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Examiners' Report
June 2013

GCE Physics 6PH04 01

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June 2013

Publications Code UA036635

Introduction

This is the eighth time that unit 4 of the specification has been examined. The assessment structure mirrors that of other units in the specification, consisting of 10 multiple choice questions, a number of short answer questions and some longer, less structured questions. As an A2 assessment unit synoptic elements are incorporated into this paper. There is a significant link to the mechanics of unit 1 and that is where the synoptic elements tend to come from.

Candidates again found this paper more accessible and were able to attempt all of the questions knowing the topic of physics that was being examined. Even where candidates failed to score marks due to lack of detail or the use of imprecise language, their answers were still relevant to the question being asked. Candidates were able to apply their knowledge to a variety of styles of examination questions. Since this is an A2 paper, candidates should show progression from AS and this is shown in the more difficult content of the A2 specification and also in the demands of the questions. In this paper, candidates were required to add to diagrams or draw circuits in several questions. Marks were often lost due to poorly drawn diagrams. Candidates should be encouraged to use a ruler whenever possible such as in drawing the electric field between parallel plates (Question 15). Full marks could be obtained for a free-hand drawing but candidates who used a ruler were more likely to draw straight, parallel and equispaced lines. In Question 13(c) many of the candidates realised that because of the increased proton number the force acting on the alpha particle would be greater and so the paths would be different. After an initial separation of the particle paths, some candidates then went on to draw the ends of the particle paths as parallel lines which is incorrect.

We often ask candidates to interpret the paths of particles but this paper showed that they need more practise in drawing the paths. There is still a need for candidates to make more effort to learn definitions, in this case conservation of momentum. Candidates need to read the questions carefully and think about the context and also remind themselves of the context as they work through the question. In the main, calculations were well done although many struggled with the current calculation in Question 14(c)(ii). Candidates need to remember that at A2 level, some of the questions can have a synoptic element and in this unit that is most likely to be from the AS mechanics. Question 15 required the candidates to realise that there were two equal and opposite forces, and in Question 17 to calculate an initial speed using a given stopping distance and time.

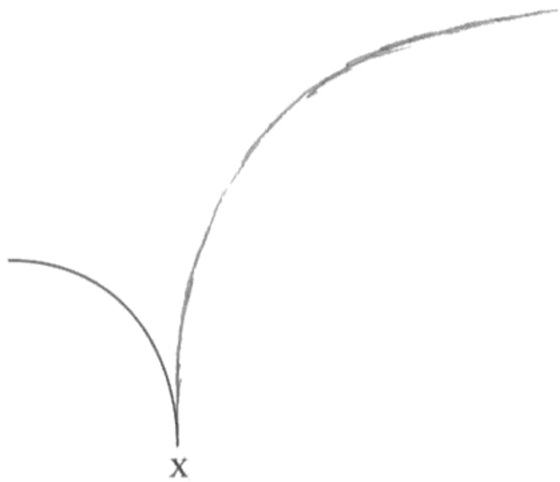
The multiple choice questions in Section A were on the whole more straightforward than in previous papers with A grade candidates often scoring 10 marks and E grade candidates scoring about 7 marks.

Question	Topic	% correct	Most common incorrect response
1	Nuclear structure	94	-
2	Magnetic force on a charged particle	77	A
3	Graphical variation of electric field strength and plate separation.	82	D
4	Angular velocity	94	-
5	Energy equations	89	C
6	Conversion of MeV/c^2 to kg	82	D
7	Identification of particle tracks	75	D
8	Centripetal force	87	D
9	Cyclotron	61	B
10	Use of de Broglie wavelength	88	D

Question 11

This question was fairly straightforward with the most common marks being 2 and 3. Most candidates got the direction correct but only about half drew a larger radius. The most common error in explaining the direction was to say that the anti-helium was negative without making the comparison to the proton being positive. A fair number of candidates quoted the formula $r = p/BQ$ but few went on to calculate the factor of two. There were several errors in reading the question such as assuming that the path of an anti-proton was asked for or not starting the path at X. Others assumed that the particles arrive together and annihilated since they were matter and antimatter.

The diagram represents the path of a proton through a magnetic field starting at point X.



Add to the diagram the path of an anti-helium 4 nucleus also starting at point X and initially travelling at the same velocity as the proton.

Explain any differences between the paths.

(5)

There are several differences between the 2 paths due to the Make up of each Item as the anti helium 4 Nucleus is 4 times larger than the proton it takes longer for it to be deflected at a right angle. Also the directions are opposite as the antiprotons have an opposite charge to a proton there fore the magnetic fields sends it ~~oppos~~ the ~~nucleus~~ negatively charged Nucleus in the opposite direction to the positively charged proton

ResultsPlus
Examiner Comments

This candidate has drawn the path correctly, scoring both diagram marks, also identifying that the charges are opposite hence the direction. Although the mass is identified as being 4 times bigger the candidate had not referred to the equation which determines the radius of a particle in a magnetic field.

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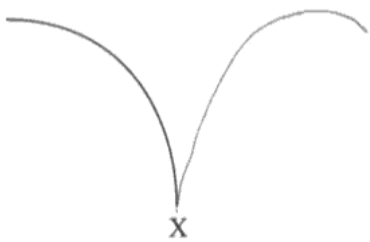
Examiner Tip

This is a descriptive type question where an explanation is needed in terms of an equation. Always think if there is an equation that might help to answer the question.

The diagram represents the path of a proton through a magnetic field starting at point X.



Add to the diagram the path of an anti-helium 4 nucleus also starting at point X and initially travelling at the same velocity as the proton.

Explain any differences between the paths.

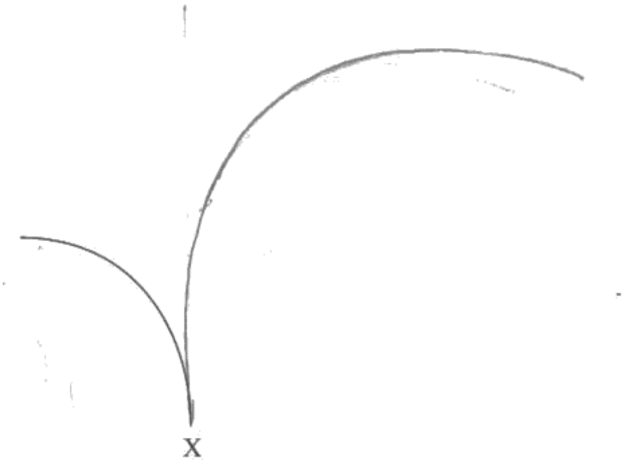
(5)

Since it is the anti-particle of the proton, it will go a different direction compare to proton, even they have the same mass, but they have a opposite charge so it goes the opposite direction.

ResultsPlus
Examiner Comments

A common answer that scored 2 marks for the direction of the path and opposite charge. This candidate acknowledged that the drawing is an anti-proton.

The diagram represents the path of a proton through a magnetic field starting at point X.



Add to the diagram the path of an anti-helium 4 nucleus also starting at point X and initially travelling at the same velocity as the proton.

Explain any differences between the paths.

(5)

The proton has a mass of 1u, and a charge of +1, whereas the nucleus has a mass of 4u, and has -2 charge, because (2x-1) + (2x0) = -2. ~~lack of charge means it is not.~~ This means it has a much greater mass and double the charge, but v is constant, so by $r = \frac{p}{BQ}$, the nucleus has $r = \frac{4mv}{B2Q}$, so the radius of the path is greater, and in the oppisite direction due to the opposite charges.

ResultsPlus
Examiner Comments

This candidate came so close to scoring all 5 marks. All of the detail is there but instead of saying the radius is twice as big, merely says that it is greater and so does not get the 5th mark.

Question 12 (a)

Most candidates correctly identified at least 3 of the strange mesons. The catch was not to include the strange anti-strange meson and quite a few candidates did include it. However, many candidates scored well on this question with over 60% of candidates scoring 4 or 5 marks. The most common error was not in the selection of the mesons but in working out the charge and strangeness of these mesons. The properties of the quarks will always be given to candidates but they are expected to be able to work out, from the data given, the properties of an antiparticle. The other common mistakes were to include *e* in the charge boxes when it is provided in the heading and to omit the + sign from positive values of charge and strangeness.

(a) From the list select the four strange mesons and state the charge and strangeness of each of them.

(4)

Meson	Charge/*e*	Strangeness
$u\bar{s}$	$+\frac{3}{3}$	+1
$d\bar{s}$	0	+1
$s\bar{s}$	0	0
$s\bar{d}$	0	−1

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Examiner Comments

The strange anti-strange meson has been included and there is an error in finding the charge of the up antistrange quark. This scored 2 marks.

Meson	Charge/*e*	Strangeness
$d\bar{s}$	0	1
$u\bar{s}$	1	1
$s\bar{u}$	−1	−1
$s\bar{d}$	0	−1

ResultsPlus
Examiner Comments

The + signs have been omitted but everything else was correct. There was a loss of 1 mark only so this scored 3 marks.

ResultsPlus
Examiner Tip

In particle physics all non zero values should have either a + or a - sign in front of them. It is not assumed that 1 means +1.

(a) From the list select the four strange mesons and state the charge and strangeness of each of them.

(4)

Meson	Charge/*e*	Strangeness
$u\bar{s}$	+1	+1
$d\bar{s}$	0	+1
$s\bar{u}$	−1	−1
$s\bar{d}$	0	−1

ResultsPlus

Examiner Comments

An example of a 4 mark answer.

Question 12 (b)

50% of candidates scored the mark with the most popular response being mass followed by lifetime and then decay products. Because this was an unusual question we did allow candidates who gave more than one option, some of which were wrong but which did include a correct response, to score the mark. This is not usual policy and candidates should be discouraged from writing a list when only one factor is required. Quite a few candidates missed the point of the question and wrote at length about how the particle could not be detected in a bubble chamber.

(b) Some of the mesons in the list have zero charge and zero strangeness.

Suggest what might distinguish these mesons from each other.

(1)

In a cloud chamber or bubble chamber the neutral particles will not leave a track as they are not charged

ResultsPlus

Examiner Comments

A common response which doesn't answer the question.

(b) Some of the mesons in the list have zero charge and zero strangeness.

$-\frac{1}{3}+(+\frac{1}{3})=0$

Suggest what might distinguish these mesons from each other.

(1)

If the meson contains a down quark and a strange quark then likely to be zero charge

ResultsPlus

Examiner Comments

Another wrong answer that doesn't answer the question but explains why there is zero charge.

ResultsPlus

Examiner Tip

Don't waste time writing an answer that doesn't answer the question.

Question 13 (a)

Considering how many times this has been examined in the past, it is always surprising how many candidates do not score well with only 56% scoring both marks. In (i) we were looking for an answer which told us that the particle were undeflected or went straight through. There were many imprecise answers such as 'the other side of the foil' or 'in a straight line'. Others tried to use angles e.g. 0 -10º without defining where they were measuring the angles from. Poor answers in (ii) were 'the atom has a lot of free space' or 'there is a lot of space in an atom'.

Question 13 (b)

Only 23% of candidates scored both marks; the most common error was to say that all of the charge is in the nucleus. Also, although the nucleus does have a high density, just saying that the nucleus is dense is not the same as saying that all of the mass of the atom is in the nucleus.

(b) Some α-particles are scattered through 180°.

State what this suggests about the structure of the atoms in the metal foil.

(2)

This suggests that the atoms contain a small, dense and (positively) charged center.

ResultsPlus
Examiner Comments

Saying that the nucleus is small and dense does not tell us that most of the mass of the atom is in the nucleus.

(b) Some α-particles are scattered through 180°.

State what this suggests about the structure of the atoms in the metal foil.

(2)

The mass of a nucleus must be concentrated into a very small nucleus that also must be positively charged in order to supply a repulsive force large enough to scatter the positively charged alpha particles through 180°.

ResultsPlus
Examiner Comments

A slip which lost a mark. I am sure the candidate meant to say that the mass of the atom is concentrated into......... This scored 1 mark for the nucleus being charged.

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Examiner Tip

Read your answer!

(b) Some α-particles are scattered through 180°.

State what this suggests about the structure of the atoms in the metal foil.

(2)

• Nucleus is positive as it deflected some positive alpha particles, positive will repel positive so even though a very small percentage some were deflected backwards.

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Examiner Comments

This scored no marks. Rutherford's experiment established that the nucleus was charged not that it was positive. He repeated the experiment with beta particles and got similar results. We treat as neutral references to positive but the word charge/ charged must be used to score the mark.

Question 13 (c)

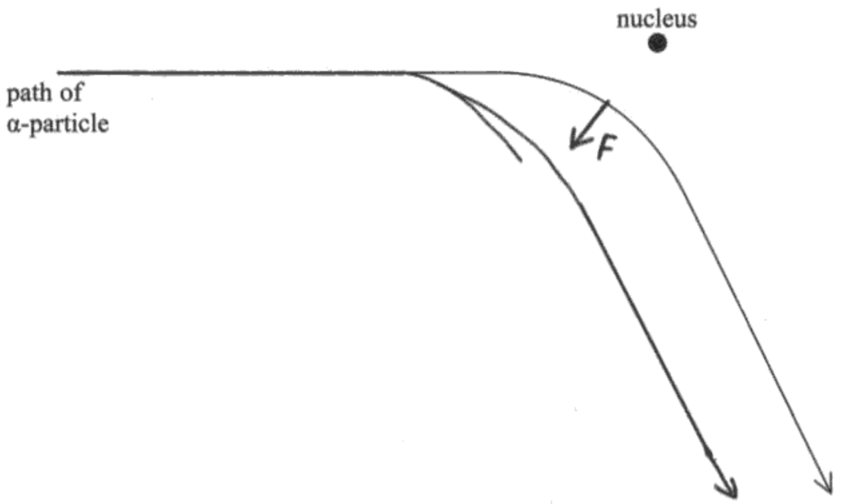
Most candidates scored reasonably well in this section with 55% scoring 4 or 5 marks but careless errors and poor diagrams lost marks.

(i) Although many did score the mark for naming the force, the most common wrong answer was 'repulsion/repulsive' followed by strong nuclear force (which is not on the specification).

(ii) Too often the force was drawn acting on the nucleus and not on the alpha particle.

(iii) Again, candidates need to read the question which asked them to draw a path of an alpha particle starting at the same place as the one in the diagram. Many didn't do this. Many candidates did not think about the overall result and that a metal with a greater proton number would result in a greater deflection. Many candidates started their deflection too late and ended up with paths that did not diverge.

(c) The diagram shows the path of an α-particle passing near to a single nucleus in the metal foil.



(i) Name the force that causes the deflection of the α-particle.

(1)

electronic repulsion

(ii) On the diagram, draw an arrow to show the direction of the force acting on the α-particle at the point where the force is a maximum. Label the force F.

(2)

(iii) The foil is replaced by a metal of greater proton number.

Draw the path of an α-particle that has the same initial starting point and velocity as the one drawn in the diagram.

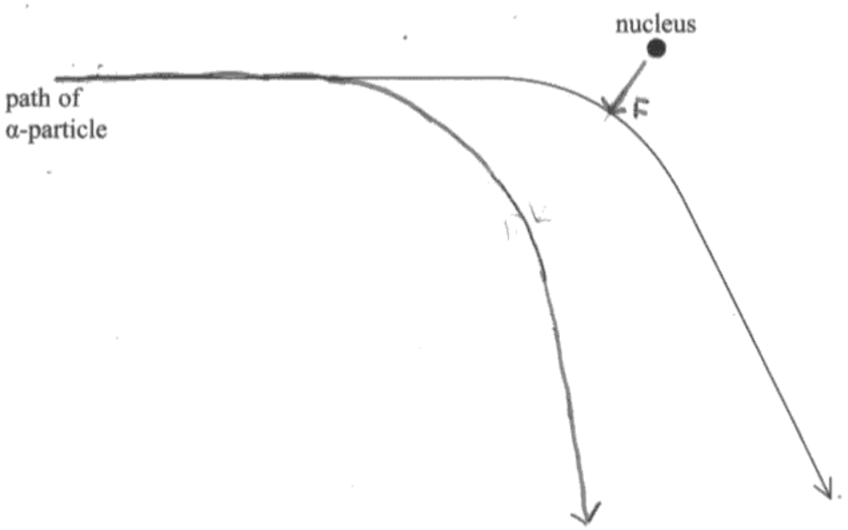
(2)

ResultsPlus

Examiner Comments

This scored the marks for the force arrow but the paths of the particles are parallel instead of diverging so a mark was lost here.

(c) The diagram shows the path of an α-particle passing near to a single nucleus in the metal foil.



(i) Name the force that causes the deflection of the α-particle.

(1)

electrostatic

(ii) On the diagram, draw an arrow to show the direction of the force acting on the α-particle at the point where the force is a maximum. Label the force F.

(2)

(iii) The foil is replaced by a metal of greater proton number.

Draw the path of an α-particle that has the same initial starting point and velocity as the one drawn in the diagram.

(2)

ResultsPlus
Examiner Comments

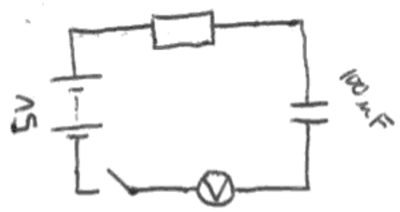
This scores the marks for the path but the force is acting on the nucleus so a mark is lost here.

Question 14 (a) (i)

There were some very good circuits, with clear standard symbols, using rulers. However, there were also a lot of sloppily drawn diagrams with components, often the switch, missing despite the question telling them which components to use. A common error was to draw a charging /discharging circuit with a two way switch where the capacitor charged without the resistor being included. It is expected that at A2 candidates know the standard symbols but we did accept some non-standard symbols if they were labelled. A circle with a Ω in it is a symbol for an ohmmeter and so this is not acceptable as a symbol for a resistor.

(a) (i) Draw a diagram of the circuit he should use.

(2)

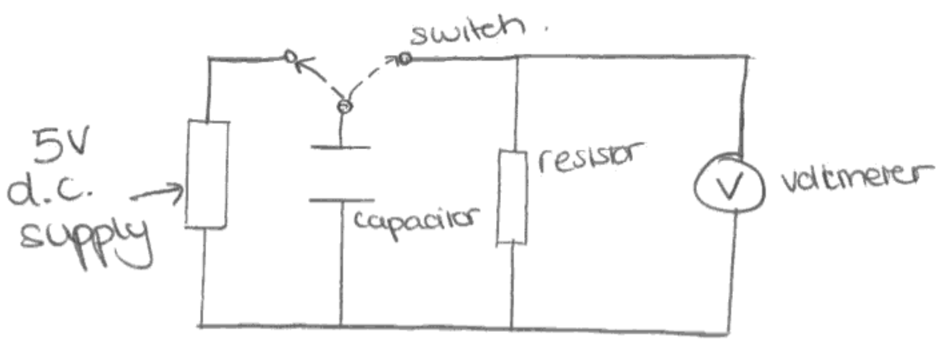


ResultsPlus
Examiner Comments

There is an expectation that at A2 candidates know that voltmeters are connected in parallel.

(a) (i) Draw a diagram of the circuit he should use.

(2)



ResultsPlus
Examiner Comments

A common wrong answer. A circuit which many candidates are familiar with but not appropriate for this question.
It did score the mark for the voltmeter being in parallel.

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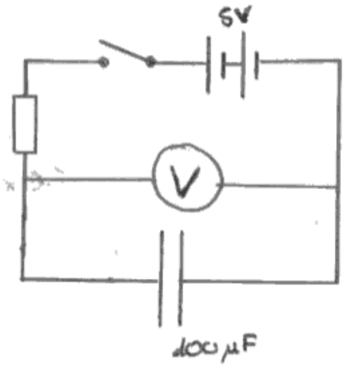
Examiner Tip

The question was about how the potential difference across the capacitor varied as it was charging. The circuit drawn would have led to the capacitor being instantly charged.

(a) (i) Draw a diagram of the circuit he should use.

(2)



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Examiner Comments

An example of a circuit scoring both marks.

Question 14 (a) (ii)

A very large number of candidates scored nothing here because they think dataloggers are more accurate or precise and many thought they were useful in this case because they eliminate human reaction time when stopping and starting a stopwatch, which is not the case in this type of experiment. A common given advantage was that it would plot the graph which somehow implies that humans can't plot a graph. Credit was given for it plots the graph automatically. Some candidates seem to think that a datalogger records readings continuously rather than at short time intervals. Many of the candidates have misconceptions about dataloggers.

Question 14 (b) (c)

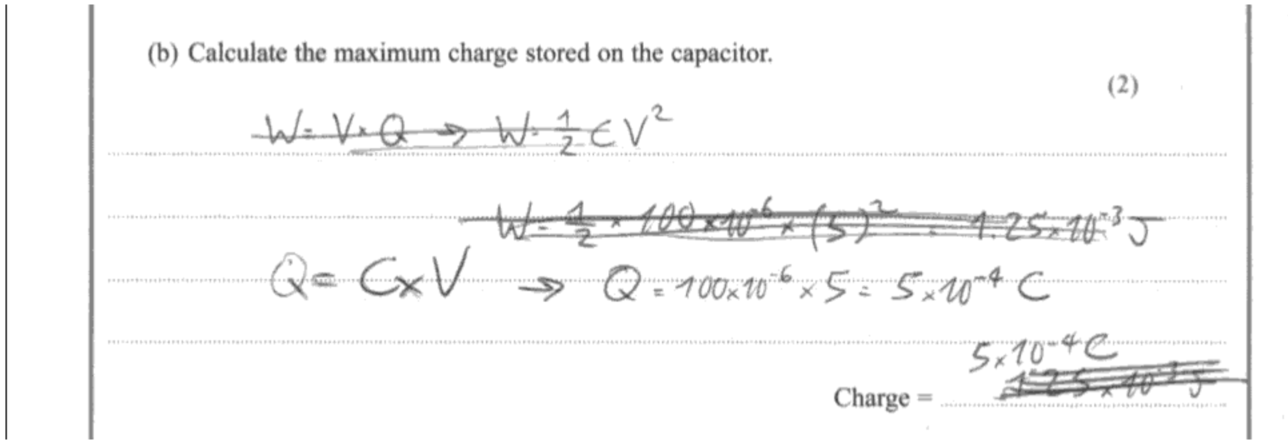
Although only 10% of candidates scored all 9 marks, over 70% of candidates scored 4 or more marks.

(b) Generally well done; there were issues with powers of ten for some candidates, and a few candidates could not rearrange the equation.

(c)(i) This was more straightforward than some candidates realised. Having been asked to find the total charge, the use of the word average should have triggered that this was a charge/time calculation. Apart from the power of ten errors again the common wrong answer was to find the area under the graph. It is to be assumed that they did this without thinking that potential difference x time does not equal current.

(c)(ii) The question clearly asked candidates to estimate the initial rate of increase of potential difference, i.e. draw a tangent at *t*= 0. Many did not draw a tangent or drew one at about *t*= 3 s. Because it is difficult to draw a tangent at *t*= 0 a wide range of possible gradients was accepted. Some candidates also failed to convert the ms to s. Quite a few candidates who did get a gradient within range, just could not work out how to get a current and so left their answer as the gradient. It was this part of the question where most marks were lost.

(c)(iii) Candidates could score both marks if they used their answer to (ii) with 5 V. Quite a few candidates who did not score well in (ii) gained both marks in this section.


(b) Calculate the maximum charge stored on the capacitor.

(2)

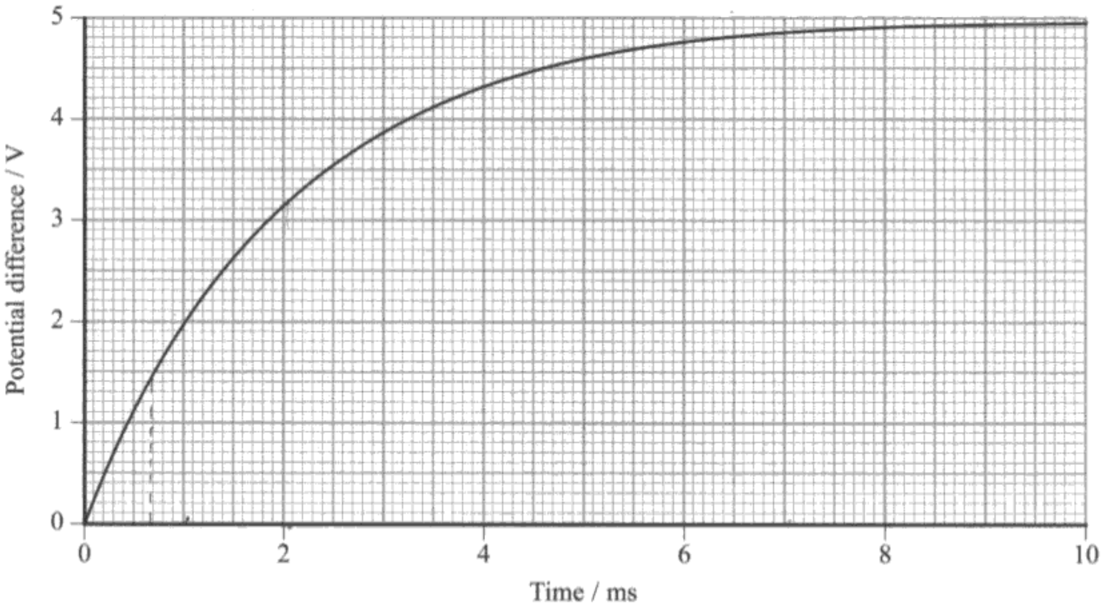
$\cancel{W = V \times Q \rightarrow W = \frac{1}{2} C V^2}$

$\cancel{W = \frac{1}{2} \times 100\times10^{-6} \times (5)^2 = 1.25\times10^{-3} J}$

$Q = C \times V \rightarrow Q = 100\times10^{-6} \times 5 = 5\times10^{-4} C$

Charge = $5\times10^{-4} C$ $\cancel{1.25\times10^{-3} J}$

(c) The graph shows how the potential difference across the capacitor varies with time as the capacitor is charging.



(i) Estimate the average charging current over the first 10 ms.

(2)

$I = \frac{Q}{t}$ $\quad I = \frac{CV}{t}$ $\quad \rightarrow I = \frac{100\times10^{-6} \times 4.95}{10\times10^{-3}} \times 0.5$

$I = 0.025A$

Average charging current = 0.025A

(ii) Use the graph to estimate the initial rate of increase of potential difference across the capacitor and hence find the initial charging current.

(3)

$\frac{V}{t} = \frac{1.4}{0.7\times10^{-3}} = 2000\,Vs^{-1}$

$I = C \times \frac{V}{t} \quad I = 100\times10^{-6} \times 2000 = 0.2A$

Initial charging current = 0.2A

(iii) Use the value of the initial charging current to find the resistance of the resistor.

(2)

$R = \frac{V}{I}$ $R = \frac{\cancel{5}-1.4}{0.2} = 18\ \Omega$

$2.05 \times 10^{-3} = R \times 100 \times 10^{-6}$

$R = 20.5\Omega$?

Resistance = 18Ω

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Examiner Comments

(b) correct: 2 marks.

(c)(i) This was often seen, where the answer was divided by 2. The candidate presumably thought that the maximum current has been found because the maximum charge had been used. 1 mark.

(c)(ii) No gradient drawn, candidate has assumed the initial part of the graph is straight. This allowed 1 mark for the gradient but the range for the value of resistor was based on candidates drawing a tangent and not assuming it was straight. 1 mark.

(c)(iii) This candidate has used 5 - 1.4 V. The 1.4 V is the potential difference used in (ii) so candidate has used a potential difference and scores 1 mark for 'use of ' the equation but not the answer mark.

5 marks scored in total.

(b) Calculate the maximum charge stored on the capacitor.

(2)

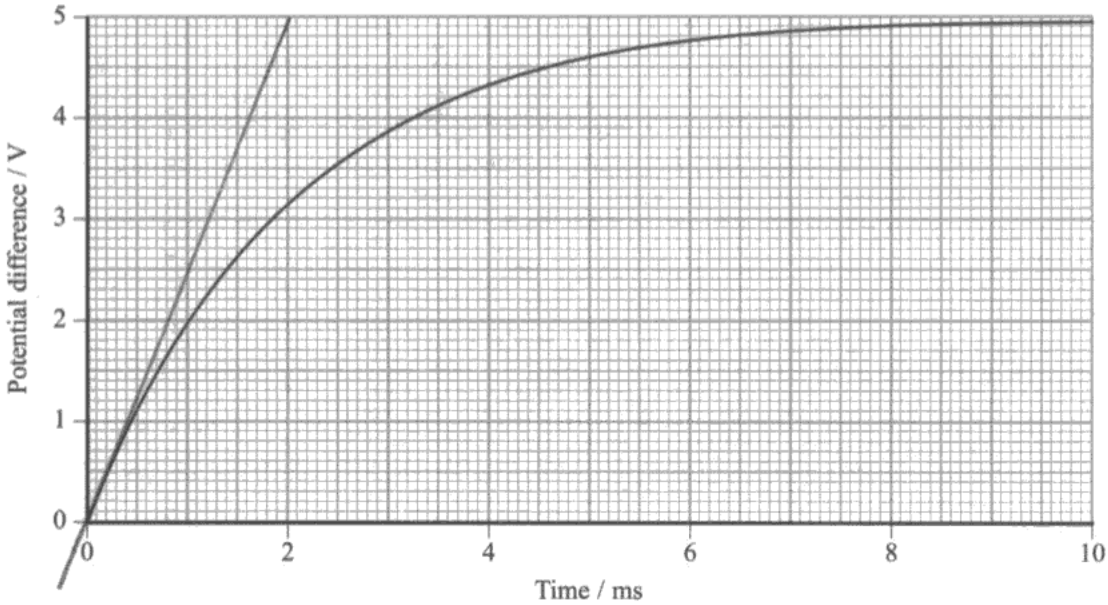
$Q = CV$

$Q = 100 \times 10^{-6} \times 5$

$= 500 \mu C$

Charge = $500 \mu C$.

(c) The graph shows how the potential difference across the capacitor varies with time as the capacitor is charging.



(i) Estimate the average charging current over the first 10 ms.

(2)

$Q = CV = 4.95 \times \cancel{10 \times 10^{-3}}\ \cancel{5}\ 100 \times 10^{-6}$

$Q = It$. $I = Q/t = \frac{4.95 \times \cancel{5}00 \times 10^{-6}}{10 \times 10^{-3}} = 0.0495$

$\approx 0.05 A$

Average charging current = $0.05 A$.

(ii) Use the graph to estimate the initial rate of increase of potential difference across the capacitor and hence find the initial charging current.

(3)

Gradient of tangent at $t = 0$

$5V / 2\times10^{-3}s = 2500 \, Vs^{-1}$.

$I = \frac{CV}{t} = 100\times10^{-6}F \times 2500 \, Vs^{-1}$

$= 0.25 \, A$.

Initial charging current = $0.25 \, A$.

(iii) Use the value of the initial charging current to find the resistance of the resistor.

(2)

$V = IR$

$R = V/I = 5/0.25 = 20 \, \Omega$

Resistance = $20 \, \Omega$

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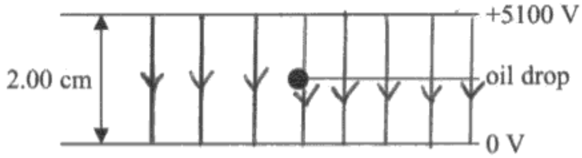
Examiner Comments

A model answer, gradient drawn, all calculations correct and all units included. This scored the full 9 marks.

Question 15 (a)

This was generally well answered with 63% of candidates scoring 3 marks and 26% scoring 2 marks. Where a mark was lost it was because the spacings were not even or because the candidate had only drawn the field over part of the region, usually one side or other of the drop.

For a particular experiment, a p.d. of 5100 V was required to hold a drop of mass 1.20×10^{-14} kg stationary.



(a) Add to the diagram to show the electric field lines between the plates.

(3)

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Examiner Comments

A model answer scoring all 3 marks.

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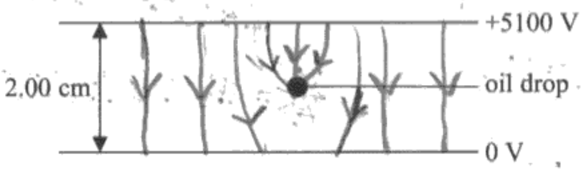
Examiner Tip

This candidate has used a ruler which ensures that the lines are straight, parallel and evenly spaced.

For a particular experiment, a p.d. of 5100 V was required to hold a drop of mass 1.20×10^{-14} kg stationary.



(a) Add to the diagram to show the electric field lines between the plates.

(3)

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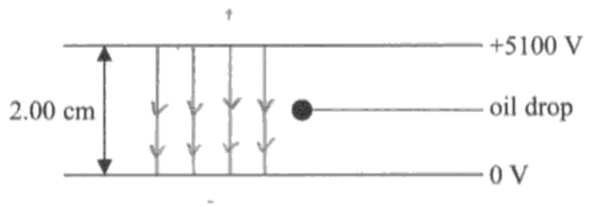
Examiner Comments

Not seen often but some candidates thought that the oil drop would affect the field. This scored 1 mark for the direction of the field.

For a particular experiment, a p.d. of 5100 V was required to hold a drop of mass 1.20×10^{-14} kg stationary.



(a) Add to the diagram to show the electric field lines between the plates.

(3)

ResultsPlus

Examiner Comments

Common answer, still scored 2 marks.

Question 15 (b)

81% scored the mark.

Question 15 (c)

Most candidates correctly identified weight/W/mg. Many lost the second mark by failing to identify the type of upward force. Many referred to it as an attractive force. Interestingly hardly any referred to it as a repulsive force. Some candidates labelled it as EQ without defining the symbols.

(c) Complete the free-body force diagram to show the forces acting on the oil drop. You should ignore upthrust.

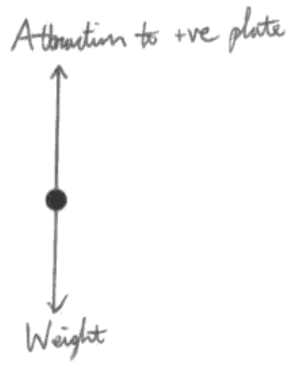
(2)

ResultsPlus
Examiner Comments

In free body force diagrams there is always a weight force so we do accept mg or W as a label. However for other forces it is necessary to use words or, if symbols are used, to define the symbols.

(c) Complete the free-body force diagram to show the forces acting on the oil drop. You should ignore upthrust.

(2)



ResultsPlus

Examiner Comments

A common wrong labelling for the electric force. At A2 candidates have studied fields and should appreciate that the effect of both plates is to create a field which exerts a force on the oil drop.

Question 15 (d)

(i) Nearly all candidates converted the 2 cm to 0,02 m and the majority obtained the correct value for E the electric field strength. Those who did not get the value of E were those who used 1 cm as the value of *d* presumably assuming it was the distance of the drop to a plate rather than the plate separation.

Strong answers then proceeded to find the force on the drop due to this field in terms of Q and equate it to the weight of the drop. Weaker responses, where candidates perhaps did not understand the need to use two equations, chose to use $E = kQ/r^2$ which is incorrect. The formula which had to be used was EQ = mg but that does not appear on the formula sheet. The key was in the question where they were told that the p.d. is adjusted until the drop is stationary i.e. balanced forces.

(ii) Most candidates scored 1 mark for realising that they had to divide their answer to (i) by 1.6×10^{-19}C. However, some failed to realise that electrons are quantised and left their answer as 2.9 electrons. Where mistakes had been made in (i) they often arrived at a minute fraction of an electron or millions of electrons. Candidates did not seem bothered by this and made no effort to recheck their earlier work

(d) (i) Calculate the magnitude of the charge on the oil drop.

(4)

$E = V/d$ $\quad d = 0.02\text{m}$

$E = \frac{5100}{0.02} = 255\,000$ $\quad F = ma \quad F = 1.2\times10^{-14} \times 9.81$

$F = 1.18\times10^{-13}\text{N}$

$E = F/Q \quad Q = F/E \quad Q = \frac{1.18\times10^{-13}}{255000}$

Charge = $+4.62\times10^{-19}$C

(ii) Calculate the number of electrons that would have to be removed or added to a neutral oil drop for it to acquire this charge.

(2)

$Q = ev \quad 4.62\times10^{-19} \div 1.6\times10^{-19} = 2.89$

Number of electrons = 3

ResultsPlus

Examiner Comments

A model answer, well laid out with equations written in symbols and numbers.

(d) (i) Calculate the magnitude of the charge on the oil drop.

(4)

$F = mg = 1.2 \times 10^{-14} \times 9.81 = 1.1772 \times 10^{-13}$ N.

$E = \frac{V}{d} = \frac{5100}{0.02} = 255000$ Vm^{-1}.

$E = F/Q$, $Q = EF = 255000 \times 1.1772 \times 10^{-13}$

$= 3.00186 \times 10^{-8}$ C

Charge = 3.00×10^{-8} C.

(ii) Calculate the number of electrons that would have to be removed or added to a neutral oil drop for it to acquire this charge.

(2)

$(3 \times 10^{-8}) \div (1.6 \times 10^{-19})$

$= 1.88 \times 10^{11}$ electrons added

Number of electrons = 1.88×10^{11}

ResultsPlus
Examiner Comments

This candidate has understood the physics and is using the correct equations but fails to rearrange *E* = *F/Q* correctly losing two marks. This answer then leads to a ridiculously high number of electrons which is not queried and so only the 'use of' mark is awarded.

Question 16 (a)

This question provided excellent discrimination with marks 1, 2 and 3 each being achieved by about 30% of the candidates. Virtually all candidates realised that this question was about electromagnetic induction but candidates continue to have many misconceptions about this topic such as the current being induced in the iron core. Very few candidates identified that the iron core would become magnetised and/or would increase the magnitude of the magnetic field that the coil was in. This meant that very few candidates scored the full 4 marks. Although many candidates had an idea about how this was working, they were often not specific enough in their language or in the basic physics principles involved. Some candidates were just regurgitating their notes without addressing the context. For this sort of question a logical flow of steps is important which is why candidates need to think about the context and not just write down key words or phrases. We did accept references to flux cutting but since this was a static situation, candidates should have written about the coil being in a continuously changing magnetic field.

The live wire produces an alternating magnetic field (flux) which passes through the iron core and makes this an electromagnet.
The flux cuts the coil of wire inside the 'jaws' and because the current is alternating, there is a change in the magnetic flux linkage.
This change in magnetic flux induces an e.m.f. across the wire, according to emf $= -\frac{d\phi}{dt}$.

ResultsPlus
Examiner Comments

An example that scores all four marks. Since so few candidates referred to the magnetic effects of the iron core, it was decided to accept the reference to the core becoming an electromagnet as sufficient for this paper.

Each current carrying wire ~~has~~ produces ~~an electric field around it. This~~ magnetic field around the wire. As the current alternates, so does the magnetic flux around it, and inside the jaws. As there is a change in magnetic flux, e.m.f. is induced inside iron core of the jaws.

ResultsPlus
Examiner Comments

This scored 2 marks and was a typical answer. There was a stand-alone mark for using the phrase 'induced e.m.f.' which was awarded, even as in this case, where the induced e.m.f is in the wrong place.

There is a.c. current in the wire that is being tested, so an alternating magnetic field is present around the wire. The magnetic field is 'cut' by the coil of wire and as a result an emf is induced in the wire. the jaws must be closed in order for the amp-clamp to be a complete circuit.

ResultsPlus
Examiner Comments

Another common answer where everything the candidate has said is correct; there is just no mention of the iron core.

Question 16 (b)

54% of candidates scored this mark. Common errors were to say that a direct current does not produce a magnetic field or to refer to the initial change in magnetic field as the current is turned on/off. Some candidates merely stated that an e.m.f. needs an alternating field (true) but did not state that the direct current produces a constant field.

(b) State why the amp-clamp cannot be used with a steady direct current.

(1)

There would be no changing magnetic field ∴ no rate of change of flux linkage

ResultsPlus
Examiner Comments

The mark is awarded for the first line.

(b) State why the amp-clamp cannot be used with a steady direct current.

(1)

A steady direct current cannot produce a magnetic field.

ResultsPlus
Examiner Comments

A common wrong answer.

ResultsPlus
Examiner Tip

Think of the physics. (a) was about an induced e.m.f. which requires a changing magnetic field. All currents produce a magnetic field but the field of a direct current is constant which is why the amp-clamp does not work.

Question 16 (c)

This was very poorly answered with only 10% of candidates scoring any marks. Most candidates seem to believe that mains appliances run on DC and that insulation stops magnetic fields. Currents being too small was another favoured option.

(c) The amp-clamp cannot be used with a cable that is used to plug a domestic appliance like a lamp into the mains supply.

Explain why not.

(2)

The cable contains a live and neutral wire. Each have the same current but in opposite directions, so their magnetic fields would cancel each other out so there is no change in flux through the coil, and no e.m.f is induced.

ResultsPlus
Examiner Comments

Not often seen but this is a model answer scoring both marks.

(c) The amp-clamp cannot be used with a cable that is used to plug a domestic appliance like a lamp into the mains supply.

Explain why not.

(2)

Those wires, ~~[illegible]~~ for safety reasons, have very low currents (by having a high resistance, $V=IR \therefore I \propto \frac{1}{R}$). The small current does not produce a magnetic field strong enough to be detected by the coil of wires $\therefore$ It doesn't induce an emf.

ResultsPlus
Examiner Comments

A typical incorrect response.

(c) The amp-clamp cannot be used with a cable that is used to plug a domestic appliance like a lamp into the mains supply.

Explain why not.

(2)

The mains Supply a ~~dc~~ direct Current, which Cause a non-changing magnetic field, hence no E.M.F can be induced.

ResultsPlus
Examiner Comments

It was rather concerning how many candidates wrote that mains electricity is DC.

Question 16 (d)

Candidates found this section very hard, reinforcing the idea that candidates find this topic difficult. They managed reasonably well in section (a) because it fitted the pattern of similar questions that have been set in the past and the use of a few key words/phrases meant that at least some marks were gained. When candidates get to the last part of a question they should go back and just remind themselves what the question is about. In this case it is using the amp-clamp to measure the current in a live wire. For (d)(i) we were looking for the link between measured e.m.f. in coil and current in live wire. Some candidates who did understand what was being asked did not gain credit because they simply said the current affects the flux/e.m.f. Faraday's law was often quoted but not related to the current that produces the flux. In (d)(ii) we did accept just the idea that a different frequency would affect the e.m.f. but candidates really did struggle here and were unable to separate out ideas of current/field/e.m.f. to give logical answers.

(d) (i) Explain why the amp-clamp can be used to determine the magnitude of different alternating currents with the same frequency.

(2)

by increasing current size, a larger magnitude of magnetic fluxfield is created. a larger emf would be created, giving a larger reading than a lower current

(ii) The amp-clamp may **not** be reliable when comparing alternating currents of different frequencies.

Suggest why not.

(2)

a faster frequency would generate a larger emf, this would look like a larger current passing through by giving a higher value. This is because there would be a smaller value for t in emf = $\frac{BAN}{t}$

ResultsPlus
Examiner Comments

Very few candidates scored all four marks but this one did with a clear logical answer showing an excellent understanding of the physics.

ResultsPlus
Examiner Tip

The stem at the start of a question is important. As you work through a question, keep going back and remind yourself of what the question is about.

(d) (i) Explain why the amp-clamp can be used to determine the magnitude of different alternating currents with the same frequency.

(2)

If there is a greater current, the induced emf will be greater, and so the voltage reading will be higher.

(ii) The amp-clamp may **not** be reliable when comparing alternating currents of different frequencies.

Suggest why not.

(2)

~~The~~ Increasing the frequency of the AC would also increase the induced emf, so it would be impossible to determine the magnitude of the current

ResultsPlus
Examiner Comments

This response scored 1 mark in each section. In (i) there is no mention of flux which is what links the current and the e.m.f. but at least there is understanding of the relationship between the current and e.m.f.

In (ii) there is realisation that changing the frequency affects the e.m.f. but there is not enough about the two variables which affect the e.m.f.

Question 17 (a)

Only 16% of candidates managed to score both marks for the explanation of conservation of momentum. A common error was to omit the requirement to have no external forces. However, for the first marking point a common answer was to say 'the momentum before a collision is the same as the momentum after a collision', with no reference to total/sum or a system. Candidates should realise that since they have been asked to explain what conserved means, they should not use it in their answer. 'Conservation of momentum means that total momentum is conserved' does not gain any marks.

17 (a) Explain what is meant by the principle of conservation of momentum.

(2)

It means that the total momentum before must equal the total momentum after, provided that no external forces are acting.

ResultsPlus

Examiner Comments

This scores 2 marks. Although the use of the word collision/ explosion was not insisted on, there did need to be a sense of an event happening so the use of the words before and after were sufficient.

17 (a) Explain what is meant by the principle of conservation of momentum.

(2)

Momentum cannot be gain ober or lost. in an over all system by but can be lost from one body to another

ResultsPlus

Examiner Comments

This scored no marks. There is no sense of an event; this answer imples that momentum just randomly moves form one object to another.

ResultsPlus

Examiner Tip

This is a definition that can be learnt.

17 (a) Explain what is meant by the principle of conservation of momentum.

(2)

The principle of conservation of momentum states that total momentum before a collision is total momentum after.

ResultsPlus
Examiner Comments

A common answer that scores 1 mark.

Question 17 (b)

This section with a total of 6 marks provided excellent discrimination with a good spread of candidates over the mark range.

(i) This was the most difficult part of this section with only about half finding the correct speed. The difficulty was in finding a suvat equation that did not have acceleration in it. Able candidates used *v* = *s/t* to calculate an average speed and then doubled it to get the initial speed. However, the common wrong answer was to give the average speed (0.53 m s^{-1}) as the answer.

(ii) Again about half of the candidates got this mark. Some wrote that they assumed the acceleration was zero which was justification for their answer to (i) but completely wrong in the context of what was actually happening.

(iii) The majority of candidates scored three marks here. A common mistake was to omit to add the mass of the pellet to the mass of the car for the momentum after collision. The majority of candidates who found the speed in (i) to be 0.53 m s^{-1} used the 'show that' value of 1 m s^{-1}, which was sensible. Some candidates did use the 0.53 m s^{-1} value in their calculation and this led to a pellet speed of 62 m s^{-1}. If they had left that as their answer they would have gained 3 marks for an error carried forward. However, having been happy to get about half the 'show that' value for (i), they did not like getting half the 'show that' value for (iii) and randomly doubled their answer, thus losing a mark.

(b) The picture shows a toy car initially at rest with a piece of modelling clay attached to it.

A student carries out an experiment to find the speed of a pellet fired from an air rifle. The pellet is fired horizontally into the modelling clay. The pellet remains in the modelling clay as the car moves forward. The motion of the car is filmed for analysis.

The car travels a distance of 69 cm before coming to rest after a time of 1.3 s.

(i) Show that the speed of the car immediately after being struck by the pellet was about 1 m s^{-1}.

(2)

$v^2 = u^2 + 2\left(\frac{v-u}{t}\right)s$

$v = 0$

$-u^2 = \frac{-2u}{t}s \quad \therefore \boxed{u = \frac{2s}{t}}$

$u = \frac{2s}{t}$

$u = \frac{2\times(0.69)}{1.3} = \boxed{1.06\ m/s}$

(ii) State an assumption you made in order to apply the equation you used.

(1)

The deceleration is constant

(iii) Show that the speed of the pellet just before it collides with the car is about 120 m s^{-1}

mass of car and modelling clay = 97.31 g
mass of pellet = 0.84 g

(3)

$m_1 v_1 = m_2 v_2'$

$0.84(v_1) = (97.31 + 0.84)(1.06)$

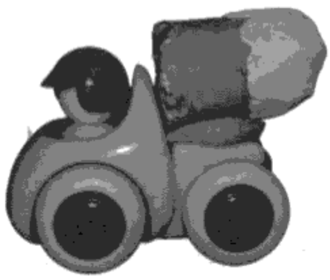
$(0.84 \times 10^{-3})(v') = (98.15 \times 10^{-3})(1.06)$

$v_1 = \frac{0.1040}{0.84 \times 10^{-3}} = \boxed{124 \text{ ms}^{-1}}$

ResultsPlus
Examiner Comments

A model answer, well laid out, scoring all 6 marks.

(b) The picture shows a toy car initially at rest with a piece of modelling clay attached to it.



A student carries out an experiment to find the speed of a pellet fired from an air rifle. The pellet is fired horizontally into the modelling clay. The pellet remains in the modelling clay as the car moves forward. The motion of the car is filmed for analysis.

The car travels a distance of 69 cm before coming to rest after a time of 1.3 s.

(i) Show that the speed of the car immediately after being struck by the pellet was about 1 m s^{-1}.

(2)

$S = \frac{d}{t}$ $\quad \cancel{\frac{0.069}{1.3}}$ $\quad \frac{0.69}{1.3} = 0.53 \text{ ms}^{-1}$

(ii) State an assumption you made in order to apply the equation you used.

(1)

velocity is constant.

(iii) Show that the speed of the pellet just before it collides with the car is about 120 m s^{-1}

mass of car and modelling clay = 97.31g
mass of pellet = 0.84 g

(3)

$p = mv$

~~$0 + 0.09731 \times 0 + 0.84v$~~

$8.4 \times 10^{-4} v = 9.815 \times 10^{-2} \times 1$

~~$0.09731 \times 0 + 0.00084v = 0.0995 \times 0.0995 \quad 0.099571$~~

~~$v = 0.099571 \times 0.53 = $~~

~~0.00084~~

$v = \frac{9.815 \times 10^{-2}}{8.4 \times 10^{-4}} = 116.8 \text{ ms}^{-1}$

ResultsPlus
Examiner Comments

(i) A common incorrect answer.

(iii) The candidate has added the mass of the pellet and has used the 'show that' value, scoring 3 marks. It would have been better to show the addition of the 2 masses in case of an arithmetic error.

Question 17 (c)

(i) Not many candidates really understood why the speed of the car would now be greater. Most realised that it was to do with momentum and so scored at least one mark. Many focused on the fact that the pellet was no longer imbedded in the clay and so said that because the mass was less, the speed was greater. Since the question told candidates that the car was moving faster, there was not a mark for saying that the momentum of the car was greater. Even those candidates who realised that the pellet now had a negative momentum were unable to explain that the pellet had undergone a greater change in momentum. Some candidates wrongly thought that the second collision was inelastic and answered this part in terms of energy, scoring no marks.

(ii) This was difficult to explain concisely and although candidates perhaps had an understanding of why the car would move faster, few were able to express themselves well enough to gain the mark.

(c) The modelling clay is removed and is replaced by a metal plate of the same mass. The metal plate is fixed to the back of the car. The experiment is repeated but this time the pellet bounces backwards.

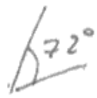
*(i) Explain why the speed of the toy car will now be greater than in the original experiment.

(3)

- Since the pellet bounces backwards
- the change in momentum of the pellet is greater
- So the force on the toy is greater ($F = \frac{\Delta mv}{t}$)
- So the speed of the toy will be greater.

(Since the pellet bounces back, it has negative momentum, so the toy must have a greater velocity to balance this ($m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$)

(ii) The film of this experiment shows that the pellet bounces back at an angle of 72° to the horizontal.



Explain why the car would move even faster if the pellet bounced directly backwards at the same speed.

(1)

- change in momentum greater

- because the vertical component of the pellet's speed acts against the ground.
- if the pellet were horizontal, the vertical component would equal 0 therefore greater horizontal component so the toy will also have a greater velocity ($U_1 \cos 72 < U_1$)

ResultsPlus

Examiner Comments

(i) A rare example of an answer that scored all 3 marks.

(ii) The idea of horizontal and vertical is there but refers to velocity whereas the answer should have been in terms of momentum or force so the mark is not awarded.

(c) The modelling clay is removed and is replaced by a metal plate of the same mass. The metal plate is fixed to the back of the car. The experiment is repeated but this time the pellet bounces backwards.

*(i) Explain why the speed of the toy car will now be greater than in the original experiment.

(3)

In the original experiment, the pellet remained in the modelling clay, meaning that the collision was inelastic and kinetic energy was not conserved - some of the kinetic energy was transferred to its surroundings as heat or during plastic deformation of the clay. However, in the modified experiment, the pellet bounces backwards, indicating that the collision is elastic and kinetic energy is conserved so more E_k will be transferred to the toy car and ~~so~~ due to $E_k = \frac{1}{2}mv^2$, its speed will be greater.

(ii) The film of this experiment shows that the pellet bounces back at an angle of 72° to the horizontal.

Explain why the car would move even faster if the pellet bounced directly backwards at the same speed.

(1)

Angular momentum has to be conserved and so less energy would go towards speed. The greater the angle, the less amount of energy ~~converted~~ used for speed.

ResultsPlus
Examiner Comments

Bouncing backwards is not sufficient evidence to determine that a collison is elastic (this was not). This response scores no marks for (i)

(ii) Angular momentum is not on the specification.

(c) The modelling clay is removed and is replaced by a metal plate of the same mass. The metal plate is fixed to the back of the car. The experiment is repeated but this time the pellet bounces backwards.

*(i) Explain why the speed of the toy car will now be greater than in the original experiment.

(3)

Due to the pellet bouncing backwards the pellet has a negative momentum after calision meaning the momentum of the car must increase to maintain a total of 0 momentum ~~and~~ as mass is constant.

(ii) The film of this experiment shows that the pellet bounces back at an angle of 72° to the horizontal.

Explain why the car would move even faster if the pellet bounced directly backwards at the same speed.

(1)

~~the momentum would be larger due~~ to All of the momentum would be conserved horizontally where as at an angle some is vertical causing the car to lose some velocity - as energy transferred into ground.

ResultsPlus
Examiner Comments

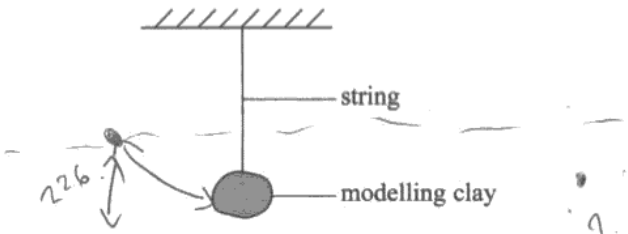
(i)This candidate has the idea of negative momentum but omits the significant comment about the change in momentum of the pellet being larger.

(ii) The candidate fails to say that the horizontal component of momentum would be greater.

Question 17 (d)

This question was a good test of candidates' ability to work through an argument in a logical manner. It required them to realise that the calculations worked backwards from the end situation and it was only the weakest of students who did not. As ever, care in reading the question is important; the question said that all calculations were correct and the table of data had the mass of pendulum and pellet. However quite a few candidates said that the mass of the pellet had not been used in the calculation and so the calculation was wrong. For a question like this candidates need to take an overview and think about what is most important. Some said the KE after impact should be greater because air resistance had not been accounted for: but for a pendulum starting from rest and rising 22.6 cm, air resistance is going to be negligible. Most candidates realised that it was not an elastic collision but they often wanted the difference in KE to have been transferred as sound whereas an increase in thermal energy is the most significant change. Very few candidates followed the argument through to the end to say that the KE of the pellet before impact was greater than 0.16J.

(d) The student tests the result of the first experiment by firing a pellet into a pendulum with a bob made of modelling clay. She calculates the energy transferred.



$0.16 = \frac{1}{2}mv^2$

The student's data and calculations are shown:

Data

mass of pellet = 0.84 g
mass of pendulum and pellet = 71.6 g
change in vertical height of pendulum = 22.6 cm

Calculations

change in gravitational potential energy of pendulum and pellet
= 71.6×10^{-3} kg × 9.81 N kg^{-1} × 0.226 m = 0.16 J
therefore kinetic energy of pendulum and pellet immediately after collision = 0.16 J
therefore kinetic energy of pellet immediately before collision = 0.16 J
therefore speed of pellet before collision = 19.5 m s^{-1}

There are no mathematical errors but her answer for the speed is too small.

State and explain which of the statements in the calculations are correct and which are not.

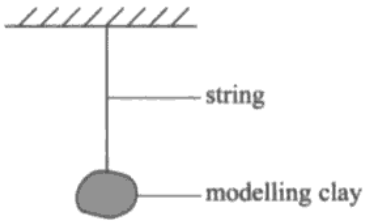
(4)

Firstly, kinetic energy of pendulum and pellet after collision must have been higher because there was no perfect transfer of energy from kinetic to potential energy as air resistance did work against clay which meant that for modelling clay to displace 22.6 cm vertically, more than 0.16J were needed. Also, the collision was inelastic, kinetic energy was not conserved. Therefore kinetic energy before collision was greater than after it. Thus, both the 2nd and 3rd lines are incorrect statements in a real life situation. This means, kinetic energy of pellet before collision was much greater than 0.165. $E=\frac{1}{2}mv^2$, hence, velocity of pellet is much greater.

ResultsPlus
Examiner Comments

This scores 2 marks for the idea of inelastic collision and the statement in the last line that the KE of the pellet was greater than 0.16J.

(d) The student tests the result of the first experiment by firing a pellet into a pendulum with a bob made of modelling clay. She calculates the energy transferred.



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Data
mass of pellet = 0.84 g
mass of pendulum and pellet = 71.6 g
change in vertical height of pendulum = 22.6 cm

Calculations
change in gravitational potential energy of pendulum and pellet
$= 71.6 \times 10^{-3}$ kg $\times$ 9.81 N kg^{-1} $\times$ 0.226 m = 0.16 J
therefore kinetic energy of pendulum and pellet immediately after collision = 0.16 J
therefore kinetic energy of pellet immediately before collision = 0.16 J
therefore speed of pellet before collision = 19.5 m s^{-1}

There are no mathematical errors but her answer for the speed is too small.

State and explain which of the statements in the calculations are correct and which are not.

(4)

The kinetic energy after the collision is correct because it is calculated from recorded values however the kinetic energy of the pellet before the collision is wrong because some of its kinetic energy is transfered to sound and thermal energy in the collision so the E_k of pellet before would be higher meaning speed of pellet before would be higher

ResultsPlus
Examiner Comments

This scored 3 marks. There is no clear statement that the energy before collision is greater than 0.16J.

Paper Summary

Key points to help candidates improve their performance are:

- Think carefully before applying the first equation that comes to hand. Some calculations are multi-stepped. You may have to combine 2 equations so there is not always an equation on the formula sheet that will enable you to do the calculation in one go.
- Thoroughly learn key facts and definitions.
- Read the questions carefully and answer the question that is asked.
- For context based questions, always think for a moment before starting to answer the question.
- For long questions as you move through the various parts, reread the stem of the question to remind yourself what is says.

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