edexcel
advancing learning, changing lives

# Examiners' Report June 2007

GCE

## GCE Physics (8540/9540)

Edexcel Limited. Registered in England and Wales No. 4496750
Registered Office: One90 High Holborn, London WC1V 7BH

A PEARSON COMPANY

Edexcel is one of the leading examining and awarding bodies in the UK and throughout the world. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers.

Through a network of UK and overseas offices, Edexcel's centres receive the support they need to help them deliver their education and training programmes to learners.

For further information please call our Customer Services on 0870 240 9800, or visit our website at www.edexcel.org.uk.

June 2007

Publications Code 019008

# Contents

## 6731/01

As in previous years there were very few candidates who did not make some attempt at most parts of each question. The improvement in the clarity of written communication noted in January was, on the whole, maintained in this examination.

### Question 1

The difference between distance and displacement was described well. The position of the train at the completion of the journey shown by the graph also presented little problem to the majority of candidates. The plotting of the velocity time graph was not as well answered. The velocity during the first 4 minutes was usually drawn correctly as a line parallel with the time axis. However, the velocity for the final 4 minutes was often incorrectly shown either continuing beyond 8 minutes or drawn above the time axis, incorrectly indicating its direction to be the same as in the first 4 minutes. Failing to convert minutes to seconds in calculating the velocities was common.

### Question 2

Question ai was answered well. Question aii produced many correct responses most of which used

$v^2 = u^2 + 2as$. Those that tried to solve the question using $s = \frac{u+v}{2}t$ then $s = ut + ½at^2$ often came unstuck. There were of course the usual errors most common of which was to set $v = 3\ ms^{-1}$ and $u = 0$. For part c there was a sense that candidates simply guessed at the answers. There were less than 20% who obtained both marks.

### Question 3

Most candidates were able to suggest a method of applying a constant measurable force and to describe how to measure a velocity at a point. However, candidates who described the latter using a ticker timer and tape were often unable to explain how to use the results to obtain the velocity. Those who used a stop watch and ruler were clearly not answering the question. The answers given to part b were often left incomplete eg equations given but not explained; distances and times mentioned but not defined. For part c most knew that a graph of force against acceleration would demonstrate the relationship, but frequently did not mention that the graph would pass through the origin. Those that drew a sketch graph gained the marks easily. Some lost marks because of incomplete descriptions such as 'plot a graph' without stating clearly what should be plotted. Part d was not answered well. It was not unusual for candidates to argue that Newton's second law involves 'no external force' and that friction was an external force and therefore had to be eliminated, thus confusing Newton's law with the condition applied in the principle of conservation of linear momentum. It was clear that the idea of resultant force was not understood. Generally there was much confusion evident in the answers to this question even from otherwise good candidates.

### Question 4

Virtually all candidates used the equation for weight, but only 40% converted grammes to kilogrammes successfully. For bi the weight of the pen was often shown acting at the wrong point. A significant minority showed it acting through the pivot! In bii candidates who had marked the weight acting through the wrong point and then used this position for calculating the weight of the cap were given credit for applying the principle of moments, but not for the answer. At least on this occasion most candidates did make some attempt to carry out an appropriate solution and did not simply state a moment value as the answer to the force, as was the case in June 06. Questions ci and cii were answered well. No moment is produced by the force because 'the pen is balanced' and 'the sum of the moments clockwise = sum of the moments anticlockwise' were the most common incorrect responses to ciii.

**Question 5**

Less than a third of candidates answered part a correctly. 'Friction' and 'engine' often featured in the wrong answers given, but the error seen most frequently was to get tyre and road the wrong way round. Bi and bii were answered well. The most popular way to explain why the kinetic energy does not change in answer to 5c was in terms of Newton's second law. Generally such explanations were more likely to result in both marks being awarded. Those who used the energy transfer approach often lost their way and obtained no marks. The idea that energy is 'lost' to other forms was not credited. It was not unusual for candidates to equate work and force as though they were the same quantities, such as in 'this happens due to the forces of friction and air resistance becoming equal with the work'.

**Question 6**

Questions a and c were, as expected, answered well. B was more of a challenge - about 60% managed to get one of the symbols right.

**Question 7**

Most candidates obtained at least one mark for part a. This was usually for the calculation of the volume of a single atom. Some thought this was the answer. Setting the volume equal to $\frac{4}{3}\pi r^2$ was fairly common and omitting the unit, having done all the hard work, was an all too frequent occurrence. For part b there were some excellent answers to this more difficult question. Candidates who simply repeated the information given in the question, and there were quite a few who did this, obtained no marks. The fact that the mass of the atom and the mass of the nucleus are virtually the same and that density is mass per unit volume are both crucial points in the explanation as to why the nuclear density is $10^{13}$ times greater. Many candidates stated just one of these facts and therefore could not give a satisfactory explanation in answer to this question.

**Question 8**

The meaning of spontaneous was understood by less than 10% of candidates. Most thought it meant random. The mark for the meaning of unstable was only given were it was clear that the description was with reference to the nucleus and not, for instance, the atom. This was in line with previous practice. For bi most obtained just one mark. To obtain both marks there had to be some clear evidence that more than one value of half life had been found and an average taken. Again this was consistent with similar requirements in the past. Less than 50% of candidates obtained the mark for bii not because less than 50% knew how to work this out, but because they omitted to assign any unit to the value of decay constant they had calculated. For part biii the most common errors were to miss the $10^7$ factor for the activity and not to convert the decay constant from $h^{-1}$ to $s^{-1}$.

## 6732/01

In many ways this was a fairly straightforward paper which produced a range of quality of answers from the candidates. What was disappointing was how poorly the definition questions were answered. A robust knowledge of definitions is essential for success in this subject and definitions can be learnt, with enough practice, by the whole ability range of the candidates. Another area of weakness is a lack of precision in the choice of words used for descriptive answers.

### Question 1

This question was well answered by the more able candidates and provided good differentiation for weaker candidates. It was (iii), the quantity which was a rate of change of another quantity in the list, which proved the most troublesome, with many candidates writing charge instead of current. Possibly candidates did not read the stem of the question properly and felt it was wrong to use the same quantity more than once.

### Question 2

It was unusual to give all three marks for part (a), with the common answer being to say that resistance decreases because *n* increases with no reference to the other terms in the equation staying constant. This type of question has been set in the past and it is important that all terms in an equation are referred to. Too many candidates said that resistance increased because *v* increased and *n, A* and *Q* all stayed the same. Part (b) proved very tricky for weaker candidates because they did not appreciate that the voltmeter reading would remain constant. They also showed a lack of understanding of the question because when asked which meter is used to indicate temperature they often said a thermometer or a thermistor. The more able candidates who did realise the significance of the ammeter frequently did not score the last mark for an assumption made. Often what was given was a precaution e.g. making sure there wasn't a zero error on the instruments.

### Question 3

It was surprising how many candidates did not make reference to Ohm's Law despite the prompt in the question. Also, a lot of candidates lost time and marks by writing about the nichrome wire and there were also those that could state what Ohm's Law was, but didn't go on to say that it didn't apply to the tungsten filament. A worryingly large number of candidates seemed to think that the gradient of the graph gave them $1/R$, while other candidates reported that as the resistance increased, the current decreased. Part (b) was quite straight forward with many candidates scoring full marks. Some candidates did not realise that the simple addition of two currents from the graph was all that was needed for the last part and embarked on a very tortuous route of calculating the resistance of the nichrome wire, doing a resistor in parallel calculation, followed by another $V=IR$ calculation. Apart from the time penalty, this method often resulted in an arithmetic error so there was a lot of unnecessary effort for one mark.

### Question 4

The calculation part was again quite straightforward for the more able candidates. The common error that was made, in finding the resistance of a strip, was to divide the total resistance by five instead of effectively multiplying by five. However many of the candidates who made this error went on successfully to use their value to calculate the length of the strip. Part (c) produced a range of responses with few candidates scoring both marks. There was a requirement that the answer be given in terms of an equation and this was often missing. A large number of candidates wanted to alter the dimensions of the strips or the applied potential difference despite the wording of the question, another example of candidates not reading the question properly.

### Question 5

The definition of e.m.f was very badly done by the majority of candidates despite the fact that last summer's paper asked for the definition of the volt. This is a straightforward definition as given in the specification and is something that all candidates are capable of learning. In determining the value of $r$, many candidates failed to realise that the p.d. across the internal resistance was 4 V. Having calculated the power dissipated across the external resistor many candidates went on to use this power to calculate the energy wasted in the battery, showing a lack of understanding of the question.

### Question 6

Another poorly answered definition. Many candidates talked about it being the energy needed to raise 1kg by 1 K, i.e. no mention of temperature and too many said "it was the heat needed……". It was clear that many candidates did not have any idea about the definition of internal energy and gave vague answers or tried to answer in terms of the first law of thermodynamics. Some candidates who referred to molecules and potential and kinetic energy lost a mark because of imprecise use of words. Instead of saying it was the sum or total of the two energies, they made statements such as, "it is the measurement of potential and kinetic……".

### Question 7

A heat pump deals with the transfer of thermal energy and so there was an expectation that candidates would refer to thermal energy or heat energy. Many candidates just talked about energy being transferred and so did not score the first mark. The diagram was often badly done with the most complex system of arrows sometimes being drawn. The majority of candidates were able to correctly identify the hot and cold reservoirs of a refrigerator.

### Question 8

This question was very badly done with many candidates just quoting definitions of the terms without actually applying them to the lamp. Apart from the entirely incorrect answers where candidates thought that $\Delta Q$ stood for charge, there was again evidence of students not reading the question properly and assuming that the question was about the first 60 seconds after the lamp was turned on, some giving values for the start of the operation and also for 60 seconds later. Some candidates ignored the values and talked about positive and negative values. Surprisingly few candidates realised the link between internal energy and temperature and so were unable to make the statement that $\Delta U$ was zero because the temperature was constant. Many candidates also thought that $\Delta W$ was zero because no mechanical work was done. Although quite a few candidates scored full marks for the last part of this question, many lost marks for an imprecise answer, such as not saying that the useful energy was the light or having identified the 4% as useful, then going on to say that most of the energy became thermal instead of 96% or the rest of the energy became thermal. Some candidates said that the rest of the energy was lost as heat, light and sound. Obviously not giving much thought to what they were writing.

- Candidates should be aware that repeating a question is not required and will not score marks, although sometimes making a link between parts of the question may do so; the key here is that something has to be added.
- Diagrams should always be labelled: examiners saw quite a number of diagrams with no labels and this always results in lost marks.
- Some candidates seem happy to use the exam paper as a free-form sketchpad, with parts of answers scattered throughout margins and "blank pages". It is worth emphasising that responses should be written on the response lines in the exam paper.
- Bullet points are very much encouraged, as used here.

## Topic A - Astrophysics

Definitions of luminosity and intensity in (a) were not as well known as examiners had expected, with luminosity often being referred to as "brightness" or "light emitted". Part (b) was well tackled by almost all candidates, showing that candidates were comfortable with these basic Astrophysics equations. Rather worryingly, some candidates simply did not bother to include any units for their answer and lost two marks here. Some very good answers were seen in part (c), although a vague reference to gravity did not gain credit. A number of responses erroneously discussed hydrostatic equilibrium, which did not gain marks. The Hertzsprung-Russell diagram (d) was tackled well, although the location of the Sun was often inaccurately plotted. The logarithmic nature of the scales on the diagram was not so well explained, with few candidates stating that the scales increased in multiples of a number. In (e), many candidates incorrectly stated that the baseline was 1AU or the "diameter of the Earth". Part (f) saw some confusion between radius and diameter, a number of candidates substituted a radius in km straight into the equation.

## Topic B – Solid Materials

In (a) a significant minority of candidates only referred to macroscopic differences and thus missed out on the two marks available for discussing movement of atoms and/or breaking of bonds. In (b), many candidates showed no knowledge that the area under a stress-strain graph gives energy density, with many misquoting " half stress x strain" for zero marks. Although almost all candidates could quote the correct formula for the Young modulus, not all took values from the linear part of the graph and powers of ten were frequently omitted. Most knew that the metal was tough but the non-linear part of the graph had to be referred to in order to justify plastic behaviour; reference to a "large area under the graph" was only given credit if this was done. Part (c) produced many good responses, with some confusion in the calculation, where an area of $2.69 \times 10^{-7}$ $m^2$ was often incorrectly equated to 0.3 mm. Properties of rubber were expected in (d), where confusion between elastic and plastic behaviour was sometimes seen by examiners. The final part of this question carried the instruction "use your graph" and some otherwise convincing answers scored nothing here because this was not done. Force components and moments produced a variety of responses in (e), from the very poor to the very good, as is often the case with the final question in a paper; it was clear that some candidates were not familiar with moments for systems of non-parallel forces.

## Topic C – Nuclear and Particle Physics

Marks for this topic are often quite polarised, with candidates either confidently answering questions, or having little understanding of the topic. Most candidates scored well in (a) with some knowledge well beyond the specification being shown at times. Comments about changing quark flavours had to be worded carefully: " weak interactions change flavour" did not gain a mark (this is not *always* the case), whereas " weak interactions *can* change flavour" did. One interesting answer referred to "intermediate vector bison", which presumably roam the plains mediating interactions. The calculations in (b) were mostly done well, but an occasional mistake was using $A \div 3$ instead of $A^{1/3}$ in (i). The alpha particle spectrum saw a number of beta spectra being drawn, together with a few very creative, but less successful, attempts. In (c), a number of candidates reversed their equation, but were still able to pick up marks for correct nucleon and proton numbers. A change of neutron to proton was frequently incorrectly given; "the nucleus loses a proton and gains a neutron" was insufficient to gain this mark: a change was required. Part (iii) saw a variety of approaches. The simplest of these (simply doubling the activity twice) was by far the most successful. PHY6 exponential equations met with mixed success, although some candidates multiplied the activity by $2^{2.09}$ and scored full marks. The process of pair production in (d) was often confused with matter-antimatter annihilation. Hadrons in (e) were, on the whole, well understood. Parts (i) and (ii) were very straightforward marks, but a bewildering array of quarks were seen; some which did not gain credit included calm, strong, strange*ness*, beauty and truth. As expected, only a minority of candidates gave both possible $\pi^0$ compositions.

## Topic D – Medical Physics

The differences in (a) required a comment on *each* source. "Ultrasound imaging uses reflection but X-ray imaging does not" did not gain a mark, needing some comment on attenuation or absorption of X-rays. There was some confusion with tracer studies with the patient occasionally being labelled as the source. In (b), a small minority incorrectly referred to elution cells in (ii), and many answers lacked depth in (iii), where the question asked candidates to *explain* advantages, as opposed to simply stating them. Most responses in (iv) discussed rotational beam therapy but few actually explained why this technique reduced the dose to the patient – this can be tried on www.**insidestory**.iop.org
The calculations in (d) were competently done with the omission of $10^6$ and contradictory units (*B* given in m $s^{-1}$) being errors sometimes seen by examiners. Part (e) was well answered with accurate graph plotting usually seen: many candidates scored very well here.

## 6733/2A

### Question 1A

Those candidates who had digital micrometers had no difficulties in the section. Those using analogue micrometers could sometimes misread the scale by 0.50 mm, e.g. 1.51 mm instead of 1.01 mm. Good candidates repeated their measurements and checked the thickness at several different places. When calculating the number of slides in the stack, a number of weaker candidates did not round the number of slides to an integer value.

There were a number of problems when the mass ratio was determined. Weaker candidates often placed the single slide at one end of the rule and the stack at the other end. The rule then had to be balanced off centre. This does not give the correct answer because the moment of the weight of the rule is included in the calculation. The better candidates clearly showed the centres of mass of the stack, the single slide and the metre rule on the diagram and then showed their measurements clearly to these points. Examiners expected measurements to be taken to the nearest mm, but a number of candidates took readings to cm precision.

Most candidates successfully set up the circuit. Typical mistakes made by the weaker candidates included;

- Incorrect units for the current e.g. a reading of 32 A rather than 32 mA.
- Wrong precision for the voltage e.g. 2.5 V rather than 2.45 V.
- An incorrect calculation of resistance e.g. 2.45 / 32 = 0.077 Ω.
- An inappropriate number of significant figures in the resistance calculation.
- Missing units for any of the three quantities.

Because error carried forward was allowed to the second resistance calculation, most candidates gained full marks in that section.

### Question 1B.

Most candidates drew the rule with the set square in the correct position to test that the rule was vertical. Whilst most candidates obtained 4 marks for the measurements in section (b), there were a number of elementary errors;

- Some candidates quoted times incorrectly, e.g. 0.0203 s.
- Values were not quoted to the correct precision e.g. 38 cm or 2 seconds.
- Some candidates only took a single measurement of each quantity.
- Units were sometimes omitted from one or both of the quantities.

Only the best candidates stated sensible precautions taken when determining *t*.
Most candidates could state the equation describing direct proportionality. The most common error in this section was the use of an inappropriate number of significant figures for the value of *k* and the omission of units from the value.
The second set of measurements had the same list of errors as those taken in part (b). Good candidates obtained a value of *k* here that was within 10% of the previous value of *k*.

When determining the percentage difference between the 2 values of *k*, candidates were not using the mean value of *k* as the denominator. To gain a mark for the comment candidates had to relate their percentage difference to likely experimental percentage uncertainty.

In the planning part of the experiment candidates had to carefully distinguish between the two distances involved, i.e. the distance the sphere travels down the slope ($s$) and the horizontal distance travelled after leaving the bench ($x$). Many good candidates obtained 5 marks in this section. Weaker candidates discussed plotting graphs of distance against time etc.

## 6733/2B

Many of the above comments which apply to 2A equally apply to 2B. A few additional points related to paper 2B are described below;

### Question 2A

The knife edge was placed on the block of wood so that the wire loop could be suspended from the metre rule. This would have made the position of the centre of mass relatively easy to determine. Quite a number of candidates still placed the loop of wire on top of the rule.

Those candidates who attempted to convert from $cm^3$ to $m^3$ often obtain an incorrect value for density because of an arithmetic error. It is quite acceptable in the practical exam for candidates to leave the density in $g/cm^3$.

### Question 2B.

This question was testing the relationship between the horizontal distance $x$ and $\sqrt{h}$. This was a more complicated equation than that required in 6733/2A, however in this group the equation was given whereas in group 1 candidates had to write the equation for themselves. However the more complicated form of the equation made the planning of the experiment more difficult to describe. The marks of this group were therefore adjusted to bring them in line with group 1.

## 6734/01

This was another straightforward paper, with plenty of simple calculations which most candidates performed capably. As in January, it was clear that they had been well prepared for the more predictable topics. However some of the questions requiring explanations explored less familiar areas of the specification, and the response to these was much more sharply differentiated.

### Question 1

Asked to add words to complete four simple word equations, most candidates were successful with at least three. However in the intensity equation some added numbers as well, giving "$4\pi$ (radius)$^2$ " rather than simply "area", whilst in the equation for accelerating voltage many answers were imprecise, suggesting merely "charge" rather than "electron charge".

### Question 2

This question asked how candidates would demonstrate that light waves can be polarised. Most of them knew all about the theory of the experiment, and were determined to tell us, but they frequently missed important practical detail, such as the source of the light or the means of observing it. Polaroids were often poorly named (e.g. "polarised sheets") or poorly understood. Many candidates failed to distinguish between the action of a polaroid on a light beam and the analogy of a rope passing through a slit, so that polaroids were often described as having slits, confused with diffraction gratings or drawn to look like metal grilles. We asked for a full description of what was observed, but whilst most people knew that two polaroids "at right angles" do not transmit light, few stated clearly that when one is rotated the intensity passes through maxima and minima at $90^0$ intervals. However almost all candidates knew why sound waves cannot be polarised.

### Question 3

Parts (a) and (b), about the kinematics of a wheel on a moving car, were well answered, with most candidates able to identify the directions of velocity and acceleration and to calculate the rotation period. Part (c) asked them to explain the effect of under-inflated tyres on the reading of the speedometer. The structuring of the question made it relatively easy, but even so it was pleasing to see how many candidates, who have often been criticised in the past for weak explanations, were able to give clearly reasoned answers. A few missed out by failing to realise that, even where only one mark is offered, the instruction "explain how" or "explain whether" requires a reason as well as a statement of the effect.

### Question 4

In part (a), most candidates displayed a good knowledge of stationary waves on a string and identified the wavelengths and frequencies successfully. A really good answer to the question why the end points of the string must be nodes would have married together properties of each ("the ends of the string cannot move, and nodes are points where there is no displacement") but this was rarely seen; fortunately for the candidates, the mark scheme was more generous and nearly everyone gained credit, with a significant number talking about destructive interference of the travelling waves.

Part (b), about electron waves in a hydrogen atom, proved harder. The last bit asked why waves with more nodes represent states of higher energy, and the preceding calculation of an electron's momentum from its de Broglie wavelength was intended to act as a hint. Most people, apart from occasional problems with units, performed the calculation successfully, but unfortunately they rarely took the hint. Only a few argued from more nodes to shorter wavelength and hence higher momentum and kinetic energy. The majority claimed that more nodes meant a higher frequency and hence a higher energy. Unfortunately this approach overstrains the analogy between waves on a string and de Broglie waves. Unlike the former, de Broglie waves do not have a constant velocity, so one cannot deduce higher frequency from shorter wavelength; it can really only be deduced from higher energy, making the argument circular. Those candidates who correctly linked higher energy to higher frequency by $E = hf$ were awarded a mark, but they were in a minority, most people confining themselves to vague remarks about electrons of higher frequency being somehow more vigorous. A few tried a different approach, arguing that since the orbits of high energy electrons were further from the nucleus there would be room for more nodes around the circumference.

**Question 5**

Part (a), which asked for a diagram of the waves inside the harbour, was disappointing. Many candidates seemed to have forgotten what they probably knew at GCSE: that with a wide gap, the waves travel essentially straight ahead with only limited diffraction at the edges. Many diagrams were poorly drawn, with no attempt to use a ruler or to space the wavefronts correctly. Other common errors included plane wavefronts extending well into the "shadow" region, wavefronts with sharp kinks at each end, and excessive amounts of diffraction. The mark scheme criterion of diffraction by less than $45^0$ was arbitrary and generous, but even so it was often exceeded, with many diagrams being more appropriate to a narrow than to a wide slit. A few excellent diagrams were seen, but they were very much the exception.

Part (b) was far better. Apart from a small minority who tried to use the formulae for uniform acceleration, most candidates knew how to calculate the amplitude, and a pleasing proportion got the correct answer. The majority scored at least two of the three marks for the displacement-time graph, the commonest error being the most elementary: a failure to label the displacement axis properly, with scale and unit.

**Question 6**

The first two parts saw candidates on familiar ground, with nearly everyone calculating the wavelength correctly, and the majority able to identify the effects of changing wavelength and slit separation on the gradient of the graph. However part (c), about coherence, was much more discriminating. Roughly half the candidates identified the essential property of coherence, that the phase relationship remains constant. Many others just said that the sources were "in phase", which was rather restrictive but, more importantly, might have been true only at one instant. A number simply said the sources must have the same frequency, which did not convince us that they understood the point. Only the very best candidates were able to explain why coherence was necessary for interference to be observed. Many thought that with incoherent sources superposition would not happen at all; others claimed that the waves would interfere destructively, whilst many more just said the results of superposition would be "random", without being precise enough to earn any of the marks offered.

**Question 7**

Part (a) described two light beams and asked candidates to explain in what senses it was correct and incorrect to say that the blue beam was the more energetic. It discriminated well between those who could marshal their knowledge to address the question as posed, and those who just used it as a trigger to write all they knew about the photoelectric effect. Nearly everyone pointed out that blue has a higher frequency than red, but they often failed to talk about photon energy, saying merely that the blue beam is more energetic "because $E = hf$". In explaining how the statement was incorrect they rarely stated precisely what the relative intensities implied about energy flow, although quite a few compared the numbers of photons in the beams.

Part (b) produced many good definitions of work function, although candidates often omitted the word "minimum", failed to say what was emitting the electron, or talked of electrons in the plural. Those who knew that $f_0 = \varphi/h$ calculated the threshold frequency without difficulty, but those starting from $E = hf - \varphi$ were less successful; instead of substituting $E = 0$ they searched around for a value and frequently used the intensity figure from the table in desperation!

**Question 8**

The first and last parts of this were familiar calculations for which candidates were well prepared. In part (a), most people identified the energy levels by a suitable calculation, but they often lost a mark by describing the transition as upwards instead of downwards. The recession velocity in part (c) was usually correct, too, although a significant minority used the wrong wavelength in the denominator of the calculation.

Candidates were much less comfortable explaining the absorption line in part (b). Many had no idea and described the production of an emission line instead, apparently unperturbed that the light emitted would have to be dark. Those who knew about absorption were often vague or wrong about where it occurred (the Earth's atmosphere was often mentioned) or about what happened when the light was subsequently reemitted. Many, too, forgot to refer back to the energy level diagram and specify the transition involved. Nevertheless, with the aid of the QOWC mark good candidates often obtained full credit.

## 6735/01

This paper worked well, allowing candidates to score highly in questions with a variety of foci. Most candidates were able to access all questions, with many showing themselves able to produce perceptive and lucid analyses of situations requiring a descriptive approach. Contrary to the usual pattern, calculation type problems were not tackled with markedly greater success than descriptive ones, though in the latter category the quality of answers was sometimes limited by the confusion of closely-related ideas or the inappropriate use of technical terms. Otherwise capable candidates were sometimes significantly let down by their inability to substitute fully in an inverse square law equation, or by a failure to couch a descriptive answer so that it lay within the prescribed context.

### Question 1

Part (a) was a straightforward exercise for the great majority who recognised the context and spotted that the period of the orbit would need to be identical to that of the Earth's rotation. The unit of ω was confidently and correctly stated by all but a very few.

Part (b) was harder, defeating a number of weaker candidates whose speculative jottings of equations in various re-arrangements failed to reveal an avenue to pursue. A common false start was a conviction that the acceleration of the satellite would automatically be 9.81 $ms^{-2}$. Those who did identify the need to pair up an equation peculiar to the gravitational context with a general one for circular motion took various routes, often showing sound instincts for selecting an approach that would minimise the amount of algebraic manipulation needed later. A good many survived the calculation stages to reach the correct value for the orbit height, while those who fell at the arithmetical fences were often able to attract 2 of the 4 marks for sensible Physics and good intent. An interesting feature of completed solutions was the range of values apparently believed possible, ranging from orbits that would skim the ground to those that would lie entirely outside our galaxy. Candidates need to be encouraged to consider the implications of the numerical answers they arrive at.

### Question 2

A significant minority were thrown off course here because they misunderstood the implications of the diagram, answering the first and last parts of this question as though it were an example of circular motion. This prompted force arrows that were perpendicular to the path rather than directly away from the gold nucleus, and later encouraged the belief that there was either constant acceleration or constant deceleration. Sadly, a few who probably intended to show the force directions correctly were sufficiently careless with alignment to squander the credit that careful drawing would have earned.

In part (ii) there were too many candidates who set out to use a Coulomb's Law expression, but took their eye off the 'inverse square' part, perhaps to concentrate on the charge values. As a result there were a great many instances where the denominator in their substitution did not have a distance value squared, a fundamental error that barred access to any marks. In the numerator there was often confusion over the maths of the charge values, with the '2' and '79' values mistaken for charge magnitudes in themselves, rather than as multiplying factors of the electronic charge. Some leeway was allowed here at the outset, but the intention to find the product of charges had to be communicated. One common error was to confuse expressions for field and force so that only a single charge value was used.

Ultimately a good number did take enough care over substitution to reach the correct numerical answer, but nowhere near as many as should have been able to.

**Question 3**

This question saw some disappointing answers from otherwise strong candidates in part (a), yet conversely some very thorough analyses of the situations in parts (b) and (c) from students whose performance elsewhere was less promising.

Initial judgements at a (i) were mostly correct and probably instinctive for many candidates. However, justification for this decision, sought specifically with reference to energy, elicited too many responses based solely on ideas of charge. It seems likely that this was simply through over-hasty reading of the question, but in some cases it was clear that the two were thought to have some inherent physical equivalence. Although a convincing argument could be constructed from a charge-based approach, it was not what the question asked for, and the absence of any reference to energy, or use of a relevant energy equation, made two of the five possible marks inaccessible. Another common weakness was the vague assertion that 'V is constant'. This means simply that it is invariant over time, not that the values across the capacitor combinations will be the same, so did not attract the credit for that specific, key recognition.

Alongside the inability to discriminate effectively between charge and energy, there was also the tendency in some to confuse charge and capacitance itself. It was not uncommon, for example, to read that 'capacitance increases with voltage', or to have a candidate assert that a quoted capacitor combination equation gave the value of charge stored. An unfortunate few compounded their problems by losing themselves in the maze of their reasoning and arriving at precisely the opposite conclusion to the one they had set out to reach.

In parts (b) and (c) the examiners were looking firstly for a visual observation, with the newly-introduced, large-value resistor affecting in turn either the discharging or charging process. This observation then needed support from a brief, relevant statement about the changed circuit behaviour.

Written in the context of the specification content for the module, straightforward, qualitative answers in terms of energy or charge were expected rather than answers springing from an appreciation of time constants. In fact a whole range of analytical approaches was adopted, offering an insight into students' ability to think through a problem from a variety of perspectives. Of these, the impact of increased resistance on the time constant was the cornerstone of many of the more persuasive arguments. A great many answers were impressively detailed, making pleasing reading and rapidly earning full credit.

**Question 4**

The need for a further explanatory answer at part (i) here might have dismayed a few, but the wording of the question gave clear direction as to where to find several of the marks available. Notwithstanding this, there were a good few answers whose language and logic was impenetrable, and far too many that neglected to make reference to even a single turning moment, despite the specific instruction.

Identifying the underlying nature of the interaction itself was problematic for a sizeable minority. Belief that the mercury became electrostatically charged and repelled a like-charged wire was almost as common as a suspicion that electromagnetic induction was giving rise to a current/emf/force 'opposing the change', while others opted to press Newton's third law into inappropriate service. Imagined interactions of electric and magnetic fields or some interference phenomenon were proposed by a few. Even for those that did indicate the relevance of Fleming's Left Hand Rule, the kindly-chosen spatial relationship between field and current directions as often as not led to suggestions of forces to the left or out of the page, or threw up new conflicts when clockwise and anticlockwise terminology was introduced later.

Where a force in the plane of the page was decided upon, it was not always interpreted successfully in terms of a moment about P. Only in the rarest of cases did the argument develop to the point where the displacing moment was understood to disappear in the absence of current flow once the wire left the mercury, while the fact that the moment due to the wire's weight then returned it towards the vertical was almost entirely overlooked.

Having struggled to score highly in the first part of the question, though, most candidates found the last two sections really very straightforward, even if the application of the equations did require a little care to identify the relevant length values. Far more candidates thus gained the full 5 marks for these calculation parts than were able to secure them through their earlier descriptions.

A small number of candidates, having failed to get the first calculation stage correct, persisted in working with the force value they had generated despite it lying well outside the range of values that would round to the one given. Candidates must be alert to the key 'show that……. is about' phraseology that signifies that a value consistent with that quoted will be needed later.

### Question 5

The use of Fleming's Right Hand Rule to deduce the direction of the induced current was the essential initial step towards the first mark here, but by asking for the resulting polarity the question was made far more searching. It was clear from the additional labelling of current directions on a few scripts that most candidates believe that current flows from the positive terminal to the negative one within a supply, rather than in the opposite sense. This is a subtle, counter-intuitive point that centres could usefully emphasise.

The explanation required in part (ii) was relatively obvious, but some answers were disappointingly vague. A significant oversight for many was the failure to account successfully for the invariance of the emf value, with 'constant rotation' a popular but inadequate point of reference.

The calculation exercise at part (iii) produced some interesting answers. Common weaknesses were the failure to include an area term at all, or an inability to recall the formula for the area of a circle; confusion of radius with diameter or the introduction of a circumferential term being most popular. The former lapse led to the frequently-seen but entirely incorrect 1.12s. More resourceful in their drive to simplify expressions, a few students correctly included an 'A' term in their introductory equation, then simply cancelled it out because the question stem suggested that the hub area was negligible. This invalid manoeuvre took them to the same numerical destination as the first group. A further problem sprang from the determination of candidates to introduce a value for 'N'. This resulted in plenty of evidence of spoke-counting on diagrams and irrelevant factors of 24 appearing in many calculations.

An alternative route to a correct answer through determination of spoke velocity was adopted by a small minority, but a vital factor of 2 was usually overlooked because of a failure to realise that the rim velocity would be double the mean spoke velocity.

In the final three steps, relatively easy marks should have been accessible to candidates of all abilities, but many lost them unnecessarily. Failure to respond to the second of the twin strands of 'state and explain' was a common oversight, despite the provision of three answer lines. Where assertions about the effect on the emf were correct, promising explanations were often undermined, if not toppled altogether, by the confusion of terminology. Vertical, horizontal, perpendicular and parallel were all muddled quite frequently, as were flux, flux density and flux linkage. Many candidates suggested in the very last part that there would be 'no change' when they probably meant to say that there was 'no emf'. A significant error of Physics was evident in the thinking of a minority of students who seemed to believe that there would be no emf unless the wheel was rotating in a plane exactly perpendicular to the field direction.

## 6735/2

In general the papers followed the pattern of previous years and the balance of marks was spread across the different skill areas to be tested. In both groups, Question B scored more highly than the other two. This was probably because of the straightforward circuits, which made the subsequent readings easier to take than in some similar questions in the past.

### Group A

### Question 1A

The timings were generally well done, with most candidates taking the necessary number of oscillations with suitable repeats. A significant number of candidates lost the mark for the calculation of the constant *A* as they either gave it the wrong unit or, more commonly, no unit at all. It is important that candidates realise that nearly all quantities have a unit and that they should always work out the correct one from the equation given.

Finding the mass of an object by using the principle of moments has been asked several times before and was correctly done by many candidates. However, the standard of diagrams was generally disappointing. Arrows should be drawn to end exactly where they are indicating a measurement, in particular on the centres of mass of the rule and the centre of the 50g mass. Some candidates failed to pivot the rule at the previously determined centre of mass and so scored very few marks.

A surprising number of errors occurred in the calculation of density, mainly due to carelessness with units and significant figures, although some candidates actually used the wrong formula. Very few candidates got the mark for suggesting that as the volume of the pendulum bob had only been measured to 1 (or possibly 2) s.f., the density could only be quoted to the same precision. Most candidates attempted some percentage uncertainty calculation, but then did not relate this to the density.

### Question 1B

Although most candidates got a good set of readings, evaluating $C^{-2}$ and $I^{-2}$ produced unit and power of 10 problems. Another common mistake was to round some of the values down to just 1 s.f., so much as to render the data almost worthless.

Graph work was generally disappointing, with the biggest problem being the choice of scales. There is usually an obvious scale for the numbers generated so that the data points fill at least half the page. Most candidates who chose an awkward scale then mis-plotted points or calculated the gradient incorrectly, thereby losing a significant number of marks.

Because of the powers of 10, the calculation of V proved tricky. Many candidates obtained values for *V* of kV, presumably without realising that this was unlikely with a 12 V supply! The slightly cleverer candidates got a sensible value by sleight of hand - no credit was given for this unless all the working was clearly correct.

Most candidates were able to deduce that the capacitors had to be connected in series, yielding a value of 1.5 μF. However, many lost the final mark by giving the value as 1.50 μF (3 s.f.) when the values of the capacitors were only given to 2 s.f.

**Question 1C**

Most candidates were able to draw a correct circuit, but marks were lost through lack of detail in the description. Candidates were expected to say that they would vary the current, measure $I$ and $V$ and then calculate $R$ from $R = V/I$. The sketch of the variation of $R$ with $V$ was very poorly done, with a majority of candidates only getting 1 mark for showing that the resistance increased. Very few realised that the lamp would still have a resistance when $V = 0$, or showed that $R = 6\ \Omega$ when $V = 12$ V.

Most candidates were able to get the correct logarithmic equation and expressed their values of $\ln P$ and $\ln R$ to 3 or 4 sf. However, far too many chose a graph scale that was much too small because they tried to include the origin, and did not label the axes correctly as $\ln(P/\text{W})$ and $\ln(R/\Omega)$. This has been commented on in Examiners' Reports virtually every year, but many Centres appear not to be teaching this correctly. Many candidates found the gradient by taking points from the table. This practice is to be discouraged as often the points do not actually lie on the line of best fit or it gives rise to a triangle that is too small.

Part (d) asked candidates to describe *and explain* how they would find the resistance of the filament at room temperature. Those who said that they would use an ohmmeter (which was not many) rarely said that this was to minimise the current and prevent heating. Those choosing to use a voltmeter-ammeter method needed to say that they would include a large series resistance for the same reason.

**Group B**

**Question 2A**

Finding the mass of a rule by the method of moments is a reasonably easy task and most candidates were able to do this well, although the same comments apply here as in Group 1. Candidates should be able to communicate using a good diagram that shows clearly their experimental arrangement with appropriately clear measurements. The width and thickness of the rule were usually measured correctly and the average found from repeats, with most candidates getting the density calculation right.

The timing of the oscillations was well done, with very many candidates getting results very close to the accepted values. As in Group 1, very few candidates quoted a unit for the constant $A$ and consequently lost this mark, whatever they did with the calculation. A common error was the failure to convert $h$ into metres so that it was homogenous with $g$. Substitution using SI units cause candidates confusion, invariably leading to wrong answers.

The last part expected a discussion of the uncertainties in terms of the relative magnitudes of the two values for $T$ and $h$. This was done poorly, with many candidates discussing either $T$ or $h$, but not *both*.

**Question 2B**

Hardly any candidates needed assistance setting up the circuit and most got good marks for accurate measurements, although a few connected the resistors in parallel. As in Group 1, units and powers of 10 proved a big stumbling block in the table and invariably led to incorrect values for the capacitance.

Again, graph work was generally disappointing with candidates choosing poor scales and 'forcing' a best fit line through the origin. This is not always appropriate, as here, and leads to lost marks as the line no longer fits the points. The gradient calculation proved fairly easy but keeping control of the powers of 10 did not. Only 2 s.f. was allowed for the final value for the capacitance as the data for the resistances was to 2 s.f. As in Group 1, most candidates missed this point, otherwise the question was very well done.

**Question 2C**

Magnetic field diagrams – like the moments diagram in Question A – are an essential means of communicating information and should be neatly and carefully drawn. Candidates appeared to be familiar with this type of magnet and diagrams were mostly good.

A good diagram in part (b) could score three of the seven marks, but few managed this. Candidates should remember to say what they would vary as part of their description of the method. Many candidates described taking a measurement but did not go on to say that they would then take a range of measurements. The need to 'tare' the balance was widely mentioned but few candidates considered using vernier callipers to measure the gap or the necessity to have a wooden stand and clamp. Although unfamiliar with the actual experiment, few candidates were unable to score at least some marks here.

As in Group 1, the units in the table should be $\ln(x/\text{mm})$ and $\ln(F/\text{mN})$ and only scored the mark if expressed in this form. Again, the origin was *not* needed on the graph and should not be included unless the intercept is called for. Very many graphs showed inappropriate scales giving an almost vertical line of plots and consequently poor gradient calculations. A significant number of candidates omitted the negative sign for their value of the constant $b$, or incorrectly assigned units to it.

**Summary**

To score more marks candidates should

- be encouraged to put more time and effort into diagrams - neatness and accuracy are expected;
- improve their graph work - inappropriate scales and careless plotting lost a lot of marks this year;
- consider units more carefully, especially in unfamiliar calculated quantities and in the expressions for logarithmic quantities;
- consider the appropriate use of significant figures and base these on the precision of the data given.

## 6736/01

By recent standards this was a challenging Synoptic paper and a significant minority of candidates crossed out an incorrect or incomplete response and wrote their answer elsewhere in the paper or on a separate sheet. A fair number of part-questions remained blank but there were few candidates who failed to reach the end of the paper.

### Question 1

The passage, though describing a familiar device, included some unfamiliar physics. The questions relating to it included a number that involved interpreting the words of the passage, e.g. part (a)(ii), and several that required little more than quoting from it. The calculations in parts (d)(ii), (f) and (g)(i) discriminated only at the lower end where handling powers of ten or finding the correct units proved awkward. The algebra required in dealing with the deflection of a charged particle in an electric field – part (e)(i) – was generally well done.

Three questions deserve special mention: in part (b)(i) candidates often tried to identify the critical temperature on the graph by adding a vertical line close to 374 on the horizontal axis and a sizable minority chose – wrongly – to write gas above and liquid below the curve. The unusual demand in part (d)(i) to show two statements to be 'consistent' led to a myriad of responses no two of which were identical while the requirement in part (g)(ii) to introduce a value for normal atmospheric pressure led to values over an enormous range despite the statement in the Specification under General Requirements that candidates should appreciate 'the order of magnitude of common physical quantities'.

### Question 2

That the graph in part (a) covered less than one half-life period caused considerable problems and led to this discriminating well while not, except in (ii), requiring the use of any exponential mathematics (it was also noticeably more difficult than the testing of an inverse relationship in last June's paper). In (i) the straightforward method of calculating values of $A_1/A_2$ at equal intervals of $t$ was not often seen but a range of correct approaches gained credit. Those hoping to plot a graph of $\ln A$ against $t$ gained marks for method but could not use it successfully. The idea in (iii) that values of $A$ and $N$ for a source were needed was only appreciated by the best candidates. An intriguing variety of suggestions, mostly valid, were offered in part (b)(ii) and in (c)(ii) the lack of a unit for the wavelength often lost the last mark.

### Question 3

The experimental description in part (a)(i) was more routine than that in last June's paper, though some candidates were led astray by the given value of approximately 10 $\Omega\ m^{-1}$ for the wire's resistance per unit length, taking the value to be precise. Where an ohmmeter was used it was often incorrectly shown with a power supply in series. In part (b) there was some confusion between half-life $t_{½} = RC\ln 2$ and time constant $\tau = RC$, but this did not prevent candidates from showing that either was independent of both $d$ and $A$. The attempt to examine the concept that capacitors in parallel have the same p.d. across each in part (b)(iii) did not work, most candidates choosing to discuss the situation in terms of charges or, worse, in terms of current (this confusion mirrored that of last June's question about cutting a slinky in half).

**Question 4**

It was not anticipated in part (a) that candidates would be familiar with the precise nature of electromagnetic waves but it was none-the-less disappointing that many referred to the vibration of particles rather than fields. The responses to (ii) might have been better had the Examiner asked for candidates to draw a coil on the diagram instead of asking them to describe a three-dimensional situation in words. The homogeneity exercise – part (b)(i) – was more complex than that in last June's paper, involving as it did the unit for each of W, $F\ m^{-1}$ and $N\ C^{-1}$ or $V\ m^{-1}$. There was some evidence of rushing in (iii) where too often the use of the inverse square rule was missed. The familiar two-source superposition diagram in part (c) mirrored the microwave oven question in last June's paper but it was perhaps unfortunate that the two paths that needed measuring here were each a whole number of wavelengths. Very few candidates recognised that the line directly between the two in-phase sources contained a series of nodes and antinodes separated by $\lambda/2$.

## 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 | 21 |

### 6732

| Grade | Max. Mark | A | B | C | D | E |
|---|---|---|---|---|---|---|
| Uniform boundary mark | 90 | 72 | 63 | 54 | 45 | 36 |
| Raw boundary mark | 60 | 41 | 36 | 31 | 27 | 23 |

### 6733

| Grade | Max. Mark | A | B | C | D | E |
|---|---|---|---|---|---|---|
| Uniform boundary mark | 120 | 96 | 84 | 72 | 60 | 48 |
| Raw boundary mark | 96 | 70 | 62 | 54 | 46 | 39 |

### 6734

| Grade | Max. Mark | A | B | C | D | E |
|---|---|---|---|---|---|---|
| Uniform boundary mark | 90 | 72 | 63 | 54 | 45 | 36 |
| Raw boundary mark | 60 | 45 | 41 | 37 | 33 | 30 |

### 6735

| Grade | Max. Mark | A | B | C | D | E |
|---|---|---|---|---|---|---|
| Uniform boundary mark | 90 | 72 | 63 | 54 | 45 | 36 |
| Raw boundary mark | 96 | 68 | 62 | 57 | 52 | 47 |

### 6736

| Grade | Max. Mark | A | B | C | D | E |
|---|---|---|---|---|---|---|
| Uniform boundary mark | 120 | 96 | 84 | 72 | 60 | 48 |
| Raw boundary mark | 80 | 47 | 42 | 37 | 33 | 29 |

Further copies of this publication are available from
Edexcel Publications, Adamsway, Mansfield, Notts, NG18 4FN

Telephone 01623 467467
Fax 01623 450481

Email publications@linneydirect.com

Order Code 019017 June 2007

For more information on Edexcel qualifications, please visit www.edexcel.org.uk/qualifications
Alternatively, you can contact Customer Services at www.edexcel.org.uk/ask or on 0870 240 9800

Edexcel Limited. Registered in England and Wales no.4496750
Registered Office: One90 High Holborn, London, WC1V 7BH