 (Millikan's photoelectric experiment)

Part (a) of this question rewarded good skills in completing tables, plotting points, drawing curves and straight lines of best fit and interpretation of graphs and produced some very pleasing responses. A large number of candidates could not read the horizontal axis properly for (a)(ii), so that a straight line from, for example, (4×10^{14} Hz, 0 V) to (12.8×10^{14} Hz, 3.5 V) produced a gradient triangle of base 4.8 Hz, or 12.8 Hz, or 12.8×10^{14} Hz.

Part (a)(iii) and (b)(i) were well done but, possibly through fatigue, (b)(ii) often did not follow the flow of the question. Many could suggest a possible shortcoming of Millikan's experiment, but surprisingly few pointed out that Millikan's largest possible value (just calculated) was outside the NPL range.

Many had a reasonable attempt at part (c), which picked up on the last sentence in the advance notice material [*However, Millikan was still not convinced about Einstein's theory of light particles (photons)*] in terms of the 'How Science Works' specification statement *identify and discuss ways in which interplay between experimental evidence and theoretical predictions have led to changes in scientific understanding of the physical world*.

G493 Physics in Practice (Coursework)

General comments

The vast majority of Centres are to be congratulated regarding the efficient manner in which they managed the setting, marking and compilation of the coursework portfolios for this session. The high quality of much of the work seen was a testament to how well teachers had prepared their candidates to meet the requirements of the AS coursework component of Advancing Physics. Here it is worth reminding Centres that the Institute of Physics awards a prize for the best portfolio submitted each year.

There were relatively few clerical errors this session, but their presence can cause delays to the moderation process and generate additional work for Moderators. Thus it is important that the addition and transcription of marks is checked prior to submission. Sometimes errors arose from the use of + or - symbols to indicate instances where the criteria had either been exceeded, or not quite met. Although this practice can be useful when assessing the work, the numerical marks for each strand must add up to the total mark awarded. Also, whilst evidence of internal standardisation is welcome, the inclusion of more than one Assessment Form can be confusing.

It is expected that teachers annotate candidates' work as this enables the Moderator to easily check that the assessment criteria have been correctly applied. Examples of positive achievement should be indicated, but it is particularly useful for teachers to point out where they recognise that poor physics or mathematics has been done. 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.

Quality of Measurement task

The majority of the experiments carried out for the Quality of Measurement task were appropriate and covered a good range of physics from the AS course. Experiments to measure '*g*' were a popular choice for this task, 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 for as many as 8 suitable methods for measuring '*g*' is provided in Activities 110E, 120E and 130E of chapter 9 of the Advancing Physics CD-ROM. Those Centres choosing to guide their candidates towards the sensor projects in Chapter 2 of the course should ensure that the work carried out satisfies the new assessment criteria, rather than simply following the procedures relevant to the legacy specification. In particular, it is important to note that reference is made to uncertainties and systematic errors in all four strands of the criteria. Although these aspects were covered well in most Centres, candidates in others did not seem to appreciate their importance and they were sometimes referred to rather cursorily, if at all.

There is useful guidance provided in the Advancing Physics AS book and CD-ROM which may help to clarify candidates understanding of uncertainties and systematic errors. The *Case Studies* on Quality of Measurement provide useful background information, whilst the section on '*How to deal with uncertainty in measurements*' in the *Data and Measurement Skills* section of the CD gives more specific advice. There are a number of experiments on the CD which may help to develop an appreciation of uncertainties in measurements 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. Candidates understanding can be enhanced through such activities as 195E and 200E, relating to the power and magnification of lenses in Chapter 1 or Activity 150E, relating to measurements of Young modulus and breaking stress in Chapter 4. Ideas of progression in experimental work can be addressed though, for example, Activities 250E-253E '*Measuring wavelength better and better*' in Chapter 6. Final preparation for the

Quality of Measurement task might be done though the briefing for the '*Team sensor task'* or '*Team measurement task*' (Activities 400E in Chapters 2 and 9 respectively).

In some Centres it appeared that candidates worked together in pairs, or small groups, when carrying out the practical work for the Quality of Measurement task itself. This is not what is intended, as it does not allow them to demonstrate evidence for strand A '*Quality of practical work in the laboratory*' or strand B '*Quality of thought about uncertainty and systematic error, and attempts to improve the measurements*'. In a number of other Centres all candidates carried out the same experiment; a particularly popular choice being the measurement of the resistivity of a metal wire. Whilst this latter approach is acceptable, if the work is carried out by the candidates independently, it can often lead to the methods, tables of data, graphs and reports being very similar. It is the responsibility of the Centre to ensure that the work submitted for assessment can be authenticated as being that of the individual candidate concerned. It may be easier to do this if a range of possible experiments were provided, allowing the candidates at least some element of choice. This would then also provide a better preparation for the Practical Investigation component of the A2 course.

In strand A '*Quality of practical work in the laboratory*' it is expected that candidates provide written evidence that they have addressed 'safety' to satisfy the descriptor dealing with '*careful methodical work*'. This was sometimes lacking, even in cases where there were obvious potential hazards with the experiment. A short risk assessment (which may find no meaningful risks) is a simple solution. It is also expected that '*data are carefully recorded as they are taken*' if maximum marks are to be awarded here. Important details in raw data are sometimes omitted in 'tidied-up' accounts of the experiment; for example some candidates provided tables of just their average results.

In strand B '*Quality of thought about uncertainty and systematic error, and attempts to improve the measurements*' candidates need to identify the sources of uncertainty and, if possible, systematic error in their measurements. Whilst the first part of this was done reasonably well by most candidates, relatively few went on to actually implement their suggested improvements to the experimental methods and apparatus used. It is sufficient to concentrate on the largest source of uncertainty, which may perhaps be in timing the fall of an object in an experiment to measure 'g'.

In strand C '*Quality of communication of physics in the report*' errors or omissions in the recording and presentation of data were not always noted, and the marking of this aspect was often too lenient. This commonly applied to missing/incorrect units and/or to inconsistent/ inappropriate use of significant figures in tables of results. Similarly, graphical plots sometimes lacked clear labels, uncertainty bars or appropriate best fit lines. This tended to apply particularly to computer-generated graphs.

In strand D '*Quality of handling and analysis of data*' it is expected that information should be extracted from the gradients, intercepts or other features of graphs, rather than simply from tabulated data, if high marks are to be awarded. Any interpretation 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 such as why a graph of, for example, 's *against* t^2' might produce a straight line in a '*g by free-fall*' experiment.

Physics in Use task

Annotations on the candidates' work tended to be less thorough than for the Quality of Measurement task, sometimes making the moderation process rather difficult. In the case of a PowerPoint presentation comments on the printouts of the slides themselves are particularly helpful.

In strand A(i) '*Independence*' it is expected that the chosen material is set in a clear context at the start to satisfy this first descriptor. Examples of novel contexts seen this year were 'bamboo in scaffolding', 'aluminium in hair straighteners' and 'willow in cricket bats'. Thus it was disappointing to see the presentation of a substantial number of candidates starting with a title such as 'copper', 'diamond', or 'Kevlar'. Whilst all of these are all suitable choices of material, it is not sufficient for candidates to write about its general properties and then to suggest possible uses almost as an afterthought. It can be helpful to couch the title as a question, such as 'Why is steel used in ski-lift cables?', as this immediately focuses the candidate on the properties needed for that application.

In strand A(ii) '*Sources*' a large number of candidates did not appreciate the need to fully identify their sources of information and this aspect was often leniently assessed. It is worth pointing out that the specification states that the sources used should be '*clearly attributed*' for the award of maximum marks here. In particular it is expected that the bibliography should identify the sources in sufficient detail for them to be followed up if desired. Vague references to 'brittanica.com', 'matweb.com', 'physicsworld.com' 'wikipedia.com', 'youtube.com' and even 'google.com' are worthy of little credit. The full web address should be quoted for internet-based sources, preferably with a meaningful description of the author/company concerned if this is not evident from the web-address alone. For a journal, such as New Scientist, it is expected that reference should be made to the particular issue consulted, and that the authors name, date of publication and relevant page numbers should be given where possible. For books the author, date of publication and relevant page numbers should be quoted, rather than merely its title. Candidates should also indicate the contribution that each source has made to their presentation, for example by simply linking the source to the slide number concerned. Here it is worth pointing out that the wording of this strand on the Assessment Form has been modified since last year to make this aspect of the criteria more explicit. Whilst most Centres used the current version of the form, a small minority were still using the 2009 version. Also, candidates should be encouraged to provide their bibliography in a separate Word document rather than, as was so often the case, as the final slide in the presentation itself. This would also help to address some issues regarding legibility.

In strand A(iii) '*The presentation'* it was difficult to judge the quality of the work produced by some candidates as the printout of their slides was too small to read. Candidates who do not produce a clear record of their presentation should not be awarded high marks here. Although presentations are enhanced though the inclusion of illustrations and images, at least some of these should be of a scientific nature, helping to explain the macroscopic and microscopic properties of the material concerned. Relatively little credit should be given for the inclusion of photographs or 'clip-art'.

In strand B '*Use and understanding of physics*' it is expected that a range of both macroscopic and microscopic properties of the material are discussed for the award of high marks. It is also important to explain why the properties are important in the chosen context. Thus any failure to place the material in a specific context at the start is likely to result in candidates being penalised here as well as in strand A. Candidates should provide evidence for their understanding of physics on the PowerPoint slides, talk notes or other documentation. 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 it is assumed that any errors not noted have been overlooked when awarding marks.

G494 Clockwork Universe

1 General Comments

The marks earned by candidates on this paper ranged from 58 to 7 out of 60, with the most likely mark being just over half marks. Most candidates attempted all of the questions and there was no evidence of candidates not having enough time to complete all of the questions.

As ever, most questions which involved calculations proved to be easier than those which required written explanations. Too many candidates are hindered by the lack of a physics vocabulary in their writing. For example, the majority of candidates confuse energy and charge in the context of capacitors, with the term discharge equally likely to be linked to charge or energy or potential difference.

Most candidates failed to be put off by the stretch-and-challenge questions and had a go although few had the skills to navigate their way successfully through them.

Centres need to make their candidates aware that each of the Section B questions is driven by its context. Too often, weak candidates would lose marks at the end of these questions by forgetting information from earlier on. This was particularly true of the last question, where many candidates forgot the previous parts about the forces on, and the total energy of, a comet in an elliptical orbit and proceeded to try and calculate the speed of an object in a circular orbit by equating gravitational and centripetal forces.

2 Comments on Individual Questions

Section A

This section contained a number of short questions to test candidates over the whole content of the unit. With a few exceptions, the questions were intended to be straightforward and accessible. The vast majority of candidates earned all of the marks for Q1, showing an excellent understanding of units. The calculation of Q2 only proved to be difficult for weak candidates, probably because it involved squaring just one of the quantities involved. However, even strong candidates struggled to provide an explanation for the variation of current with time, with only a small minority earning both marks. Most candidates only wrote about the capacitor and didn't relate its rate of loss of charge to a current in the ammeter. It was good to find that most candidates understood Brownian motion for Q3, although weak candidates often failed to square root their answer to part (b) and ignored N completely in part (a). Q4 started with the easiest calculation of the paper, followed by one of the hardest. Strong candidates had no difficulty in calculating the activity, but weak candidates did not know where to start. Most candidates earned at least one mark for Q5, with the majority earning both. Many weak candidates could not attempt part (b) of Q6 because they were required to recall that internal energy is approximately NkT - strong candidates had no such problems. The majority of all candidates earned at least one mark for Q7 and Q8. Matching graphs to axis labels for Q 9 proved too difficult for many candidates, with only the strongest earning both marks.

Section B

10 This question about gases contained both calculations and explanations. The former proved to be much easier than the latter. Few candidates earned full marks for their account of atmospheric pressure, mostly because they assumed that it was enough to say that particles colliding with the ground exerted a force, instead of discussing the momentum changes involved. Surprisingly, many candidates were unable to use algebra correctly for part (b)(i), often omitting constants without replacing the equals sign with a proportional sign. Part (b)(ii) was a stretch-and-challenge question, and, as expected, only a small minority of strong candidates earned both marks. Most candidates failed to explain exactly what the Boltzmann factor calculated for the system, leaving their answers too vague to earn the mark. However, most candidates could successfully use the BF in the calculation and use it to explain the variation of pressure with temperature.

11 The graph of part (a)(i) only confused some weak candidates, especially those who assumed that time had to be on the horizontal axis. In part (a)(ii) many candidates omitted to say that the speed of the pulse was constant, concentrating instead on justifying why the time there had to be the same as the time back. The vast majority of candidates earned the marks for the next two parts, but only the strongest were able to calculate the velocity of the asteroid - the three steps of the calculation defeated many. Although many candidates knew that the wavelength of the pulse would be different on its return, only a few bothered to quote the Doppler shift formula to explain how it could be used to calculate the velocity of the asteroid.

12 Although the vast majority of candidates were able to explain why kinetic energy was not conserved in the collision, a substantial (and perverse minority) insisted on using energy conservation to find the velocity of the mass (earning no marks). Weak candidates often assumed that velocity was conserved (because the numbers worked out nicely) or simply got lost in the calculation. Candidates are not good at momentum conservation calculations - a similar question in last session's paper was also poorly answered. However, it was good to see that candidates could draw good sine curves for part (b), but only half got the correct phase. The modelling calculation of part (c)(i) was another stretch-and-challenge question, with only a small minority of candidates earning all three marks. Too many candidates ignored the instructions and tried, without success, to use a sine formula for x in terms of f and t instead. An even smaller number of candidates suggested using smaller time intervals to improve the accuracy - most assumed it was an experiment and suggested better initial measurements.

13 Many candidates lost marks in part (a) through careless drawing of the tangent and normal to the trajectory of the comet. The calculations of kinetic and total energy proved, as expected, straightforward for strong candidates, but too many forgot the context for the last part and tried to balance centripetal force and gravitational force to calculate the speed of a comet in an elliptical orbit.

G495 Field and Particle Pictures

1 General Comments

This was the first G495 paper. As it combines the traditionally challenging areas of physics covered in the later parts of the course with the synoptic element of the Advance Notice paper it is encouraging to see that the mean mark was 61 (s.d. 19) and that the marks ranged from single figures up to 99 out of a maximum 100. It was clear that Centres had prepared their candidates carefully for the Advance Notice element. The majority of the candidates attempted all the questions and there were very few unfinished scripts.

The shorter questions in Section A proved to be accessible to the majority but the proportion of correct answers to the more extended questions of Section B was also impressive. Candidates were not put off by questions set in a novel context. Some papers suggested that Section C was answered before Section B - a good choice for those who were well-versed in the ideas of Drude and others.

As is often the case, the descriptive/explanatory questions proved to be the most differentiating. It may be that candidates have more practice in arithmetical questions during the course. Whereas the best answers were extremely impressive there was a considerable proportion of papers where the (slightly) extended writing required was poorly constructed. Candidates often wrote down ideas they recalled from the course but did not use these ideas to produce a coherent explanation. This area may be improved by setting more descriptive tasks during the course and encouraging focused discussion sessions.

2 Comments on Individual Questions

Section A

This section consisted of short questions that tested knowledge of simple concepts and basic arithmetical techniques. Most of the questions in this section were straightforward and gave very few difficulties. The difficulties are highlighted below:

Question 1(b) was a simple calculation of electric force using an equation provided in the Data booklet. The only common error was to confuse force with potential energy or simply forget to square the value for the separation of the charges.

Question 2(c) was incorrectly answered by many - only about one in three candidates picked the correct value. If the candidate did not realise that it is possible, as an approximation, to assume a uniform field over the 5mm distance then the question will have proved difficult.

Although candidates were not penalised for the shape of the flux loop in 3(a) it was disappointing to see so many right-angled flux paths.

Question 6, on radium decay, showed that many candidates do not distinguish between alpha particles and helium atoms. This led to errors in the second part of the question in which a surprising number of candidates assumed that the product of the decay was harmless, inert helium.

Question 7(b) also revealed some misunderstandings. A significant proportion of the candidates divided the exposure (in sievert) by the mass to find energy absorbed rather than multiplying. This suggests that the idea of exposure as energy absorbed per kg may need to be given a higher profile when covering this part of the course.

Section B

Question 9. This question was about the half life of fast-moving muons. The first part of the question, requiring a simple statement of charge and lepton conservation, was not well answered. Many responses focused solely on charge conservation and so did not gain the second mark. Another common error was to state that neutrinos and anti-neutrinos are oppositely charged. Part (b) proved to be a simple calculation. Encouragingly, many candidates scored all three marks for the more challenging part (c). Part (d) was answered well by a significant proportion of the candidates although some did use a very roundabout method to reach the answers. The question ended with a problem relating experimental results to the theory of special relativity. The most common error was to give an opinion without backing this up with calculations. It is important for candidates to understand that an explanation can include calculations.

Question 10. This question was about transformers. As it included two explanatory sections it is not surprising that some candidates found it quite difficult. It was noticeable that many candidates clearly knew a fair bit about the context of the question but could not quite focus their responses to succinctly answer the question set. Explanations often included correct physics that was not germane to the situation and therefore not given credit.

Part (a)(i) proved surprisingly difficult, many responses suggested that flux is out of phase with the current. A number of candidates drew very poor curves that only just gained the mark. Part (a)(ii) required an explanation of the secondary emf falling to zero when the current in the primary coil is a maximum. Although the markscheme was fairly generous in this part many answers did not link ideas with sufficient clarity to score both the marks. Quoting Faraday's law was not sufficient, the question required a good understanding of the relationship between flux, current, and induced emf. Part (b) was well answered - candidates are good at number crunching. However, some did not gain marks for (b)(ii) even though this was a very simple sum. This showed that the importance of flux linkage is not fully understood.

Part (c) was quite challenging for many, with only about half the candidates gaining all three marks. Once again, weaker candidates failed to link simple concepts into a coherent argument. Two easy marks (for 'eddy currents' and energy losses) were gained by many, but the idea of a lower maximum flux leading to a lower rate of change of flux was only found in the best candidates.

Question 11

This question was about accelerated charges. The first three parts were very accessible and showed that the majority of candidates understand the concept of rest energy and the conversion from joule to electron-volt and vice versa. However, many failed to include the conversion factor in (d)(ii) and so calculated the field strength using energy in eV rather than J. This gave an extraordinarily high magnetic field, but this did not seem to bother the candidates who clearly did not have a feel for field strengths.

Question 12

The final question in Section B concerned wave-like behaviour of electrons. Parts (a) and (b) were well answered. Part (c) was more testing, many responses included wholly incorrect statements about wavelength doubling leading to a doubling of kinetic energy. The last part of the question was also difficult for many. The calculation of the energy difference between the n = 1 and n= 2 levels was not always completed - many responses simply gave one value of energy. The calculation in part (d)(ii) was reasonably straightforward for the better who candidates and many gained the first two marks for the question through a number of acceptable methods. However, even amongst the better candidates there was confusion about the conclusion. Many responses suggested that an electron would be promoted from one level to another if the energy of the incident photon was greater than the energy gap. This may suggest that this is an area that needs more focus in class.

Section C

The majority of the candidates had been well prepared for this part of the paper. However, there were some surprising areas of difficulty. This may reflect that teachers cannot prepare their students for every eventuality. This shows in the observation that the 'obvious' questions were very well performed.

The section opened with a relatively straightforward question on charge. The examiners were surprised that under a quarter of the candidates gained the mark for b(iv), which simply required stating that glass is a poor conductor.

Question 14 was about the motion of electrons in a vacuum. Part (a) was reasonably well answered by the majority. Similarly, the calculation in (b)(i) gave very few problems, with more than three quarters of the candidates gaining the mark. However, only about a fifth of candidates gained the marks in (b)(ii). Many responses suggested that the final speed of the electrons was, in fact, the average speed. What was expected to be a simple question proved to be highly discriminating. The misunderstanding in (b)(ii) was carried forward into (b)(iii) where many candidates stated that the speed remained constant, or that the electrons were in a vacuum. The first suggestion is obviously incorrect, the second is part of the stem and therefore not markworthy. It may be useful to remind candidates that they cannot gain marks by restating the stem of the question.

Question 15 was very well answered - it was encouraging to see AS material tackled so well in the final A2 paper.

Candidates found the last three questions more difficult. This may well be due to the length of the examination, but there was little evidence of candidates running out of time. Question 16 was about electrons in a metal modelled as particles of an ideal gas. Part (a) required an algebraic explanation which was well performed by most. However, relatively few candidates gained the mark in (b) for realising that the speed will go up by a factor of root two when the temperature doubles. As part (a) concerned the same equation this low facility was surprising. Candidates were on firmer ground with the calculation in part (c). In part (d) many responses gained one mark for stating that electrons had high speeds in random directions but fewer candidates completed the argument by linking current to net movement of charge. This proved a useful discriminator.

Question 17 was the most challenging on the paper. In part (a) candidates were required to show that the units of current density were the same as the product of conductivity and field strength. Many simply did not attempt this. Many responses were a tangle of units and symbols which kept the examiners staring at a patch of screen for considerable periods of time, trying to unpick the candidates thinking. For example, the letter A was used in some responses as indicating area and current. Others confused current density with density of materials. However, the better candidates gave very concise and clear answers. One examiner reported: 'it was lovely to see the simplicity of approach by those who knew what they were doing.'

Part (b) proved to be the most difficult on the paper with only one in six candidates reaching the correct answer. All the difficulties mentioned for 17 (a) were revisited in this part. This was a little disappointing as this idea had been clearly flagged in the advance notice.

After the algebraic questions the final parts were relatively easy. Medium and high-scoring candidates can calculate and will do so happily. The graph in part (d) similarly caused few problems, although a common error was to have resistivity disappear completely at 5 K. There were some weird and wonderful lines drawn by those who did not understand the context, but most responses gained at least one out of the two marks.

The final question was quite discriminating - a candidate who gained all the marks for this question probably performed well enough across the entire paper to gain an A grade. Part (b) was not answered well by the majority. Candidates do not seem to read any text that follows a pencil symbol. They should be encouraged to do so. It was surprising that many candidates had little ideas about the Geiger-Marsden scattering experiment and assumed that electrons were shot at the gold leaf. Others knew about the experiment but failed to gain both marks because they did not make the connection between experimental observation and its link with the theory. Part (c) was relatively simple but many candidates gave very woolly answers to what they perhaps considered a woolly question. The question linked to the previous part, in part (c) the expectation was for the candidates to realise that a useful theory must explain observations.

G496 Researching Physics

In this first session of the new A2 coursework module about 360 centres submitted the work of 4,591 candidates. The centre assessors are to be congratulated for their hard work in preparing and marking the diverse range of work on offer from these candidates. Embracing a new specification is always a challenge and centres will have been concerned not to miss any important differences in the new assessment scheme. The tendency to play safe and to suggest only straightforward titles and topics is understandable but it was good to see that some centres bucked this trend and fostered the true spirit of investigation.

The request for the moderation sample is now generated by OCR's system automatically and is triggered by the submission of marks either directly by electronic data submission or by the receipt of the MS1. An alarming number of centres seemed to have made careless transcription and arithmetic errors which now results in a substantial amount of extra administration for the moderator. Where small numbers of candidates are involved (less than 15) it is recommended that all of the scripts are sent regardless of the number requested. This will save the centre time in selection and the moderator some time in those rare cases where extra scripts are required. The most common complaint from moderators in this session was that centres had not annotated the scripts in enough detail. In the worst cases there were absolutely no marks of any kind on the scripts to suggest that they had been marked at all. Centres that fail to offer marking comments in support of their assessments are putting themselves at a much greater risk of adjustment than those that annotate assiduously. The best centres offered a plethora of useful comments and amplified explanations from the candidate for the benefit of the moderator who had not seen the work done.

The advantage of this new assessment scheme, over that which preceded it, is that it repeats the assessment model developed at AS in G493 (Physics in Practice) precisely. The two components at A2, namely 'Research Briefing' and 'Practical Investigation' are similar in demand to the 'Physics in Use' and 'Quality of Measurement' components of the AS coursework being marked out of 10 and 20 marks respectively. Some centres failed to restrict the length of their candidates' Research Briefings and some allowed work that was too restrictive to be undertaken for the Practical Investigation.

The portfolios for each candidate should be presented as a single document not offered separately by their components. Plastic folders, comb binding or cardboard files must not be used.

Research Briefing

The need for candidates to identify a topic of interest and then focus on only the vital physics underpinning that choice proved a more challenging task than might have been anticipated. Only the very best students were able to include relevant physics at the appropriate level without its inclusion seeming contrived. The synoptic nature of the task meant that there was a vast range of titles on offer from every part of the course. Some centres, perhaps unwisely, allowed some of their candidates to tackle esoteric topics offering limited opportunities to demonstrate any knowledge of the A2 physics course at all. Chaos theory, Quantum Computing and Inter-stellar travel were some of the most common topics in this category. The much quoted 'I'm sorry this letter is so long, I didn't have time to write a shorter one', springs to mind often when candidates are preparing this work. The shorter letter is what we are hoping to achieve. Some identified huge volumes of pertinent material and seemed reluctant to jettison it costing them marks for Strand A iii(Quality of writing) where an upper word limit of 2000 words is clearly stated. Centres are advised to insist that candidates include a word count to ensure they do not fall foul of this technical requirement. Most candidates were aware of the need to include a bibliography and the best realised that this needed to be linked to the content in a way that allowed the assessor to see how each entry had contributed to the work as a whole. The lack of any A2 Physics in some of the work resulted in candidates losing marks in Strand B (Use and Understanding of Physics). It is expected that candidates will extract the essential physics ideas and seek to present them on paper in continuous prose to an audience of their peers. There is no requirement for a formal presentation of the type required for the AS 'Physics in Use' component although some centres obviously chose to tackle it this way.

Moderators only expect to see the essay; any supporting material generated in conjunction with this work must not be submitted. For Strand Biii (Understanding and critical thinking) there is a requirement for Centres to assess their candidates understanding of the work they have produced. This might take the form of a private interview between the teacher and the candidate or a wider forum in which the individual is questioned by the rest of the group. Evidence that this has taken place is required by the moderator and to this end, brief notes about the questions asked and the answers offered should be included with the students work. Moderators reported that in the main centres had assessed the Research Briefing accurately, in line with the published criteria, but had not supplied evidence about the questions asked and the answers given.

Practical Investigation

This task builds on the work done at AS in the 'Quality of Measurement' task. The skills students have acquired in making measurements accurately form the backbone of this work but not its heart. The emphasis in the Practical Investigation needs to be on the desire to solve a problem not merely to assemble a vast array of data uncritically. Far too many centres allowed their candidates to carry out formulaic work. The relationship between the periodic time of a simple pendulum and the usual variables is not a suitable topic for an Investigation nor is the measurement of e/m using a piece of standard demonstration equipment. The candidates own ideas should play a part in the development of their project and standard experiments do not offer suitable scope for this development. Physics should guide every step of this project from the planning stage through the preliminary experimentation and in particular inform the analysis of the final results. Moderators reported centres where all of the candidates investigated slightly different aspects of the same topic which is a practice I would like to see discouraged. It is essential that the chosen topic gives the candidate an opportunity to investigate the effect of more than one variable in their chosen experiment. Candidates choosing to investigate only categoric variables definitely put themselves at a disadvantage when it comes to analysing their data. A risk assessment is expected and candidates should be encouraged to make statements about the safety aspects of their chosen experiment even if the experiment carries essentially no risk.

In Strand C (Quality and presentation of observations) candidates generally understood the need to include headings with units in their tables of results and made some attempt to control the number of significant figures used appropriately. Some candidates seem to give very little thought to the layout of tables and do not appreciate the need for them to help 'tell the story'. Page after page of repetitive data is of little or no use if it isn't analysed to reveal an underlying pattern. Students would be well advised to stand back and ask 'what is my data showing me?' rather than 'how can I get my datalogger to generate even more data?' The need to consider the uncertainties present in the data gleaned should not become the overarching concern. Obviously it is important to know how accurate your measurements are but this must not be the sole aim of a two week project. It is better to have revealed a convincing link between the variables involved rather than to have stalled in trying to assess how accurately one variable was measured. The conclusions offered for Strand D (Conclusions and evaluation) can often be limited by the complexity of the task. The lack of a decent range of data sometimes results in a less secure conclusion but this should not prevent candidates being ambitious. A good number of candidates in this session set out to establish a link between the variables involved in their experiment that they knew existed at the outset. The best candidates analysed their results intelligently, plotted good graphs with sensible, labelled scales and included major and minor gridlines adding best fit lines either by hand or by using Excel depending on their level of IT expertise. Their conclusions were consistent with their data, not offered despite their data! It was pleasing to see a substantial number of candidates writing their Research Briefing essay on the same topic they chose to investigate practically. This led to a greater depth in both components than might have resulted if they had chosen two unconnected topics.

The Institute of Physics continues to offer prizes for the best A2 portfolios each year. A healthy number of high quality reports were submitted for consideration this year.

As the criteria for the assessment of this component become more familiar I expect to see centres allowing their candidates the freedom to tackle more daring projects. We all have our favourite areas of experimental interest and it is difficult not to allow this to influence our students but the challenge for our new cohort is not to play safe but to exceed our expectations and delight us with their ingenuity.

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