CCEA GCE - Physics
(Summer Series) 2015

Chief Examiner's Report

Foreword

This booklet outlines the performance of candidates in all aspects of CCEA's General Certificate of Education (GCE) in Physics for this series.

CCEA hopes that the Chief Examiner's and/or Principal Moderator's report(s) will be viewed as a helpful and constructive medium to further support teachers and the learning process.

This booklet forms part of the suite of support materials for the specification. Further materials are available from the specification's microsite on our website at www.ccea.org.uk

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GCE PHYSICS

Chief Examiner's Report

Candidates are advised that poor handwriting carries a risk. Examiners will try to read all that a candidate writes but sometimes it is impossible to decipher the writing. It is incumbent upon candidates to produce writing and diagrams of good quality so that their physics knowledge and understanding can be revealed.

Assessment Unit AS 1 Forces, Energy and Electricity

Many candidates performed very well in this module but other candidates were hampered by a lack of knowledge and/or poor mathematical skills. In general, candidates performed better in Questions 1 – 5 than in Questions 7 – 10.

Q1 All parts of this question were accessible to most candidates.

(a) Almost all candidates accurately stated the Conservation of Energy Principle.

(b) Again, almost all candidates defined power correctly.

(c) This calculation was well done. A number of candidates correctly determined the mass per second but did not quote it to two significant figures. Candidates are advised that converting values to standard form is the best way to express any value to a particular number of significant figures.

Q2 This question was well answered by many candidates. The final part discriminated well and was only successfully answered by a minority of candidates.

(a) **(i)** Most candidates successfully converted from km h^{-1} to m s^{-1} but not all of them showed each step in the conversion clearly.

(ii) Sketches of the velocity-time graph tended to be good with almost all candidates choosing an appropriate scale for the time axis.

(iii) Most candidates correctly determined the area between their line and the time axis. Some opted to calculate the displacement using equations of uniform acceleration and most did so correctly.

(b) **(i)** Newton's Second Law of Motion was stated in an appropriate manner by most candidates. The most common error here was failure to state that the force acted in the same direction as the acceleration.

(ii) Many candidates failed to gain any credit in this part. The most common error was forgetting to factor in the component of the weight acting parallel to the slope. A less common mistake was forgetting to convert mass to weight.

(iii) Most candidates had a logical approach to this calculation. However, a variety of mistakes resulted in only a relatively small number of candidates achieving full marks. Many candidates attempted this calculation by considering the motion of each vehicle separately rather than by the relative acceleration between them.

Q3 Responses to this question were generally very good. Most methods described utilised an electronic mechanism to time an object falling a known distance. There were very few Data Logger experiments described that gave a value for the acceleration of freefall.

(a) The diagrams of most candidates conveyed sufficient information to achieve full credit. However, it is disappointing to have to draw attention to the poor or very poor quality of many diagrams. Candidates are advised to take reasonable care and attention to produce diagrams of a quality that allows the extent of their Physics knowledge and understanding to be fully assessed.

(b) Candidate responses here were consistent with the method described in Part (a). Candidates who opted for a data logging method did not always provide enough detail when discussing the data required. For example, the specific lengths of the double interrupt card would be required for one method.

(c) Almost all candidates obtained a value for the acceleration of freefall by plotting displacement against drop time squared and doubling the gradient.

(d) Reliability of results is a concept with which some candidates experienced confusion. Many responses did not clearly state what was being repeated and averaged and could not be credited.

The quality of written communication evinced was generally excellent.

Q4 Parts of this question challenged many candidates.

(a) A large number of candidates were unable to name the type of path taken by a projectile.

(b) Only a small number of candidates failed to gain the mark for this question.

(c) **(i)** This predictable question was not well answered by many candidates.

(ii) A range of mistakes was evident in this calculation but the most common was failure to use the correct component of velocity. Candidates are advised to consider their mathematical answers in the context of the question. In this situation, it is impossible for the direction relative to the horizontal, asked for in Part (c)(ii), to be greater than 37°. A candidate calculating a value greater than 37° ought to realise that a mistake has been made!

Q5 This question was reasonably well answered.

(a) Many candidates incorrectly stated that the object had to be stationary rather than in rotational equilibrium. Most candidates knew that the resultant moment had to be zero about the same point for equilibrium.

(b) **(i)** Whilst most candidates progressed through this question easily, a significant number struggled to set up the problem. Many candidates attempted to take moments about a point other than the elbow and because they had two unknown forces, couldn't progress.

(ii) Setting up the equilibrium of translational forces was well done by most candidates. Most of these candidates went on to obtain a force consistent with the values they obtained.

Q6 Candidates responded positively to all parts of this question.

(a) **(i)** The Young Modulus was generally well defined.

(ii) Base unit analysis of the pascal was also well answered.

(b) **(i)** Few candidates experienced problems with determining the tension in each wire.

(ii) Most candidates correctly divided stress by the Young Modulus to obtain the strain. Only a few candidates added a unit and were penalised one mark.

(iii) Most candidates realised that the extension in the wire is the product of strain and unstretched length.

(iv) The successful completion of this part of the question depended on the realisation that the extension produced in both wires is the same – not all candidates indicated an appreciation of this. Almost all of those candidates who showed this appreciation went on to obtain full marks. Some calculated the wire radius rather than its diameter.

Q7 This question was well answered although few candidates scored full marks.

(a) The definitions of resistivity given by almost all candidates conveyed the necessary information.

(b) Many candidates struggled to provide explanations that were worthy of both marks.

(c) **(i)** The sketch graph produced by most candidates was accurate and received full credit.

(ii) The temperature name at which a material becomes a superconductor was generally well known. A number of candidates incorrectly stated Curie temperature.

(iii) This question was misinterpreted by some candidates who described a technology that utilised superconductivity rather than the advantage the superconducting technology had over its non-superconducting alternative!

Q8 Aspects of this question challenged many candidates.

(a) Definitions of electromotive force were good.

(b) **(i)** Most candidates knew that the electromotive force was equal to the terminal potential difference when the switch was open and was greater than the terminal potential difference when the switch was closed.

(ii) The fact that the axes on this graph were inverted from those normally used caused problems for many candidates. The electromotive force was correctly obtained by most candidates.

(iii) Most candidates calculated a value for the internal resistance by substituting data into $V=E-Ir$. Only a few candidates used the gradient of the graph method.

Q9 Few candidates successfully completed this question.

(a) The complexity of this resistance calculation confused almost all candidates. Most achieved some credit, usually for the parallel combination of 6Ω and 2 Ω.

(b) Most candidates were able to determine the current drawn from the battery. Many went on to correctly determine the ratio of the current split but some allocated the incorrect part of the ratio split to the 2 Ω resistor. The calculation of power was generally well done although there were some candidates who used data not directly relevant to the 2 Ω resistor, for example, taking the potential difference to be 15 V.

Q10 This question was quite well answered although many candidates found Part (b) challenging.

(a) Candidates were generally very familiar with this type of question and responses were very good.

(b) This unstructured question was less well done. The responses of many candidates lacked any discernible logic. In many cases there was no attempt to determine the current drawn from the battery which made it difficult for candidates to achieve any credit.

Assessment Unit AS 2 Waves, Photons & Medical Physics

Candidate performance in this module is good.

Q1 This question was extremely well answered.

(a) Almost all candidates named the missing regions of the electromagnetic spectrum and placed them in the correct order.

(b) The calculation of the wavelength of a radio wave given its frequency was very well answered and only a small number of candidates introduced a power-of-ten error.

(c) Most candidates were able to state three differences between electromagnetic waves and sound waves.

Q2 Most candidates responded positively to all parts of this question.

(a) This part was well answered by most candidates but few obtained full marks as the partially reflected light, for incident angles up to the critical angle, was frequently omitted. Carelessness was exhibited by a number of candidates who, despite clear wording in the question, drew diagrams and discussed refraction for light passing from air into water.

(b) **(i)** This calculation was very well executed. Most candidates picked up on the subtlety that required a value of the refractive index correct to three significant figures in order to show that it was correct to 1.4.

(ii) Many candidates failed to compare the size of the refractive indices of water and the cornea and then to link that to the amount of refraction at a water cornea boundary.

Q3 Candidate responses to this question were good.

(a) **(i)** In general, candidate answers were sound. However, some candidates incorrectly moved the lens or lens and screen when locating the image position.

(ii) The subtlety here of realising that the minimum height of screen required depended on the maximum size of image obtained and therefore data Set 1 should be used escaped some candidates. Most candidates calculated a magnification correctly and used that value to calculate the image height consistent with their values.

(b) Most candidates performed this calculation flawlessly. However, there were still some who calculated mean values for object distance and image distance and used those in the lens equation. As there is no physical justification for this technique, such answers received no credit.

(c) Those candidates who responded to both the describe and explain parts of this question tended to score well.

Q4 Some candidates found parts of this question challenging.

(a) Of those candidates who did not receive full marks, the most common reason was for failure to state or imply that the two waves meet and interfere.

(b) **(i)** Candidates are advised that multiple responses will be penalised if even a single incorrect answer is included in their options. For this reason many candidates were penalised for including 'different amplitudes' in their response to this question.

(ii) Sketches of the resultant wave were usually good.

(c) **(i)** The identification of nodes and antinodes was well done by most candidates.

(ii) Most candidates answered this question by calculating the speed of the wave on the string and the length of the string. There were some candidates who, incorrectly, took the node-node distance to be the wavelength. Very few candidates realised that if the wavelength is six times larger the frequency must be six times less since the speed is constant. A number of candidates did not attempt this question.

Q5 Most candidates performed well in this question.

(a) This part was generally well answered.

(b) **(i)** Good responses indicated the distance across multiple fringes and then scaled down. It was evident from responses that many candidates don't realise that fringe spacing is from the centre of a dark (or light) fringe to the centre of the adjacent dark (or light) fringe. In addition, as measurement was accomplished using a rule that can measure to the nearest millimetre, values for fringe spacing that are expressed to a greater precision cannot be justified.

(ii) The calculation of screen-slit distance was usually consistent with the candidate's data.

Q6 Many candidates struggled to respond positively to all parts of this question.

(a) **(i)** Microphone was the only response credited here. Sound detector was a common answer but it didn't specify an electrical output which was required of the detector in this context. Besides, a microphone is a very common piece of apparatus used in sound experiments.

(ii) In this describe and explain type question candidates who addressed both parts tended to score well. However, few candidates described the display as sinusoidal and responses frequently failed to identify what was multiplied by the timebase setting.

(b) Explanations of diffraction are generally good and the responses of most candidates correctly indicated the condition for maximum diffraction. Some candidates lost credit for describing diffraction as a 'bending' rather than a 'spreading'.

Q7 This question was well answered.

(a) Most candidates knew the term 'computed tomography'. Candidates are advised that very poor spelling and/or half-remembered responses are unlikely to be credited in this type of question.

(b) Imprecise candidate engagement with this question cost many candidates marks. The focus of the question was on the radiation used and not on the techniques or equipment employed.

(c) Most candidates appreciated that pregnant women were unsuitable for a CT scan because of the harm that the ionising x-rays would cause the foetus. There was evidence of candidate confusion between MRI and CT scans in the context of this question.

(d) Most candidates produced responses that highlighted the three dimensional nature of the information on the (human) body which the computer compiles from the scan.

Q8 Parts of this question challenged many candidates.

(a) **(i)** Most candidates correctly stated what a photon is and described that an electron moving to a lower energy level would produce one. The responses of some candidates incorrectly indicated that they felt the ground state had to be involved.

(ii) This calculation was very well executed.

(iii) This calculation was also well done. The most common mistake was in combining the 3.11 eV photon release with the -4.23 eV electron ground state.

(b) **(i)** Candidates are advised that it is important to specify the application of the laser in the example chosen. Better candidates, in this question, stated that the laser was used to reshape the lens and/or cornea in laser eye surgery or that the laser was used for bloodless cutting of tissue in keyhole surgery etc.

(ii) These terms are generally well known. However, many candidates ignored the rubric to explain the terms in the context of laser light and therefore lost credit.

Q9 Candidate responses to this question were mixed.

Those candidates who engaged fully with the question scored highly because they discussed diffraction/interference/polarisation as wave phenomena and the photoelectric effect as a particle phenomenon. Good responses provided a correct amount of detail on the phenomena. Many candidates did not focus on electromagnetic radiation but, in error, discussed electron diffraction.

The quality of written communication was generally very good. The relevance of responses was excellent but too many candidates let themselves down with poor spelling, punctuation and handwriting.

Assessment Unit AS 3 Practical Techniques

The general performance by candidates in this unit continues to be very strong.

Q1 Many candidates performed poorly in the latter parts of this question.

(a) **(i)& (ii)** The measurement of rubber band length was very well done with almost all candidates appropriately recording the length to the nearest millimetre to match the precision of the measuring instrument. A small number of candidates lost the mark for Part (ii) of this question because the measured length of the rubber band did not show an increase with load. A sizeable minority of candidates failed to calculate the increase in length from that measured in Part (i) and consequently forfeited the mark.

(b) **(i)** Most candidates have a good appreciation of proportionality and were able to compose apt responses to this question. Some, unfortunately, did not state whether proportionality was exhibited by their results but launched into a general explanation of proportionality. Others, incorrectly, argued that since both variables were increasing they were proportional.

(ii) This question was challenging for many candidates. The subtlety of finding the difference between two measured lengths was missed by a large number of candidates. A common response was to simply explain the uncertainty in using a metre rule in this context. Responses that considered the parallax uncertainty and the uncertainty in using a rule held unsteadily by hand, both of which were relevant in this context, were few!

Q2 This question was very well answered.

(a) **(i)** Almost all candidates successfully performed the lens/mirror manipulation to obtain a focal length that was recorded to the correct precision and fell within tolerance.

(ii) Most candidates calculated a value for the focal length that was consistent with their object and image distances and were awarded the second marking point. Fewer candidates gained the first marking point because responses frequently indicated a larger object distance than image distance. This indicates that the apparatus was manipulated incorrectly and a real diminished image obtained rather than the real magnified image required.

(b) The technique of determining percentage difference was very well done. The accessibility of this question was increased because candidates were free to select the value to which the other was compared.

Q3 All parts of this question were accessible to most candidates.

(a) **(i)–(iii)** Almost all candidates correctly repeated timings for multiple oscillations. Candidates are advised that the number of oscillations should be such that the percentage uncertainty in the measurement is significantly reduced; this means the number of repetitions is context dependent. Furthermore, candidates should appreciate that repetition and averaging does not confer reliability on a measurement. Rather, reliability is observed by obtaining a sequence of similar readings which are then averaged to obtain a 'best fit' value.

(b) **(i)** The majority of candidates selected the equation that best matched their results.

(ii) Most candidates provided compelling explanations and received the mark for this point. Responses were fairly evenly split between those explaining why it couldn't be the other two equations and those that calculated a value for constant A.

Q4 Responses to this question were generally excellent.

(a) **(i)** Most candidates drew good circuit diagrams although polarity was not always appreciated.

(ii) Almost all candidates manipulated the apparatus to obtain results that were characteristic of a light emitting diode and so were credited with both marks.

(b) **(i)** Almost all candidates realised that more values for voltage and current were required, but not all of them specified over what range and so failed to pick up the mark.

(ii) Again almost all candidates found a switch on voltage that was consistent with the results they recorded in Table 4.1.

Q5 Many candidates were challenged by parts of this question.

(a) **(i)** Completion of Table 5.1 was very well done by most candidates. Only a small number of candidates flouted the instruction to quote values for the gear size to two significant figures and an even smaller number miscalculated any gear size.

(ii) Most candidates handled this question part very well and realised that four gear sizes were repeated. There was a naivety in the responses of some candidates in that they argued with the 'six gear' premise of the question.

(b) **(i)** Candidates scaled the axes well, plotted points accurately and drew sound best fit (trend) lines. In a few cases candidates were penalised for scales that consigned all the plotted points to a small area of the available grid, or for drawing a best fit line that had all the points not on the line to one side of the line.

(ii) The calculation of gradient was generally very well done. Most candidates showed on their graphs the two points they were using to make the calculation: this is a good examination technique.

(iii) The calculation of cadence from the gradient troubled very few candidates.

(c) **(i)** Most candidates correctly went back to Equation 5.1 in order to answer this question and most correctly substituted the largest number of teeth on the front gear and the smallest number of teeth on the rear gear to find the gear size for this smaller wheel.

(ii) Almost all candidates realised that the gear size, calculated in Part (i) of this question, had to be substituted into Equation 5.2 along with the cadence they calculated in Part (b)(iii) and obtained a speed consistent with their values. The application of the Error Carried Forward (ECF) protocol meant that the majority of candidates obtained full credit here.

(iii) The calculation of cadence was very well done; candidate substitutions into Equation 5.2 were generally accurate.

(d) Almost all candidates correctly calculated the time in hours but some did not convert to minutes and so lost the second mark.

Assessment Unit A2 1 Momentum, Thermal Physics, Circular Motion, Oscillations and Atomic and Nuclear Physics

The general standard of candidate responses to the questions in this paper was very high.

Q1 Parts of this question challenged many candidates.

(a) In Part (i) of this question, most candidates followed a correct procedure for determining the angular velocity of the roundabout. This value for the angular velocity was used correctly, in Part (ii), by the majority of candidates to determine the linear velocity.

(b) It is strongly suspected that, in most cases, the weakness of candidates' responses here reflected their ability to express themselves in writing rather than flawed understanding of the physical concept tested. Many responses failed to clearly state that the ball's resultant velocity was as a consequence of two (perpendicular) velocities.

(c) Almost all candidates provided good statements for the conservation of momentum principle, as required in Part (i). The responses of many candidates to the calculation in Part (ii) frequently introduced one or more errors. Some candidates did not work out the resultant velocity of the ball and others omitted to add the mass of the ball to the mass of the child sitting on the swing.

Q2 Most candidates found all parts of this question accessible.

(a) Most candidates stated a form of the ideal gas equation to conform to that stated in the specification and went on to identify each term. Partial credit was awarded to other correct relationships involving pressure, temperature and volume. Explanations of why a heated aerosol explodes were generally good but many candidates failed to state that the number of moles of gas present and the volume occupied by the gas were constant and forfeited a mark.

(b) In Part (i) most candidates appreciated that the can volume divided by 22.4 x 10^{-3} m^3 would give the number of moles of the ideal gas present in the can. A standard error when following this method was to use the diameter, 5 cm, rather than the radius, 2.5 cm; this was only penalised one mark. Some candidates substituted values they could recall about standard temperature and pressure into the ideal gas equation and were appropriately rewarded. In Part (ii) the substitution of the candidate's values into the ideal gas equation was usually accurate and the thermodynamic temperature correctly determined. Surprisingly, a large number of candidates added 273 when converting to degrees Celsius! In Part (iii), almost all candidates correctly determined the mean kinetic energy of a single molecule but many candidates did not scale this up for all the molecules in the gas.

Q3 Responses to Part (a) were generally disappointing. Parts (b) and (c) were well answered.

(a) Many candidates failed to engage with the precise context given in this question. That is, many failed to discuss the magnitude and direction of the resultant force. This poor engagement often continued with the introduction of other terms (harmonic force, unbalance force etc) that the examiners suspect were synonyms for resultant force; it is poor examination technique not to use the terms given in the question as it introduces doubt as to what exactly is meant. Finally, candidates are advised to use the term 'weight' for the force of gravity acting on a mass rather than 'gravity' (which was not credited).

A great many candidates forfeited a mark for the quality of their written communication. The relevance of the arguments of many candidates was questionable because they did not focus on the specific nature of the question asked.

(b) Most candidates were able to use the data given in this question to calculate the period and amplitude of the motion. Only a small number of candidates forgot to programme their calculators to radian mode; they were penalised one mark. The graphs drawn by most candidates were good, although some candidates lost a mark for not showing two, or more, cycles.

(c) This part was generally well answered. Candidate responses indicated that there was a high level of understanding about the damping of systems with the potential to oscillate.

Q4 Parts of this question challenged many candidates.

(a) This commonly asked question was well answered. Whilst most candidates received full credit in this question, many responses did not engage directly with the motion of the alpha particles that led to the conclusions of a small nucleus which was positively charged.

(b) This multi-stage calculation challenged many candidates. Most candidates exhibited a reasonably good appreciation of the steps involved in performing the calculation. However, many made mistakes along the way. Some candidates incorrectly used 76 x 93 kBq as the initial activity, despite the wording of the question directing them to calculate the initial activity. Another common mistake was to miscalculate the time interval as six hours.

(c) The simple Part (i) of this question was overlooked by lots of candidates. Part (ii) was very well answered with many candidates providing detail on how the negative gradient of a ln A versus t graph is related to the half-life.

Q5 Most candidates were able to engage positively with all parts of this question.

(a) Explanations of nuclear fission were generally very good.

(b) In Part (i) of this question many candidates incorrectly inserted the atomic mass number in the space for the number of neutrons. In Part (ii), the calculation of energy release in a fission reaction was very well done. Candidates are advised to show their working out clearly in multistage calculations so that examiners can, more easily, see and therefore credit good Physics - even if a mistake has been made in an earlier part of the calculation. Correct answers were obtained by those who worked through using mass difference, Einstein's mass-energy relationship and those who recalled that 1 u = 931 MeV. Part (iii) required candidates to divide the answer they obtained for Part (ii) into 478 MW. Some candidates were confused by the instruction to calculate the number of reactions *per second*!

(c) In Part (i) a number of candidates failed to compose a response to explain the use of heavy water as a coolant that attracted the mark. Some candidate responses indicated that heavy water was also used as a moderator and whilst this is true, it didn't use the provided information about specific heat capacity to answer the question as to why heavy water is a better coolant than water. However, in Part (ii) many candidates correctly calculated the change in heavy water temperature that would result from a single fission using the specific heat capacity relationship.

Q6 This question was answered very well.

(a) In Part (i) the benefits of generating electricity using nuclear fusion rather than nuclear fission were well known. Some responses veered from the comparison between fission and fusion and incorrectly asserted that there were no greenhouse gas emissions. Others carelessly stated that there was a greater energy output in fusion compared to fission without stating per unit mass or per nucleon. In Part (ii) explanations of why the benefits are 'potential' tended to be good and the difficulty in maintaining a high enough temperature was generally appreciated.

(b) Almost all candidates appreciated how the fact the plasma particles were charged meant they could be controlled by a magnetic (or electric) field. In Part (ii), the toroidal shape was also well known. Candidates are advised to use the terms 'torus', 'toroidal' or 'Tokamak' in naming the shape of the magnetic bottle used in JET.

(c) In Part (i) it was well understood that gravitational confinement was impossible on Earth because the mass of plasma required was much too large. Candidate responses that did not mention mass were not credited. In Part (ii) almost all candidates correctly named *inertial confinement* and most went on to explain the use of an ion or laser beam to heat a fuel pellet.

Q7 Candidates tended to find this question very accessible.

(a) In Part (i) a minority of candidates drew a tangent to the curve at 40 °C which meant that most candidates lost the first marking point. A large number of candidates incorrectly measured the time at which the temperature was 40 °C and divided that into 40 °C. In Part (ii) most candidates were awarded full marks. The drawing of the graph in Part (iii) was well done. However, many candidates lost credit because they chose scales that confined all the plotted points to a small area. Candidates are advised to consider the position of a best fit line so that there are as many points to one side as there are to the other and to ensure that rogue points are labelled. In Part (iv), almost all candidates appreciated that if Newton's Law of Cooling is correct then a linear best fit line that passes through the origin should be obtained. However, sometimes the candidate's conclusion was not consistent with the graph drawn!

(b) This question was very well answered. Almost all candidates correctly found the logarithmic form of Equation 7.1 and from it deduced that the gradient was negative, the intercept to be ln 90 and the abscissa when y = 0 to be (ln 90)/0.012. Most sketch graphs were consequently correct.

Assessment Unit A2 2 Fields and their Applications

Q1 Candidate performance in this question was generally good.

(a) Few candidates experienced any difficulty in calculating the gravitational field strength.

(b) Most candidates showed the consistency between Newton's law of universal gravitation and Kepler's 3rd law well but some candidates were careless in how they performed this task and consequently lost credit. A common mistake was to omit the square on π. Candidate performance in part (ii) of the question was strong. There were approximately equal numbers who answered this question by calculating the constant ($4\pi^2/GM$) and who used the ratio method ($T^2/R^3=t^2/r^3$). A number of candidates incorrectly added the radius of Mars to the orbital radius of Phobos and of those, most were inconsistent as they did not then subtract the Mars radius from their calculated answer to get the orbital radius of Deimos. In Part (iii) most candidates performed the calculation of gravitational attraction correctly.

Q2 Candidate performance in this question was generally good.

(i) The calculation of electric field strength at the location due to each charge was well done by almost all candidates. However, the responses of many candidates evinced confusion over the direction of the field due to each charge and this often resulted in them combining the strengths incorrectly.

(ii) The calculation of force was very well done. Candidates are advised to view equations as descriptions of how the universe operates rather than as collections of letters and symbols so that the Boltzmann constant is not substituted into this type of calculation!

(iii) Most candidates correctly used their value for electrostatic force and the geometry of the arrangement to calculate the tension in the thread to which sphere A was attached.

(iv) The weight of sphere A was usually calculated correctly with approximately equal numbers of candidates using Pythagoras's Theorem to those using trigonometry.

Q3 This question was answered very well by most candidates.

(a) Most candidates were awarded full marks for this part. It is particularly important in these 'Show that..' questions that candidates write their responses in a logical order.

(b) **(i)** The circuit diagrams produced by most candidates attracted full marks with many candidates simply showing a charging circuit with all components in series. Candidates are advised to produce good quality diagrams.

(ii) Candidate descriptions of how the circuit was used to obtain the data from which the time constant could be obtained were usually appropriate for the circuit suggested in Part (i).

(iii) Almost all candidates went on to describe how the time constant could be obtained from a graph of voltage (or current) against time. Very few candidates suggested the drawing of the semi-logarithm graph.

The quality of written communication demonstrated by most candidates was very good.

(c) Part (i) of this question was very well done; few candidates had any difficulty in calculating the charge stored on the capacitor. Unfortunately, in Part (ii), many candidates incorrectly considered the capacitors to be connected in series and so lost credit.

Q4 Many candidates found parts of this question challenging.

(a) **(i)** This calculation was not well done. Many candidates failed to even state a version of Faraday's equation for the first mark and very few candidates correctly linked a change in flux density with the time taken for the change.

(ii) Many candidates realised that this part of the question tested Lenz's law and correctly deduced the magnetic field direction. For others, the context of the question appeared to be the greatest obstacle and this prevented them from showing their Physics knowledge and understanding.

(iii) Examination answer technique was tested in this straightforward question; not all candidates described and explained! Often the candidate failed to state that the voltage measured for solenoid Y would increase and consequently lost a mark. Explanations tended to be very good and made relevant comment about the increase in the magnetic flux linkage.

(b) This question part was well answered. Almost all candidates knew that the iron core was laminated and most, correctly, stated it was to reduce eddy currents. Some responses were too general to be credited because they just stated that the laminations reduced energy loss.

Q5 Most candidates were able to engage positively with all parts of this question.

(i) This 'show that' question was reasonably well done and the logic behind the candidate's working was usually obvious.

(ii) This part of the question was very well done. A small number of candidates converted to nanoseconds incorrectly.

(iii) Again the marks in this part were gained by most candidates. In this case, marks were awarded for the direction of the field and its effect on the path of the electrons. Indicators of a uniform field - parallel and evenly spaced field lines – that were missing in many diagrams went without penalty in this case.

(iv) A majority of candidates correctly combined the equations F=Eq and E=V/d to obtain the size of the vertical force on the electrons. Most candidates went on to determine the acceleration of the electrons that was consistent with their force and to use it correctly with the equations of uniform acceleration to obtain a value for the deflection.

(v) Most candidates knew that the magnetic field must be into the page in this part of the question. Few candidates specified that the field had to be perpendicular to the page and lost the second mark.

Q6 This question of the cyclotron was well answered.

(a) **(i)** Almost all candidates appreciated that the cyclotron had to have a vacuum so that the protons do not lose energy to the air molecules by colliding with them.

(ii) Most candidates knew that in the absence of an accelerating electric field the proton speed would remain constant. A significant number incorrectly stated that the protons were not in an accelerating field when inside a dee; such candidates did not consider the acceleration due to the magnetic force field and forfeited the mark for this part of the question.

(iii) The calculation of proton orbital radius under the conditions described was generally well done.

Q7 Some candidates appeared unfamiliar with some of the physics tested in this question.

(a) In Part (i) of this question, the explanations of 'fundamental particle' were generally very good. Most candidates, in Part (ii) correctly named a lepton, however some missed out on the mark for this part because they offered 'lepton'. Candidates should note that 'lepton' is a class of particles and the question clearly asked for an example of a particle (in this class).

(b) This question was very well answered. In Part (i) the vast majority of candidates correctly identified the neutron and the proton as baryons and went on to provide the remainder of the required information. Part (ii) was also well answered.

(c) In Part (i) a large number of candidates were unable to write a full/consistent quark equation for beta decay. One of the two most common answering errors was to make a statement about the baryons rather than the quarks. For example: "A neutron turns into a proton". The other common error was in not writing the equation for the decay of the W- boson. In Part (ii) it was well known that the weak nuclear force is responsible for β- decay.

Q8 Aspects of this question challenged many candidates.

(a) Part (i) of this question elicited a mixed set of responses. Some responses read like a mark scheme with a clear logic running through the response. Other responses had lots of equations and algebra and indicated that the candidate was groping for the derivation. Almost all candidates correctly showed the power of the wind delivered to the turbine in Part (ii). The tricky Part (iii) caused problems for many candidates. The most common incorrect response was to cube 2 rather than 1.02!

(b) In Part (i) the calculation of the wavelength of the laser light was generally well done. Most candidates continued to identify the radiation as belonging to the infra-red region of the electromagnetic spectrum. In Part (ii) whilst the majority correctly determined the minimum light transit time, some, mistakenly, incorporated the radiation wavelength into the calculation.

(c) It was apparent to most candidates that the correct response to Part (i) of the question was related to the relative strength of the metals. Few, however, were awarded full marks. The resistance calculation, in Part (ii) was not well done. Many candidates correctly ascertained the resistance of the steel and aluminium strands. However, very few candidates correctly combined the parallel strands. Calculating the power loss in Part (iii) was generally well done.

Assessment Unit A2 3 Practical Techniques

Q1 Most candidates performed very well in this question.

(a) The overwhelming majority of candidates used the Vernier callipers correctly to obtain the diameter of the wire; and of those, most repeated the measurement and took an average to satisfy the reliability criterion.

(b) **(i)** A number of candidates experienced practical difficulties in determining the resonant positions, however, most obtained increasing values that fell within the acceptable range. A small number of candidates unnecessarily recorded additional resonant frequencies for each suspended mass.

(ii) The finding of the first position of resonance and subsequent recording of results in the unloading phase was well done by most candidates.

(iii) The calculation of average frequency was extremely well done by candidates and almost all gained the first marking point. Unfortunately, very few candidates obtained credit for their comment on the reliability of the data. It seems that most candidates view the averaging process as conferring reliability rather than reliability being a function of the similarity in repeated measurements which are then averaged to obtain a 'best-fit' for the reliable data!

(iv)–(v) Almost all candidates correctly found the logarithm to base ten of their average resonant frequencies and suspended masses. Too many candidates either ignored the instruction to record answers to two decimal places or were careless and rounded incorrectly. In either case, they forfeited easy marks.

(c) Graph drawing is overwhelmingly good. However, there are two points on which significant numbers of candidates lost marks. First, when scaling an axis it is a requirement to maximise the area in which plotted data points lie while at the same time using a sensible scale; many candidates squashed their points into a small area. Secondly, greater consideration should be afforded the best fit (trend) line to ensure that the line serves as a weighted average of the plotted points; many candidates had all points not on the best fit line either above or below the best fit line.

(d) **(i)** Almost all candidates determined their gradients in a manner that was awarded full credit. Only a few candidates were penalised because they were using points that were not far enough apart (5cm vertically or horizontally). A number of candidates forfeited marks because they misread values or used tabulated points that were not on the best fit line.

(ii) It is worth remarking on the fact that many candidates worked out the logarithmic form of Equation 1.1 in Part (i) even though it was not required until this point. Too many candidates did not follow the instruction to state the value to one significant figure and were consequently penalised.

(iii) The calculation of a theoretical value for k was well done. A common error was in not squaring the value for the length of the tensioned metal wire.

(iv) Most candidates realised that log(k) was the intercept. Some candidates, incorrectly, used the point where their best fit line crossed the y axis even though the y axis did not correspond to the line $x = 0$! However, most attempted to calculate a consistent value for k by substituting their data about the suspended mass and the resonant frequency into one of the equations along with their value for the index n.

Q2 The majority of candidates completed this question successfully.

(i) Too many candidates forfeited marks because they quoted values to an incorrect number of decimal places/significant figures; length should be to three decimal places because a rule measuring to the nearest millimetre was being used and times should be to two decimal places because the stop watches/clocks candidates were using measured to the nearest centisecond. It was pleasing that most candidates repeated their measurements and worked out a reliable value for the periodic time of each card. The calculation of periodic time by some candidates was wrong (usually for the shorter cards) because the candidate did not scale down the time for N oscillations by the correct value of N!

(ii) Few, if any, candidates secured both marks here and very few responses were awarded even one mark. Despite almost all candidates appreciating the difficulties in determining the timing data, responses were vague and expressed in non-scientific language.

(iii) The calculation of Aspect Ratio was well done although many candidates failed to spot the switch in the number of significant figures from card C as the lengths from then had only two significant figures. Many candidates forfeited the second mark here.

(b) Candidates, once again, demonstrated their competence with graph plotting. Most graphs were awarded both marks although there was a lot of latitude given for the best fit curve. Candidates require better training in the drawing of best fit curves. Very few candidates drew curves that followed the trend suggested by their points. Instead, many drew their curves from point to point which meant credit was given to the candidate for getting a curve with the minimum between 0.4 and 0.6 even though the interpolation skill looked for was not clearly evident.

(c) **(i)** Too many candidates omitted the square for the unit of period squared and frequently candidates introduced an error in the calculation of (4c + 1/c).

(ii) Most candidates picked up both marks here. There was enormous variation in the quality of the data obtained by the candidates which resulted in a very generous examination of the best fit line.

(iii) A pleasing number of candidates obtained full marks for this part of the question. A large number of candidates ignored the graph when answering this question. Candidates should be instructed that using the graph provides information that is more accurate and reliable than substituting data directly into an equation.

Q3 Responses to this question were disappointing.

(a) **(i)** Almost all candidates appreciate that the graph verified the Joule Law of Heating but fewer were able to explain that the proportionality was conveyed by a linear best fit line passing through the origin.

(ii) Most answers to this question indicated the correct response but were expressed in a way that made it hard to award the mark. Candidates often failed to make the point that the experiment is compromised because the temperature of the water does not change when boiling even though heat energy is continually supplied.

(b) Candidates tended to score highly in this part of the question. There were two common causes of lost credit; many candidates omitted a means of varying the current through the heating coil and others introduced a second, unnecessary source of heating the water bath.

There was a large variation in the quality of diagrams produced. Candidates are advised that marking points may not be apparent in poorly/carelessly drawn diagrams and that it is in their own best interests to produce good/carefully drawn diagrams. Please note that examiners will always attempt to find each marking point.

(c) **(i)** It was apparent that very few candidates had a correct appreciation of this experiment. Very few candidates realised that the same mass of water was heated for the same length of time with the same heater operating with a different current (power). Most candidates described something akin to specific heat determination – it was as if they were trying to recall an experiment rather than devise the experiment.

(ii) This part was well answered. Most candidates are familiar with the strategies to be employed when conducting heating experiments. Candidates are advised to consider the practicality of the methods they suggest in the context of the experiment about which they are answering.

(d) This part was well answered with most candidates opting for a theoretical determination based on rearranging Equation 3.2 rather than using the ammeter-voltmeter method with the coil.

(e) This part of the question was well answered. While some candidates did not realise that k could be obtained from the equation of the trend line that was given in the question and calculated their own value, full credit was often still obtained.

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