GCE EXAMINERS' REPORTS

GCE (NEW)
PHYSICS
AS/Advanced

SUMMER 2017

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GCE PHYSICS (NEW)

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AS UNIT 1

General comments:

This was the second Unit 1 examination to be sat based on the new specification. The examination contained questions from all sections of the specification along with questions specifically related to experimental technique, data handling and uncertainty analysis. In addition, questions were set to test candidates' ability to provide accurate, logical and well-constructed extended responses and also to test candidates' understanding of ethical issues related to science in our society. Questions based on kinematics, the physics of materials, stellar physics and particles were also set.

Examiners felt that candidate responses were mixed. While responses to questions on stellar physics, particles and projectiles were encouraging, a significant number of responses to questions on materials, Newton's 3rd law and experimental technique, including the handling of uncertainties, did not score as well as expected. Details are provided below. Once again, candidates displayed good mathematical skills, especially in substituting, re-arranging equations and finding components of forces. A significant improvement was seen in interpreting data from graphs and tables. However, examiners felt that candidates' use of significant figures was not as well understood as was the case in the previous year. Again, details are given below.

Examiners commented favourably on the candidates' ability to communicate ideas clearly and succinctly. Responses to the QER question in particular were, on the whole, clear, unambiguous and logically structured. Spelling, punctuation and grammar was usually very good.

Specific comments:

Q.1 (a) Many candidates could explain the term ductile in terms of the metal being drawn into a wire. Far fewer candidates could explain, on an atomic scale, how the addition of carbon atoms made steel less ductile than iron. Few referred to edge dislocations, describing instead the effect of the carbon atom in terms of inhibiting the sliding movement of whole planes of atoms rather than dislocations moving through.

(b) Most candidates used appropriate equations to determine the strain, stress and force applied to the wire. In some cases however, candidates determined 'F' using the Young modulus in (ii) and then used it to calculate the applied stress. The value of 'F' was then used again in (iii). Surprisingly few candidates could determine the elastic energy stored in the wire.

(c) Only a minority of candidates could place T and C in appropriate places on the diagram. Most candidates did not appreciate that the pre-stressed steel bar should be positioned towards the bottom of the beam. A significant number of candidates however could describe how the steel bar inhibited crack propagation within the concrete.

Q.2 (a) Nearly all candidates correctly determined the mean jump height. However, a significant minority incorrectly used the precision of the instrument to determine the absolute uncertainty. Many candidates were penalised for significant figure errors.

(b) The majority of candidates stated (and used) the principle of conservation of energy correctly to derive the given formula. In part (ii) (I), most explained the uncertainty in both measurements was low and could be considered negligible. However, few described the overall effect of these measurements on the overall uncertainty. In some cases, candidates calculated the uncertainties correctly and showed them to be very small in comparison to the uncertainty in jump height. A significant number of candidates were penalised for referring to the balance and caliper readings as being ‘accurate’ rather than ‘precise’. In (II), a large number of candidates failed to include ‘g’ when substituting into the formula. Other common errors included giving an incorrect unit (or omitting it altogether) and using an inappropriate number of significant figures in their answers. About half of the candidates could give acceptable reasons as to why their value of k was likely to be smaller than the true value in (III).

(c) No credit was given for candidates who referred to light gates as a method for reducing the uncertainty in k. Also, many candidates suggested using a different spring which did not answer the question and was not credited.

Q.3 (a) Many candidates drew an acceptable line of best fit through the given data points and used it to correctly determine the gradient. Nearly all candidates used the base units of force (kg m s^{-2}) to show that the unit of the gradient was kg^{-1}. However, very few candidates correctly determined the mass of the glider. The majority did attempt to find the reciprocal of the gradient (their answer to (i)), but then failed to subtract the value of the fixed masses (0.06 kg) from their answers to determine M. A significant number of candidates confused the terms ‘quality’ and ‘sufficiency’ in (iv). This was a pity as, in most of cases; relevant comments were made but related to the incorrect word. For example: *‘The quality of data is not good because too few data points are plotted’* and *‘There are sufficient number of data points because they all lie close to the line of best fit’.*

(b) A significant number of candidates were credited in (i) as ‘error carried forward’ from (a)(iii). However, many candidates did not multiply their answers to (a)(iii) by ‘g’ and/or gave different values to the force on the glider due to the air and the weight of the glider. In (ii), many candidates quoted Newton’s third law but were unable to explain why the two forces shown did not form a Newton 3rd law pair of forces. This was a poorly answered question.

Q.4 (a) Many candidates did not provide a precise and complete definition of a *black body*. Reference to ‘*electromagnetic*’ or ‘*all wavelengths*’ was often omitted in their answers.

(b) These parts were generally well answered. In (i), many candidates could identify at least two (from three) differences between Polaris and Chi Pegasi. References to the temperature and luminosity of Polaris being 'hotter' and 'brighter' than Chi Pegasi (or vice-versa) were accepted. However, reference to colour being 'redder' or 'bluer' were not accepted. Candidates needed to refer to Polaris appearing 'blue (or white)' and Chi Pegasi being 'red (or orange)' to be awarded the mark. Nearly all candidates used Wien's law and information from the graph correctly to show that the surface temperature of Polaris is 7 250 K. In (iii), many candidates could recall and use $I = \frac{P}{A}$ correctly to determine the luminosity of Polaris. However, a significant minority of candidates omitted the factor '4' when attempting to calculate surface area. In (iv), nearly all candidates used the appropriate equation to determine a correct value for the surface area of Polaris. Few however, went on successfully to find the radius of the star. Often, candidates (again) failed to include the factor '4' in determining radius from their calculations of surface area.

Q.5 (a) Many candidates failed to recognise the significance of the body starting from rest and consequently provided confused and complex solutions, a significant number of which were mathematically incorrect. Many, for example, could not multiply out $(u + at)^2$, the most common wrong answer $u^2 + a^2t^2 = u^2 + 2ax$.

(b) A poor response overall. Unsurprisingly, many candidates considered 'velocity' rather than 'acceleration' in their answers. Of the few candidates who correctly identified graph 3 as showing the correct combination, even fewer could provide correct and clear reasons for their choice in terms of the forces acting on the projectile.

(c) Most candidates used appropriate equations of motion correctly to determine the height of the bench in (i). Again, most candidates could determine the magnitude of the resultant velocity in (ii), in some cases as ecf from (i). However, far fewer candidates were able to determine a direction of travel for the bottle. In some cases, a correct angle was calculated but not clearly explained (or shown on a diagram), in which case no credit was given.

(d) Candidates, in addition to identifying the statement as being 'untrue' were expected to provide two reasons why it was the case. The majority only provided one, the most common response being that the flight time depended on the initial vertical velocity.

Q.6 (a) A well answered question. Many candidates provided correct, clear and succinct answers for forces and moments. A common error was to omit 'resultant' or 'sum of' (or equivalent) in their answers.

(b) Most candidates could apply the principle of moments correctly to determine the tension in the wire. However, a small number of candidates used an incorrect trigonometrical relationship to determine the perpendicular component of the tension when finding the anticlockwise moment.

(c) In (i), many candidates identified the 1.5 mm cable as being the most appropriate cable diameter to use and could provide acceptable reasons for their decision in terms of ‘Safe Working Loads’ (SWLs). A few candidates chose the 2.0 mm cable, arguing that the SWL for the 1.5 mm cable was ‘only just’ above the tension in the cable and therefore it would be more appropriate to use the 2.0 mm cable to provide extra security. This response was credit worthy. Responses to (ii) were usually relevant and credit worthy. However, many candidates only provided one reason when two were expected. All the possible answers outlined in the mark scheme were seen.

Q.7 There were many encouraging and detailed responses to this QER question. Candidates, on the whole, seemed confident in their responses, providing well-structured and coherent descriptions of the processes in the given decay. Many candidates described the processes related to baryon, charge and lepton conservation correctly, a significant number doing so in a simple tabular (or equivalent) form, which was acceptable. Many, but not all candidates identified the interaction as being ‘weak’ in nature and could explain their answers in terms of either neutrino involvement or change in quark flavour. The best responses also included a quark flavour analysis. Weaker responses tended to pick out one or two of the conservation laws only. Some candidates were unable to identify the electron antineutrino.

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AS UNIT 2

General comments:

In general the electricity questions scored rather better than those on the other topics. The potential divider question (3), although presented in an unfamiliar format, was done particularly well. At the other end of the scale, questions on stationary waves (4(b)) and the wave aspect of electrons (7(b)) were generally poorly answered, even though they called mainly for recall and were without nasty twists.

Specific comments:

Q.1 (a) Most candidates found the drift velocity successfully, though the wrong value for A was sometimes put into $v = \frac{I}{nAe}$, or mistakes were made in the algebra.

(b) Some candidates calculated the energy transfer using I^2Rt; others did a number of piecemeal calculations, not always successfully. A pleasing number gave collisions between electrons and ions (or atoms or lattice) as the transfer mechanism.

Q.2 (a) (i) The resistivity was calculated correctly more often than not. Predictably the common mistakes were in powers of 10, since length and diameter were given in mm.

(ii) Most candidates added percentage uncertainties in the measurements and derived the absolute uncertainty in the resistivity from their total. Many, possibly the majority, failed to count the percentage error in diameter twice, to take account of the diameter being squared. The alternative method – calculating the maximum possible resistivity allowed by the measurements and subtracting the mean value found previously – was seldom seen.

(b) Many candidates realised that the question allowed only one way of reducing uncertainty: using a longer length of wire. This gained the first mark. The second, rarely given, was for pointing out that this would make the resistance larger and so reduce the (nearly 5%) uncertainty in its value. [The percentage uncertainty in length was so small in the first place as to be hardly worth dealing with.]

Q.3 (a) There were a number of methods successfully used to confirm the output pd. Occasionally, marks were withheld because the working could not be followed.

(b) The first mark was given for putting the correct data in the equation to find the power in R_1, or in R_2, or in both resistors together. Sometimes the mark could not be given because of a mismatch between pd and resistor. Candidates who had successfully considered R_1, had little more to do except the calculation; those who'd considered the total resistance needed to tell us that since the power (0.24 W) was less than 0.5 W, then the power in R_1, must be also!

(c) Most candidates gained two marks for using the resistances-in-parallel formula to determine the new 'bottom resistance'. After that, mistakes were often made. The commonest, perhaps, was to keep using the original main circuit current (0.020 A). However the proportion of clear and correct answers was pleasing.

Q.4 (a) (i) To determine how far the wave travels in 0.34 s, most candidates chose to proceed via the wave speed. The commonest error was in extraction of λ from the diagram.

(ii) The 'snapshot' of the wave at t = 0.34 s was drawn correctly by most candidates, as an upside-down version of the snapshot at t = 0. Presumably it was realised that 0.34 s amounted to a whole number of cycles plus half.

(b) (i) A node in a stationary wave is a point of zero amplitude. "A point of no displacement" is ambiguous because *all* points in a stationary wave have no displacement twice every cycle. On this occasion we gave benefit of doubt and accepted it, but it is not a safe definition. The separation of the nodes in this case was usually given correctly, but an appreciable minority gave the full wavelength.

(ii) We needed candidates to tell us that between adjacent nodes the particles oscillate in phase, but that there is a phase reversal at each node – or equivalent. This was generally answered poorly, not because of missed subtleties but usually because the candidate didn't seem to know how to use the terms 'in phase' and 'in antiphase'.

(iii) Most knew that stationary waves could be seen as a case of interference, but not all stated or implied that the interfering waves needed to be travelling in opposite directions (and needed to have the same frequency and amplitude). For the other mark we needed mention of reflection (as this gives rise to the 'backward-travelling' wave).

(iv) Most candidates told us, correctly, that the nodes would get closer together (we accepted the wavelength decreasing) when the frequency was increased.

Q.5 (a) The commonest faults in accounts of how to determine the wavelength of laser light using Young's slits were writing (for no reward) about the role of interference and diffraction, and *not* writing about how the *measurements* are made. It was quite common for there to be no mention even of a ruler. Nonetheless there were many 'middle band' answers. These included an understandable diagram and clear statements of which quantities had to be measured and where they went in the equation for λ. For the top band we needed just a little about how to achieve accuracy. Even stating that we measure between the *centres* of bright fringes sufficed if the basic account and diagram were good. Some of the best candidates specified measuring with a ruler between centres of the m^{th} fringe and the n^{th}, and dividing their separation by $(n - m)$ in order to find Δy. We even had a few accounts of repeating the measurements for different values of D, plotting a graph of Δy against D, and finding λ from the gradient $\left(\frac{\lambda}{a}\right)$ – *not* essential in order to score full marks!

(b) (i) Despite the unfamiliarity of the question, most candidates drew the correct triangle, and many labelled lengths of sides correctly. Fewer realised that the triangle showed that $\tan\theta_1 = \frac{\mathbf{0.0153}}{\mathbf{0.600}}$, whereas $\sin\theta_1 \approx \frac{\mathbf{0.0153}}{\mathbf{0.600}}$ needed some justification.

(ii) Here, by contrast, was a familiar request: to determine a wavelength by using the grating equation in the first order. The success rate was quite high. Many candidates chose to work out θ from its sine, given as a fraction earlier, and then to calculate sin θ. Those who substituted the fraction itself into the grating equation may or may not have realised that they were using the Young's slits equation (perfectly appropriate here).

(iii) There was great success in determining the highest order, though the reason given for its being so high (39) was often wrong, e.g. slit spacing so small, distance to screen so large.

Q.6 (a) (i) *Total internal reflection* was usually named as such. The minority who thought the process was *refraction* generally failed in the next part, too.

(ii) The commonest successful approach was to determine the critical angle (61°) at the glass-water interface, and to point out that since 45° < 61° the periscope won't work properly. A minority approach was to use the Snell's law equation with 45° as θ. This was fine as long as the conclusion was drawn that since the equation yielded a value for θ_2 (54°) there was refraction and therefore not TIR. There were many cases where Snell's law was wrongly applied, with mismatches between angles and media.

(b) (i) There was considerable success in calculating the transit time of light through a monomode fibre. As expected the commonest mistakes were omitting n, or taking the speed of light in the fibre as cn rather than $\frac{c}{n}$.

(ii) Most candidates knew the difference in the way light propagated in monomode and multimode fibres. Most also knew about the overlapping of data that may happen in a (misused) multimode fibre. What was often lacking was the ‘bit in the middle’: a clear statement that in the multimode, *each pulse* arrives spread out over time because of the different paths by which it travels, and that this doesn’t happen in the monomode.

Q.7 (a) (i) Candidates needed to state how the pd must be increased from zero until the microammeter reads zero (or decreased from maximum until the microammeter shows a current). The voltmeter reading is then the required $E_{\mathrm{k\,max}}$ in eV. Less precise descriptions (for example referring without explanation to the ‘stopping voltage’) could not score both marks.

(ii) The calculation of ϕ was usually done well, though the need to handle both eV and J caused some difficulty.

(iii) Many candidates sensibly calculated the energy of a 650 nm photon and compared it with ϕ, stating why there was no emission, but not everyone explained why making the light brighter didn’t help; those who did generally showed understanding.

(b) (i) Those candidates who recalled the meaning of *momentum* (p) were usually able to work out the electron’s speed, given its de Broglie wavelength.

(ii) Many candidates did not gain the ‘easy’ mark, for telling us that the bright and dark rings show the wave aspect of electrons. We also accepted “... show that electrons can diffract (or interfere)”. The second mark (more elusive) was for the graphite crystals acting like diffraction gratings (no detail needed) or for some reference to a diffraction or interference pattern due to the arrangement of atoms in the graphite.

Q.8 (a) (i) The (routine) calculation of photon wavelength corresponding to the U–L transition was done well, except by some weak candidates who gave us just the frequency or who failed to transpose the equation correctly.

(ii) For both *absorption* and *stimulated emission* we required statements about electrons and about photons. In the case of absorption we needed to be told (but weren’t, always) that it was a *photon* that was absorbed (or that disappeared), and that an electron was promoted from L to U. With stimulated emission there were many poor descriptions, some of which seemed to arise from misconceptions (for example that the stimulating photon has to promote the electron in the first place) and some from omissions (e.g. failing to state that the electron drops from U to L, or that for each stimulating photon there are two after the event.

(iii) Most candidates correctly stated that stimulated emission was more likely than absorption, because there was a population inversion.

(iv) Both the short-lived requirement for P and the longevity requirement for U could be, and often were, explained as keeping up the population of U. For P, the additional point could be made that it needed to empty fast in order to allow continual pumping of electrons from L.

(b) We required at least one physics-based advantage or disadvantage of power transmission by laser beam instead of by electrical power lines. There were plenty to choose from: inefficiency of high power lasers, the need to transfer light energy to a more versatile form for end-users, elimination of resistive heating of wires, saving of metals used for wires... Three more points needed to be made; as well as the above, these could include environmental or common-sense considerations (such as danger of light beams to planes, elimination of the eyesore of pylons and danger of electric shock). Some candidates chose a single aspect, sometimes rather speculative (e.g. cost), and hardly delivered any sort of discussion.

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A2 UNIT 3

General comments:

This was the first time that Unit 3 of the new specification had been examined. In addition to numerical questions akin to those of the old specification, it incorporated a QER question and an unseen comprehension.

Many candidates understood what was being asked in the questions and responded appropriately. These well-prepared candidates gained good marks on individual questions and scored high marks overall. In other cases there was scope to develop presentation, knowledge and/or understanding. The presentation of a few scripts made it difficult to read and follow some answers and candidates are reminded to present their work using clear handwriting and in orderly fashion.

All questions were accessible with essentially all candidates attempting all questions within the allocated time. The scores for the questions fell into two categories. The cohort in general scored well in Questions 1, 2, 3 and 5, but the general percentages were significantly lower in Questions 4, 6 and 7. Question 5, with the experimental analysis, had the highest average percentage whilst Question 6 had the lowest.

The mathematical demand of the paper was generally within the capabilities of the candidates. The *show* sections of Question 6 tended to be the most challenging and candidates are encouraged to set out their working clearly and logically.

Specific comments:

Section A

Q.1 (a) Most candidates were able to draw a diagram of the experimental set-up, or give a basic description, required to identify the types of radiations. In general they attributed a drop in count rate with a few sheets of paper to the stopping of alpha radiation. Lack of clarity tended to occur when describing the consequence of replacing the paper with a few mm of aluminium, where a further drop in the count rate (to that with paper) occurred if beta radiation was present. Many candidates mentioned the requirement of measuring the count rate with the source but without an absorber. The number mentioning the need to accommodate background radiation i.e. without the source, was significantly less.

(b) (i) This was answered well by most candidates, with the result given in units of either per second or per day. A few forgot to insert the unit.

(ii) Most candidates recognised the 5 periods of half-life in the 57.0 days and indicated that the activity is reduced by a factor of 2^5= 32.

(iii) This was also generally answered well. A few candidates gave the activity at the end of the 57.0 days as a percentage of the original activity, without taking the final step of determining the percentage decrease in activity.

Q.2 (a) Most candidates knew that elements of small nucleon number underwent fusion and those of large nucleon number underwent fission, and could give a basic description of the processes. Fewer candidates related the processes to the shape of the graph, with the most stable elements being at the maximum (near ${}^{56}_{26}\mathrm{Fe}$). Fewer still remembered to mention the release of energy that arises because of the mass defect.

(b) The calculation of energy released in the fusion process was carried out correctly by most candidates. A few did not obtain the correct answer, often attributed to the final step of converting the mass defect in amu to MeV.

(c) Most candidates were able to identify a benefit and an issue of the generation of electricity by nuclear plants. However, many failed to address the final part of the question by discussing the relative importance of the issue and benefit. This was a straight forward mark for those who had attempted to state their opinion on the relative importance with a supporting statement.

Q.3 (a) Most candidates scored the three marks for this part. A few failed to indicate that ΔU is an *increase (or change)* in internal energy and so lost the first mark. Others were vague in the meaning of Q and W saying that they were heat transferred in/out of the system or work done by/on the system respectively, and so lost these marks. Candidates are encouraged to know the meaning of symbols in the given equation for the first law of thermodynamics.

(b) (i) This part was also generally answered well. Most candidates gave correct descriptions of the processes. There was the occasional answer that was incorrect mainly for process C to A. A few did not give the correct responses in the second column for the work done. Values were occasionally inserted in this column, but these were not needed as stated in the question.

(ii) In general this was answered very well. Sometimes there was miscalculation and occasionally a negative result, which was incorrect given the sign convention used.

(c) (i) Many candidates had a good idea of how to address this part, applying $PV = nRT$ to show that the temperature is the same on the curved path C to A as it is at C (or A). This was a *show* question and so a clear statement of working was required.

(ii) This was a discriminating part. Candidates used different methods to estimate the area between the two curves from C to A (the difference in the net work done in the two cycles): counting squares, application of the trapezium rule, drawing triangles. A large uncertainty on the correct value was applied in the marking, and many who used a sensible method of working gained both marks.

Q.4 (a) There were some very good answers to the QER, with the candidates describing the three areas coherently: increase in temperature – kinetic theory effect, forces by and on the container walls using Newton's second and third laws of motion, and the increase in pressure. These candidates were awarded 5 or 6 marks. A few were also able to cover this in a succinct and very logical description. At the other extreme, some candidates did not go much beyond a description of one of the three relevant aspects, usually the kinetic theory, and so would have scored 1-2 marks. These answers also tended to loose coherence in presentation.

(b) (i) Most candidates calculated the rms speed of the five molecules correctly. Occasionally the mean speed was calculated rather than the rms. In other instances the division by 5 was not correct or the square root was not applied.

(ii) The responses to this part were varied. The answer required the combination of equations, which many candidates attempted, and calculation of the rms speed for the oxygen gas at the given temperature. Different approaches could be used, but in general the errors arose from the values used for mass. A statement was also required comparing the answer with that calculated in (b)(i) and ecfs were applied for this.

(iii) This final part required the use of the new pressure of 1.2 × original pressure to calculate the new rms speed. An ecf was applied here for the rms speed calculated previously.

Q.5 In general this question was answered very well, showing that the candidates were confident with experimental practices in the subject.

(a) This was a straight forward *show* question, requiring the application of $\text{speed} = \frac{\text{distance}}{\text{time}}$ over a period. Many chose to address it from the standpoint of angular velocity over a period, which was also acceptable.

(b) Most candidates calculated the values correctly for the three empty columns of the table. However, some used too many significant figures, in particular for the v^2 column and so forfeited the fourth mark. A few did not obtain correct values in the column for T (and occasionally v) and ecfs were then applied to the following columns provided the working was consistent with that required.

(c) (i) The correct equation was identified by most candidates for the centripetal force. Many did not insert the mass of 0.01 kg into the equation and so lost the second mark.

(ii) There were some very good answers to this *show* question with many candidates giving credible working. Others lost a mark for lack of clarity in the working. Some were not able to equate the equations, containing the different masses, in a convincing way to obtain the result.

(d) (i) In general the graph was plotted well. Ecfs were allowed for incorrect values of v^2 in the table in part (b). Marks tended to be lost because of not utilising the graph space to its best capacity and the occasional point that was incorrectly plotted. Many candidates showed the ranges of the line of best fit used for calculation of the slope, which was put to good use in the following part.

(ii) Many candidates scored full marks for this part to analyse the graph. It required the gradient from the graph in (d)(i) and the use of the equation given in part (c)(ii). An appreciable margin of uncertainty was allowed on the final value of the acceleration due to gravity, but a unit was required. Marks tended to be lost when the gradient was calculated incorrectly, the gradient was determined from only one data point, or the gradient was well removed from the correct value because of incorrect values of v^2 in the table in part (b). The method mark could however be gained in these instances and the final mark if within the accepted range. Regrettably too many candidates forgot to insert the appropriate unit.

(iii) Many gave a sensible suggestion on how to improve the experiment, mainly by taking repeated measurements or by taking more measurements over a larger number of rotations or a larger range of values of radius R.

Q6. This question required the application of physics and mathematical approximation to the oscillation of a bob at the end of a light string. It proved to be the most challenging question on the paper.

(a) (i) Despite the forces on the mass being clearly indicated in the diagram by T (for tension) and mg (for weight) a surprising number of candidates failed to identify both forces and tended, incorrectly, to cite "centripetal" force.

(ii) This *show* part required consideration of the components of the two forces along the arc. It required the statements that T does not have a component along the arc, that the component of the weight along the arc is $mg \sin \theta$ and that this is in the direction opposite to that of θ i.e. negative direction. This proved to be challenging.

(iii) Candidates seemed to be slightly better equipped to answer this *show* part, in transforming the force component given in part (a)(ii) into acceleration, by applying the approximation for small angle and applying the geometrical relationship between θ, s and l.

(iv) A discussion was required here to relate the equation given in (a)(iii) to the definition of simple harmonic motion. It was not sufficient to merely give the definition of SHM.

(b) (i) The correct formulae were used by most candidates to determine the period and frequency, with the correct answers also being calculated.

(ii) A few candidates used the given maximum angle θ_{max} in radians to calculate $\sin\theta_{\mathrm{max}}$ and showed that both the angle and sine of the angle were essentially equal. They then stated that the approximation given in (a)(iii) was valid for the maximum displacement, and hence that the use of SHM was valid.

Section B

Q7. (a) Good attempts were made by many candidates to explain a megamaser and how it works in their own words, having read the article on Lasers in Space. This reflected a good understanding of the article. However, there was a tendency to overwrite rather than concentrate on the essential points.

(b) Many candidates failed to address this part correctly. A few used a sensible value for the wavelength of light and calculated the corresponding frequency correctly, gaining a mark. Relatively few applied the proportionality to estimate the lifetime of the microwave maser transition. The question reflects the importance of the application of mathematical methods to physics. The range of acceptable answers covered the range of acceptable wavelengths for visible light.

(c) In contrast, the application of Hubble's law to calculate the distance of the galaxy in Mpc was correct by most candidates. Errors occasionally arose due to miscalculation or because of a needless attempt to change units (despite being told in the question not to change the units).

(d) Most candidates showed an awareness of the need to use the Doppler shift to determine velocity, but then found it difficult to express clearly the process of determining the acceleration.

(e) (i) The formula for centripetal acceleration was used by most candidates in this part. Many calculated the correct distance of the gas disk from the black hole either in metres or in kilometres. However, there were others that did not get the correct answer, for example because of forgetting to square the velocity, or not converting the unit of acceleration correctly from per year (indicated in bold in the question) to per second.

(ii) This required the use of theory (geometry shown in the second diagram of the article) and uncertainty analysis where two percentage uncertainties had to be combined. Many candidates succeeded in gaining all four marks, for the calculations (including uncertainties) and the required statement for the comparison. Others succeeded to different degrees. An ecf was applied from (e)(i).

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A2 UNIT 4

General comments:

The general standard of performance of candidates is to be commended. The statistics indicate that the paper was of the right level of difficulty and provided good differentiation for the cohort of applicants. There was little evidence of candidates struggling with time restrictions this year.

Topics
The weakest topics this year were electromagnetic induction and magnetism (Q4&5).

Language
Many of the questions requiring explanations were answered quite well this year e.g. 3(a)(iii), 3(b)(ii), 3(c)(ii) but 4(a)(i), 4(b)(i) and 4(b)(ii) proved to be more difficult. The golden rule of using short sentences still applies but few candidates lost marks due to linguistic skills. While 4(a)(i) and 4(b)(i) were quite difficult to explain, most marks were lost on 4(b)(ii) (the 6 mark QER) by not answering all that was required in the question.

Mathematics
Few problems with algebra were encountered this year.

Show that
Candidates should realise that the final answer is given so extra proof is required. Either they should provide one more significant figure than is given in the question or they should show the last substitution step before the final answer.

Evaluative questions
Many instances of good answers e.g. 1(a)(ii) but the most difficult aspect of these questions is often understanding what is required as an answer or reading the question carefully e.g. 4(b)(ii).

Practical skills
Some basic skills need practice e.g. obtaining the uncertainty in a gradient from a steepest and least steep line, see 4(a)(ii). Also, the subtleties of the notation *(quantity ± uncertainty)unit* need clarification, see 4(a)(iii).

Section A

Q.1 (a) (i) A gentle opening question and almost universally well done. No problems with algebra were encountered but there were occasional candidates who could not obtain the length of the side from the correct area.

(ii) Well answered, in general, with all candidates working out a suitable approach to the problem. As expected, the most common fault here was confusing the methods for combining parallel and series capacitances. Sometimes the same candidate would combine series and parallel capacitors correctly for 1&2 but then combine them incorrectly for 3&4.

(iii) Mostly known that a dielectric (of higher permittivity) was required.

(iv) A surprising fraction of the cohort could not obtain or recall $E = \frac{Q^2}{2C}$. This then led to some very bad physics. A common mistake was to try to incorporate $E = \frac{V}{d}$ with E as the energy stored by the capacitor.

(b) (i) Generally well done but a disappointing fraction of the cohort did not know that the time constant of the circuit was RC.

(ii) Answers here were usually completely correct or completely wrong with the majority being correct.

(c) (i) Only a minority knew the correct shape for a charging capacitor but the majority knew how to incorporate the time constant.

(ii) More candidates knew this exponential decay curve. Unfortunately, those candidates who knew the correct answer to the previous part were more likely to plot an increasing current.

Q.2 (a) Very well answered but occasionally both arrows were in the wrong direction and, very rarely, both arrows pointed radially outward (or inward) from the charges.

(b) A good differentiating question - it provided the full range of available marks (0 to 5). The most common dropped mark was the final mark for the omission of a unit (or a wrong unit).

(c) As ever for "show that" questions, the correct answer was usually obtained. However, many candidates still struggle with the addition of scalar fields.

(d) Not an easy question but it is surprising how few candidates could start from the pretty standard equation: $eV = \frac{1}{2}mv^2$. The final mark was for realising that the potential must be negative - this was infrequently obtained but a surprising number of completely incorrect answers obtained this mark by ensuring that their answer incorporated a minus sign.

Q.3 (a) (i) Well answered, with even those who placed the larger mass on top being able to obtain the correct answer (by subtracting their answer from d).

(ii) Generally well answered but there is still a minority who cannot obtain $v = \frac{2\pi r}{T}$ or its equivalent. Also, a small number of candidates input the incorrect r (and obtained a velocity many orders of magnitude too large).

(iii) Most candidates realised that this was to do with a small redshift but fewer were able to state that a small redshift would be difficult to measure. All too often they just repeated what was in the question - that small velocities are difficult to measure.

(b) (i) Well answered but sometimes the incorrect radius was used.

(ii) The stress caused most problems here. Many candidates could not use $\sigma = \frac{F}{A}$ correctly, either to obtain the stress or the force (using the breaking stress). A highly unusual common mistake was to use the volume of the bar rather than its cross-sectional area.

(c) (i) A straightforward calculation that was almost always correct (no penalty for the omission of the negative sign this time).

(ii) Considerably tougher but most candidates were able to explain that as PE decreased, KE increased.

Q.4 (a) (i) The difficulty with this question was that most candidates did not realise that Newton's 3rd law was involved. They realised that the force on the magnet must be upwards and then contrived a wrong answer using Fleming's left hand rule to justify this – which usually resulted in zero marks.

(ii) This is a standard question but it was difficult to envisage how few candidates would obtain full marks. The mean was invariably correct except for the very rare incorrect rounding or arithmetic slip. An incorrect percentage uncertainty of 10% (using the spread rather than half the spread) was more common than the correct answer. Also, far too many candidates gave their final percentage uncertainty to too many significant figures. Uncertainties and percentage uncertainties should be quoted to ideally 1 significant figure or a maximum of 2.

(iii) This is a more difficult skill than the previous part but usually done better. The final mark is the most difficult to obtain:
(0.295 ± 0.032)T, 0.295T ± 0.032 T or (0.30 ± 0.03)T, 0.30T ± 0.03 T are all perfectly acceptable. However, these were rarities.
Far more common were:
(0.3 ± 0.03)T, (0.300 ± 0.03)T, (0.295 ± 0.03)T, (0.295 ± 0.0322)T, (0.30 ± 3.2×10^{-2})T, (0.2953 ± 0.0322)T and even 0.30 ± 0.03 with the unit omitted. At this level, candidates should be able to quote the answer in the form *(quantity ± uncertainty)unit*. The following answers would have been accepted this year but, in truth, they are not quite good enough at this level.

($2.95 \times 10^{-1} \pm 3.2 \times 10^{-2}$)T. Although this answer satisfies the criteria for 2 significant figures in the uncertainty and the decimal places are consistent, it is not immediately apparent that they are consistent and it is cumbersome to read. No publication would ever present data in this manner.

0.30 T ± 0.03 or 0.30 ± 0.03 T. These answers are unideal because the unit only appears in the answer or the uncertainty but not in both (note that 0.30 T ± 0.03 T is fine).

(b) (i) This explanation was not answered as well as expected and provided the full range of marks. The most common mistake was obtaining the wrong direction for the force on the charge carriers but other omissions were common.

(ii) Not a difficult six mark question but the vast majority of the candidature did not read the question carefully enough. There were two parts required of the explanation – firstly, the effectiveness of confirming $F = BIl$ and secondly the measurement of B. Unfortunately, it was only a small minority that thought to mention the quality of the lines of best fit (for which half the marks were awarded).

Q.5 (a) (i) Well answered generally but more candidates should have stated that the circuit was complete.

(ii) Slightly more subtle but many candidates were able to state that the horizontal component was not being cut. It was more difficult to state that the flux due to the horizontal component was zero.

(b) Quite well answered with a surprising number of candidates recalling the equation: $E = Blv$.

(c) All of the hand rules (FLHR, FRHR, right hand grip) could be used to obtain the correct answer and, rather generously, they were all accepted. However, the direction of the current in the resistor was correct in probably less than 50% of the candidature.

(d) It was pleasing to see so many candidates using $F = BIl$ to obtain a value of the force but, on the other hand, it was disappointing to see so few naming air resistance, drag or friction as a resistive force.

Section B

Q.6 **Alternating currents**

(a) (i) Understanding and using Faraday's law was not a problem, however stating that the flux cutting (or rate of change of flux linkage) was proportional to the angular velocity was less common.

(ii) A good range of marks was seen here. A surprising number of candidates though that the shape of the curve was sinusoidal because of the direction of cutting lines of flux. Nonetheless, it was pleasing to see many candidates noticing the non-uniform B-field.

(b) (i) Well answered in general but candidates should be wary of simply repeating what is stated in the question e.g. "emf is rate of change of flux hence emf is proportional to angular velocity" instead of "emf is rate of change of flux and rate of change of flux is proportional to angular velocity."

(ii) Adding the resistance and reactance was the main obstacle here - it must be done using phasors i.e. $\sqrt{82^2 + 82^2}$ and not simply 82 + 82.

(c) (i) These explanations were not as clear as might be expected. Only a small minority thought of drawing a phasor diagram (not essential but often worth a mark).

(ii) Very well answered although the $\sqrt{2}$ caused many unnecessary problems.

(iii) Well answered although there were many understandable miscalculations. A common bad mistake was adding the reactances of the capacitor and inductor.

(iv) A surprising number of candidates went on an algebraic adventure using $\frac{\omega_0 L}{R} = \frac{1}{R}\sqrt{\frac{L}{C}}$ as a starting point rather than just putting the numbers into the RHS of the equation. Too many candidates calculated the correct Q value of 1.9 and then stated that this value was small and hence gives an excellent sharp resonance curve.

Q.7 **Medical Physics**

(a) (i) This was not answered as well as expected with a number of candidates describing the electron gun (heating element) rather than describing the deceleration of electrons at the target element. Some candidates explained the production of the line spectrum by the removal of inner electrons being replaced by outer electrons and this was perfectly acceptable.

(ii) This was very well answered and it was really pleasing to see that the vast majority of candidates either left the answer with no units or used the unit s^{-1}.

(iii) This was also well answered with the majority of candidates choosing a correct equation of motion.

(iv) This was well answered.

(b) The majority of candidates appreciated that there was a much higher radiation dose for the CT scan compared with a conventional X-ray and also that CT scans are much more expensive than X-rays.

(c) This was generally well answered with a number of candidates going beyond that expected by calculating the reflecting ratio as 0.036 or the percentage reflected as 3.6%. Unfortunately some candidates did not appreciate that a 3/4% reflection would lead to a very clear ultrasound echo.

(d) (i) A number of candidates struggled and appeared to confuse the energy state of the nucleus with energy levels of electrons. A lot of candidates also failed to mention that it was hydrogen nuclei that were being investigated.

(ii) This was generally well answered.

(e) (i) This was generally calculated correctly although some candidates ignored the units of the absorbed dose and many forgot to use Sieverts (Sv) as the unit of dose equivalent.

(ii) Candidates needed to specifically state that beta particles were less ionising than alpha particles just less mass or smaller was not enough.

Q.8 **The Physics Of Sports**

(a) In general this was answered well. Nearly all the candidates realised that they had to converts the mass of the leg and the foot.

(b) (i) This proved to be more discriminating with many candidates not being able to use the correct components of velocity.

(ii) I. This was poorly answered and very few candidates gave the definition of the moment of inertia as $I = \sum_{i=0}^{i} m_i r_i^2$ with a full explanation of symbols. Also r was quoted as being the radius when the distance from the axis of rotation should have been used to explain r.

II. Candidates were able to determine the angular momentum correctly.

III. Many candidates were able to determine the rotational kinetic energy correctly but they stated that there was no linear kinetic energy due to the velocity being zero at the greatest height and they had not realised that the component of velocity was $18\cos 50^0$ at the greatest height.

(c) (i) The factor was determined correctly by the majority of candidates from the ratio of the cross-sectional areas. Only the more able referred to the drag force equation and stated that F was directly proportional to A as density, velocity and C_D were constant.

(ii) The final part also proved to be more discriminating with only a minority of candidates stating that there would be no change to the factor and only a few candidates were able to state that F was still directly proportional to A.

Q.9 **Energy And The Environment**

(a) (i) Nearly all candidates used the intensity equation correctly to determine the intensity of the radiation reaching the Earth's outer atmosphere.

(ii) Most candidates used the multiplying factors of 20% and 15% correctly to determine the 'usable' power per m^2. Fewer candidates could use this value to determine the total area of solar panels needed to give a total output of 8 GW. In some cases, candidates attempted to convert their (correct) answers given in m^2 into km^2 and they did so incorrectly.

(b) (i)-(ii) Nearly all candidates could state Wien's law and use it to show that the peak wavelength of radiation emitted by the earth is in the infra-red region of the em spectrum.

(iii) Few candidates achieved full marks here. Most gained some credit for stating that both water vapour and CO_2 absorbed IR radiation and re-emitted it in all directions. Few candidates referred to the graphs and their values of absorptivity at various wavelengths.

(iv) Few candidates could explain the term 'positive feedback' in terms of the greenhouse effect. Successful candidates did refer to increased water vapour at higher temperatures leading to increased absorptivity of IR radiation and increased temperatures. Credit was also given for answers describing the effect of increased temperatures on melting ice caps and permafrost.

(c) (i) Few candidates could define the term U-value and give a factor which it is affected by. Common errors were to use the term 'energy' rather than 'energy per second' (or rate or power) and 'temperature' rather than 'temperature difference'.

(ii) Nearly all candidates used the U-value equation correctly to calculate the energy per second transmitted through the outer wall.

(iii) Most candidates substituted correctly to determine the outside temperature to be -16 °C (or 257 K). A significant number of candidates obtained a value of +16 °C however and were penalised one mark for either incorrect substitution or arithmetic.

WJEC
GCE PHYSICS (NEW)

Summer 2017

A2 UNIT 5

EXPERIMENTAL TASK

General comments:

The experimental task was generally very well answered with the vast majority of candidates having been well prepared for the test. The investigation differed slightly from previous years in that candidates were asked to calculate error bars and uncertainties from ‘real’ results. In the vast majority of cases this was done very well.

Specific comments:

(a) Writing a plan of the investigation was generally poorly done. Very few candidates showed evidence of having taken trial readings and the general method was often not sufficiently detailed with candidates not describing the ranges or sample sizes used. An attempt at a risk assessment was made by the vast majority of candidates but this was often unrealistic, for example some candidates suggested goggles should be worn in case the marble ‘jumped up’ and hit them in the eye. Only a few candidates pointed out that there were no real risks in the investigation.

(b) The table was generally well done, however some candidates omitted units for some of the columns particularly for the uncertainties and a number of candidates also calculated the uncertainty for t^2 incorrectly. Almost all candidates carried out repeat readings and included an appropriate range and used suitable significant figures.

(c) The graph was very well done in the majority of cases with all points correctly plotted and a very good attempt made at drawing the maximum and minimum gradients. This was particularly impressive considering they were using ‘real’ results that in some cases made the drawing of these lines difficult. The marking team made allowances for these problems and points obviously off the lines of fit were considered anomalous even if this wasn’t stated by the candidate.

(d) (i) The gradients and percentage uncertainty were often calculated correctly. The main reason that some candidates lost a mark was for giving the percentage uncertainty in the mean gradient to more than two significant figures.

(ii) Some candidates lost a mark for giving the absolute uncertainty in acceleration to more than two significant figures.

(e) (i) The teacher assessed marks for the height of the track above the bench were, on some occasions, only given to the nearest centimetre rather than to the nearest millimetre. The range of heights accepted was increased to allow the range 0.100 m to 0.150 m and the teacher assessed marks were adjusted accordingly.

(ii) The vast majority of candidates were able to correctly calculate $g\sin\theta$ and make a correct conclusion.

(iii) Friction and air resistance were correctly given as reasons why the experimental value for acceleration was less than that predicted by theory, however very few candidates stated that the resultant force (and so acceleration) decreased with either velocity or time.

PRACTICAL ANALYSIS TASK

General comments:

The practical analysis task was generally very well answered with the vast majority of candidates having been well prepared for the test. Candidates displayed good mathematical skills and an understanding of how to analyse results from a practical. A significant number of candidates were not able to draw a correct circuit diagram for the discharge of a capacitor with some not using appropriate symbols for components.

Specific comments:

Q.1 It was apparent that candidates had been prepared very well for the question. The majority of candidates were able to determine the mass correctly. Marks were lost for not determining the volume correctly or for realising that the uncertainty for the volume was multiplied by 3 since the radius/diameter was cubed.

Q.2 (a) Many candidates were not able to draw a circuit diagram with correct symbols or they gave the symbol for a fixed power supply when a variable supply should have been used.

(b) Nearly all the candidates had been well prepared and were able to re-write the equation $U = kV^n$ in the form required to determine k and n. Subsequently; the data was correctly used to enable the correct graph to be plotted.

(c) All the candidates were able to plot the graph correctly. Some candidates lost marks due to incorrect plots and not using a suitable scale.

(d) n was determined and calculated correctly from the graph.

(e) Nearly all the candidates were able to comment on the comparison with the equation.

(f) This proved to be more discriminating with only the more able candidates being able to draw a correct conclusion and compare two capacitor values. Candidates did not realise that they had to use a data point from the line of the graph to determine k.

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