GCE

Examiners’ Report

Edexcel GCE
Physics (8540/9540)

June 2003

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EXAMINERS' REPORTS

Introduction

In the theory papers (Units PHY1 – PHY5) there are two skills being assessed:

- AO1 Knowledge with understanding
- AO2 Application of knowledge and understanding, synthesis and evaluation

Further elucidation of these is given on pages 5 – 6 of the Specification. In formulating their answers to particular questions candidates should bear these skills in mind. In certain responses, direct quotation of theory, however correct, will only gain full credit when it is applied to the situation described in the question. Some questions expect interpretation of the information given in the stem. Again, full credit will only be gained when the candidate's response specifically addresses the stem – the general quotation of 'bookwork' is not what is expected.

6731 Unit Test PHY1

Maximum mark	60
Mark range	0 - 59
Mean mark	32.7
Standard deviation	11.9

When reading through and checking their answers, candidates should ensure that these are sufficiently precise, are not ambiguously worded and answer the question posed.

Qu.1 A surprisingly large number of candidates, having drawn correct vector diagrams, calculated the force rather than using their diagrams to measure it (the number of significant figures being the 'give-away'). Many candidates used the wrong diagonal, giving the force as (about) 11 N. Candidates' success with identifying vectors was noticeably centre specific.

Qu.2 Those who selected $\upsilon^2 = u^2 + 2as$ were generally successful. Those who tried to apply other equations of motion generally did not realise that two formulae would be needed and stalled half-way through the calculation. Weaker candidates used acceleration = velocity/distance. The common error in calculating tension was to use an incorrect value for mass. A surprisingly large number of candidates omitted the assumption, thereby not gaining this mark. In explaining why the tension must be less than the weight many candidates tried to explain what would happen had the tension been greater, with the 'string will snap' being a frequent answer.

Qu.3 Several candidates referred to the result rather than the measurement(s) as being more accurate. A wide range of experimental methods was seen. Generally speaking, those who described the electromagnet and trapdoor or lightgates methods were successful, although many gave themselves a time penalty by unnecessarily explaining how to calculate *g* from the measurements. A surprisingly large number of responses used a hand-held stopwatch for the timing. Many candidates identified *g* as 'gravity' or 'gravitational force' – such answers were too woolly.

Qu.4 The most common error in adding arrows to the diagram was to show *Y* acting at the left foot. In explaining "how this situation illustrates the principle of moments" a common fault was to quote formula(e) from the given list without adapting or relating it (or them) to the situation posed. Most candidates ignored force *Z* completely rather than attempt to explain why its moment about P was negligible. Weaker candidates spoke of (anti)clockwise *forces* rather than moments.

Qu.5 Many candidates applied $mgh - ½\ m\upsilon^2$ here. Even though the stem of the question states the cyclist travels at constant speed, candidates wrote that the lost g.p.e. is transformed into kinetic energy. Few correctly estimated the rate of doing work climbing the hill, most candidates failing to recognise the connection with the first part of the question.

Qu.6 The most common slip amongst even the best candidates was not to state that the momentum of the alpha particle is equal to that of the radium nucleus. Some went no further than to state 'momentum before equals momentum after' which did not justify their answer.

Qu.7 The nuclear equation was incorrectly completed in a surprisingly large number of scripts. The decay constant and activity were calculated by a pleasingly large number of candidates. However, there were two very common slips. First, few candidates quoted a unit for the decay constant and, secondly, even fewer converted the value of $t_{1/2}$ from years to seconds.

Qu.8 A large number of candidates quoted correct facts about α, β and γ radiations, but unfortunately these were not relevant to which test identifies what radiation as asked in the question.

Qu.9 All parts of this question were answered well, but individual candidates did not answer all parts equally well. On several scripts responses were ambiguously worded.

6732 Unit Test PHY2

Maximum mark	60
Mark range	0 - 59
Mean mark	31.6
Standard deviation	10.9

The paper proved quite accessible with all but the weakest candidates scoring well on the calculation questions. Questions that require the use of algebra and or symbols, prove to be a challenge for most candidates. It is worth noting that where candidates are taught beyond the Specification it is useful to them to know exactly what is required for the actual Specification and consequently the examination. This is particularly relevant to Qu.7.

Qu.1 The calculation was generally well done. Not all candidates understood the implications of the graphs, assuming that the graphs gave a visual impression of resistance values. Some candidates failed to read the question properly and did not refer to current in their answers while others had the right idea but omitted key words leading to an ambiguous answer. The reason why Lamp A was brighter was rarely explained properly with too many candidates failing to realise that in a series circuit the current is the same through both lamps. Far too many said that the current reaches A first and so it used up most of the energy.

Qu.2 Virtually no candidates scored full marks for this question. The value of the internal resistance of an e.h.t. supply was rarely known despite it being included in the Specification. There was a general lack of awareness of magnitude and often a complete disregard of units. Despite the question saying that values could be used more than once there was a reluctance by candidates to do so.

Qu.3 The first part of this question had a similar success rate to the first part of Qu.1. Candidates who identified $I = nAvq$ as the key to the problem were often successful in the second part of the question but a relationship between two variables can only be established if the other terms remain constant. Candidates who did not refer individually to the other quantities that remain constant lost marks. A significant number of candidates gave answers based on resistance and ease of travel. Such answers scored no physics marks but many candidates scored the written communication mark.

Qu.4 Since this was a 'show that' style of question it was important that candidates started with $R = \rho l/A$. Those that did not lost the first two marks. Some candidates showed that it was dimensionally possible but this also did not score the marks. The calculation in this question was more difficult than the earlier ones and this was demonstrated in candidates' work with a significant number failing to manage the powers of ten. In the last part of the question some candidates gave themselves a time challenge by completing two arithmetic calculations instead of one algebraic one but could score full marks. Difficulty arose here with candidates who could not visualise the film and were not sure which of the variables to equate.

Qu.5 A sizeable minority of candidates confused specific heat capacity with latent heat but in general the definition was known. Acceptable units of temperature were ^{o}C or K but not ^{o}K. The question asked for a circuit diagram with the circuit symbol for either a heater or a resistor. However, many candidates either drew a circuit with nothing between the sockets or a diagram of a combination of circuit and apparatus. Neither of these could score full marks. Because this experiment involves heating the metal for a significant amount of time, it was expected that a means of adjusting the circuit to maintain constant current and potential difference would be included. This was very centre dependent. For "other apparatus" some candidates listed everything including crocodile clips and wires but sometimes omitted the balance and/or timing device. The last part on experimental techniques was well answered by most candidates but quite a few candidates think that digital means more accurate.

Qu.6 This question was often well answered with a significant number of candidates scoring full marks. Common errors were to forget to convert kJ to J or to subtract the temperatures and then add 273. Quite a few candidates having made one of these errors then equated two obviously different values without comment. Most candidates referred to the heating of water but less than half referred to the latent heat and considered the heating of the trough itself.

Qu.7 Many candidates could not express the pascal in base units and many thought that as n is a number it has no units. Showing that average kinetic energy of a molecule is proportional to temperature was a challenge and proved a good discriminator. Candidates need to know that for this module they do *not* require knowledge of the Avogadro number or the Boltzmann constant and therefore there are no marks for using these values. Some were so determined to use Boltzmann's constant that they missed out the early stages of the work or did not define the constant. The main reason that many candidates scored badly was because of a lack of understanding of the macroscopic and microscopic properties of a gas and so they quite happily used m as the mass of the gas and the mass of a molecule. The graph produced some interesting responses. The challenge of reading the question correctly weeded out the most careless and the rest went on to usually give the correct straight –line relationship. Failure to label the axes properly cost many the easy first mark but many managed to get the mark for the intercept on the temperature axis. Of the best candidates, only a few correctly linked R to the gradient. A good number came close, emphasising the linear relationship between pV and temperature T but failing to make the explicit link.

Qu.8 Very poor definitions were given, many just elaborating on the abbreviation or referring to forces pushing charges round. A good number realised that they were looking for a statement about energy but very few produced a fully correct answer worthy of two marks. The circuit diagrams often scored no marks because candidates did not have a load resistor. Many of the graphs were poorly or carelessly labelled and candidates who showed e.m.f. varying with current demonstrated a complete lack of understanding. Even when candidates proposed a graph of V against I many could not over-ride the instinct to associate increasing current with rising potential difference.

6733/01 Unit PHY3

Maximum mark	32
Mark range	0 - 32
Mean mark	17.5
Standard deviation	6.4

Each Topic started with a general prefix question which illustrated some confusion in this area. Whilst most scored well here, pico- and centi- often appeared, as did kila, killa and killer, none of which were accepted. A frequently seen error was kilo with an 'a' and 'o' superimposed; candidates should appreciate that any doubt over what they have written could lose marks and simply re-writing their answer may have avoided this.

Topic A (Astrophysics)

Red giant formation was generally well described with sufficient detail to secure full marks; references to where the processes occurred (e.g. in the core/in outer shells) was key. Some knowledge of the electromagnetic spectrum is a part of Wien's law and candidates needed to refer to an increase in λ_{max} as being related to a shift towards the red end of the visible spectrum. Very few candidates appreciated the importance of the decrease in T and the effect on T^4 in Stefan's law. An understanding of pulsars was fairly centre-dependent; the concept of radio beams sweeping through space was often missed; references to radio waves being emitted as pulses were often made. Calculations were generally well done; many candidates wrote down the correct equation but then neglected to square D in the $4\pi D^2$ term. There was a general misunderstanding about CCDs, which were often said to have better resolution than photographic emulsion.

Topic B (Solid materials)

It was a shame to see many candidates losing a mark by not using a ruler when adding a line to the stress-strain graph, although some free-hand lines were deemed straight enough here. Relating strength and toughness to the graph proved to be beyond many candidates. The instruction 'use your graph' for the hysteresis question was often ignored; candidates need to ensure that they do what is asked. Slip planes were rarely seen, with most candidates labelling the edge dislocation; bonds were also rarely mentioned, as many candidates simply repeated the question. Calculations were mostly done fairly well, although 'energy stored = force × distance' was often used rather than 'average force × distance'.

Topic C (Nuclear and Particle Physics)

Binding energy was a somewhat vague concept to most candidates. Responses included

- energy to bind a nucleus together
- energy to bind an atom into molecules
- energy required to make a nucleus

Accuracy proved a problem for candidates when sketching the binding energy per nucleon graph; peaks at nucleon number 56 with a *slight* subsequent fall were needed. Relating this to stability proved centre-dependent. Charge and baryon number conservation was done well, with zero values being shown most of the time. Worryingly, balancing a nuclear equation proved difficult for a large number of candidates, with ${}^{1}_{0}n$ eluding many. The half-life question was often over-complicated by the use of exponential equations which are not part of the Specification at this level.

Topic D (Medical Physics)

Explanations of uptake studies were, on the whole, of a good standard, although radio-pharmaceuticals were infrequently mentioned and the concept of requiring several readings for a function test was very rarely seen. Reasons for technetium were often far too vague; repetition of the question was insufficient to earn marks here. It would appear that diagnosis with X-rays is studied more than therapy, since the proton number dependence on X-ray attenuation was rarely given by candidates. Multiple-beam explanations were unusually good. Precautions during therapy produced an interesting range of answers, sometimes highlighting a confusion with diagnosis:

- wear a lead jacket (or even lead suit)
- wear a white coat and a badge
- use safety glass

The idea that air reflects ultrasound is very common: mentioning that ‘reflection occurs at the skin because of a large change in specific acoustic impedance’ is the sort of detail expected in a specialist Topic. Translating 4×10^{-5} s to 40 μs in order to add *two* pulses to the grid was done only by the best candidates.

6733/02 Practical Test PHY3

Maximum mark	48
Mark range	1 - 48
Mean mark	26.8
Standard deviation	8.0

Despatch of Confidential Instructions

For this examination we trialled releasing a simple list of apparatus in advance of the Confidential Instructions. This was not found to be helpful and will not be repeated. Despatch of the Confidential Instructions will continue to be about 2 months before the examination. For January examinations the despatch is sent to centres who have made actual entries; for June it is sent to centres on the basis of estimated entries, since the deadline for entries is within 2 months of the summer practical tests. If the Confidential Instructions are not received in your centre please check the status of your entries with your examinations officer and with Edexcel's Entries and Certification Department.

In general, virtually all candidates showed competent skills in obtaining adequate data of suitable precision and accuracy. The better candidates improved the quality of their observations through using good techniques and repeat readings where appropriate. Candidates were considerably less skilful in the planning and analysis aspects of the paper. This was particularly so in the second question of both papers. Candidates need to be taught that discussion of results must be based on *quantitative* analysis and that the description of how they would plan an experiment should clearly state all the measurements that they would take and how they would process them.

GROUP 1 (2A)

Question 1A

The majority of candidates used ten spheres in a channel which were shown as close packed. Often set squares were shown at the end of the line of spheres but they were rarely shown with one of the perpendicular edges of the set square along one of the horizontal edges of one of the rules. The scale reading that would need to be taken from the rule in order to determine the length of the ten spheres were rarely shown. Candidates should not assume that the end of a metre rule corresponds exactly to 0 mm. Good candidates obtained a value of d within the expected range of the Supervisor's value.

In order to gain full credit for the percentage uncertainty examiners expected candidates to show clearly that the uncertainty was in the measurement of l rather than d. For this reason a unit was required with the uncertainty so that this could be checked. For example 0.1 cm in 15.2 cm giving a percentage uncertainty of 1.3% gained 2 marks, but 0.01/1.52 giving 1.3% only gained one mark. Most candidates used 10 marbles when finding the mass and obtained a value which was in the expected range of the Supervisor's value. Good candidates obtained a density value which was in the correct range and was quoted to an appropriate number of significant figures. Weaker candidates often attempted to convert to kg m^{-3} (which was not necessary) and obtained incorrect answers because of incorrect conversion of the volume to m^3. Weaker candidates often quoted values of density to four or more significant figures. The experimental arrangement in part (b) discriminated well. Good candidates showed two metre rules on the diagram checking the height of the string above the bench at two different places. Set squares were also shown at the bases of the rules to show that the rules were perpendicular to the bench which was assumed to be horizontal). Weaker candidates often attempted to check that the string AB was horizontal by using a set square against the vertical sstand. This was given 1 mark but is not regarded as a very good technique. Some attempted to check that there was a right angle between the vertical string connected to the mass hanger and the string AB. This was not given any credit because it was felt that the strings would move when the set square was positioned.

The main fault on the free-body force diagram was that many candidates failed to distinguish between the tensions in the horizontal and the inclined string. Most candidates gained reasonable marks for the calculation. Typical mistakes included:

- not putting their data on to the diagram
- using a vertical force of 0.3 g = 2.94 N, rather than 3.92 N
- using too many significant figures for the value of the tension in the horizontal string
- using 400 g = 3920 N for the weight of the mass
- in some cases obtaining a negative value for the horizontal tension (by taking the square root of a negative number) because their measured tension was less than 3.92 N

Question 1B

The majority of candidates obtained full marks for setting up the circuit and taking the appropriate reading. Minor errors at this stage included:

- the omission of units
- using units of A for current rather than mA

Good candidates had no difficulty with parts (b) and (c) and often the total of 10 marks was scored. The mark scheme allowed a number of compensation marks at each stage so that the full range of marks between 0 and 10 was scored in these two sections. Compensation marks included the following:

- In part (b) if candidates chose the wrong set of results they could still gain the calculation mark, e.g. 6.11 V/80.5 mA = 75.9 Ω gained 1 out of 4.
- In (c)(i) if candidates divided either V_1 or V_2 or the average of the two values by their answer to part (b) they gained 1 out of the 2 marks. As an alternative to this they could also state their answer to (a)(ii).
- Correct answer should have been (a)(i) value – (c)(i) answer, but (a)(i) value – (a)(ii) value was allowed.
- Candidates should have subtracted 0.7 V from V_1 in order to obtain the p.d. across the resistor R_1. However, examiners allowed 0.7 V to be subtracted from either V_1 or V_2 or the average of the two values.

An alternative approach to parts (c) (ii) and (c) (iii) was successfully applied by some candidates. The total resistance of the arrangement was found by using V_1/I_1. The resistor R_2 was in parallel with the series arrangement of the diode and the resistor R_1, hence the resistance of the series combination could be found. The current in the series combination could then be found by using V_1/(series combination resistance). The resistance of R_1 could then be found by using

series combination resistance – resistance of diode

The diode resistance was found using 0.7 ÷ (answer to (c)(ii)). Despite the impressive approach used by some candidates in parts (b) and (c), the answers in part (d) were disappointing. Hardly any candidates correctly drew a potential divider and very few candidates said that the connections to X would have to be reversed so that both the forward and reverse characteristics could be investigated. In (d)(ii) most weaker candidates drew the forward diode characteristic, which could score 2 marks if the axes were correctly labelled. However, a number of candidates labelled the axes the wrong way round so that the line effectively curved the wrong way. A correct diode characteristic showing the reverse characteristic as well as the forward could score 3 marks. Good candidates also showed the correct linear sections and scored 5 marks. Note that because the linear sections pass through the origin the resistance may either be defined as V/I or $\Delta V/\Delta I$. Some candidates lost this mark because they said that the resistance was the gradient of a graph of I against V when, in fact, it is the reciprocal of this gradient.

GROUP 2 (2B)

Question 2A

Most candidates got the first two marks for taking three or more timings in part (a), but only the better ones drew clear diagrams to show precisely how they determined their time accurately, e.g. using the same point on the trolley and keeping their eye level with that point. Many candidates gave over-optimistic estimates of the uncertainty of their measurements, merely quoting the precision of their stopwatch or the range of their readings, which was significantly less than acceptable human error of 0.05 – 0.10 s. Similarly, answers of more than two significant figures for the frictional force were penalised as the angle of the slope was only given to two significant figures. In part (b) candidates were much happier setting up a potential divider circuit from the given diagram than they were either last year or in 6733/2A when they were asked to draw the circuit. Very few candidates were unable to record accurate values for the current and voltage, but the weaker candidates made little headway with the analysis. As in Group 1, the lower ability candidates were able to pick up two or three marks for some correct V/I calculations, but only the best candidates were able to complete the analysis.

Question 2B

In part (a) similar problems arose as in Group 1. A large number of candidates attempted to check whether the string was horizontal by the use of a set square held against the vertical stand. Although this gained one mark it was not such a good technique as checking the height of the string above the bench at either end using a rule held vertical with a set square. Good candidates measured the vertical height between B and C using a similar technique and *showed their readings* to indicate that they had done so. A significant number of candidates gave a value for θ when they were asked for $\cos\theta$; others were unable to cope with the necessary trigonometry. Many candidates made errors in calculating the theoretical value for $\cos\theta$, e.g. not expressing the mass in kg or omitting g. Although the type of analysis required in part (c) has now been asked several times, the responses were still disappointing. Having been asked to calculate the percentage uncertainty in their value of R, the candidates should then have calculated the percentage difference in their two values for $\cos\theta$ and then made a comment based on these two calculations. This is a skill that students should be encouraged to develop. In part (d) many candidates were confused by the fact that there were *three* dependent variables and a very common error was to suggest plotting W against R to give a gradient equal to $\cos\theta$. Only the most able candidates realised that a graph of $\cos\theta$ against W/R, giving a straight line through the origin of gradient 1, was what was needed. As descriptions were also poor, a lot of candidates got very few marks for this section.

6734 Unit Test PHY4

Maximum mark	60
Mark range	1 - 58
Mean mark	32.0
Standard deviation	10.4

Candidates had sufficient time to finish this paper and most attempted all of the questions. Calculations were generally tackled competently: candidates showed their working and were careful both with units and with powers of ten. Diagrams could have been employed more often to illustrate an answer and those that were required could have been drawn more precisely. However, the quality of written communication on this paper was pleasing.

Qu.1 Calculations in this question were successfully done. The majority were able to determine the angular speed in the first part whilst only a small number made arithmetic mistakes with the final calculation of acceleration, typically forgetting to convert km to m and to square the angular speed. A method using the relationship $g = GM/r^2$ gained full marks but it did rely on candidates correctly quoting the mass of the Earth. Most concern arose from the inability of many to draw the free-body diagram force for the satellite. There was confusion about the number of forces acting on the satellite whilst diagrams involving speed were often presented. Candidates wanted to label the force 'centripetal' rather than identify its exact nature. Explanations of the cause of the acceleration were very rarely related to the fact that there was an unbalanced force on the satellite so most answers explained the acceleration in terms of changing direction and velocity. Few scored the 2 marks available for this middle section.

Qu.2 Rarely did any candidate score full marks for the table. Most used the terms 'high' and 'low' correctly in describing the amplitudes at the higher frequencies but all too often their confused answers suggested that this demonstration had not been fully understood. Many did not realise that off resonance there would hardly be any motion of the string, but the majority were confident in their drawings of the second and third harmonics. Full descriptions of the behaviour of the electron in the hydrogen atom tended to be centre-dependent. There were some excellent responses but most of the candidates only commented on the standing wave aspect of the behaviour and failed to relate the possibility of different standing wave patterns to higher frequencies. That said, most were able to express their ideas clearly and so were able to score the quality of written communication mark.

Qu.3 This question did not score well. All too often candidates offered factual information without using it to answer the question. Some successfully identified a regular pattern of concentric rings as the observation for crystalline diffraction whilst others realised that the atomic spacing was close to the de Broglie wavelength but it was rare to see both the explanation and the observation. There was much more success with the second part of the question. Many referred to the instantaneous emission of electrons and the existence of the threshold frequency and they often explained observations in terms of one to one collisions and photon 'packets' of energy. Many wrote at length though about intensity and the kinetic energy of the photoelectrons without gaining any credit. Again, much explanation was given about diffraction at the double slit and the consequent overlapping but many failed to state what was seen. Vague terms such as 'areas' or 'regions' did not convey sufficiently the concept of equally-spaced bright and dark fringes. There was some confusion between the double slit interference and the single slit diffraction patterns but some supported their answers well with labelled diagrams. Explanations of interference by superposition were often detailed and reflected a thorough understanding of the phenomenon.

Qu.4 Most candidates returned a competent score on this question. They were able to calculate the frequency and to categorise it as UV. Very few indeed, however, remembered to tell us that spectral lines are to be observed against a dark/white background, whilst many chose to explain how a line spectrum is formed. The correct value of 411 nm was often calculated although some, having determined the Doppler shift, chose to subtract it from the original wavelength. A significant number of candidates were satisfied with substituting in $c = f\lambda$ and so failed to score marks for this section. Success in working out the number of seconds in a year and in 1.0×10^9 ly was often seen but a significant number of candidates failed to use the speed of light in the next stage of their calculation or they managed to substitute into $\upsilon = Hd$ incorrectly. That said, many candidates scored full marks for this calculation. There was an equal level of success with the last calculation. Some needlessly recalculated using $\upsilon = Hd$ and so tended to make arithmetic errors whilst others correctly multiplied the initial recessional velocity by four.

Qu.5 The meaning of the term monochromatic was well understood but the description of the experiment itself often excluded the obvious. Candidates were willing to take several sets of readings for current I and distance d but they were often only recording I. The better candidates realised that plotting I vs $1/d^2$ would give a straight line through the origin, but far too many were content simply to refer to a doubling of d producing a quarter of I based on two sets of readings. Many realised the relevance of doing the experiment in a darkened room in order to remove any unwanted sources of light. The calculation of maximum wavelength was competently done except for those who tried to use the de Broglie equation. Some confused frequency with wavelength.

Qu.6 Many candidates were correct in placing the mass below the equilibrium position but fewer drew their acceleration arrows pointing towards the centre of oscillation. The amplitude was usually correctly stated but too many omitted the unit or misread the amplitude value as 0.65 m. The calculation of the spring constant was well done. Most candidates were able to determine the periodic time from the graph and then to substitute in the formula $T = 2\pi(m/k)^{1/2}$ in order to find k. Those that tried calculating the acceleration from the graph then using $F = ma$ with $F = kx$ often made arithmetic errors. A significant number had difficulty giving the appropriate units with the answer but overall the question was very well done.

Qu.7 Many candidates were imprecise in their diagrams: wavelengths were not kept constant. Diffraction at the narrow gap gave good circular wavefronts but diffraction at the wider gap gave wavefronts that were often too curved or ones that showed an amount of diffraction similar to that in the first situation. The definition of wavefront was poorly answered with many candidates talking about a line joining points in phase on the same wave. In the last part of the question it was expected that candidates would first recognise that the LW had the longer wavelength and then that it was diffracted to a greater extent than the VHF around the mountains. All too often there was no comparison made with only general comments made about diffraction. This type of response scored no marks.

Qu.8 This question scored particularly well. Most candidates were able to determine the gradient of the graph and then went on to work out the slit spacing. The main sources of error were with powers of ten or multiplying instead of dividing by the gradient. The majority successfully managed to add a second line with half the gradient of the first to the graph.

6735/01 Unit Test PHY5

Maximum mark	40
Mark range	2 - 40
Mean mark	25.2
Standard deviation	7.4

There was no evidence that candidates were short of time or that the paper's content was inaccessible. Nearly all completed the paper and gained some marks on most questions.

Qu.1 This question was not answered well. When drawing the path of the alpha particle most candidates appreciated that it would be deflected. What was less understood was that the deflection begins immediately the particle moves into and stops when it moves out of the electric field between the plates. A sudden change of direction on leaving the field was a popular but inaccurate feature of many diagrams. Correct answers to the calculation proved more elusive than expected. The most common errors were to regard the potential gradient as the force and the use of 1.6×10^{-19} C for the charge on the alpha particle.

Qu.2 For candidates who have had adequate practise doing capacitor calculations this proved a rewarding question. Many achieved full marks. A frequent error was to use six volts for the potential difference across C_2 when calculating the charge stored for the series connection.

Qu.3 The calculation of the horizontal component of the Earth's magnetic flux density was in most cases performed successfully, though some lost a mark because their calculator was operating in the wrong degree mode. Having completed this part correctly it was disappointing that so many should then decide to use 4.8×10^{-5} T in calculating the induced voltage. A popular, but wrong, explanation for why there is no induced voltage, was that the motion and field have to be perpendicular. Credit was given to those candidates who realised that a small voltage would be induced across the diameter.

Qu.4 Candidates need to be reminded that a moment spent in reflecting on what a question is asking is rarely wasted. This question is illustrative of this point. It asks not just *why* the pendulum is damped, but why it is *rapidly* damped. Very few answers addressed this point. Candidates were keen to state Lenz's law, which they often did perfectly, but applied it without understanding. Thus answers which stated that the induced e.m.f. or the induced current opposed the motion, as though they were resistive forces, were common.

Qu.5 Many scored well on this question, but very few obtained all six marks. Assigning no charge to the right hand sphere and omitting the negative sign in the final answer were the primary reasons for this. The candidates who converted 50 eV to joules were complicating a simple question and in so doing lost a mark unnecessarily.

Qu.6 In general candidates found this a straightforward question and many perfect answers were given. If marks were lost it was often the result of a slip, such as forgetting to square root the final answer or failing to square the distance between the moon and the mass *m*.

6735/02 Practical Test PHY5

Maximum mark	48
Mark range	2 - 48
Mean mark	28.5
Standard deviation	7.4

Despatch of Confidential Instructions

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GROUP 1 (2A)

In general most candidates showed good practical skills in making observations and taking straightforward readings. The better candidates used good techniques to obtain more accurate data but only the best candidates showed the more advanced skills of detailed analysis expected at this level.

Question 1A

Most candidates were able to set up the circuit in part (a) without help and get a correct value for the initial current, expressed in μA as was required. A few candidates ignored the instructions and gave their answer as, e.g. 1.54×10^{-4} A , which lost a mark. The better candidates took averages of repeated timings and sketched good curves; weaker candidates simply took single readings and drew inaccurate curves, often with the line asymptotic instead of meeting the time axis at I_0 .

In part (b) many candidates got the first three marks for indicating more than one order of spectra on both sides of the central maximum, with the colours shown correctly. The better candidates also got the next two marks, remembering that red light had the lowest frequency. Grade A candidates showed the correct absorption, with an appropriate frequency range, and got very high marks for this question.

Question 1B

Relatively few candidates suggested a good technique for counting the number of turns, such as extending the spring or taking particular care to account for the half-turn at the end. Fewer still stated that they used a reference point at the centre of oscillations to aid timing. Even if a marker is not provided, candidates should attempt to use some convenient point. Good candidates who timed 20 oscillations, with repeats, invariably obtained more accurate results and so got more marks. Many candidates took the uncertainty in their timing to be their range of values when this was much less than reasonable human error (0.05-0.10 s); others simply took the precision of the stopwatch (0.01 s) and said that this was the uncertainty in T –

showing a total lack of understanding of the situation. Quite good candidates lost marks by failing to give the constant *s* any units and by not quoting its value to 3 s.f. The subsequent analysis was generally very poor: candidates were expected to calculate the percentage difference between their two *s* values, using the average as the denominator, compare this with twice the percentage uncertainty calculated in (a) and then make a suitable comment. It should be emphasised to candidates that this type of analysis must be *quantitative* to get any marks. The analysis of the equation for *T* was extremely poor, with very few candidates getting any marks. Overall candidates scored disappointingly low marks for this question.

Question 1C

Good grade A candidates got 6 or 7 marks for the first part of the question, whilst grade E candidates probably calculated the frequency correctly, got a mark for an incomplete diagram and a further mark for measuring between nodes or antinodes. The idea of measuring across several nodes was not well understood or clearly expressed. Tables showed carelessness in the number of s.f. and/or a lack of units for $1/f$ and whilst plotting was generally accurate, a very significant number of candidates forced their line through the origin. They therefore missed the whole point of the exercise – to show how a graph could eliminate systematic error – but were given credit for saying that a graph would give an average value. Most candidates used a large triangle to calculate the gradient, and hence the speed, but often made errors in powers of ten or s.f. in their final answer.

GROUP 2 (2B)

Question 2A

In part (a) the majority of candidates correctly determined the volume of the water below the 50 ml mark on the burette although some candidates only quoted the volume to 1 s.f. Not all candidates explained clearly how they determined the time for half the volume of water to run out of the burette, in particular not stating the reading on the burette when this occured. Common faults with the calculation of the time constant were the omission of units or the use of an inappropriate number of significant figures. Similar problems arose with candidates quoting answers for the resistance to 5 or more significant figures.

When determining the periods of oscillation in part (b), a number of candidates clearly determined the period of vertical oscillations, evident from the fact that both time periods were the same. Good candidates obtained periods in the expected ranges by timing a large number of oscillations - where oscillations are heavily damped candidates are expected to repeat the measurement several times in order to obtain an accurate value for the period. Most candidates obtained a correct value for the percentage uncertainty in the diameter but candidates had the same problem with the percentage uncertainty in the period as in Group 1. Candidates should be encouraged to show all their working in such questions to show clearly how they arrived at their answer. Good candidates realised that it was necessary to check the ratios of periods and diameters in order to confirm direct proportionality, whilst the best candidates compared the percentage difference between their two ratios with twice the total percentage uncertainty determined previously and commented appropriately.

Question 2B

Virtually all candidates set up the circuit correctly. Because of the difficulty in obtaining accurate values for the compass deflection, examiners awarded marks for general trends in the results. Full marks could be obtained from a minimum of 5 tabulated results, spread over a large range, with repeat measurements of either θ or I. Weaker candidates tended not to repeat measurements nor to tabulate tanθ values. There were also systematic errors in the measurement of I in some cases.The special precautions mark, which was very rarely scored, was related to taking repeat observations, either when the current was increasing and then decreasing, or when the current was reversed. When the gradient of the graph was determined the majority of candidates used a large triangle and in most cases obtained a reasonable value for the answer. However, there were a number of problems associated with the calculation of the horizontal component of the Earth's magnetic flux density. Candidates had difficulty relating the gradient of the graph to the given expression: having found the gradient, a number of candidates then went back to use an experimental data point to calculate B_{hor}, or, where candidates *could* relate the gradient to the expression, they were then unable to rearrange the expression to make B_{hor} the subject of the equation. In other cases, values were not in S.I. units when substituted into the equation, e.g. the current was left in mA.

Question 2C

The main problems in (a)(i) were the use of both d.c. and a.c. supply symbols (e.g. drawing the symbol for a dry cell and labelling it 'a.c. supply') and too many s.f., or no units, for Z (both V/A and Ω were allowed). Weaker candidates in (a)(ii) were not able to substitute into the equation correctly. In some cases values were not squared and in others 1 μF was thought to be 1×10^{-3} F. In (a)(iii) only good candidates successfully compared the given equation with $y = mx + c$ and realised that the a.c. supply would need to be replaced by one which had a variable frequency. Some candidates suggested that a 'variable power supply' should be used. This was not given credit as it was not clear that the *frequency* would be variable as opposed to the voltage.

In part (b) graph plotting was often poor. Candidates had a great deal of difficulty coping with the first Z^2 value of 10 555 Ω^2, or had a vertical scale which started at 0 and rose to 10 000, which meant that the first point in the table could not be plotted. In some cases candidates attempted to plot this point just above the grid so that it was effectively plotted as 10 055. A vertical axis starting at 2000 and rising to 12 000 would have enabled all the data to be plotted correctly. Another common error was a change of scale at 10 000, e.g. a correct scale from 2000 to 10 000 and then the next reference point on the axis at 20 000. Good candidates gave units in the table and correctly calculated the capacitance of the capacitor, whilst weaker candidates lost marks by omitting the units or giving incorrect powers of ten.

6736 Unit Test PHY6

Maximum mark	80
Mark range	0 -79
Mean mark	46.9
Standard deviation	14.3

The mean mark was high, possibly because the questions asked about the passage were carefully structured and partly because the way the paper is marked is sympathetic to the need for candidates to show what they can do across the whole Specification.

Qu.1 The passage worked well, the relatively straightforward part (b) giving most candidates some confidence early on. However, what was meant by a circuit being 'short-circuited' in part (a) was not generally known. That charge can be found from $I\Delta t$, i.e. the area under the graph, in part (c)(i) was almost universally understood, the discriminating element being getting the numbers correct, and the I^2R calculation in (ii) only gave difficulty to those who failed to read off the maximum current from the graph. As usual candidates; ability to test the homogeneity of the equation in part (d) was closely linked to their overall performance, weaker answers tending to be a half-page of 'waffle' amongst which the Examiner had to search for correct physics. Parts (e) and (f) examined the physics involved in spinning up the disc. A majority of candidates failed to score any marks in (e)(i) and few understood the force required in (ii), most of the marks gained here being for the calculation in (iii). Most started with a relevant formula in part (f), with the subsequent explanation being only managed by the stronger candidates. The final problem on circular motion in a gravitational field took the weaker candidates a long time judging by the amount they wrote, and it was perhaps unfortunate that circular motion appeared again in the next question.

Qu.2 That protons carry a positive charge was mentioned by a small minority in response to part (a)(i) of the question. The physics of the cyclotron, examined in (ii) and (iii) and worth 9 marks, discriminated well. In (ii) weaker candidates tended to quote a 'formula' they had learned for cyclotrons and then twist it round to produce the required result; better candidates started with $m\upsilon^2/r = Be\upsilon$ or equivalent and did the algebra, the half circle sometimes giving a bit of trouble. In (iii) the synchronicity between the a.c. supply and the orbiting protons, though difficult to express, was managed by the better candidates and most were able to discuss the mass increase as the protons approached the speed of light. The substitutions in (v) were rarely correct as the mass of the proton was usually taken to be that of an electron and not as 1 u – 1.66×10^{-27} kg. The analogy examined in part (b) was disappointingly answered, particularly (i) where candidates of all abilities seem determined to attribute something to Newton's third law, especially when discussing $mg = T\cos\theta$. The idea of giving the bob a push every half revolution was very rarely mentioned in (iii).

Qu.3 After struggling with the analogy in Qu.2(b) candidates found much of this question accessible, though part (a) caused some problems. There did not seem to be a problem in taking measurements from the diagram in (b)(i), but those who measured the height of tube A to be > 39 mm lost a mark. Boyle's law was stated in (ii) to be $p \propto V$ by the weakest. The experimental description in (c) worked well with (i) discriminating in the lower mark range and (ii) in the upper. Both emission and absorption spectra were given credit as were a variety of phrases that were used synonymously with energy levels, for example energy states or orbitals.

Qu.4 As expected, weaker candidates often referred to x as a distance in part (a)(i) and omitted to mention that x as displacement must be measured from the equilibrium position. The units in part (b)(i) were generally well managed except by those who by now were rushing. There is still much misunderstanding of how to test for exponential change as examined in (ii). It was expected that ratios would be calculated or half-lives measured (the latter being tricky to judge as one could not see the curve linking the maxima that the candidate was attempting to use). The final sketch usually gained 2 marks out of 3, there being no attempt to insist on the precise shape of the energy-time curve.

GRADE BOUNDARIES AND UNIFORM MARKS

The raw mark obtained in each Unit is converted into a standardised mark on a uniform mark scale, and the uniform marks are then aggregated into a total for the subject. The tables show the boundaries at which the raw marks are converted into uniform marks. Raw marks within each grade are scaled appropriately within the equivalent range of uniform marks.

Units converted to 90 uniform marks

Unit	Maximum mark	Grade				
		A	B	C	D	E
	Uniform marks 90	72	63	54	45	36
	Raw marks					
PHY1	60	41	36	31	26	21
PHY2	60	41	37	33	29	25
PHY4	60	42	38	34	30	26
PHY5	96	73	67	61	56	51

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.

Units converted to 120 uniform marks

Unit	Maximum mark	Grade				
		A	B	C	D	E
	Uniform marks 120	96	84	72	60	48
	Raw marks					
PHY3	96	64	56	48	41	34
PHY6	80	61	55	49	44	39

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. Grade boundaries for the individual papers are not available.

STATISTICS

The provisional percentages of candidates obtaining at least the indicated grade are:

Unit	Entry	Cumulative percentage of candidates at Specified Grade				
		A	B	C	D	E
PHY1	9609	29.6	44.8	59.0	71.6	82.6
PHY2	10 911	22.8	35.7	50.0	63.2	74.1
PHY3	10 861	28.4	46.2	63.9	77.0	87.3
PHY4	5721	20.6	33.6	47.1	60.6	72.0
PHY5	6951	19.2	33.5	48.9	60.9	71.7
PHY6	6958	19.5	33.6	47.9	59.6	70.6

Advanced Subsidiary award

Provisional statistics for the award (7580 candidates)

	A	B	C	D	E
Cumulative %	23.7	40.0	56.4	71.1	83.9

Advanced award

Provisional statistics for the award (6950 candidates)

	A	B	C	D	E
Cumulative %	26.8	46.7	64.1	78.9	92.0

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