RECOGNISING ACHIEVEMENT

GCE

Physics B (Advancing Physics)

Advanced GCE **H559**

Advanced Subsidiary GCE **H159**

OCR Report to Centres

June 2013

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Advanced GCE Physics B (Advancing Physics) (H559)

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

OCR REPORT TO CENTRES

Overview

Once again, the four papers taken in this session have shown the best candidates performing to very high standards. There was plenty of evidence that most centres had prepared the candidates carefully. This is particularly clear in the advance notice sections of G492 and G495. It is also clear that a lot of the teaching is very much in the spirit of the Advancing Physics course.

The comments on the individual papers will give more detail of candidates' performance but there are certain areas that can be highlighted. The very best candidates gained marks in all areas of the paper and showed an understanding of the basic skills of rounding values, significant figures and the need for clarity in diagrams. All candidates managed one-stage calculations and simple manipulations. The weakest candidates showed less familiarity with the factual basis of the course. The mid-range candidates demonstrated an understanding of the simpler concepts of the course but were more likely to make unnecessary errors in such areas as use of graphs and diagrams and unit manipulation. There is evidence that suggests that candidates do not read the whole question before embarking on the early stages, leading to muddled or incomplete answers that do not always focus on the context of the question.

Legibility remains a problem for some candidates and a few still write answers beyond the space given in the question. It may be helpful to remind candidates that they should use the space provided wherever possible.

The coursework boundaries have remained stable for many sessions. This suggests that internal moderation and assessing is being performed with care and follows the guidance given. The coursework reports and moderators comments will be useful to centres in future preparation of candidates.

GCSE and GCE/A level Science development, tell us your thoughts…

OCR is currently in the process of re-developing GCSE and GCE Science specifications for first teaching from September 2015. To assist with this work we would welcome your feedback regarding anything you would like to see changed or included as part of the new qualifications. If you have any comments/questions regarding GCSE or GCE Science developments please e-mail ScienceDevelopment@ocr.org.uk or join the OCR Community (www.social.ocr.org.uk) to be kept updated.

In summary,

GCSEs are being re-developed for first teaching from September 2015.

- The courses will be linear with separate Science (Biology, Chemistry and Physics) and a Double Award Science;

- There is no Single Award Science as part of the DfE Programme for Reformed GCSEs in Science.

For more details see http://www.ocr.org.uk/ocr-for/teachers/newsletters/agenda/, http://www.education.gov.uk/schools/teachingandlearning/qualifications/gcses/a00221366/gcse-reform and http://ofqual.gov.uk/news/ofqual-launches-consultation-on-gcse-reform/

GCE/A levels for Biology, Chemistry and Physics are also being revised for first teaching from September 2015. (Other Sciences will be developed in a later phase.)

- AS is to be a standalone qualification that does not count towards the A level, covering half the content of an A level and delivered over one or two years;
- The AS could be designed to be co-teachable;
- The standard of the AS is to remain broadly as it is now;
- A level is to be a fully linear, fully synoptic, two year course.

For more details see www.ofqual.gov.uk/news/ofqual-publishes-a-level-reform-correspondence/

Developers

During September, OCR will be advertising for Developers to assist with the drafting of new qualifications for Science. It is expected that adverts will be posted to the OCR website and TES and a notification will be posted on www.social.ocr.org.uk. Alternatively if you register your interest *via* e-mail to ScienceDevelopment@ocr.org.uk, we can send you more details when Developer roles are advertised.

G491 Physics in Action

General Comments

The paper seemed to be accessible to all candidates and was sufficiently challenging for the best. Time did not seem to be an issue with little evidence of candidates struggling to complete the paper. Most of the questions seemed to be fairly straightforward, overall performance was similar to recent papers, with a slightly higher mark profile and satisfactory spread.

Comments on Individual Questions

Section A

1 This question concerned selecting the correct current-voltage characteristic for a fixed resistor, filament lamp and LED. It produced a range of answers, so was not trivial. Over three-quarters selected correctly, the most common error being to confuse the filament lamp and LED graphs. The correct identification of the fixed resistor alone scored 1/2.

2 **(a)** Part (a) involved calculating a lens power from its focal length and handling the reciprocal was straightforward for most, a few made POT errors eg 1/20 = 0.05 D.

(b) Part (b) provided more differentiation, requiring candidates to handle the concept of wave curvature. For those that applied:
curvature out = curvature in + curvature added by lens,
it was straightforward as the sign of the curvature in was given at -0.4 D. A single easy mark was available for selecting the lens formula, but many confused distances with curvatures in the formula and ended with reciprocal answers. Another common error was to multiply wave curvature by lens power:
ie -0.4 x 5 = -2 D.

3 This question concerned the waveform and frequency spectrum of a dolphin click.

(a) Candidates were asked for the time period of the major frequency component. They could get this directly from the waveform, 5 waves in 100 μs so 20 μs per wave. Alternatively they could use 1/f using the peak frequency from the spectrum. There was good differentiation, many just stated the pulse time of 100 μs for which there was no credit, and others missed the prefix k in kHz and made the POT error: 1/50 = 0.02 s which could score 1/2.

(b) Candidates found part (b) much easier getting the bandwidth of the click from (160 – 20 = 140) kHz.

(c) Interpreting the logarithmic intensity scale was again more differentiating, despite candidates being told that for each 10 dB increase the intensity became x10 greater. Quite a few seemed unfamiliar with logarithmic or “times” scales, and used the interval 60 to 90 dB to produce a variety of intensity ratios other than the correct 1000.

4 **(a)** Stating the meaning of hardness was mostly well answered, but weaker candidates gave "lists" and risked making a contradictory statement.

(b) Candidates were asked to explain the benefit of hardness to an axe edge, poor answers were repeats of part (a), or too general eg not causing damage to the head, rather than stating to keep its edge or equivalent.

(c) In part (c) most scored a mark for correctly naming another appropriate physical property, but many could not define their chosen property satisfactorily for the second mark. There was considerable confusion shown in defining strength, stiffness and toughness, all of which were appropriate choices.

5 Two straightforward calculations about a rechargeable battery were well answered and the facility was high. In part (b) most wrong answers were because candidates either forgot to convert 9 minutes to seconds, or because they confused charge and energy in working out the mean power output.

6 This question was about conductance. In part (a) the facility was high, but some weak candidates confused conductance with resistance, and there were POT errors because they took 45 S rather than 45 mS as the conductance. In part (b) candidates had to work out the total conductance of a network of conductors, and the differentiation was much higher, with a good scatter of wrong answers, more or less evenly distributed amongst the alternative values offered. Most candidates showed no working, thinking they could work this out mentally.

7 This question showed an image of a natural scene alongside a contrast improved version. Part (a) involved using a contrast improving algorithm and was almost always correct, providing little differentiation. A few weak candidates thought multiplying by zero was the same as multiplying by one and got -2.1 for the first answer. In part (b) candidates had to identify the imaging process applied, and the facility was over a half. Wrong answers mentioned increasing clarity, edge detection or changes in brightness, which did not relate to the calculation in part (a).

Section B

8 This question was about aspects of a pressure sensor used in a blood pressure monitor.

(a) (i) About a third of candidates described the proportional relationship shown as only 'linear' or 'as P increases V increases' or described a positive correlation, all weaker than the correct answer of (direct) proportionality.

(a) (ii) In part (a)(ii) to calculate the sensitivity of the sensor candidates performed very well. Less than a tenth made errors; these were largely caused by candidates calculating inverted gradients or drawing very small triangles on the graph to calculate the gradient, leading to errors taking their answer outside the acceptable range. There was also some confusion over unit multipliers, although units requested mV/mmHg were those on the graph axes, these candidates could still score the method mark with POT error.

(b) (i) In part (b)(i) candidates were asked to calculate the mean values of heart rate and peak pressure from a graph showing blood pressure against time. Over half of the candidates scored 4/4 which was encouraging. Many candidates made errors counting the waves, calling the first peak” one” rather than” zero”, but could still gain credit for a near rate. Others did not read the stem putting 120 mmHg for the peak pressure without realising they were being asked for the mean of peak pressures. The overall facility was over three quarters.

(b) (ii) In part (b)(ii) asking for description of other features shown by the graph data, there was much more differentiation and facility near to a quarter. There were some poor descriptions, lacking detail, or highlighting rather trivial features such as the time of the lowest pressure, these were not credited.

(c) In part (c) candidates were asked to calculate the number of bits needed to code for a digitised version of the blood pressure signal. The facility was over half and differentiation good. For the first hard mark candidates had to get 400 levels and use it in $\log_2(400)$ calculation or raising 2^n to get 400 levels. Quite a few gave 400 as their answer in bits or used 200 or 100 levels and scored zero.

9 This question was about e-books and memory capacity and downloading rate.

(a) (i) Part (a)(i) was as expected a fairly easy mark showing that a typical paperback book is under 1 Mbyte of information; but some were caught out by rounding errors and confusion about converting from Giga to Mega etc. As always computer k = 1024 was accepted but not expected.

(a) (ii) Part (a)(ii) was novel asking the candidates to estimate the pages per book and words per line in a typical book. It was pleasingly well answered by most, although there were some very odd estimates of numbers up to - 32400 pages in a book!, 50 words on a line! Some premature byte to bit conversion lost some the second mark in calculating the total information in their book. Some wily candidates worked back from the value in part (a) to make sure they were on target! Of course no penalty was applied for this.

(b) (i) Candidates were asked to calculate an information transfer rate to download an e-book in under one minute. Half got full marks for this using either their own estimate of book size or the value offered from part a). Any sense of a rate could gain the first easy mark, but missing x8 for bytes to bits conversion was a fairly common error.

(b) (ii) Candidates were asked to calculate a carrier wave frequency. This was well answered with over three quarters getting full marks. The straight forward calculation did lead to a recurring decimal answer 8.33×10^8 Hz and use of the recurring sign was penalised as an SF error, as was quoting the final answer to one or more than three SF. Some threw away the second mark by RE rounding error quoting 8.34×10^8 Hz. Markers endeavour to only penalise RE a maximum once in any paper.

(b) (iii) Part (b)(iii) was difficult involving a good grip of the concept bandwidth, which only 5% of candidates could demonstrate. About a quarter of candidates got the first easier mark for frequency >> bit-rate. Most candidates gave the impression they thought all frequencies up to the carrier frequency were available for information transfer, rather than a narrow band centred on the carrier frequency. Those that did gain the second mark made this clear explicitly or estimated the ratio bandwidth/carrier frequency or its inverse.

(c) Candidates had to argue an advantage and a disadvantage of e-books to society. Many QoWC penalties were applied for spelling, punctuation and grammar, or for considering only the individual rather than society, but many made reasonable suggestions. The facility was well over a half.

10 This question concerned the mechanical properties of steel and concrete and composite materials.

(a) (i) Candidates were invited to describe the composite material concrete from an image of a polished section. The facility was just over a half. Most candidates made it clear that a composite has more than one material component, but missed the second vital point that they should be bonded together to transfer load. Alternatively candidates could also gain two marks by naming two components clearly visible in the image eg stones in mortar.

(a) (ii) Part (a)(ii) was more differentiating, with just above 10% of candidates scoring 3 or 4/4. They were asked to explain why concrete can be strong in compression, but is weaker under tension. There were very few good explanations of strength in compression, most marks being awarded for good descriptions of brittle behaviour in tension - by stress concentration at tip of crack and crack propagation. Few gained this QoWC mark because of an incomplete or absent description of compressive strength. It was hoped that candidates would transfer their knowledge of ceramics mentioned on the specification to make suggestions about concrete.

(b) (i) Candidates were given the stress strain graphs to breaking of concrete and for steel to the elastic limit. They had to calculate how many times stiffer steel is than concrete. The facility was pleasingly high, better candidates knew to take ratio of graph gradients from linear portions getting the answer 5 very quickly. Weaker candidates did not take values from appropriate sections of graph, or made reading errors. There were also many POT errors on Young Modulus calculations.

(b) (ii) Candidates were asked to compare the strength of concrete in compression and in tension from the same graph. The facility dropped here to under a half with several repeating gradient calculations as in part bi), or comparing steel and concrete again (not reading the question carefully enough).

(c) (i) In part (c)(i) a steel reinforced concrete beam was introduced using pre-tensioned steel to put a concrete beam into compression. The facility was reasonable at under a half. Few argued that the forces on the anchor plates were in equilibrium. Many wrote about steel and concrete being under 'same tension', many repeated the question stem without proper development of 1/5 argument, simply focussing on more area less stress.

(c) (ii) Candidates were asked to write down the tensile stress in steel when the concrete is strained to 0.075% compression. There were many POT errors for the answer 150 Pa rather than MPa. Another common wrong answer was 30 MPa by candidates who forgot to increase the stress by the factor of 5 introduced in part (b).

Note: References to ‘facility’ relate to the proportion of candidates answering the question correctly.

G492 Understanding Processes/Experimentation and Data Handling

General Comments

The entry for this paper was slightly down on June 2012. All Examiners reported that the level of difficulty of the paper was appropriate, and that candidates were in general better prepared than in previous sessions, although there were some who found the paper too challenging. There was no evidence of candidates suffering from shortage of time in this paper.

Candidates continue to handicap themselves by a lack of organisation in laying out their work and many have difficulty with algebra and the use of trigonometric functions. Legibility continues to be an issue reported by examiners: sometimes it is very difficult to make out what the candidate intends, and in that case, credit cannot be given.

Comments on Individual Questions

Section A

1 & 2 Questions 1 & 2 were done well, with most getting at least 2/3 marks on each. Q1(a) proved to be one of the most discriminating questions on the entire paper.

3 This question was answered well by candidates, with most getting both marks.

4 This question was well done by most candidates, with the occasional candidate not able to use the photon energy to find the number of photons emitted per second.

5 Candidates who did illustrate (b) with a sketch phasor diagram were almost assured of the mark: those who described it in words often did not convince.

6 This question was mostly well answered, although the majority of candidates used the resultant force rather than the drag force in (c), and so lost a mark.

Section B

This section is usually the most demanding part of the paper, as the contexts are new; this year, a distinct attempt was made to moderate the demand in this section, and it proved very slightly easier than Section C as a consequence. Candidates showed good mathematical fluency and laid out their work more effectively this year. Explaining themselves in continuous prose remains a skill that many lack. In most questions in this section candidates gained high marks on the earlier parts, but found the latter parts more demanding; the questions were designed with this aim.

7 Kicking a football

Parts (a) and (b) were well done, but (c) proved much more demanding with many trying to duplicate the shape of the original force-time curve.

8 Standing waves on a string

This was the most demanding question in section B. The explanation of the formation of standing waves in (a) was done much more convincingly than in previous years, and the calculation in (b) proved straightforward for most. Part (c) was more demanding, as few gave a generalised proof (ideally an algebraic one) and most had just the one mark for identifying the length of a 'loop' as ½λ. In part (c) most were able to choose an example of a standing wave that they had met before (often in past-paper practice: seiches, didgeridoos and guitars were all frequently seen) but some failed to identify the types of waves involved.

9 Modelling free-fall

This question was well tackled by most candidates. The suvat calculations in (a) were convincingly done, and most identified the feature of the model indicating uniform acceleration in (b)(i). In (b)(ii) it was gratifying to see how many candidates recognised that increasing displacement, with increasing differences between values, indicated acceleration, and could express that clearly. Part (c)(i) was well done, but in (c)(ii) many forgot that this was a model and invoked air resistance. In (c)(iii) most realised that a reduction in Δt was required, but only the best could explain why: many just stated, 'It would be more accurate.'

10 Bi-colour LED

In (a), many seemed not to trust the simple 'it's a mixture of red and green, which both have maxima at 0°' and gave more elaborate (and incorrect) explanations involving phase and phasors, presumably because it sounded physicsier. (b) was done well – in previous examinations these types of question have proved less accessible to many – and there were relatively few power-of-ten errors. Misunderstandings about the nature of arcsin(1.04) abounded: the commonest answer was that it gave a value of θ greater than 90°; as long as the candidate indicated that there was no solution to the equation, then credit was given. Part (d) was generally well done, with most candidates laying their work out clearly (even if not necessarily working down the page), and examiners commented on how well most candidates did this part.

Section C

Most candidates had prepared well for this section, which proved slightly harder than section B this year. As always, some did not seem to have worked through the advance notice material adequately and were clearly rushing towards the end.

11 Simple measurements using a temperature sensor

This was intended to be a gentle introduction to this section, and most candidates tackled it well. (a) and (b) were generally good, but (c) proved a bit more hit-and-miss. A number of candidates in (c)(i) lost a mark for failing to demonstrate evaluation of the resolution of sensor B: the value 0.04 °C is given in the question. A number of candidates re-calculated the value they had already obtained in (a) for the sensitivity of B, often with quite different values, for either (c)(i) or (c)(ii), although in (c)(ii) many successfully deduced the temperature change directly from the graph.

12 Trolley down a ramp

(a) Parts (a)(i) and (a)(ii) were intended to be straightforward, but many candidates lost marks for mis-plotting points (some did not plot points at all).

(b) Calculations of the gradient in (b)(i) were often flawed by basing the calculation on to small a triangle, or else not basing the calculation on the best-fit line but on two of the data points which did not lie on or near the line, or assuming the line went through (0,0) while their line clearly did not. Few realised that the gradient had the same units as the *y*-axis as sin θ is dimensionless; the commonest unit suggested (by good candidates, too) was m ^{2} s $^{-2}$ sin θ^{-1}. Part (b)(ii) was rarely answered well, and few attempted to illustrate their answer with clear vector diagrams.

(c) In (c), many chose both air resistance and friction as the two experimental factors affecting the value of *g* obtained. This was allowed only if it was clear that this was solid-solid rubbing friction acting on the trolley (strictly, at the axles, but this was not insisted on). Explanations were sometimes good, but often did not justify the way in which the obtained value for *g* would be in error — better ones could state, for example, 'θ is hard to measure accurately, and if it is measured as larger than it really is, this will result in too small an acceleration and too low a value of *g*'. In this part, weaker answers revealed confusion about controlled and experimental variables.

13 Measuring the speed of light

(a) Part (a) was usually done well, although a number did not answer the question set in (a)(iii) which does require a calculation of (3.2 km)/(reaction time from (a)(i)) for both marks.

(b) Part (b)(i) was well done by most, but (b)(ii) proved very difficult, with the lowest facility on the entire paper; candidates really needed to make it clear that Michelson's extraordinary precision meant that the slight difference due to the slower speed of light in air, compared with a vacuum, needed to be accounted for. Many tried here to explain why light travelled slower in air. Part (b)(iii) was well done, with different approaches possible.

(c) Part (c)(i) proved demanding (nearly as much as (b)(ii)) as most could see that it wasn't easy to find the middle of the 'blobs' but stated that this was because they were large, rather than large <u>and</u> irregular. Many just quoted the fact that the diagram was marked with a 1 cm grid. (c)(ii) was well done, although there were many power-of-ten errors, which is surprising when the answer should have been recognisable. The commonest error here was moving from an inter-blob separation of 6 ± 1 cm to a wavelength of 12 ± 1 cm instead of 12 ± 2 cm.

G493 Physics in Practice

General Comments

The moderation process for the vast majority of centres was straightforward this year as the overall quality of administration was high. Following the request for the sample most centres responded promptly in submitting well-organised portfolios together with the associated documentation. However the use of plastic wallets and cardboard folders is not recommended as this can provide unnecessary work for moderators; it is sufficient for candidate work to be securely fastened together. The thorough checking of the addition and transcription of marks prior to submission was appreciated and there were few clerical errors this year. However, whilst evidence of internal standardisation is welcome, the inclusion of more than one Coursework Assessment Form can be confusing and the definitive mark must be clearly indicated.

It is expected that the work of candidates should be annotated to show where marks have been awarded as this enables the moderator to easily check that the assessment criteria have been applied correctly. 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.

Many centres were allocated the same Moderator as in 2012 and some had clearly acted on the specific feedback given in their individual reports last year. However in other cases Moderators reported similar discrepancies relating to the awarding of marks to those noted last year. Common issues for each of the two tasks are summarised below.

Quality of Measurement task

Centres appear to have encouraged candidates to undertake a wider variety of experiments for the Quality of Measurement task, the vast majority being appropriate and covering a good range of physics from the course. An interesting variation on the standard resistivity experiment made use of carbon putty rather than the more usual constantan or nichrome wire. Experiments to measure '*g*' were a popular choice, but it is not intended that methods based on timing the period of oscillation of a pendulum are undertaken as the theory lies outside the AS level specification. Guidance on suitable methods for measuring '*g*' is provided in the activities section of chapter 9 of the Advancing Physics CD-ROM. The properties of lenses (chapter 1), sensors (chapter 2), materials (chapter 4) and waves (chapter 6) are other fruitful areas of the AS course. Giving candidates the opportunity to choose from a range of possible experiments also provides a better preparation for the Practical Investigation component of the A2 course.

In strand A '*Quality of practical work in the laboratory*' candidates are required to provide written evidence that they have addressed relevant safety issues to satisfy the descriptor dealing with '*careful methodical work*'. This was sometimes lacking, even in cases where there were clear potential hazards with the experiment. A short risk assessment (which may find no substantial risks) is a simple solution.

In general, candidates are now demonstrating a greater understanding of uncertainties and systematic errors in strand B. However some candidates tended to focus solely on the resolution of the measuring instruments used, rather than considering the (often larger) range of repeated measurements. There are a number of experiments on the CD which may help to develop an appreciation of this aspect of uncertainty at an early stage of the course. For example, ideas of '*Plot and look'* can be introduced through Activity 110E: '*Using a digital multimeter to measure resistance*' in Chapter 2 or Activity 100E: '*Measuring breaking stress of materials*' in chapter 4. A common shortcoming in strand B was the lack of an appropriate evaluation of the effect that any suggested improvements to the experimental method had made to its outcome. This idea of progression in experimental work can be addressed through, for example, Activities 250E-253E '*Measuring wavelength better and better*' in Chapter 6.

In strand C '*Quality of communication of physics in the report*' errors in the recording and presentation of data such as missing/incorrect units or the inconsistent/ inappropriate use of significant figures in tables of results were sometimes overlooked by the centre assessor. A few candidates embarked on potentially interesting projects that did not lend themselves to drawing graphs. In such cases teachers should offer advice, directing the candidate down a more appropriate path in order to give them greater opportunities to meet the assessment criteria. Candidates should be penalised for graphical plots which lack clear labels, uncertainty bars or appropriate best fit lines. In general, candidates electing to produce computer-generated graphs using Excel were less successful than those who drew them by hand. A common fault was in the choice of a 'line' graph, rather than the more appropriate 'scatter' one. Although primarily assessed here the relevant physics should be integrated into the report, rather than being dealt with in a separate 'theory' section near the start, or tacked on at the end.

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

Physics in Use task

The vast majority of candidates now use PowerPoint as their chosen medium for the Physics in Use presentation. However, it was difficult to judge the quality of the work produced in some cases as the printout of the slides was too small to read easily. Candidates must produce a clear record of their presentation to be awarded high marks in strand A(iii). There also tended to be less teacher annotation for this task, either on the Coursework Assessment Forms or on the work itself, and this made the moderation process more difficult. Teachers can assist the moderator by commenting on the oral aspects of the presentation, for example by indicating whether the candidate was able to expand on the information presented on the slides. The quality of candidate responses under questioning may also be recorded. Printouts of slides should be annotated to highlight aspects of both good and poor physics; otherwise the moderator may assume that any errors not noted have been overlooked when awarding marks.

In strand A(i) some candidates did not appreciate the requirement to place their chosen material in a clear context, tending to list its general properties rather than those related to a specific use. A clear context for the material also enables candidates to focus on the relevant macroscopic and microscopic properties in strands B(ii) and B(iii). It can be helpful to couch the title as a question, such as "Why is steel used for deep sea pipelines?" as this immediately focuses the candidate on the properties needed for that application. Other interesting topics chosen this year included aluminium 6061 in scuba diving tanks, carbon nanotubes in a space elevator, fibreglass in gymnastic bars, high-carbon steel in theatre fly system wires, slate in roofing tiles, titanium for bone implants, transparent aluminium and its use in armoured windows and Tyvek polymer in medical packaging.

The use of 'sources' in strand A(ii) of the assessment criteria continues to improve. Here candidates are now identifying the information used more clearly by, for example, quoting the full web address for internet-based sources. There were also improvements in the subsequent linking of the information sources to the presentation itself, often achieved by simply linking the name of the source to the slide number concerned. However, print-outs of the source material itself should not be sent to the moderator. It is preferable to provide the bibliography as a separate Word document rather than as the final slide of a PowerPoint presentation, as the resulting small text can then be particularly difficult to read.

G494 Rise and Fall of the Clockwork Universe

General Comments

Marks earned by candidates on this paper ranged from 58 to 6 out of 60, with a mean mark of about 40. It was good to see that there was no evidence that candidates ran out of time, and that even weak candidates felt able to have a go at all of the questions.

As ever, even strong candidates found it difficult to earn full marks on the questions which require them to respond in extended prose. Sometimes this is because they only have a shallow (or wrong) understanding of the physics, but more often it is because they do not sequence their arguments properly, contradict themselves or omit important stages of the explanation.

Whereas most candidates find it easy to earn full marks by using familiar formulae, many are at sea when it comes to calculating quantities which require them to combine formulae from the data sheet.

Comments on Individual Questions

Section A

1 This is the customary units question at the start of the paper. As always, the first one is supposed to be straightforward recall and the second one requires a bit more thought. Surprisingly, both turned out to be equally difficult, with only two-thirds of the candidates being able to identify the correct unit for gravitational potential.

2 Although this question has been asked many times in the past, many candidates still do not understand that the equation is used to model the radioactive decay of a single nucleus. It was disappointing to find that only a minority of candidates could earn full marks for this question and that the same number earned no marks at all.

3 Few candidates had any difficulty in identifying the correct assumption for this question.

4 Although the vast majority of candidates were able to do the calculation to show that momentum was not conserved, only half were able to suggest a good reason why. Many incorrectly assumed that loss of energy during the collision automatically meant that it didn't conserve momentum either.

5 Showing how to calculate the value of the resistor was probably the easiest question on the whole paper. However, the rest of the question provided excellent differentiation. Candidates who confused half-life with time constant could still earn half marks, but those who ignored the question and tried to use $Q = Q_0 \exp(-t/RC)$ followed by $Q = I/t$ to unsuccessfully obtain a value for RC earned nothing.

6 Although the majority of candidates could draw the curve correctly below the resonance, only a minority drew it correctly above the resonance. Many had the amplitude returning to the low frequency value instead of tending towards zero; others had a second resonance peak at 6 Hz.

7 Only half of the candidates could identify the correct force-distance curve for the situation described in the question. Many candidates seemed to forget that force is a vector, so must change sign at some point when moving from the Earth to the Moon.

8 This calculation provided some differentiation because it not only required candidates to merge two formulae from the Data Sheet, but also required them to take a square root at the end. Quite a few forgot that last stage. Candidates who obtained an approximate answer by using kT as the kinetic energy of a molecule could earn two out of the three marks.

9 Although many candidates had no difficulty earning full marks for their response, almost as many earned no marks at all. Some failed to provide enough detail, assumed that the universality of CMBR meant that it had to originate at one point in the past, that CMBR was produce by the red-shift f receding galaxies. Very few candidates knew the origin of the radiation which is now CMBR; many assumed that it is red-shifted gamma radiation produced in the Big Bang itself. Finally, as ever, a significant number of candidates describe the Big Bang and its aftermath as an explosion into pre-existing space rather than the emergence and subsequent expansion of space itself.

Section B

10 It was good to find that the vast majority of candidates were able to calculate the number of particles in the balloon, with only a very small minority forgetting to convert temperature into kelvin. Calculating the mass of gas in the balloon provided more of a challenge, with a few candidates seemingly unable to calculate the number of moles. Although it was good to find that most candidates were able to earn marks for their explanation of part (b), it was noticeable that many forgot to talk about the direction of the force on the balloon when particles bounced off it, a crucial factor in why the balloon does not collapse. As ever, candidates carelessly lose marks by not carefully writing out every step in the argument. Part (c) was the first stretch-and-challenge question, designed to be only accessible by candidates operating at higher grades. Although weak candidates could earn marks by calculating a pressure from an incorrect number of particles (many assumed that since the density remained the same, so must the number of particles), many strong candidates had no trouble in seeing a way through to the correct answer.

11 Although the vast majority of candidates had no trouble with the initial calculation of part (a), far too many could not use the same rule correctly in part (b). Although many candidates earned a mark by showing that the value of g is proportional to l, most then ignored the situation described in the question and assumed that the increase in length of the pendulum increased the value of g. Only a minority of candidates realised that the value of l used in the calculation would be too small for the measured value of period, resulting in a decrease in the calculated value of g.

Part (c) was also synoptic, asking candidates to draw a vector triangle to show the resultant of the forces on the pendulum. The majority of candidates earned zero, mostly because they failed to clearly label the sides and the angles. Only a small minority earned full marks by drawing the correct triangle complete with arrows going in the right directions. The last part of the question should have been familiar; given a graph showing how one variable changes with time, sketch the variation of another variable with time. The vast majority of candidates were able to sketch a sinusoidal curve with appropriate constant amplitude and period, but only a minority could choose the correct phase.

12 Taken as a whole, this question about the orbits of satellites provided excellent differentiation, with weak candidates earning very few marks and strong candidates earning most of them. Although nearly all correctly drew the direction of the gravitational field outside the planet, about a third of candidates earned no marks at all for part (a)(ii). Of those candidates who pointed out that the force acted at right angles to the velocity, only a minority added the second link in the argument (ie no work was done). This was despite the fact that this was a thinly-disguised version of a question that has been asked many times before. Part (a)(iii) was also a variant of a calculation which has been set in previous sessions; only strong candidates knew what to do and earned full marks. Some weak candidates trawled the Data Sheet for a likely formula and calculated the gravitational potential, calling it the velocity. Part (a)(iv) required candidates to merge two formulae from the data sheet to do the calculation; as ever, weak candidates calculate potential instead of potential energy, sometimes using mgh, for no marks. Part (b) was the second stretch-and-challenge question of the paper. It proved to be suitably difficult, with many candidates incorrectly assuming that both satellites had to have the same total energy.

13 The vast majority of candidates had no difficulty in earning full marks for the calculation of the ion momentum of part (a)(i). They found the calculation of the force on the thruster from the ion emission rate of part (a)(ii) slightly harder and only half of them could calculate the resultant annual change of speed of the spacecraft for part (a)(iii). The latter was synoptic, so was expected to be trivial. Part (b) required candidates to demonstrate their understanding of the Boltzmann factor and the physics behind it in a novel context. The majority of candidates managed to earn two out of the three marks for their explanation of ionisation at high temperatures; many lost the third mark by failing to explain that the collisions between particles of the gas allowed some of them, at random, to gain energy at the expense of others. Although many candidates were able to correctly calculate the value of the Boltzmann factor for part (b)(ii), only half of them could say what this meant for the process being considered.

G495 Field and Particle Pictures

General Comments

This paper produced a good spread of marks and most candidates completed all questions. The calculation questions were particularly well-answered. Once again, questions requiring explanatory answers proved more challenging. The best answers showed an impressive grasp of technical vocabulary and logical analysis. The responses to Section C showed that most centres had carefully prepared their candidates for the Advance Notice section.

Comments on Individual Questions

Section A

1 Candidates showed good recall and understanding of the relationship between units. Part (a) gave very few problems. In part (b), J s^{-1} was a common error as candidates focused on the rate of change.

2 This recall question was answered with confidence.

3 The majority of the candidates chose the correct gamma factor, showing a greater understanding of the equation than candidates in previous sessions.

4 This simple calculation was answered correctly by almost all candidates.

5 This is a more challenging question than many in Section A. Correct responses showed a clear method, as required. The majority of correct responses used the area under the line. Some candidates treated the area as a single trapezium and reached a result above the tolerance limit. 'Counting squares' was the most reliable approach. Obtaining full marks by other methods proved more challenging with the best responses showing an interpretation of the situation as a radial field. Some candidates incorrectly assumed that the field was uniform. This is an area that can be covered in class; candidates may find it surprising that an expected value may be obtained through using an incorrect method.

6 **(a)** To gain marks in this question candidates were required to show the direction of force with a degree of care. Only a very small minority incorrectly drew the force arrow pointing towards the nucleus.

(b) This part also required careful drawing. Most candidates correctly showed that the proton was deflected by a smaller amount. The best responses also showed a symmetrical path with the greatest change of direction at the nearest point to the nucleus. This will be a useful point to highlight in class.

7 Both the simple calculations in parts (a) and (b) were answered correctly by most candidates.

8 In part (a) the algebraic manipulation proved straightforward. Part (b) was more challenging. A common error was to choose 2.0 as the ratio. Candidates making this error missed the connection with the equation derived in part (a).

9 In part (a) good answers went beyond merely stating that the equipotential spacing increases but also made the point that the difference in potential between lines is a constant. The second point is necessary to complete the explanation. Part (b) was correctly answered by the majority of the candidates with a minority reversing the direction of the field.

Section B

10 **(a)** **(i)** Good responses to this question made it clear that a pole on the rotor is attracted to its opposite on the stator. Responses such as 'unlike poles attract' were not sufficient for credit.

(a) **(ii)** This was answered well, with many responses arguing that flux lines have a tendency to shorten. This showed confident interpretation of flux diagrams.

(b) The majority of candidates showed an understanding of the idea of permeance in a magnetic circuit. Good responses used precise language such as 'increasing the cross-sectional area' rather than the ambiguous phrase 'increasing the area'.

(c) This part proved challenging as it required the candidates to interpret two diagrams and a graph.

(c) **(i)** The best responses made it clear that flux in the coils is proportional to current and that the flux reaches a peak in one pair of coils when it is zero in the other pair. As the graph included time values it was necessary for answers also to give specific time intervals. Candidates should remember to use all the relevant data available in answering descriptive or explanatory questions.

(c) **(ii)** The best responses made the point that the net flux is the sum of the Y-coil flux and X-coil flux and then described how the direction of net flux changed over time.

(d) The answers to this part were generally encouraging and showed an appreciation of a relatively complex argument. Many candidates scored all three marks and either avoided the rather general statement 'opposes the change producing it' or placed it in a clear, valid context. It was encouraging to read clear explanations moving from flux change generating an emf and current through to the current interacting with the changing field.

11 This question concerns a fusion reaction.

(a) **(i)** This two-stage calculation gave few difficulties. The best responses calculated the change in mass in amu and then converted this into kg. Less confident candidates converted to kg at each stage and this occasionally led to rounding errors.

(a) **(ii)** This simple mass-energy calculation gave very few problems. The most common error was forgetting to square the velocity of light.

(b) The best responses to this question clearly calculated the potential energy of the nuclei at 10^{-14} m separation and then argued that the potential energy of the system approaches zero at large separations so the work done is equivalent to the potential energy calculated at the separation given in the question. Implicit reasoning was accepted. Some responses showed a lack of understanding of the system and reached the expected numerical value through an incorrect method.

(c) **(i)** This proved to be a very straightforward question.

(c) **(ii)** The best responses to this part of the question broke the argument into two parts. For example: 'when particles collide energy can be transferred from one to another, with one particle gaining energy and the other losing energy. If a particle gains energy from a number of successive collisions it may have sufficient energy to fuse.' Some candidates described the second part of the argument as a particle 'getting lucky' and having successive energy-gaining collisions. This is a helpful picture but candidates should remember that stating 'particles get lucky' is not a sufficient explanation. Candidates also gained credit through correctly stating that the energy calculated in (c)(i) is an average and that particles in a system will have a range of energies.

12 This question concerns an isotope used in medicine.

(a) This calculation proved straightforward.

(b) The second calculation in the question was clearly answered by the many. The intermediate answer line helped focus the candidates' thoughts. The most common error was omitting the factor of one thousand in keV.

(c) This follows from part (b) and requires candidates to read the stem of the question with care. This was not always the case as many responses gave a value that was a factor of one hundred too high by ignoring the fact that 99% of the photons pass through the body. It is frustrating that gamma rays have a quality factor of 1 as this means that there is no numerical difference between the gamma dose in gray and dose equivalent in sievert. It was very pleasing, therefore, to read many responses which correctly included ' x 1' in the working. This is certainly a practice that should be encouraged.

(d) The best responses to this calculation and discussion question were most impressive. Although the calculations were fairly simple, they did include pitfalls for the unwary. The greatest cause of confusion was the blurring of the distinction between percentage risk and the number of likely cases. This question will be useful in teaching as this issue about risk and number of cases which will always arise when a question includes a phrase such as 'the risk is 5% per sievert'. The final mark was for linking individual and global risk. Many struggled to link their arguments in a clear manner and did not gain this mark. The best responses acknowledged the risk but suggested that there are benefits to the procedure.

13 This question is about the principle of the mass spectrometer.

(a) (i) The first part of the question is a simple calculation. It was accessible to the vast majority of the candidates.

(a) (ii) This part proved to be surprisingly difficult. Most candidates correctly calculated the force on the moving particle due to the magnetic field but only the better responses realised that this is equal and opposite to that produced by the electric field. A substantial minority of the candidates stated that 'this force is too small to affect the particle'.

(b) (i) This algebraic manipulation, testing the candidates' knowledge of the centripetal force, was performed with confidence by nearly all the candidates.

(b) (ii) This calculation involves substituting values into a given equation. It was accessible to most candidates.

(b) (iii) Most candidates realised that a more massive ion would be deflected less than the original ion. The best responses attributed this to the effect of increasing mass when all other variables are held constant. Many did not complete the argument, and did not receive credit.

Section C

These questions are based on the Advance Notice article which focuses on some aspects of the physics of violins and electric violins.

14 This question is about the physics of vibrating strings.

(a) Most candidates gained the mark here through recognising that the fundamental mode of vibration occurs when string length is half a wavelength.

(b) This is a very straightforward calculation, although many candidates were penalised for giving too many significant figures in the answer.

(c) This question is of a type that is often seen in papers and candidates gained marks here for clearly showing the manipulation. The most successful method employed was to begin by recognising that the units of tension can be written as kg m s^{-2}. Other methods, as given in the mark scheme, were also credited but only rarely seen. The question was a good discriminator.

(d) **(i)** This example of algebraic manipulation was less successfully performed. Candidates often lost marks for failing to make clear each link in the argument.

(d) **(ii)** This 'show that' question gave candidates a lot of structure to work with and most reached the expected answer.

(d) **(iii)** The best responses explained that the value of μ will decrease and then gave a very clear reason why this is the case. Weaker responses omitted detail. For example, stating 'there is less mass' is not sufficient, whereas stating 'there is less mass in the length of string between the bridge and the nut' is a complete explanation.

(d) **(iv)** The last part of this question allowed most candidates to gain one mark for stating the effect of a reduction of μ on the frequency of vibration. The second marking point proved more difficult to reach. Once again, this required a complete explanation to gain the mark and candidates needed to make the proportionality $f \alpha \sqrt{\frac{1}{\mu}}$ clear. The best candidates did this or gave a full explanation using the equation given in the stem of the question.

15 This question focuses on the concept of resonance.

(a) This part proved to be a good discriminator. The best responses included a full description of the criteria for resonance and the effect on the oscillator when those criteria are met. These responses included a specific example in which the driving force and the oscillating body were clearly shown.

(b) This was an accessible question, with most candidates correctly identifying that there is maximum displacement at the antinodes. Perhaps surprisingly, a significant minority confused node and antinode.

(c) The best candidates explained clearly that the resonance frequency will increase and supported their explanation with reference to the equation $f = 1/2\pi\ (k/m)^{1/2}$. Many other responses correctly identified an increase in frequency but gave little supporting material.

16 This question is about electromagnetic induction in the coil of a pick up.

(a) Most responses gave a correct field for the coil and gained the first mark. The best responses showed a clear deviation of the flux lines due to the steel string and gained the second mark.

(b) This is a relatively simple calculation and most candidates reached the expected value. A common error was using the diameter of the wire rather than its radius.

(c) Almost all candidates scored these marks.

(d) This is a very simple calculation. Most candidates scored both marks, but a substantial minority ignored the length of the wire and assumed that the resistance is 50 Ω.

(e) This part of the question requires a clear explanation of a relatively complex situation. Many candidates answered this well and had obviously been well-prepared for such questions. Good responses included a clear description of changes in circuit permeance and flux changes in the coil and focused on the vibration of the string as the cause of these changes through changing the air gap between string and coil. These candidates also showed an understanding of the technical vocabulary of permeance and permeability. Weaker responses confused the emf induced in the coil with the emf induced in the steel string. This led to confused and incomplete answers.

17 **(a)** This question requires candidates to explain the piezoelectric pickup. Once again, the best candidates gave very clear answers that showed careful preparation. Many candidates correctly described the transfer of vibrations of the violin body to the pickup and linked this to the deformation of the pickup leading to the generation of an emf. The very best candidates compared this with the electromagnetically induced emf of the other form of pickup. Less impressive responses focused on the piezoelectric crystal without putting this into the context of the question.

(b) This question was accessible to most and a wide range of responses were credited.

18 This is a fairly accessible question and it was encouraging to see that the majority of the candidates attempted it – showing that time was not an issue on the paper.

(a) This standard question involves calculating a frequency from time trace. Most candidates scored the mark but some read the x-axis units as seconds rather than milliseconds.

(b) Most candidates gained the first mark – that the fundamental frequency of both notes is the same, there were a number of references to ‘the same amplitude’ which were not penalised if the correct reason was given. The second mark proved more difficult to reach. The best responses correctly identified that higher frequency components are present in the second trace. Writing that ‘other’ frequencies are present did not earn the mark.

G496 Researching Physics

General Comments

The quality of coursework offered by candidates for this component of the Advancing Physics examination continues to be high. Centre assessors are becoming increasingly confident about their ability to interpret and apply the criteria for assessment and are aware of the need to provide evidence to the Moderator in support of these assessments. The impressive range of interesting topics on show for both the Practical Investigation and the Research Briefing was also very pleasing. A very small number of centres had made transcription or arithmetical errors when transferring their marks to OCR's system which resulted in an unfortunate delay during moderation. This delay is best avoided by careful checking of the marks when they are submitted.

Research Briefing

Physics students would not naturally rank the skill of 'writing an essay' high on their list of reasons to choose 'A' level Physics but it is at least a task that they understand.

In Strand Ai (Independence) some centre assessors note the fact that a student has worked independently and award 5/5 for this skill automatically. It should, however, be noted that it is also important that the topic chosen is appropriate and includes a significant understanding of at least some 'A' level Physics. The need to set the work in a clearly identified context and to provide information about the sources they have used is also well understood. What is not quite so obvious to some is the need to link those sources clearly to the place in the report where they made a contribution. Furthermore, the assessment grid for the Briefing clearly states that for a candidate to achieve 5/5 for Strand Aii (Use of Sources) there must be a clear attempt to 'cross-check' the validity of the sources used. This is something that very few students did although Moderators reported that many still seemed able to attract full marks for this skill. Some topics of a more edgy nature will automatically throw up anomalies in the information gleaned leading the student naturally on to a discussion about source authenticity but all candidates should be encouraged to consider their sources critically regardless of topic.

The assessment of the student's understanding of the content in their report is covered in Strand Biii (Understanding and Critical Thinking). This strand requires evidence about the questions asked and the competence of the answers given during an interview with the candidate. A space is provided on the assessment grid to report this information although some centres unfortunately submitted work using an older version of the grid without this important modification. Moderators reported that where their assessment of Research Briefings differed most with centres was in their interpretation of Strand A and this often led to the recommendation of an adjustment to the centre's marking.

Practical Investigation

Spending about 20 hours on a single experiment is a challenge for even the most able students at this level. The choice of context is absolutely vital. Those who have carried out some initial feasibility studies to ensure that their idea works are at a definite advantage over those who simply hope for the best. Having at least one continuous variable to measure should be the starting point for most viable Practical Investigations. The temptation to gather more and more data rather than to assess what the data already gathered means continues to be a pitfall for some. The use of Data Loggers to gather results seems simply to exacerbate this problem for some candidates. The best students allow the development of their experiment to be guided by their findings, the weakest just seem to meander.

Moderators report that the graphs and tables presented by the candidates this year were better than previously. There were fewer graphs offered without major and minor gridlines or that were not clearly titled or with axes labelled inappropriately. Uncertainty bars are now added as the norm though some of these are somewhat meaningless. Some students unable to get acceptable results from their spread sheet packages decided to draw some good graphs by hand which of course is perfectly acceptable. Some very confusing, borderless tables continue to be submitted by weaker candidates which extend across several pages without the headings being repeated and without a useful alignment of the headings and data in the columns. Some candidates insist on gathering all their data tables and graphs together in an appendix at the end of their report which should be discouraged as it interrupts the flow for the reader. The analysis of data offered by some students tends to be almost wholly mathematical. The best students, however, demonstrate an ability to apply the physics which they have learnt to their own context often predicting a relationship which can then be verified by drawing a straight line graph.

Students should be discouraged from using an asterisk when they mean a multiplication sign and producing powers of ten in a very odd way. Eg 10 x 10 rather than 10*10 and 1.6 x 10^{-19} rather than 1.6^-19 or even 1.6 EE - 19. Good analysis clearly linking the evidence gathered to a conclusion remains extremely rare.

Coursework is time consuming and demanding for both teachers and students. The best candidates continue to research some genuinely novel topics and gain a great deal along the way. Centres should rightly be proud of the high quality of work that they manage to tease out of their best students. The spirit of investigation is still very much alive in Advancing Physics Centres across the country.

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

OCR Customer Contact Centre

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

www.ocr.org.uk

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