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Examiners' Report Summer 2008

GCE

GCE Physics (8540/9540)

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Summer 2008

Publications Code UA020379

Contents

6731/01 Unit Test PHY1

All parts of all questions were attempted by most candidates. The improvement in descriptive work noted in recent examinations was not as apparent on this occasion. For example some candidates struggled to construct explanations that could be understood in answering questions 4 and 5.

Question 1

Few candidates obtained all four marks. Marks were lost in classifying the quantities as scalar or vector. Gravitational potential energy for instance, was generally considered to be a vector quantity.

Question 2

This question on motion graphs was answered much better than the corresponding question in the January examination. However, in (a)(i) only some responses stated that the acceleration in the first 4 s was uniform. In part b the more able candidates obtained all three marks, though many obtained 2 marks. The problem was again the first 4 s which required a curve with increasing negative gradient. A straight line with negative gradient was the most common wrong answer for this. A significant number drew the graph starting from (0,0), for which no marks were awarded.

Question 3

The easy access candidates have to past papers and mark schemes should mean that the definition of laws, which appear frequently in papers, should yield opportunities for picking up full marks. Some candidates however, were unable to gain full marks in defining the principle of conservation of linear momentum. The word 'total' or equivalent was omitted when referring to the momentum and the condition that no external force must act was not mentioned. Parts (b)(i) and (b)(ii) were answered well with most obtaining all four marks. In part (b)(iii) few candidates grasped the idea that if the velocity was changing an external force would be acting. An 'argument' given in answer to this question was; '….. because the momentum remains constant and the mass does not change, therefore the velocity must not change'!

Question 4

Part (a) was answered well. When full marks were not obtained this was usually because their answer to the force that pairs with *W* was wrong. 'Ground' was not acceptable as previous schemes have made clear. However, the confusion between ground and Earth was less noticeable than in previous years.

Part (b) was not as well answered. For the direction of the force P many showed a horizontal arrow pointing to the left. There was no appreciation of the need to maintain the tilt of the wheelbarrow. The explanations in part (b)(ii) focussed solely on the requirement to move the wheelbarrow forward.

Question 5

Full marks were obtained by most candidates in answering part (a). Part (b)(i) proved more difficult but there were many who answered this successfully. Candidates struggled to give coherent explanations for the limiting position of the ornament. Some considered forces only, not the moments created by the forces as they should have done. Where they did attempt to use moments their accounts were often unclear as to what moments they were referring to and/or about what point the moments were acting. It has been suggested in previous reports that using bullet points can often help candidates create a clearer picture of what they want to say.

Question 6

There were many perfect answers to part (a). A common wrong solution, which in fact gave the right answer, was to substitute the magnitude of the acceleration (1.5 m s^{-2}), calculated from $F = ma$, into $v^2 = u^2 + 2as$ with u set equal to 0. This obtained one mark for the acceleration value. The correct solution, of course, was to set $v = 0$ and to substitute -1.5 m s^{-2} for a. Candidates mostly obtained both marks for part (b). Few candidates obtained a correct value for the momentary force in part (c). Most simply left their answer incomplete with just the resultant force calculated ie 5 N. They failed to add 2.75 N to their answer.

Question 7

Parts (a) to (d) were answered successfully by many candidates. Transcription and power of ten errors were often the reasons why full marks were not obtained. Sensible answers to part (e) were rare.

Question 8

Part (a) was not answered well. Common errors were; to show the direction of B to change after the nucleus had been passed; to show B deviated downwards; to show the track of A to be other than straight lined; to show B deflected backwards. The point where the change of direction occurs should be shown as a curve; many showed this as an instantaneous change of direction. In part (b) many simply stated the properties of alpha particles without applying them to the experiment. For example in part (b)(iii) the answer often given was 'because alpha particles have a short range in air'. A common inappropriate answer to (b)(i) was 'to protect Rutherford and his helpers'. As to why the alpha particles should have the same kinetic energy the popular response was 'to make it a fair test', when what was required was an appreciation of the need to control this variable eg '.. those with greater kinetic energy would be deflected less' for instance was the sort of response that was credited. In (b) (iii) answers that referred to '.. ionising air particles' were awarded no marks. At this level candidates should be referring to atoms or molecules not particles.

6732/01 Unit Test PHY2

There were a number of questions on this paper that asked candidates for definitions. Candidates should realise that most definitions are given by an equation which is best stated in words but can be given as symbols providing the symbols are then identified. Often candidates write a general sentence which alludes to something which might be relevant. Definitions, if learnt, mean that marks can be gained quite easily.

Question 1

There were some good answers to this question with most candidates recognising the component as a diode. Not all candidates realised that the current was in mA so a power of ten error occurred quite often here. Many candidates knew that the resistance of a diode on reverse bias was infinite but when candidates had to calculate the resistance, the common answer was zero, because they thought that dividing by zero gave an answer of zero. The last part was poorly answered with few candidates giving a real practical application. It was decided to accept answers that indicated that diodes allowed current to flow in one direction only although this is a statement about how diodes work rather than an application of a diode being used.

Question 2

The definition of resistivity was not answered well. Some responses showed candidates writing a general sentence about how resistivity impedes the flow of electrons. A significant number of candidates gave the textbook statement about it being the resistance of a cube of length 1 m and cross-sectional area 1 m^2. Whilst this statement is true it doesn't actually define resistivity. For those candidates who realised that the answer lay in the use of the formula, some omitted the cross-sectional reference to area or left their answer with resistance as the subject of the equation, rather than rearrange for resistivity. Most candidates were able to complete both calculations successfully. The last part was a good discriminator, testing candidates understanding. Some candidates thought that the diameter should increase while a lot of candidates, who realised that it had to reduce, simply halved the diameter. Few candidates worked out the radius by a simple proportion method, the majority chose to substitute into the formula for a wire of half the length. Although many candidates set up the equation, not many were able to extract the correct answer from their more complicated method.

Question 3

Another definition this time for e.m.f., which a significant number of candidates did not realise should be defined by means of an equation. This should have been another easy recall for two marks. The rest of the question was often well answered with the common error in (b)(i) being to use the e.m.f rather than the terminal potential difference to calculate the current. This is a relatively straightforward calculation and one that appears regularly in examination papers. Candidates were able to pick up some marks here but there lack of understanding meant that they lost more marks later in the question. Most candidates scored two marks for the parallel resistor calculations. Relatively few candidates were able to derive the voltmeter reading in (b)(iii). The most common error was in assuming that the current would remain the same as in (b)(i) showing that candidates do not understand that altering the resistance of a circuit leads to a change in current. The last part about the resistance of a voltmeter was generally well answered.

Question 4
Apart from a small number who correctly drew the circuit diagram, other candidates were clearly not familiar with the potential divider even though a potential divider symbol had been drawn for them. They thought of it and used it as a variable resistor. Of those who correctly drew a potential divider circuit, many placed the ammeter in the 'main' input circuit loop without realising that the current in the output loop, containing the lamp, would not be the same. Many candidates scored both marks for the graph drawing. The candidates could choose which variable they put on each axis but a common error was for the axes to be wrongly labelled for the curve that they drew. The explanation often scored three of the four marks with candidates still finding it difficult to express a rate of decrease of a quantity. Many candidates said that the increasing resistance would result in the current decreasing even though they had drawn a correct graph showing an increasing current against their increasing potential difference.

Question 5
There seemed to be a general lack of knowledge as to what thermal contact meant with some making reference to thermal equilibrium, objects being at the same temperature or heat rather than energy being transferred and consequently the first mark was rarely scored.

The specification lists an experimental demonstration for the pressure law for gases. If candidates had done this experiment then the problems with using the apparatus as a thermometer would have been more obvious to them. Few candidates were clearly not familiar with this experiment and suggested reasons such as, poor insulation, gas might escape, pressure of the gas in the tube is different to the pressure of the gas in the bulb etc. Quite a few candidates were able to identify problems correctly but interchanged the difficulty and the explanation (they weren't penalised for this) or restated the same idea in both sections. Quite significant were the number of candidates who said it wouldn't be accurate because it wasn't digital.

Question 6
This is the question that produced the largest number of fully correct answers. It also started with a definition, this time for absolute zero of temperature and answers such as the lowest possible temperature, -273 ^{O}C or the temperature where everything stops moving are not acceptable. A significant number of candidates scored the full four marks for (b)(i) but candidates who forgot to add atmospheric pressure got an answer of 0.27 mols and thought that was approximately 0.5 mols. Candidates must realise that a 'show that' question should be calculated to one more significant figure than is shown and the correct answer would round to the value shown, i.e. they should have been expecting an answer between 0.46 and 0.54. Perhaps if they understood this they would have then gone back to try to identify their error.

Question 7
Most candidates were capable of getting the first mark but some did not because they referred to air particles rather than air molecules. Few scored the second mark because the common view was that each smoke particle was hit by one air molecule. Few were able to state that there were multiple collisions leading to a resultant force. Most candidates were able to score the mark for random motion and both the diagram marks. This question was a fairly straight forward factual recall question and should have produced a better average mark if the work had been learnt.

Question 8

Part (a) required candidates to think of the order in which the numbers were to be manipulated and what was actually being asked. Many candidates got the right answer and then took the square root. There were many combinations of squaring and averaging and those that arrived at the right answer of 311640, often failed to use the correct unit. Three marks was the least common mark for this section.

In (b) a number of candidates just did not realise that changes in potential energy of the molecules are due to intermolecular forces which are assumed to be zero in an ideal gas and so did not score any marks. Candidates who did realise that this question was about intermolecular forces easily scored both marks. Some responses said that kinetic energy was conserved because of elastic collisions and then confused molecular potential energy with gravitational potential energy. A few candidates tried to prove that Kelvin temperature is proportional to kinetic energy as their answer to this part.

6733/01 Unit Test PHY3

Each topic started with a question that required the placing of ticks in boxes. Despite this part (a) question being straight from the specification, a good spread of marks were obtained.

Topic A - Astrophysics
It was clear in part (a) that many candidates had not learned the solar mass ranges from the specification here: rote-learning from the specification is required as part of effective revision. For part (b), a comparison was needed: "CCDs can detect faint images" was not, on its own, sufficient to gain a mark, since photographic emulsions can also detect faint images. Part (c) produced some responses that incorrectly referred to molecules or atoms in the core of a star. The process of nuclear fusion is about *nuclei* and any contradiction lost marks here. The luminosity ratio produced many good answers, with a few candidates selecting a direct route of T^4 r^2 ratios to get quickly to the correct answer. It is worth noting that calculating one luminosity value correctly was still worth three of the four marks, so candidates are reminded that they should always try to complete any sort of solution even if the final answer is not reached. The Hertzsprung-Russell diagram saw a minority of candidates lose a mark as they had meant to place a cross on the 10^0 line, but had not done so accurately. Only a few candidates realised that 3000 solar luminosities would lie **between** 10^3 and 10^4 for the vertical position of Y. Comparative statements were required in part (d). As an example, "a white dwarf is hot" did not gain credit, since the Sun today is also hot! A comparison, such as the word "hotter" was needed. Examiners saw considerable confusion about the future of a white dwarf star, with a worrying number of neutron stars and even black holes expected. The calculations in part (e) were mostly done well, although examiners did note that more candidates than usual seem to be forgetting to include any units. In (e)(i), some responses went directly to stating what a light year is in metres – this lost a mark since the question did ask for this to be shown. A surprising number of candidates used the incorrect number of days in a year. In parts (ii) and (iii), many responses did not square either *D* or *c* respectively.

Topic B – Solid Materials
Most candidates picked up many of the marks for parts (a) and (b), although a few incorrect units for stress were seen in (b)(ii), such as N/m or N m^2. Part (b)(iii) differentiated well and produced a variety of answers. Powers of ten were a problem for many candidates, with GPa often being interpreted incorrectly as 10^6 Pa (or the giga prefix simply being completely ignored); also, the instruction in the question to give an answer in mm was frequently ignored. Part (c) asked about a very standard experiment which any topic B candidate should be familiar with. However, some could not name the pulley and only a few candidates were aware that the wire needs to be appreciably long (in excess of two metres) in order to give a sufficiently accurate extension. Energy density as area under a stress-strain graph is still something that most candidates are very weak at, with the incorrect equation often used and the MPa unit often forgotten. The edge dislocation in (e) was often correctly named, the slip plane location was less reliable and the explanation in (iii) was poorly answered. This lack of knowledge often produced non-scoring, confused answers; the bullet points in the mark scheme are worth learning. The hysteresis curve in (f) was usually named correctly (examiners did accept some of the wonderful spellings of this word if they were phonetically correct) but the explanation often ignored the instruction, "by referring to the areas under the graph" and consequently did not score any marks.

Topic C – Nuclear and Particle Physics

The only particle in (a) that caused any difficulty was the muon, which was frequently (incorrectly) identified as a hadron and meson. In (b), a notable minority of candidates incorrectly used only proton numbers to suggest that only five alpha decays had taken place. Many justifications of the answer were incomplete: full working with both nucleon numbers had to be shown. Nuclear equations were mostly good. Part (c) responses were more varied. The text-book definition of binding energy was sometimes poorly answered and candidates often just re-wrote the question. The calculation in (ii) was usually very good, although early rounding of significant figures in this sort of question will lose some marks. Candidates who could not relate binding energy per nucleon to nuclear stability scored zero in part (iii). Part (d) was about fundamental particles and quarks needed to mentioned for credit in (i). Part (ii) was a successful question in that it allowed candidates to show knowledge of fundamental forces and then apply this to the particles involved in this interaction. The weak force was often chosen but only responses that explained why this was the case gained marks for this. Conservation laws in part (e) are required to show zero values for full marks. Some candidates considered charge conservation only and forgot about baryon numbers.

Topic D – Medical Physics

In part (b), poor diagrams are worth mentioning, especially since the question stated that a “labelled” diagram was required; incomplete labelling simply meant a mark was lost here. Amongst the many good diagrams were a few that had completely the wrong end of the stick and showed a rotating anode X-ray tube used in diagnosis. High energy X-rays in part (iii) were often described as being more penetrating, but more detail was required here to gain this mark – sometimes when proton number was mentioned it was not linked to absorption. Criticality of dose responses often only considered the consequence of too high (or too low) a dose; both were required for both marks here. Part (c) produced mixed responses, with part (i) usually scoring both marks, although very weak candidates ignored the depth being in centimetres or failing to double this value for the echo distance. There was more confusion between the pulse frequency and the wave frequency in (ii), and whilst most responses to (iii) were correct, examiners did note that 3 MHz was occasionally incorrectly used as 3×10^3 Hz. The resolution versus attenuation explanation in (iv) rarely produced succinct answers, with most candidates considering either resolution or attenuation but not both. Part (d) simply required text-book responses about the gamma camera. Marks lost here were usually due to vagueness, for example, the collimator (1) function was often stated as “only detects gammas from directly below the camera”. This might appear correct at first glance, but *all* gammas from the patient are directly below the camera – this is not the same as gammas travelling directly towards the camera. Some responses for the scintillator (2) indicated that the gammas were turned into flashes of light, which is not what happens (their energy causes photons of light to be released, which is not quite the same). Responses to part (e) were mostly very good, with only the text-book definition of biological half-life causing any difficulty for candidates.

6733/02 – Practical Tests PHY3

Group 1 (2A)

Question 1A

The majority of candidates could set up the circuit correctly and obtained a correct value for the current. The most likely error was the use of an incorrect unit, eg 55 A rather than 55 mA. In the observation of the lamps weaker candidates suggested that lamp A was not working, despite the fact that there was a current flowing in the circuit. Examiners were looking for the idea that there was insufficient power or potential difference to light this lamp. Generally voltmeter readings were taken correctly. There were three common mistakes;

- Omission of units.
- Readings that were not quoted to the precision of the instrument used, e.g. 0.2 V rather than 0.02 V.
- The readings being reversed on the answer lines.

When asked to explain the relevance of the voltage values to their observations, only the best candidates actually related the voltages to the normal operating voltages of the lamps and then went on to say why the lamps were bright or dim.

Most candidates successfully measured the time for the sphere to roll down the ramp. Weaker candidates quoted times to the nearest second or made a systematic error in the reading of the stopwatch, e.g. 0.0141 s rather than 1.41 s. Like the 55 A problem in the previous part, candidates ought to have some idea of the size of the quantities that they are measuring. The calculation of velocity was normally correct but kinetic energy calculations were not always correct. Popular mistakes included;

- Leaving the mass in g, so obtaining a kinetic energy of the order of Joules.
- Omission of units.
- Lack of knowledge of the kinetic energy formula. Some candidates used mv^2, others used mv and some even used mgh.

In (b)(iv) candidates were asked to show carefully on the diagram the vertical height h through which the sphere moved. This required a runway of finite thickness so that the positions of the sphere at the start and end of 0.8 m could clearly be seen. Many candidates simply drew a right angled triangle and did not score the first two marks in the section. Others drew a line for the runway so that it was impossible to tell to which point h had been measured. The potential energy calculation had similar difficulties to the kinetic energy calculation. However error carried forward was allowed on the mass value and units so that many candidates achieved the potential energy mark.

In (b)(v), good candidates obtained a value within the narrow allowed value range and gained full marks in this section. When determining the percentage difference between the experimental value for the ratio and 0.71, good candidates used 0.71 as the denominator and gained full credit.

Question 1B
Common errors in determining the extension of the spring as a function of the force applied included the following;

- The length of the spring was quoted to the nearest cm, e.g. 2 cm rather than 2.0 cm.
- The values plotted on the graph were often the length of the spring rather than the extension.
- Despite having a clear intercept on the force axis, the line was often forced through the origin.
- A small number of candidates used a vertical scale based on 1 cm is equivalent to 15 mm. This is a difficult scale to follow and neither the scale nor the plots mark were given in these circumstances.

Despite the fact that candidates have been asked to check that a rule is horizontal in previous papers, not all candidates gained full marks for this. The standard technique is to measure the height above the bench in 2 places to check that the heights are the same. The set square is used against the measuring rule to ensure that it is vertical. Examiners expected to see this on the diagram.

When determining the angle, heights were not always recorded to the nearest mm and a number of candidates made errors in the trigonometry calculations. A popular mistake was the use of 500 mm as the length of the side adjacent to the angle. In fact this side had a length of 400 mm since the nail was located 10.0 cm from the end of the rule.

Centres had reported a large discrepancy between the weight of a rule as determined from the reading of a top pan balance and the weight as determined by experiment. A correct calculation of the weight therefore scored full marks, independently of the value on the front cover of the answer booklet. It was disappointing to see that a number of Supervisors quoted the weight of the rule in grams. The weight is the gravitational force acting on an object and is measured in newtons.

The part of the plan that scores the least marks is the description of the experiment. Candidates should appreciate that they should use their experience in carrying out the initial results in order to describe what they are going to do in their plan.

Group (2B)

In the main 6733/2B used similar techniques to 6733/2A. In question 2A (a)(v), examiners expected candidates to compare their results with the theoretical expected values. Candidates did not do this. In the question about internal resistance, candidates were expected to observe that the voltage across the resistors decreased as the current drawn from the cell increased and that this was evidence of the presence of internal resistance in the cell. However a very small minority of candidates realised that this needed to be discussed.

6734 Unit Test PHY4

This paper proved to be more difficult than previous ones. Several parts of questions required detailed explanations which were often missing from candidates' answers. In addition to this, there were two parts where candidates found it difficult to use data to prove a relationship.

Question 1

Most candidates scored much better in part (a)(ii) than they did in (a)(i). Many showed that they did not appreciate the difference between these two parts by giving very similar answers to both. Answers to (i) from less able candidates simply gave a description of circular motion rather than answering the question asked. Candidates often stated that the force was perpendicular to the direction of a scalar quantity, i.e. speed. This misconception was again shown in (ii) where it was often stated that the direction of the speed was changing. However, there were a lot of good answers for this part which gained both marks. Part (b) was generally answered quite well. The common error was not to convert from km to m. Other errors were forgetting to take the square root of their answer and adding the radius of the earth to the given value of r. Some candidates calculated the angular velocity for which they scored a mark provided they stated its value in rad s^{-1} rather than the more common m s^{-1}.

Question 2

Responses to part (a) were very mixed. In (i), most candidates scored the first mark for moving the microphone although a significant minority did not state clearly that the microphone was moved between the speaker and the wall while some didn't move the microphone at all. There was often no reference as to how the cathode ray oscilloscope would be used. Several candidates seemed to think that they would see an actual standing wave pattern, with nodes and antinodes, displayed on the screen. The majority of the answers in (ii) suffered from a lack of detail. Many candidates produced their standard 'waves travelling in opposite directions' response without relating it to this specific situation. Few answers gave details about both phase and type of interference. It was surprising how many candidates got nodes and antinodes the wrong way round. The word 'exactly' was mostly missing from out of phase descriptions although those referring to antiphase avoided the need to include it. Answers to (iii) produced the full range of marks and it discriminated very well. Candidates generally seemed well prepared for this, even to the point where most stated how they would know the frequency. However, fewer stated that they would 'measure' a distance or explained how they would get the wavelength from this. A number thought they could measure wavelength directly from the CRO trace. Quite a few responses suggested the inappropriate method of timing and using the formula $v=x/t$; perhaps indicating that they had not seen this experiment. In part (b), many candidates realised that there would be little or no sound at a node although some of these were then unable to explain in sufficient detail why the problem wasn't serious.

Question 3
There were quite a lot of good answers to part (a) with 3 or 4 marks being regularly awarded. In (i), the amplitude was often incorrect while the frequency was mostly correct although it did occasionally suffer from a fractional answer or a unit error. Many candidates showed that they could use the correct formula for maximum velocity although answers were sometimes given to only one significant figure. Candidates who attempted to find the gradient of the displacement graph often used widely spaced values rather than ones from a tangent drawn where the gradient was steepest. Some very poor attempts at sine curves were seen in (iii) with careless drawing leading to the loss of the first mark. A significant minority did not invert the curve or put a scale on the velocity axis. Part (b) allowed many candidates to show that they had learnt how to define simple harmonic motion while at the same time demonstrating that they had little idea of how data could be used to verify such motion. Answers to (ii) often consisted of very long descriptions of the curves, their relative shapes and/or their periods. The most common credit-worthy answers involved either an a against h graph or a number of a/h ratio calculations in which case the middle two marks were often given, the first and last much more rarely.

Question 4
This question was a good discriminator. A majority of candidates identified the resonance curve. The Doppler related graph caused the most difficulty as many candidates who had the correct idea made the error of making the emitted wavelength zero. A significant minority of responses either ticked more than one letter for a given response or made no attempt to even guess an answer.

Question 5
Candidates who did not appreciate that the knots would move at different speeds struggled with this question. In (i), many candidates positioned knot T correctly but were less successful with the other three knots. A number of candidates thought that the elastic would only stretch between P and Q, leaving the distances between knots Q, R, S and T unchanged. There were many good answers to part (b). Many candidates were awarded the mark for the expansion of the Universe but a few thought the knots represented stars or planets. Only the very best candidates could do part (c). Many answers simply stated Hubble's law without 'using values' from the model to provide evidence for this. Several answers to part (d) showed that candidates could not compare the model to the real situation and accurately pick out the important differences. The most common correct answer related the 1-d model to the 3-d Universe.

Question 6

Although many candidates scored full marks for part (a), an equally large number made an error by not referring to the surface or equivalent. It was disappointing to find a significant number of candidates describing either an ionisation or an excitation energy.

The majority of candidates scored full marks for the calculation in part (b). Those who used the inaccurate value of 200 s in their calculation still usually managed to gain 2 marks. Even though the area was given, it was not uncommon to see a factor of 4π appearing in some of the calculations. In (ii), many candidates simply took this as an opportunity to write down what they knew about photoemission without really relating this to the question asked. Many candidates appeared to know that one photon ejects one electron although the way this was sometimes stated meant that it could easily be missed. A common error was to produce an answer which added little to what was already given in the stem of the question. However, several very good answers were seen.

Question 7

Many candidates scored high marks for this question; no doubt aided by the presence of three calculations. There were many good answers to the first of these although some responses showed candidates were unable to manipulate the equation correctly. The rest of part (a) was poorly done with a number of candidates referring to friction or damping. Even when the suggestions were along the right lines, the lack of detail in the answer often resulted in the mark not being awarded. The first calculation in part (b) was expected to be very straightforward. However, some candidates did not gain the mark as they did not expand the number of significant figures in their answer beyond that of the 'show that' value in the question. Candidates must learn the formula $v = f\lambda$. Not many candidates were able to associate a wavelength of 33 mm with the microwave region of the electromagnetic spectrum. Most candidates produced excellent answers to the final calculation. A small number either left their answers in J or attempted to convert to eV by multiplying by *e*.

6735/01 Unit Test PHY5

This paper functioned well overall, a good balance of question styles allowing strong candidates to score highly and less strong ones to give a good account of themselves, if less evenly. Most candidates were able to access all questions, with some showing good intuitive instincts in diagrammatic and graphical exercises even where their ability to produce supporting reasoning was limited. Particularly pleasing were some lucid and impeccably structured answers to the descriptive section at Q4b.

Question 1

Part (a) required simple statement of expressions for gravitational field strengths, which all but a very few were able to manage. Errors, where they did arise, were usually through the statement of expressions for force instead of field strength, or through oversight of the need to square the distance in the denominator. In part (b)(i) the equating of these expressions led many to the correct ratio, though some were inaccurate in their explanation and arrived at the correct numerical value without associating it with the required distances R and r. In part (b)(ii) the implication of this ratio was correctly interpreted by most, though misreading of the question stem meant that the unit of r was sometimes thought to be m rather than km.

At part (c) there were fewer good answers than might have been expected. Despite the references within the question to ‘orbiting’ and ‘circular motion’, many candidates suspected that point P itself would satisfy the requirement that SOHO, if placed there, would orbit the Sun in the manner described. Even those whose instincts prompted a correct location of L to the left of P in the diagram were often unable to justify their decision. Favourite arguments sprang from the belief that the mass of SOHO, a great deal less than that of the Earth, would necessarily require it to be nearer the Sun than point P. Others went for an ‘equidistant’ compromise, arguing unconvincingly that a mid-way position between Sun and Earth would give the necessary conditions, while discussion based on angular velocities was also commonly seen.

One weakness in answers was ambiguity in description that resulted in confusion between ‘closer to the Sun’ (than point P) and ‘closer to the Sun’ (than to the Earth). Since these related to decisions already communicated through the placing of L they did not lead to mark loss, but candidates do need to consider more carefully the precision of their language. A few candidates suggested that movement to one side or another of point P would remove SOHO entirely from the influence of one or other of the gravitational fields concerned, as though these each ended abruptly at some point in space and could be simply stepped out of by moving a short distance.

Question 2

In part (a), few candidates seemed to appreciate the distinction between the work done by the supply and the energy stored by the capacitor. However the low success rate on this part-question seems more likely to be attributable to not reading the question properly rather than to lack of understanding. The factor of 2 difference cost many credit that they might otherwise have easily gained. A surprising number then had little understanding of the magnitudes and polarities of the charges stored on the capacitor plates, with labelling that was either incomplete or wrong. It was anticipated that this would be a simple exercise, but this did not prove to be the case. Candidates could usefully consider where the 0.8 nC might come from (and go to) if this amount of charge has been stored and the capacitor is then discharged.

In part (b) the great majority argued effectively that the area under the graph was consistent with the energy storage value given, though some took a longer route, via calculation of capacitance, than was necessary. Where an answer was not convincing it was often due to confusion of the meanings of symbols Q and C, with C often thought to represent charge rather than capacitance.

In part (c) there was a tendency for candidates to over simplify the question through a presumption that the capacitors C_1 and C_2 would inevitably have the same value. Centres should ensure that this is not the only possibility that is dealt with in the course of teaching this topic. Where this simplification was made it often coloured decisions about the end-point of the graph line in (c)(ii), with many also overlooking the constraint that the final p.d. across C_2 after charge transfer from C_1 must also be 3.0 V, not more or less. They simply reproduced the graph given in (b) and concluded a capacitance value for C_2 of 0.2 nF. This barred access to full credit, though they were able to gain some for the internal logic of their decisions.

Question 3

Demonstration of homogeneity at part (a) was achieved quickly and convincingly by many, though a small number either failed to identify the unit of 'n' as m^{-1} or could not decide where to start with the unit of B, despite the several options open to them. In part (b) it was interesting to see how often 'n' was made equal to the number of turns on the coil, counted from the diagram, sometimes contrary to the decision made in part (a) for its unit. Others went so far as to introduce a new and incorrect equation, despite having been given the appropriate one at the outset and using it in part (a).

In part (c) only a few correctly identified the key idea that difference in the forces experienced was simply due to current directions being the same or opposite. A favourite but inappropriate suggestion related force to electrical polarity, as though the charges involved were static rather than flowing, or even, obscurely, to magnetic polarity. The final graphical exercise required recall of the inversely proportional dependence of field strength (and thus force) on the separation. Hence, although many correctly showed the 'mirror imaging' feature, only a minority gave the second curve its correct, halved amplitude.

Question 4

The numerical exercises at part (a) were dealt with efficiently by a good many, the first being a familiar task and the second found by most to be logically quite straightforward. Where errors did arise they were usually due to a lack of care in working rather than a failure to appreciate the underlying energetic considerations, though some confused themselves unnecessarily whilst dealing with the eV unit of energy. They either applied the factor of 1.6×10^{-19} twice or not at all in part (i), or lost themselves in calculations in part (ii) made messy by the strategy of converting all energy values to joules. A common false start here for weaker candidates was to find 8% of 2.4 eV, turning the logic of the situation irreparably on its head.

In part (b) there were a pleasing number of good, clear and logically sequenced answers. Where difficulties did arise they were most often the result of an incorrect visualisation of the situation that imagined the electrons on the screen forming an impenetrable mechanical barrier. In extensions of this some candidates believed that these clustered electrons would indefinitely continue to generate light – making the 'adverse effect' an increase in intensity - or even somehow burn a hole in the phosphor layer. Photoelectric arguments that inverted the physics of the situation were also seen, but only occasionally.

Question 5

The initial scaling of the graph was surprisingly poorly tackled. Scales with obscure factors and/or unequal intervals were all too common. Intervals of several volts or even several tens of volts were not uncommon, despite the information given.

Part (b), set in the context of induced emfs, was expected to prove a little tricky, but actually elicited a good number of correct answers. With part (i) successfully completed, though, it was a pity to see full credit for part (ii) being missed out on sometimes through a candidate's failure to employ a correct equation for the cross-sectional area of the search coil.

6735/02 – Practical Tests PHY5

Whilst the questions followed the general pattern set in previous years, the candidates were clearly more familiar with experiments involving timing skills rather than stationary waves or magnetic fields, hence Question A scored significantly higher than the other two. Question B, on the electromagnetic force on a current carrying wire, was done well by fewer candidates. This probably reflected the lack of familiarity of the candidates with this aspect of physics, especially in a practical context. The data analysis questions produced the widest range of marks, the better candidates being more familiar with the Hall probe in practice. The two practical questions produced opposite extremes of uncertainty; the timing question having very small uncertainties and the stationary wave experiment a very large uncertainty due to the difficulty in locating the resonant length with high precision. Candidates were expected to consider the percentage uncertainty of the experimental results in each particular case when discussing the support of their results for the prediction. Candidates who had a wide range of practical experience in a laboratory were likely to have fared better on these papers.

Group 1 (2A)

Question 1A

Nearly all candidates realised that a good number of oscillations is required to achieve reliable readings and that repeats are expected too, so part (a) scored well. Candidates often quoted ratios to only 2 sf when 3 sf was more appropriate to the data. Better candidates estimated the uncertainty in their timings and compared this with the percentage difference between their experimental value and the suggested value, thus considering the precision of their readings in discussing the support for the prediction. The idea of a ratio was widely interpreted by candidates; what was sought was the value obtained when dividing the value of T_P by T . Credit was given for any correct ratio but a 3 sf decimal, such as 0.718, implying a ratio of 0.718:1, was what was expected.

The timing of the capacitor charging up was very well done. The only common loss of a mark was when candidates did not state that the capacitor was discharged on each occasion before repeating the experiment.

Question 1B

The measurement of the resonant lengths in this question is not as precise compared with the timing measurements in question 1A. Candidates’ values for this were nevertheless often close to those quoted by Supervisors on the front cover.

The first part asked candidates to explain why the wire vibrated up and down in the arrangement set up on the bench in front of them; a number of candidates were unable to do this. The resonant length was accurately recorded but few candidates described any helpful technique in what is a tricky measurement to pin down. In particular, candidates were not familiar with the technique of approaching resonance from both directions and taking the average. The uncertainty in determining the resonant position is quite large and certainly more than the 1 mm precision associated with the metre rule. This was not appreciated by most candidates. Candidates did, however, have a good understanding of the stationary wave pattern and how the wavelength was derived from measurements of both resonant lengths.

Diameter measurements were well executed, but the calculation of the density, with a correct unit, would suggest that candidates need more practice on how to handle real quantities having a mixture of units.

Question 1C

A surprising number of candidates did not read the question carefully and so lost the relatively easy marks for drawing the circuit supplying current to the solenoid. The diagram showing the Hall probe produced disappointing results; candidates should be more practised at communicating by drawing. The measurement of the length *x* usually did not include the possibility of measurements inside the solenoid which was evident from the data on the next page would be a requirement.

Many candidates failed to produce a correct value for the magnetic field strength but were able to comment on the percentage difference. A number of candidates simply said that the 0.006 mT difference was small, which by itself is not helpful.

Graphs were generally well drawn, with sensible scales and clear points, but the double curve of the best fit line proved too much of a challenge for some candidates.

The last part scored well, with candidates usually comparing the value read from their graph with half the value at the centre by calculating the percentage difference. The range of skills required by this sort of question proves a good discriminator at this level.

Group 2 (2B)

Question 2A

In general, this question was well done, although the discharge times seemed to be towards the high end of the marking range in several cases.

There were 3 discussion marks for explaining that the value for the ratio of the times should be 0.500 if the capacitors were of the same value. Although many candidates understood this, their arguments were often somewhat convoluted and confused. All other elements of this question were similar to 1A, with candidates experiencing the same difficulty in expressing the ratios correctly, suggesting that they need more practice in this area.

Question 2B

The explanation of the new resonant length was well answered. As in 1B, resonant lengths were surprisingly accurate in an experiment with a large uncertainty. The technique marks reflected whether or not candidates were familiar with such an experiment and the uncertainties quoted often bore no relation to the range over which the oscillation could be considered a maximum, certainly more than the 1 mm often quoted.

Question 2C

The technique marks for determining the average diameter of the coil were seldom awarded, despite a realistic diagram which clearly showed the problems involved in doing this. Candidates' drawings showing the Hall probe were often ambiguous, either due to unfamiliarity with the apparatus or a lack of practice in communicating by drawing. Candidates must read the question carefully. A number of candidates described how they would measure the diameter of the *wire* instead of that of the coil.

Fewer errors occurred in the calculation of B at the centre of the coil as candidates simply had to substitute the data straight into the given equation.

Graphs were generally well drawn, although a not uncommon mistake was to attempt a straight line or a straight portion through the double curve. In the last part, a percentage difference, derived from reading off the value of B from the graph when $x = r$ and comparing this value with $1/\sqrt{8}$, was only determined by the better candidates.

6736/01 Unit Test PHY6

The calculations in this paper, many of a routine nature, made the whole experience friendlier than last summer's enabling weaker candidates to show what they could do and allowing abler candidates to score highly. The paper was, however, a challenge to complete in the two hours allowed, evidence for this being seen in the rushed approach adopted by many to the last part of question 4.

Question 1

In answering some of the passage questions, parts (a) to (h), it was necessary to take in evidence from more than one paragraph, making part (g) for example quite hard. Parts (a), (d) and (e) were generally well done, though a final statement giving the order of magnitude in (a) was often omitted after a correct calculation and candidates seemed to struggle in finding a value for the proton mass in (e)(ii); 9.1×10^{-31} kg was quite common. A few simply quoted the formula in (e)(i). Part (b) produced an alarming number of dipoles with the field lines going from S to N. Part (c)(ii) tested careful reading of the passage and here a surprising a number of candidates chose to draw a separate diagram rather than adding to the given one. The ability to draw an exponential curve and use a calculator for e^x in part (f) discriminated across the range. In part (g)(ii), where the mark scheme asked for evidence of energy levels and (emitted) photons, plus an explicit comment about how elements – *not* atoms – differ, only the best candidates scored highly. The last question, part (h), often produced a comment about *g* but less often one about *m*, and again this discriminated well.

Question 2

The quality of the drawings in part (a) was extremely variable, but most candidates managed to show four tubes of increasing length and an a.c. supply. Parts (b) and (c) produced very different responses, and both involved reading from the graph lines. In (b) the method was generally understood, but weak candidates used points on the dashed line below $\upsilon^2 = 2 \times 10^{16}$ m^2 s^{-2}, while in (c)(i) and (ii) both the correct method and how to pursue it was restricted to the stronger candidates. Very few had the courage to say that the length of the tubes would become the same in (iii) and a number chose to discuss the limiting speed *c* rather than describe the curve.

Question 3

Newton's first law was universally applied correctly in part (a)(i), but the moments calculation in (ii) led to lots of different methods and, probably, some wasted time. A variety of distances were measured: from C to G, from C to H, from C to where the resolved component of *W* met the line CH, from C to where *W* cuts the line CH; as well as correct distances along the dashed horizontal line. Few recognised that the scale was immaterial as it appears in each term of a moments calculation. Clear well presented calculations were few and far between. How to reduce *Y*, part (b)(iii), was often answered using practical experience of using such travel cases. Things became more generally accessible in part (b), and lots of correct responses illustrated this.

Question 4

Part (a) was very encouraging, almost all candidates registered full marks. Part (b) was another story: in (i) the boxes at top and bottom of the diagram were confused with the temperatures labelled inside them. Thus 'T_c is the cold source' was a common statement. Also 'Q_h is the heat of the hot source' was not uncommon. There were very few bullet point answers – this question cries out for this technique – listing the symbols and then stating what each one stands for. Perhaps three-quarters of answers seen for part (iii) used temperatures in Celsius. Part (c), which involves physics that led to the award of the 1997 Nobel prize, often led to a poor response, perhaps from lack of time. In (i) a correct use of the principle of conservation of momentum was disappointingly rare, while (ii) was often deemed by Examiners to show little more than a double rearrangement of the given answer – a 'creative' piece of algebraic manipulation. Those candidates who did produce the correct physics often wrote Q.E.D. to show how satisfied they felt with their achievement.

Statistics

6731

Grade	Max. Mark	A	B	C	D	E
Uniform boundary mark	90	72	63	54	45	36
Raw boundary mark	60	40	35	30	25	20

6732

Grade	Max. Mark	A	B	C	D	E
Uniform boundary mark	90	72	63	54	45	36
Raw boundary mark	60	42	37	32	27	23

6733

Grade	Max. Mark	A	B	C	D	E
Uniform boundary mark	120	96	84	72	60	48
Raw boundary mark	96	68	60	52	45	38

6734

Grade	Max. Mark	A	B	C	D	E
Uniform boundary mark	90	72	63	54	45	36
Raw boundary mark	60	39	35	31	27	23

6735

Grade	Max. Mark	A	B	C	D	E
Uniform boundary mark	90	72	63	54	45	36
Raw boundary mark	96	68	63	58	53	48

6736

Grade	Max. Mark	A	B	C	D	E
Uniform boundary mark	120	96	84	72	60	48
Raw boundary mark	80	55	50	45	40	36

Raw marks are obtained for PHY3 by multiplying the component mark for Paper 1 by 1.5 and adding it to the mark for Paper 2. Raw marks are obtained for PHY5 by multiplying the component mark for Paper 1 by 1.2 and adding it to the mark for Paper 2. Grade boundaries for the individual papers are not available.

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