GCE

Physics B (Advancing Physics)

Advanced GCE **A2 H559**

Advanced Subsidiary GCE **AS H159**

Examiners' Reports

June 2011

HX59/R/11

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.

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CONTENTS

Advanced GCE Physics B (Advancing Physics) (H559)

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

EXAMINERS' REPORTS

Chief Examiner's Report

The individual reports on the units give detailed information about the performance of the candidates in each area of the course. The performance of the suite of assessments overall is comparable to previous years. The coursework submissions were of a similar standard to previous years and once again showed impressive and imaginative work from the best candidates. Raw marks for the Physics in Action unit G491 have shown considerable improvement over previous years. Units G492 and G494 performed similarly to previous years whilst G495 was a more challenging paper than the June 2010 sitting.

There was little evidence of candidates running out of time in the examinations and, once again, it was clear that many Centres assiduously prepared their candidates for the Advance Notice papers in G492 and G495.

Routine calculations were performed with confidence in all papers. However, more developed calculations proved more challenging and the algebraic and mathematical tasks given in the A2 papers were poorly answered by weaker and middle-ranked candidates. Although such questions are intended to be discriminating, the quality of some responses, compared to the individual candidate's performance on the paper as a whole, was disappointing. A similar pattern emerged in questions involving extended writing. These may be areas that can be usefully practised in class, together with specific points made in the reports on the papers.

As always, experienced teams of Examiners provided accurate and efficient marking of the theory papers. On-screen marking of the papers allowed analysis of the performance of the papers at a question-by-question level. These statistics are the basis of OCR's Active Results, which is available to Centres (http://www.ocr.org.uk/interchange/active_results/index.html) and enables further analysis of the performance of their candidates in the examinations.

G491 Physics in Action

The reduction in context and hence reading time (particularly in section B) helped candidates to achieve completion of the paper in the hour available. Deliberately, fewer questions were worth only 1 mark, the majority being worth 2 marks. Consequently it seemed easier for candidates to pick up part marks, when their answers were not perfect; so weaker candidates were not excluded completely from some parts of questions. There were slightly more calculations and fewer explanations than usual; this helped to raise the mean mark by over 6/60 (compared to last June) to well over half marks whilst still giving a good distribution of total marks.

There was little evidence of candidates running out of time, with most candidates attempting Q11. There was evidence of some selective missing of the harder parts in sections A and B. Overall this was the most accessible Physics in Action paper since the switch to the new specification.

Section A

Q1 This was a units question with the difference that candidates had to recognise the correct single unit from a combination of quantities. Some struggled due to lack of familiarity with key formula and units.

Q2 This question asked for the new length of a rubber band from a given length and a strain. It differentiated well for lower grades since weaker candidates forgot to add the original length to the extension calculated.

Q3(a),(b) This question about material properties and failure was generally well answered.

Q4 This involved the calculation of refractive index from speed of light in a sample and in free space. A few were caught out by the significant figure penalty on more than 3 S.F. and some worked out the inverse ratio, but the question was generally well answered.

Q5(a),(b) This question was about describing and explaining lens action. Candidates who used the curvature idea tended to score well, 2 or 3/3 marks, those who took a refraction approach fared less well, especially with the explanation which they found hard to express; the slowing of light near the thicker lens centre for a longer time being particularly difficult – many just stated the light slowed more near lens centre, which was ambiguous.

Q6(a) Some candidates could not define the permanent deformation during plastic behaviour, a permanent change of state was not accepted.

Q6(b) Candidates were invited to describe changes in internal structure during plastic behaviour in either a metal or a long chain polymer. Metal answers were generally more common and better than polymer answers. Many polymer answers only picked up 1/2 marks, often stating that the polymer chains had to break, rather than unwind, uncoil or slip past neighbours.

Q7(a) Candidates were invited to find the Young modulus from a stress strain graph. This was well answered; the most common error was on powers of ten, missing the MPa on stress axis and costing some the second mark.

Q7(b) Candidates were asked to state how they would use the uncertainty bars on the graph data to estimate the uncertainty in the modulus. They responded quite well to this question suggesting the idea is being addressed in class. Some discussed over–complicated combinations of uncertainties rather than looking for the largest % uncertainty which was in the strain, but this was not penalised.

Section B

Q8 This question was about dealing with the varying resolution in an image of the two space shuttles, at different distances from the camera.

Q8(a),(b) Most candidates got off to a good start, linking the 128 greyscale level to the 7 bits required. In part b, to show that the information in the image was less than 1 Mbyte, some forgot to either include the 7 bits per pixel or to divide by 8 to convert from bits to bytes.

Q8(c) This was a high level question, asking for the ratio of distances of the two shuttles from the camera; most candidates found this difficult. The inverse ratio was very common, most candidates did not realise that the distance to the shuttle in the image was in inverse proportion to the length indicated on the image, and the QWC mark depended on grasping this. Many took a roundabout route, converting their distances to pixels and then working out the ratio. Most did get the first mark for measuring the two shuttle image lengths.

Q8(d)(i) Candidates were asked to estimate the length of one shuttle given the resolution at that position and coped with this better.

Q8(d)(ii) Here candidates were asked to estimate the resolution at the position of the other shuttle. This was answered reasonably well, and error carried forward was allowed on the ratio from (c), or their length of shuttle from (d)(i), but some lost it at the end by giving pixels divided by metres rather than the m per pixel requested.

Q9 This question was about a digital phone system subjected to noise.
Q9(a)Most got the bandwidth as the frequency interval 3100 Hz.

Q9(b)(i) Candidates were asked to give and explain the minimum sampling frequency required. Many got 6800 Hz as double the maximum frequency present in the original signal, but did not explain this in any way and scored 1/2 marks.

Q9(b)(ii) Here candidates were asked to comment on the number of bits required to code for a given amount of noise present in the signal. Most could calculate out the number of bits, but found it hard to justify. Hardly any candidates picked up the 3rd mark for QWC. Many candidates erroneously believe that the noise in a signal is only coded when the number of bits is increased, as if fewer bits filters out the noise. Better candidates explained that more bits merely gives extra detail about the noise which is redundant.

Q9(b)(iii) Candidates had to know that rate of information transmission is sampling rate x bits per sample; there were a lot of error carried forwards but many had the idea correct.

Q9(c) Here candidates were asked to give and explain an advantage and disadvantage of using a wider frequency range of the original speech signal. Many lost marks because answers did not address the detail required, particularly the explanation.

Q10 This question concerned a large scale conducting bar in a power station. The physics was familiar, but the scale was larger than is usual. Candidates coped well with the calculations and this question was the best answered question in Section B.

Q10(a)(i),(ii) Showing that the resistance of the bar was about 30 $\mu\Omega$ was well answered. Very few candidates have not got the idea that you have to show an intermediate answer to more significant figures than the 'show that' answer given. Most went on to find the p.d. across the conductor at 0.25 V.

Q10(b)(i) This involved a little algebraic manipulation to derive the equation
$A = L / \sigma R$. Candidates coped better than they have in the past with this technique. Candidates need to be aware that they need to write sufficient steps to be clear about their method.

Q10(b)(ii) This involved using the equation derived in (b)(i) and was well answered but some made hard work of it by missing the obvious equation from (b)(i).

Q11 This question was about aspects of a temperature sensor.

Q11(a)(i) Candidates were asked to describe a graphical relationship given. Many struggled to find sufficiently specific language to score marks. Linearity was commonly offered, but was insufficient for describing the initial proportionality of the data. Many tried to describe the whole range as one relationship i.e. exponential throughout and failed to score. Those that described the increasing sensitivity above 40ºC scored both marks.

Q11(a)(ii) Candidates had to find the sensitivity from the graph. Most knew the method as the gradient of the graph, but the second mark was commonly lost to a power of ten error by missing the mV multiplier.
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Q11(b)(i) In explaining why the circuit containing the sensor acts as a potential divider circuit, many focused on the idea of emf being variable rather than two resistors (internal and external) sharing the p.d.

Q11(b)(ii) This asked them to derive the familiar potential divider equation in a new context, and involved manipulating two familiar equations which they were given. Most achieved a first substitution, but full rearrangement proved discriminated the better candidates.

Q11(b)(iii) Candidates were asked to use the equation from (b)(ii) to show a 2% drop in measured emf due to sensor and instrument resistance. It was quite well answered but quite a few dropped the V and $\mathcal{E}$ too early for the second mark. Those that chose a particular emf to work through rather than in symbolic form could gain full marks.

Q11(c) This part about the choice of measuring instrument was marked generously. There was a problem with the meaning of sensitivity of an instrument given in the table as V/mm (as many instruments are) with the sensitivity as a sensor when candidates would expect mm/V. The mark scheme made allowance for this.

G492 Understanding Processes/Experimentation and Data Handling

General Comments
As in June 2010, there was little evidence of candidates running out of time, although some clearly rushed the last parts of the last question. 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 that candidates had generally been well prepared for section C by their centres.

There seemed to be a good range of marks, appropriately spread. Many candidates had a good understanding of the physics and evidenced it with the quality of their answers. However, some candidates obviously were not well prepared. Question types which appeared in plenty of past papers were still not universally done well.

Extended writing answers were on the whole answered very poorly. Few candidates could write a clear and ordered argument. That applied to both written and mathematical answers. Handwriting was in quite a few cases so poor (combined with poor communication skills) that it was difficult to decipher what the candidate was trying to communicate.

Many candidates ignored the instructions and many marks were lost through using the wrong values in calculations or giving answers to too many sig. figs.

Comments on Individual Questions

<u>Question Nos 1 – 7 (Section A).</u>

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

Q1 (compound units) was intended to be an easy start to the paper, but fewer than a third of the candidates could identify the two combinations of units equivalent to J in (b).

Q2, (orders of magnitude), had some surprising answers from many; 10^{-9} (m) was a common suggestion for the nearest value to the wavelength of visible light, presumably from thinking about nanometres, and although most candidates realised that 10^{3} (N) was closest to the weight of a person, all other values from the list were seen.

Q3 (photon paths) was answered well by most, and in Q. 4 (diffraction) about a quarter of the candidates indentified the two correct statements, with most of the remainder identifying the bottom one.

Q5 (diffraction grating) was correctly done by most

In Q6 (car performance), the value of accelerating force (a) was correctly shown by nearly everyone, and about two-thirds could go on to calculate the power in (b)

In Q7 (treasure map), nearly all candidates could find the magnitude of the displacement, but only the better ones could also find the direction. Any clear and unambiguous reference to direction, e.g. bearing 330°, 30° W of N or just a clearly labelled diagram gained credit here.

In Q8 (standing waves), almost all could explain clearly why the wavelength had to be 20 cm, but choosing, applying and drawing a conclusion from a test of the data to show it supported $f \propto \sqrt{T}$ was done only by the best. Those who claimed that the data indicated the rule was incorrect could gain a mark if they justified it by indicating that the ratio of $f/\sqrt{T}$ (or of f^2/T, or the inverse of either) showed a distinct trend, rather than remaining approximately constant. Just writing 'the three ratios are different' did not gain the third mark.

Section B

Question No 9 (rocket)

In parts (a), most identified $v = 0$ on the graph, although some referred to the gradient, but few gained both marks in (ii) as they did not note that the thrust T was assumed to be constant.

Part (b)(i) was surprisingly poorly done, even though most gained some marks. Only the very best candidates drew a tangent to the graph at $t = 6.0$ s, and of those, many used a rather small triangle to determine the gradient. In (ii), many gained a mark for the weight, but then tried to massage the figures provided to get the answer needed rather than showing understanding of resultant forces and acceleration.

Part (c) was generally well done, with most realising that the graph should curve up earlier and diverge from the one given.

Question No 10 (photoelectric effect)

This question attempted to examine quantum behaviour in a new context (Assessment Objective 2). Although photoelectric effect is mentioned in the specification, it is only as an example: this question endeavoured to explain the context fully enough for candidates to understand it.

Part (a) was the first of the longer, free-response questions, and it proved taxing. Many candidates did not attempt to address the question in terms of photons, getting at most one or two marks. Comments such as 'red waves have less energy than violet waves' could not gain credit here.

The calculation in (b) was done well. Most candidates determined the energy of a 5.6×10^{14} Hz photon, but others worked backward to find the frequency of a 3.7×10^{-19} J photon, and this was completely acceptable. Only the better candidates went on to compare the value calculated with the threshold.

In (c), many candidates described the shape of the graph, but did not explain it. It was common to see the graph at frequencies above the threshold described as 'direct proportion', which is not correct.

Many applications of dubious practicability were accepted in part (d), as the question stated 'suggest'. Good answers explained its limitation in terms of the limited frequency/wavelength range to which it would be sensitive.

Question No 11 (Rømer's measurement of *c*)

The calculations in part (a) were, well done, but candidates need to realise that, when a two-mark question requires them to show that the time taken was 71 days, an answer such as (70°/360°) × 365 days = 71 days would gain the method mark only, as there is no evidence that the value has actually been calculated out. To gain two marks, this should be
(70°/360°) × 365 days = 70.97 days ≈ 71 days.

The algebra needed to prove the equation in (b)(i) was difficult, and was often most clearly shown with a diagram. More could calculate the speed in light using the equation in (ii), but the substitution and calculation proved difficult for some.

Part (c) targeted at the higher grades, required candidates to suggest why the resulting value was too low, and should therefore have suggested either why the value of *R* used was too low, or why the time value was too large.

Question No 12 (ball in bucket)

About 60% of the candidates could identify the components of velocity in (a).

Part (b)(i) was generously marked, with four possible marking points, and this allowed many to gain 3/3 marks for identifying the correct equation and boundary conditions. In (b)(ii), however, many could not use the equation from (b)(i) to calculate the time of flight, either because they did not spot that (b)(i) and (b)(ii) were linked, or because rearranging the equation was too demanding.

Part (c) was often well answered, but only the best candidates could explain why their strategy for throwing the ball – typically lobbing it at a smaller angle θ – resulted in it staying in the bucket.

Section C

Question No 13 (water waves)

In (a), most could suggest one reason why B's method was better than A's. Many read the stem of the question as suggesting that B had actually repeated the reading of a wave passage many times, rather than timing it for many transits: this interpretation was allowed.

(b) proved harder, as many suggested 'reaction time' as a systematic error, whereas it would be a random uncertainty. Good answers suggested that the tank may not be level, or than the ruler used might not have 0 exactly at the end.

(c) was generally well done, with candidates demonstrating that they could calculate the data points, plot the graph and obtain the gradient of the resulting straight line well. This question part made an interesting comparison with 9(b), where graph skills were not good.

(d) (i) was well done, but in (d)(ii), many would write 'the uncertainties in length and depth are small' rather than comparing their percentage uncertainties with that in time. In (d)(iii) many achieved part marks for omitting to double the tank length to get the distance travelled by the wave, or for failing to round their answer.

Question No 14 (tyre testing)

Almost one in five left part (a) blank: almost all who attempted it gained the mark.

Part (b) was well done, with the only difficult point in (iii) being to justify the direction of the effect blamed for giving excessively high friction readings.

In (c)(i) many identified the fact that fewer significant figures would result in the results being indistinguishable, but few seemed to realise that the number of significant figures given is an indicator of the uncertainty in a reading.

Part (d) was well done by most.

Question No 15 (Eratosthenes measures the Earth)

Part (a) of this question, as in question 10, required an answer in extended prose. It proved more successful than that one, however, as the material was not new, but in the pre-release. Clear, well-structured answers gained credit, with the Quality of Written Communication mark being awarded only if the story told was coherent.

In (b), candidates clearly appreciated that the use of 'camel-days' as a length measurement (analogous to light-years) was not very standard, but found it difficult to explain clearly why this might be so.

The calculations in (c) proved more demanding. Most could calculate the extreme values of a stadion in (i), although the instruction 'Express your answers to two significant figures' was clearly missed by many. In (ii), calculations were often jumbled and hard to interpret, and many made the question more complicated by ignoring the rubric and using maximum and minimum values of the stadion as well as the angle. Many did not compare their values with the modern known value of the Earth's circumference, which was the whole point of the question. In (iii), only the best gained marks for realising, and justifying, that the stadion uncertainty was small compared with the uncertainty in the angle measured.

Part (d) was difficult, and many gained credit for identifying the nature of the error (the actual 'measured' overland distance was wrong) without necessarily getting the correct direction of the error (it was too large). A few gained full credit for comparison of the percentage uncertainty introduced (using the diagram, which was to scale) with the uncertainty in the angle, and realised that the distance error was less.

G493 Physics in Practice (Coursework)

General comments

The high quality of much of the work produced this session is a testament to how well teachers had prepared their candidates to meet the requirements of the AS level coursework unit. Following the request for the sample, most centres responded promptly in submitting well-organised portfolios together with the associated documentation. Candidate work should be securely stapled together; the use of plastic wallets and cardboard folders is not recommended and can provide unnecessary work for moderators.

Checking the addition and transcription of marks prior to submission is appreciated. Clerical errors can cause delays and generate additional work for moderators. Some 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 integer marks awarded for each strand must add up to the total for that task. Also, whilst evidence of internal standardisation is welcome, the inclusion of more than one Coursework Assessment Form can be confusing.

Annotation of candidates' work by teachers enables the moderator to easily check that the assessment criteria have been correctly applied. Examples of positive achievement may be referred to, but 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.

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, 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 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 assessment criteria for the post 2008 specification.

Although uncertainties and systematic errors were covered well in most centres, some candidates did not appreciate their importance and their treatment was sometimes rather cursory. There is useful guidance provided in the Advancing Physics AS book and CD-ROM which may help to clarify candidates' understanding of these aspects of the assessment criteria. 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 through the briefing for the '*Team sensor task'* or '*Team measurement task*' (Activities 400E in Chapters 2 and 9 respectively).

In some centres candidates worked together in pairs, or small groups, when carrying out the practical work for the Quality of Measurement task itself. This 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 other centres all candidates carried out the same experiment; a particularly popular choice being the measurement of the resistivity of a metal wire. This can often lead to the methods, tables of data, graphs and reports being very similar. It also makes it more difficult for candidates to demonstrate that they had made individual choices about how to carry out the task, or when suggesting and trying out possible improvements. Allowing candidates 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 'safety' 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 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 first to identify the sources of uncertainty and, if possible, systematic error in their measurements. Here some candidates tended to focus solely on the resolution of the measuring instruments used, rather than considering the (often larger) range of repeated measurements. Whilst the identification part of this was done reasonably well by most candidates, relatively few went on to actually implement their suggested improvements through modifications to their 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 indicated by the centre assessor. The marking of this aspect tended to be too lenient. For example, missing/incorrect units or the inconsistent/ inappropriate use of significant figures in tables of results were sometimes overlooked. 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 were less successful than those who drew them by hand.

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. 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; 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

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 by the assessor on the printouts of the slides are particularly helpful.

In strand A(i) *'Independence'* 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 most relevant to a specific use. 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.

Strand A(ii) '*Sources'* was often leniently assessed. Many candidates did not fully identify their sources or link the information they provided to the presentation itself. The bibliography should identify the sources in sufficient detail for them to be followed up if desired. References to sites such as 'matweb.com', 'physicsworld.com' 'wikipedia.com', 'youtube.com' or 'google.com' are too vague. 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, reference should be made to the particular issue consulted. For books the author, date of publication and relevant page numbers should be quoted, rather than just its title. Candidates should indicate the contribution that each source has made to their presentation, for example by simply linking the source to the slide number concerned. It is preferable to provide the bibliography as a separate Word document rather than as the final slide of a PowerPoint presentation.

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 must produce a clear record of their presentation to be awarded high marks here. Although presentations are enhanced through 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'* both the macroscopic and microscopic properties of the material must be discussed for the award of high marks. A clear context for the material enables candidates to focus on its relevant properties in strands B(ii) and B(iii). 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, the moderator may assume that any errors not noted have been overlooked when awarding marks.

G494 Rise and Fall of the Clockwork Universe

General Comments

<u>Section A</u>

This was intended to be a largely straightforward set of quick questions covering a wide spread of the unit specification. One calculation involving a reciprocal and a square root discriminated well. Many candidates lost marks on another question by providing simple answers which failed to convince the examiners that they had understood the full subtleties of the situation.

<u>Section B</u>

The majority of the marks for these four longer questions had to necessarily be harder to earn than those of Section A. It was therefore expected that weak candidates would struggle to earn marks in many questions where strong candidates would encounter no difficulties at all. This was certainly the case for many questions. However, all candidates struggled to answer the questions on mathematical modelling and the Boltzmann factor. This is disappointing considering the central importance of both of these topics for the unit.

Comments on Individual Questions

Q1 This was the traditional units start to this paper. Part (b) proved to be much more challenging than part (a), with too many weak candidates opting for a unit which already contained N.

Q2 The vast majority of candidates had no difficulty in earning both marks.

Q3 Almost all candidates managed to identify at least one correct statement about simple harmonic motion, with just over half able to identify both.

Q4 It was good to find that even weak candidates were able to calculate the correct answer from this question about a collision. Very few ignored the stem of the question and attempted to use kinetic energy conservation instead of momentum conservation.

Q5 Nearly all candidates correctly identified the required feature of the equipotential surfaces.

Q6 This question provided excellent discrimination. Weak candidates struggled to cope with square roots and reciprocals, but strong ones had no trouble in getting the correct answer.

Q7 This question discriminated less well than the previous one, with the majority of candidates earning the mark on both parts. However, weak candidates often failed to identify both the point of maximum acceleration and the correct equation for the displacement-time graph.

Q8 Few candidates forgot to divide their answer by 2 for part (a). However, too many candidates lost the mark for part (b) by simply stating that the "speed of light was constant" or "the distance there was the same as the distance back"; to earn the mark, candidates had to explicitly compare either the speeds or the times for the outward and return journeys. Part (c) had the same problem; simplistic answers which did not mention the decrease in pulse-echo time did not earn a mark.

Q9 The vast majority of candidates had no problem in correctly calculating the number of molecules in the bottle or sketching how its pressure should vary with temperature.

Q10 This was the first of the four questions of Section B. It necessarily had to be much more discriminating that the previous questions. Although a large majority of candidates earned all three marks for part (a)(i), many weak candidates got lost in the calculation or failed to provide enough sig. figs. in their answer to show that they had actually calculated an answer. Part (a)(ii) provided excellent discrimination, with weak candidates earning no marks for simply using the gravitational potential formula in the data book. Similarly, the calculation of part (b)(i) proved to be impossible for weak candidates, whereas stronger candidates had no difficulty in dealing with the square root and reciprocal. Most candidates had a go at the graph of part (b)(ii), but only a minority earned both marks. This was expected because both parts (b)(ii) and (c) were designed to be stretch-and-challenge questions to discriminate between candidates operating at A and A*. Many weak candidates drew graphs with the incorrect curvature or no curvature at all. Although many candidates correctly identified the attractive gravitational force of the Earth as the smoking gun for part (c), few were able to explain how this gave the projectile more kinetic energy. Most candidates forgot the force of the Moon's gravity altogether as well as failing to explain how the resultant force was able to do work on the projectile to alter its energy as it moved towards the zero-force point.

Q11 Although the vast majority of candidates were able to earn full marks in parts (a)(i) and (a)(ii), many encountered major difficulties in part (a)(iii). Weak candidates often offered the correct answer (already provided in the question) without any evidence of using the data, so earned no marks. Too many candidates lost a mark by attempting to calculate a current by dividing a value for charge by the time at which that charge was present on the capacitor plates. Strong candidates had no problem in identifying one of the many different ways of answering the question and writing down every step of their working to show their use of the data. Part (b)(i) examined the candidate's understanding of the use of mathematical models and iterative calculations. A surprising number of weak candidates moved straight on to the next question, suggesting that they had never met this process before. However, most strong candidates earned both marks. Few candidates earned any marks for (b)(ii), usually because they assumed that the question was asking about experimental errors. Answers which discussed the effect of systematic errors, internal resistance and leakage currents earned no marks. Neither did answers which said that the model should have used $Q = Q_0 e^{-t/RC}$ instead of $\Delta Q = -\frac{Q}{RC}\Delta t$. Even the strongest candidates failed to earn many marks.

Q12 This question was designed to test the candidate's understanding of the derivation of the ideal gas equation from basic principles. A disappointing number of candidates were unable to draw an arrow of even approximately the correct length for part (a)(i). Although many candidates were able to explain why the momentum change of the particle was -2*mv* for part (a)(ii), very few tried to explain why the wall had a momentum change of +2*mv*. It was disappointing to find that many candidates were using words instead of algebra to answer what was intended as a very straightforward question. A suitably qualified and developed statement of algebra, such as $mv + 0 = -mv + \Delta p$, could have earned full marks. Many candidates only answered half of the question of part (a)(iii), usually only discussing the factor of 4*r* and not accounting for the rest of the expression. Part (b)(i) provided excellent discrimination, with many weak candidates electing to start their derivation from $pV = \frac{1}{3}Nm\overline{c^2}$ (found in the data book) instead of $P = \frac{F}{A}$. This suggests that many candidates do not have a correct understanding of pressure as force per unit area. Candidates fared better in part (b)(ii), with most able to provide at least one way in which the model departed from reality.

Q13 This question was about the use of the Boltzmann factor to model the temperature variation of the fluidity of a liquid. It provided poor discrimination, with even strong candidates struggling to earn half of the marks. Part (a) proved to be unexpectedly difficult. The vast majority of candidates were unable to apply a test for exponential data. Most applied tests for linear relationships by evaluating ϕ/T or forgot about the constant of proportionality and evaluated $\ln\phi/T$. Very few candidates calculated the ratio of adjacent values of ϕ to show that it didn't remain constant. Part (b) provided excellent discrimination, with many weak candidates showing total unfamiliarity with key parts of the Boltzmann factor. As expected, only a minority of candidates were able to produce a completely correct sketch graph. It was disappointing to find a large number of curves which were exponential in spite of part (a) where candidates had to show that it was not. Part (c) required to candidates to explain how the Boltzmann factor accounted for the behaviour of the liquid. A surprising number of candidates attempted to do this without mention the Boltzmann factor at all.

G495 Field and Particle Pictures

The marks on this paper were a little lower than in June 2011. The mean mark was 56 % with a standard deviation of 17. There was very little evidence of candidates not finishing the paper and the vast majority of candidates attempted all parts of all questions. As in previous sessions, questions requiring explanatory answers proved more challenging to the candidates and the topic of electromagnetism continues to cause problems for a proportion of the cohort. This paper included more 'long' calculations which proved to be usefully discriminating. It was clear that the majority of the candidates has been well prepared for all aspects of the paper and the responses to Section C questions showed that teachers continue to make effective us of the Advance Notice paper in the lead up to the examinations.

Section A

Although this was generally well-answered a few of the questions proved to be a little more demanding for the candidates. Question 5a, concerning risks involved in X-ray screening, was poorly answered by many - perhaps this small area of the specification requires a little more focus. Similarly, the calculation involving electron transitions between energy levels in question 6 was quite discriminating. A sizeable proportion of the responses took the energy change to be 13.6 eV rather than considering a transition from one level to another. Question 7 was about a magnetic circuit and not all candidates got to grips with the situation described. Many lost a mark in part (b) by writing 'conductivity' rather than 'conductance'. Encouragingly, many candidates answered question 8 with confidence but, unfortunately, did not always set out their explanation with sufficient clarity.

Section B

Question 9 was about an experiment sometimes known as the 'macro-Millikan' demonstration in which a charged ball is suspended in an electric field between two plates. The simple calculation of field strength in part a was very accessible but, as usual, many candidates stumbled on the unit analysis in part b. The calculation of the number of electrons on the ball required in part cii also proved problematic with about a third of the candidates failing to follow the instruction to give the answer to one significant figure. The final part of the question required a discussion about the effect of a nearby beta source on the position of the ball. The answers to this part were generally encouraging and showed that the candidates were able to apply ideas in a possibly novel situation. However, a significant number failed to gain all the marks available as their answers were not clearly structured. Candidates should pay careful attention to the instructions associated with the pencil icon.

Question 10 was about electromagnetic induction and many candidates found this difficult. Part (a) was a gentle opener and most responses gained the marks available. However, some candidates considered equipotential lines rather than field lines. 10 bi was surprisingly discriminating with many candidates unable to calculate the area of a circle. The second element in part (b) asked candidates to explain why there was no emf generated when the ring was moved along the direction of the field. Only the best candidates expressed the answer in terms of zero rate of change flux. Many, incorrectly, suggested that 'no field lines were cut'. Though this is not an incorrect statement it does not explain the situation (if the ring was moved vertically field lines would be cut but there would be no emf generated). This was a challenging and subtle point which shows the limitations in explaining field effects in terms of field lines. Although the calculation in the last part of the question was performed correctly by the majority the reasons given for the calculation yielding an average value of emf were often, once again, based on cutting of field lines rather than considering the rate of change of flux.

Question 11 was about the decay of strontium-90. The first part was a straightforward calculation that gave few problems to the better and middle-ranking candidates. Part (b) required candidates to explain the energy spectrum of beta particles released. Although most correctly stated that the graph showed a range of energies few candidates provided a complete explanation involving conservation of energy. The last part of the question was a calculation of the velocity of a released particle. Many candidates failed to correctly calculate the gamma factor for the particle. A common error was giving the gamma factor as 0.88 rather than 1.88. It may well help future candidates if it is stressed that the gamma factor cannot be less than one. This particular part of this question will prove useful in classes.

Question 12 was the last of section B and concerned nuclear fission. The first two parts were unproblematic but the longer calculations in parts b and c differentiated well. Once again, middle-ranked and weaker candidates found these unstructured calculations difficult to handle, although the markscheme did give credit to incomplete answers. A common error in part (c) was to multiply by 236 rather than 235 or completely ignore the nucleon number. This is another example of a question that will be useful to work through in class.

Section C

The Advance Notice article was about defining the metre and used physics from a number of different areas. Candidate responses showed that the majority of Centres spend some time in preparation of this part of the examination.

Question 13 was accessible to most candidates although some of the lower-ranked candidates confused frequency with time period in part (b)(i).

Question 14 proved accessible until the final part which asked about the link between the standard metre and the standard kilogramme. Many candidates rushed this part and did not go back to the article - it may be useful to remind candidates that using the article during the examination can be very helpful in what are essentially questions involving comprehension of the physics in the article.

Good answers to the first part of question 15 also clearly used the article. Poorer answers relied on assumptions or guesswork. The calculations in the latter parts of this question were well-performed.

Question 16, involving the phasor model of light, opened with accessible tasks but the final part, requiring candidates to consider the effect of a slight change in the experimental set up proved to be extremely discriminating. The best candidates produced answers of brevity and clarity and scored full marks. Many candidates reached some of the marking points but, as in other questions, failed to produce a complete and clear explanation.

Question 17 was the final question on the paper and some candidates may have been flagging a bit at this point. Although the question (about the use of light to define the metre) pointed candidates to the article many of the responses did not use the article and failed to gain all the marking points. However, the best answers, as in the paper as a whole, showed that some candidates had an excellent understanding of the Advance Notice article and were able to apply such understanding in a variety of questions and contexts.

G496 Researching Physics (Coursework)

There was plenty of evidence this year that Centres are feeling a little more comfortable with the requirements for this coursework component of the Advancing Physics course. The similarity between the AS and A2 coursework assessment models is an asset for centres seeking to build on the work done by their students in the AS year but the more demanding nature of the work required from students at this level continues to present challenges for some. The most common criticism from Moderators in this session was about the complete lack of annotations on some of the scripts sent for moderation. Needless to say the majority of centres continue to annotate assiduously.

The Advancing Physics course seeks to develop the skills which foster experimental expertise and this culminates in a Practical Investigation where students are liberated from the confines of more directed work. The period over which the students undertake the Practical Investigation is an exciting one for the students, but it can also be a fraught with difficulties for the staff supervising them. The ability to know when to intervene when progress has faltered must be balanced with the needs of the assessment to be sure that the student has worked independently. Giving guidance during the course of the experiment however, does not mean that the candidate's assessment should automatically suffer as a result. Some centres seem reluctant to help their students for fear of having to penalise them during marking. Only if the help given is significant and frequent should this be necessary. Experienced centres continue to allow their students a completely free choice of topic for investigation but insist that they complete detailed planning sheets in advance hence maintaining the right to veto topics where a suitable outcome would be unlikely. These centres encourage their students to include the planning sheets as part of their experimental report. Those students who identify one or two continuous variables to investigate put themselves at a considerable advantage over those that choose only categoric ones. The best centres continue to extract some impressive experimental work from their students which is characterised by clear reports that state clearly what is being investigated at the outset. The need to present the underlying physics is apparent to most students but some seem to simply tack this on when the work is nearing completion or perhaps only when reminded. The best candidates include the physics as and when it is needed, tabulate the data they have recorded with sensible considerations of its accuracy and display their findings convincingly, using a few well-chosen graphs with sensibly selected scales and suitable ranges. Moderators reported that many graphs were submitted where units and labels were omitted as was any kind of a title. A significant number of graphs were missing a 'best fit line', had no (or incorrect) uncertainty bars and lacked major and minor gridlines. It would be helpful for many candidates if they were shown how to control MS Excel rather than simply using the default settings which can result in some very poor graphs indeed.

The Research Briefing task resulted in a wide range of interesting topics from every area of the course and quite a few from outside it. Moderators reported that this was usually the best aspect of the portfolios offered. The need to include a bibliography was understood by most candidates as was the requirement that the underlying Physics should play a major role. Most centres encouraged their candidates to use a suitable embedded referencing technique although students at this level continue to be reluctant to question the authenticity of the evidence they gather from their sources. Some simply assert that the sources are reliable rather than seeking to cross reference several to add weight to this assertion. Very few candidates draw their own diagrams with most choosing to download them from the internet even when the quality of relevant diagrams is sometimes rather poor. Assessment strand Biii (Understanding and critical thinking) requires centres to interview their candidates to ascertain the level of their understanding of the content they include. The best centres record these findings usually as notes taken during the interview. Some choose simply to mark the script with annotations such as 'when asked about this equation, the student was able to explain its meaning using appropriate technical language'. Moderators reported that some centres recorded no evidence for their assessment of this criterion at all.

The assessment of this coursework component makes significant demands on busy teachers but centres continue to produce some excellent Practical Investigations and some engaging Research Briefings. The skills learned in carrying out this work will be of immense value to those that choose to take their education further.

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