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Examiners' Report
June 2010

GCE Physics 6PH04

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Introduction

This is the first summer session for unit 4, of the GCE Physics specification which was introduced for first teaching in September 2008. The paper gave candidates the opportunity to demonstrate their understanding of a wide range of topics from this unit.

Question 11

A straightforward question and answered well. It did discriminate to some extent as many did not convert a mass into a force and some did not convert to kg.

Question 12(a)

A better understanding of e/m induction shown in June compared to January. Lenz's law was well known by many, although the phrase "emf opposes the motion/force" was seen often.

Question 12(b)

A better understanding of e/m induction shown in June compared to January. Lenz's law was well known by many, although the phrase "emf opposes the motion/force" was seen often.

(b) Explain the significance of the minus sign. **(3)**

This is due to Lenz's law which states that a magnetic force in one direction will induce an equal and opposite force.

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Examiner Comments

One mark is gained for recognising Lenz's law, but does not include induced current or refer to a change of flux linkage

Question 13(a)

A number of candidates were generally very poor at estimation or scaling, with far too many getting very low value answers by substituting values of a few centimetres into the equation. Few candidates thought to check their value of acceleration, was approximately the value of Earth's field strength.

Question 13(b)

A number of candidates were generally very poor at estimation/scaling, with far too many getting very low value answers by substituting values of a few centimetres into the equation. Few candidates thought to check their value of acceleration was approximately the value of Earth's field strength.

(b) Use the diagram to estimate the radius of the path followed by the cage's platform and hence calculate the platform's acceleration.

(3)

$r = 6\text{ cm} = 6 \times 10^{-2}\text{ m}$

$a = r\omega^2$

$= 6 \times 10^{-2} \times \left(\frac{2}{3}\pi\right)^2$

$= 0.263\text{ ms}^{-2}$

Acceleration = 0.263 ms^{-2}

(Total for Question 13 = 5 marks)

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Examiner Comments

A typical example of a correct method, but a failure to scale up the measured radius

Question 14

Those candidates who used the conservation of momentum approach usually scored better than those using Newton's third law. These answers rarely spelt out which force was acting on what.

The ability to explain the Physics of what was happening caused problems, rather than understanding the Physics itself. Candidates should be encouraged to practice at using English to explain physical phenomena.

***14** How tiny bacteria move is of interest in nanotechnology. Mycobacteria move by ejecting slime from nozzles in their bodies.

Explain the physics principles behind this form of propulsion.

(4)

This uses the law that states; forces will act in equal & opposite directions. Hence, if a Mycobacterium exerts a force of XN on the slime a force of XN will be applied to itself in the opp direction & it will therefore accelerate at $\frac{X}{m}$ ms^{-2}, with m being the mass of the mycobacterium.

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Examiner Comments

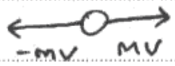
A good example of Newton's third law, but the final mark is lost because it is not clearly stated that the bacterium moves in the opposite direction to the slime.

*14 How tiny bacteria move is of interest in nanotechnology. Mycobacteria move by ejecting slime from nozzles in their bodies.

Explain the physics principles behind this form of propulsion.

(4)

Their movement is based upon the fundamental principle of the conservation of momentum. It is much like a rifle firing and there being recoil.
If the momentum of the bacteria is initially zero and it ejects slime ~~at a~~ of mass m at a velocity V the bacteria is propelled in the opposite direction as the slime with a momentum equal to that of the slime so that the total momentum of the system remains zero.



(Total for Question 14 = 4 marks)

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Examiner Comments

A good example - all four marking points are clearly shown

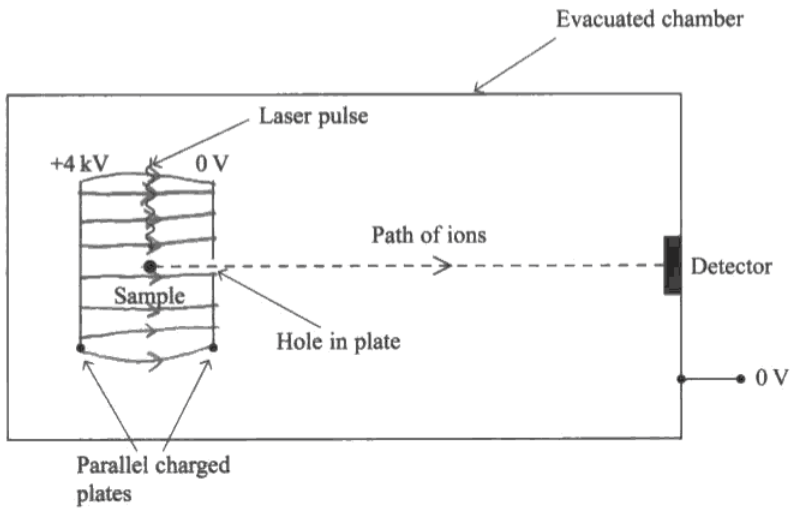
Question 15

More care is being taken with field lines, but there are still too many freehand efforts that are losing many candidates marks.

Questions(b) and (c) were generally well done although, some candidates tried to fix their answer when using 4000 V rather than the correct 2000 V.

Very few candidates gave sensible suggestions in (d), often suggesting "human error".

15 Time-of-flight mass spectroscopy uses the arrangement below to measure the mass of molecules. A laser pulse knocks an electron out of a molecule in a sample leaving it as a positively charged ion.



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

(3)

(b) The sample is midway between the charged plates. Show that the speed, v, of an ion as it reaches the hole in the plate is given by

$$v = \sqrt{\frac{6.4 \times 10^{-16}\ \text{joule}}{m}}$$

where m is the mass of the molecule in kg.

(3)

electron has +2keV of energy $= 3.2 \times 10^{-16}$ J

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

$v^2 = \frac{2KE}{m}$ ~~M~~ $v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{3.2 \times 10^{-16} J \times 2}{m}} = \sqrt{\frac{6.4 \times 10^{-16} J}{m}}$

(c) The distance between the hole in the plate and the detector is 1.5 m. The time taken for a molecule to cover this distance is 23 μs.

Calculate the mass of this molecule.

(3)

$v = d/t = 1.6m / 23\mu s = 6.5 \times 10^4 ms^{-1}$

$v^2 = \frac{2kE}{m}$ $m = \frac{2kE}{v^2} = \frac{6.4 \times 10^{-16} J}{(6.5 \times 10^4 ms^{-1})^2} = 1.51 \times 10^{-25} kg$

Mass = 1.51×10^{-25} kg

(d) There is some uncertainty in the time a molecule with a particular mass will take to cover this distance.

Suggest **two** reasons for this.

(2)

1 ~~[crossed out text]~~ there will be hundreds of molecules travelling along the same path so it is unclear when 1 will reach the detector.

2 It is uncertain when the molecule will reach the hole in the plate as it is not certain how long it takes for the laser pulse to ionise the molecule.

(Total for Question 15 = 11 marks)

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Examiner Comments

(a) Lack of care has cost the candidate two marks. The lines are not parallel or evenly spaced.

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Examiner Tip

Always use a ruler to draw field lines.

Question 16(a)

Although most candidates managed to pick up some marks, again many found it difficult to adapt their knowledge to unfamiliar situations.

Only a minority of candidates appeared to understand the context of this question. Many candidates picked up the marks for (a) and b(ii).

In part (c), most were unable to select an appropriate time for chosen voltages, or time constant, even though many gave the correct equations for the decay section of the graph.

Question 16(c)

(c) She now adds an electronic circuit to the power supply plus capacitor. Figure 2 shows the supply to the electronic circuit. This is shown in Figure 2.

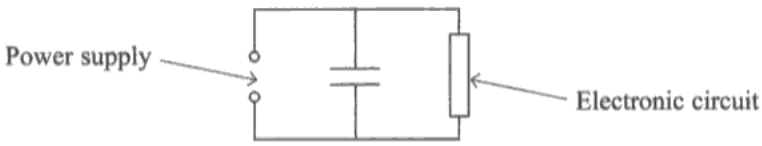

Figure 2

The variation in potential difference is shown by the graph in Figure 3.

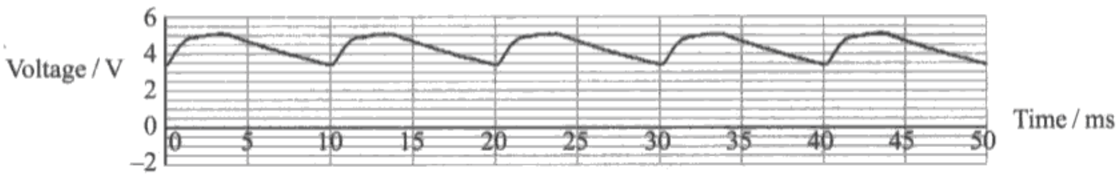

Figure 3

(i) Explain the shape of this graph.

(3)

The electronic circuit causes the power supply to produce a more constant voltage although the net voltage will stay the same

(ii) Take readings from the graph to show that the resistance of the electronic circuit is in the range 1000 Ω to 2000 Ω.

(3)

$V = V_0 e^{-t/RC}$

$4.5 = 3.5 e^{-t/RC}$

$\ln 9/7 = -\frac{t}{RC} = \frac{-2.5}{R \times 10 \times 10^{-6}}$

$= 1386\ \Omega$

(iii) Figure 3 shows that the voltage supplied to the electronic circuit still varies. How could the student make it more constant?

(1)

2 capacitors.

(Total for Question 16 = 14 marks)

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Examiner Comments

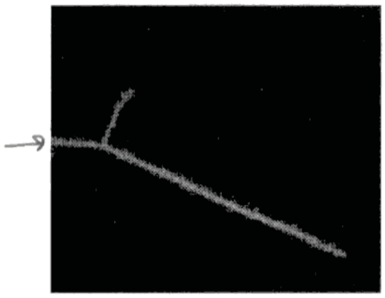
This example shows an understanding of the exponential decline. However the relationship between the voltages and the decay time does not match

Question 17(a–c)

The definition of elastic collisions was well known, but very few candidates were able to draw a suitable vector diagram to represent the conservation of momentum, and even fewer could apply Pythagoras' theorem to illustrate the conservation of kinetic energy.

Most vector sketches did not show a triangle but merely indicated 3 lines to represent direction. In part (d), candidates are still not stressing the use of an electric field and when they do often muddle magnetic and electric fields. An alarming number of candidates gave an incorrect answer to (e).

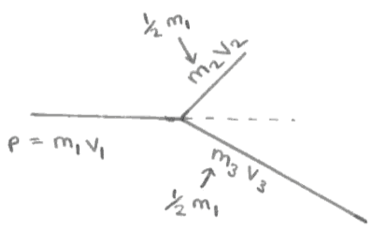
17 A low-energy particle collides elastically with a stationary particle of the same mass. The particle enters from the left of the photograph.



(a) State what is meant by collides *elastically*. (1)

Kinetic energy is conserved in the collision

(b) Sketch a labelled vector diagram to show how the momentum of the initial moving particle relates to the momenta of the two particles after the collision. (2)



$m_1v_1 = m_2v_2 + m_3v_3$

$m_1v_1 = \frac{1}{2}m_1v_2 + \frac{1}{2}m_1v_2$

$m_1v_1 = 2(\frac{1}{2}m_1v_2)$

(c) Use your answers to (a) and (b) to confirm that the angle between the subsequent paths of both particles must be 90°. (2)

Kinetic energy is conserved, and also the particles are of the same mass this means that when the momentum's are resolved the value of sin θ should be 1 ∴ θ = 90°

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Examiner Comments

Many answers simply copied the photograph, failing to show any application of vector addition using diagrams.

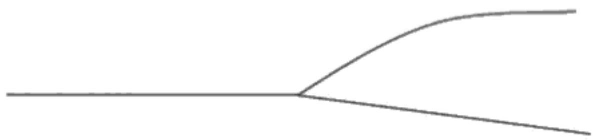
Question 17(d)

(d) (i) Explain the process by which a proton is given energy in a particle accelerator.

(3)

work done is equal to gain in kinetic energy. the particle is accelerated through a large voltage, and therefore a high work done (work done = QV). this translates to an increase in velocity, as long as mass stays constant

The diagram shows a collision between a high-energy proton (track from the left) and a stationary proton in a particle accelerator experiment.



(ii) Explain why the angle between the two paths is not 90°.

(2)

the collision is not elastic ∴ the collision angle will not equal 90°.

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Examiner Comments

A rare example of the relationship between work done and potential difference. Like many other responses, no mention of electric field.

Question 18

This question offered the opportunity for candidates to gain high scores; and many did. The basic rules of particle physics appear to be well known. Many candidates did well on (a) to (d)(i).

Many candidates did not know the convention for standard particle symbols often introducing 1's next to p (for a proton) and frequently missed the zero for a neutral kaon.

In part (d), most were able to state the relevant conservation laws (and often get 4/5 marks) without much explanation of the crux of the question – the requirement of the kinetic energy of the kaon to explain the increase in mass.

Question 18(d) (ii-iv)

(ii) Write an equation using standard particle symbols to summarise this event.

(2)

$K^- + p \rightarrow K^+ + K^0 + \Omega^-$

(iii) The negative kaon consists of $\bar{u}$ s. Deduce the quark structure of the other two kaons involved in this event.

(2)

~~K^+ : $d\bar{s}$~~ K^+ : $u\bar{s}$

K^0 : $d\bar{s}$

(iv) The total mass of the three particles created after this event is larger than the total mass of the two particles before. Discuss the quantities that must be conserved in interactions between particles and use an appropriate conservation law to explain this increase in mass.

(5)

Charge is conserved.

momentum is conserved.

charge: the charge before and after is 0.

i.e $-1 + 1 = +1 + 0 - 1 \Rightarrow 0$

momentum:

the initial momentum = momentum after collision

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Examiner Comments

Like many others, this gains a high score without mention of the kinetic energy to mass relationship.

Grade boundaries

Grade	Max. Mark	A*	A	B	C	D	E	N
Raw boundary mark	80	58	53	48	43	38	34	30

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