Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | Candidate Number

Monday 20 May 2019

Afternoon (Time: 1 hour 35 minutes) | Paper Reference **WPH04/01**

Physics

Advanced
Unit 4: Physics on the Move

You do not need any other materials.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- The list of data, formulae and relationships is printed at the end of this booklet.
- Candidates may use a scientific calculator.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over

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SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 A nucleus of ${}^{69}_{30}X$ emits a β^- particle.

Which row of the table shows the proton number and nucleon number of the nucleus after the β^- particle has been emitted?

	Proton number	Nucleon number
☒ **A**	29	68
☒ **B**	29	69
☒ **C**	31	69
☒ **D**	31	70

(Total for Question 1 = 1 mark)

2 A DVD is rotating at 570 rotations per minute.

What is its angular velocity in radians per second?

☒ **A** 1.5

☒ **B** 10

☒ **C** 60

☒ **D** 3600

(Total for Question 2 = 1 mark)

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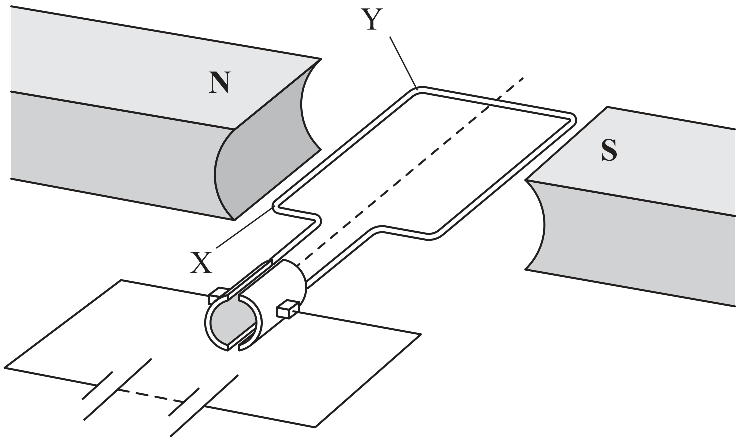
3 The diagram shows a simple electric motor.



The current in the coil is 0.4 A. The magnetic flux density is 0.07 T. The length of XY is 5 cm.

Which of the following gives the force on side XY in newtons?

- ☒ **A** $0.07 \times 0.4 \times 0.05$ upwards
- ☒ **B** $0.07 \times 0.4 \times 0.05$ downwards
- ☒ **C** $2 \times 0.07 \times 0.4 \times 0.05$ upwards
- ☒ **D** $2 \times 0.07 \times 0.4 \times 0.05$ downwards

(Total for Question 3 = 1 mark)

---

4 A kaon can decay in several different ways.

Which of the following decays is **not** possible?

- ☒ **A** $K^0 \rightarrow \pi^+ + e^- + \bar{\nu}_e$
- ☒ **B** $K^0 \rightarrow \pi^+ + \pi^0 + \pi^+$
- ☒ **C** $K^+ \rightarrow \pi^0 + e^+ + \nu_e$
- ☒ **D** $K^+ \rightarrow \mu^+ + \nu_\mu$

(Total for Question 4 = 1 mark)

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5 When two point charges, each with charge Q, are separated by a distance r the force between them is F.

Two point charges, each with charge 2Q, are separated by a distance $2r$.

What is the force between these two charges?

☒ **A** $4F$

☒ **B** $2F$

☒ **C** F

☒ **D** $\frac{F}{2}$

(Total for Question 5 = 1 mark)

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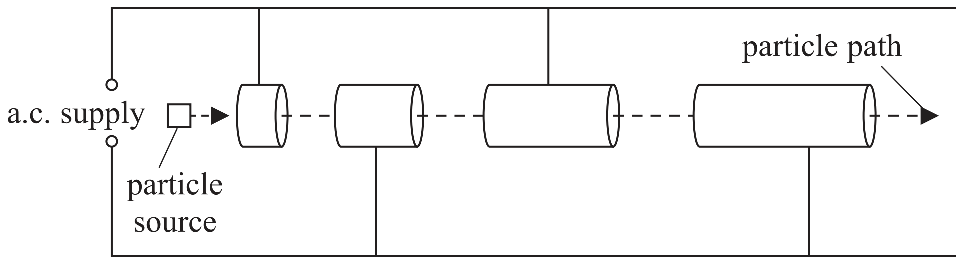
6 The diagram shows the drift tubes at the start of a linear accelerator.



At the end of the linear accelerator the drift tubes are the same length.

Which of the following is the reason for this?

☒ **A** The frequency of the accelerating potential difference is increasing.

☒ **B** The particles are no longer gaining energy.

☒ **C** The rest mass of the particles is increasing.

☒ **D** The speed of the particles is no longer increasing.

(Total for Question 6 = 1 mark)

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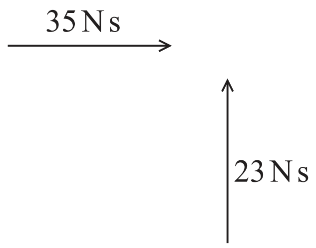
Questions 7 and 8 refer to the following situation.

An object moving north with momentum 23 N s collides with an object moving east with momentum 35 N s.



After the collision, the objects move off together.

7 Which of the following will give the magnitude of the final momentum in N s?

☒ **A** $\dfrac{(35 + 23)}{2}$

☒ **B** $35 + 23$

☒ **C** $35^2 + 23^2$

☒ **D** $\sqrt{(35^2 + 23^2)}$

(Total for Question 7 = 1 mark)

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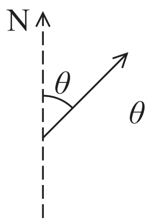
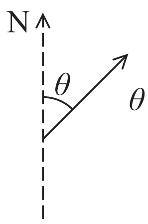
8 Which of the following gives the direction of the final momentum?

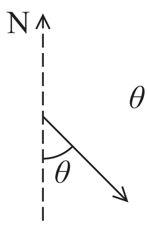
Not to scale

☒ **A**


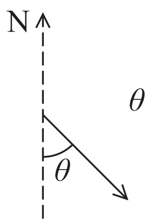
$\theta = \tan^{-1}\left(\dfrac{23}{35}\right)$

☒ **B**


$\theta = \tan^{-1}\left(\dfrac{35}{23}\right)$

☒ **C**


$\theta = \tan^{-1}\left(\dfrac{23}{35}\right)$

☒ **D**


$\theta = \tan^{-1}\left(\dfrac{35}{23}\right)$

(Total for Question 8 = 1 mark)

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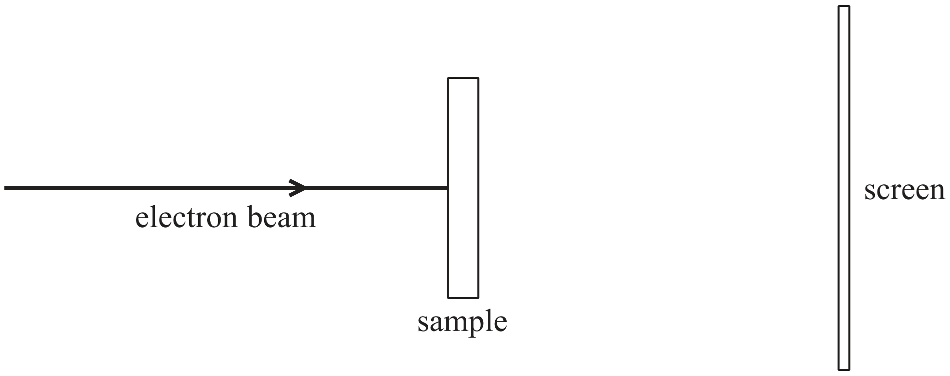
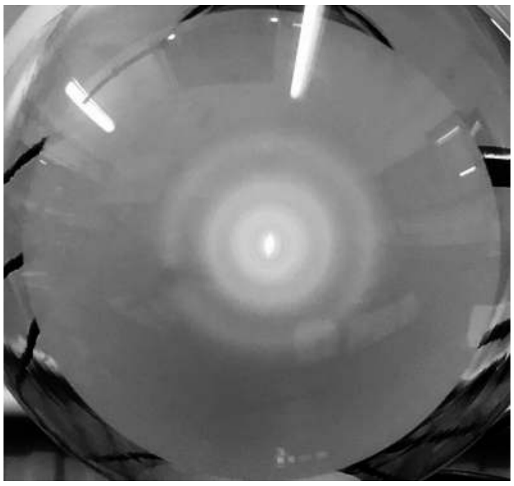
9 When a beam of high energy electrons is directed at a sample of a crystalline material, electron diffraction can occur.



This can be observed as a set of concentric circles on a fluorescent screen, as shown in the photograph.



Which of the following changes would decrease the diameter of the circles?

☒ **A** Use a crystal with a smaller spacing between the layers of atoms.

☒ **B** Use a screen further from the crystal.

☒ **C** Use electrons with greater momentum.

☒ **D** Use electrons with lower speed.

(Total for Question 9 = 1 mark)

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10 A ball has mass 0.4 kg and kinetic energy 9 J.

Which of the following gives the momentum of the ball in $kg\,m\,s^{-1}$?

☒ **A** $\sqrt{\frac{0.4 \times 9}{2}}$

☒ **B** $\sqrt{\frac{9}{2 \times 0.4}}$

☒ **C** $\sqrt{2 \times 9 \times 0.4}$

☒ **D** $2 \times \sqrt{9 \times 0.4}$

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

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SECTION B

Answer ALL questions in the spaces provided.

11 Calculate the electric field strength at a distance of 5.0 cm from the surface of a positively charged sphere.

diameter of sphere = 12 cm

charge on sphere = +34 nC

(3)

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Magnitude of electric field strength = ...

Direction of electric field strength = ...

(Total for Question 11 = 3 marks)

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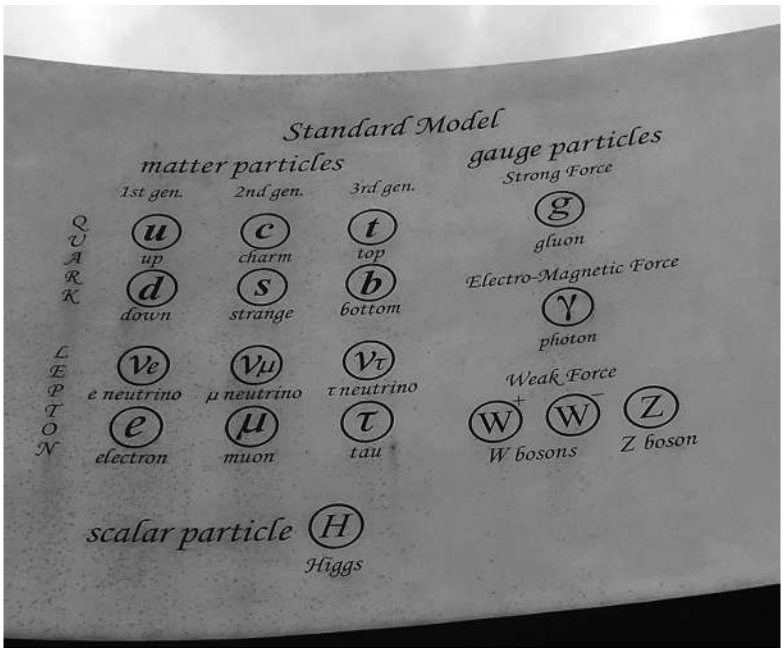
***12** The photograph shows part of a sculpture at the laboratories of the European Organization for Nuclear Research in Switzerland.



A teacher on a tour says to a group of students, "In fact, nearly all of the matter in that sculpture is made up of the two first generation quarks, in combinations called baryons, and one type of lepton. However, the matter is mostly empty space."

Explain this statement.

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(Total for Question 12 = 6 marks)

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13 The existence of the Higgs boson was confirmed in 2012.

The Higgs boson has no charge and a mass of 126 MeV/c^2.

(a) Calculate the mass of the Higgs boson in kg.

(3)

Mass = ... kg

(b) In a video about the Higgs boson the following statement is made:

"The Higgs boson can decay in many ways. Sometimes the Higgs boson decays into two high energy photons."

Calculate the frequency of the photons. Assume the photons are identical.

(3)

Frequency = ...

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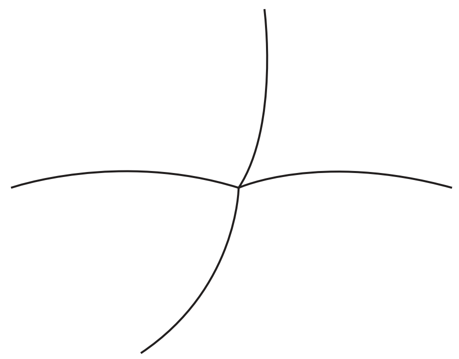
(c) The video shows the following diagram, which represents the decay of a Higgs boson. The lines are tracks of decay particles moving in a magnetic field perpendicular to the diagram.



The video commentary includes the statement:

"Sometimes the Higgs boson decays into four electrons."

Discuss this statement.

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(Total for Question 13 = 9 marks)

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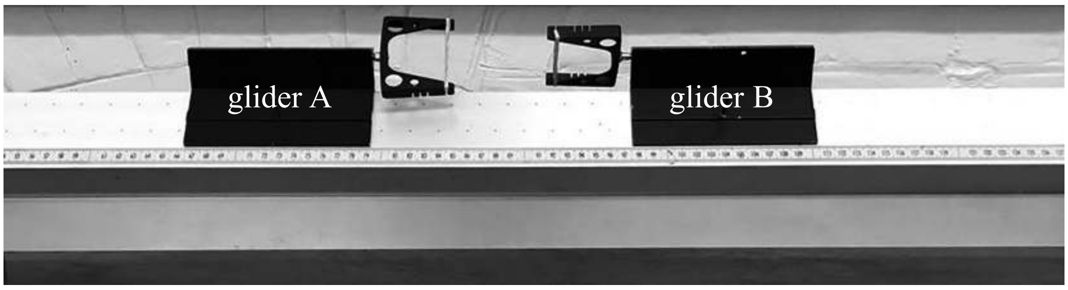
14 A student investigated elastic collisions using an air track as shown. The friction between the gliders and the air track was negligible.

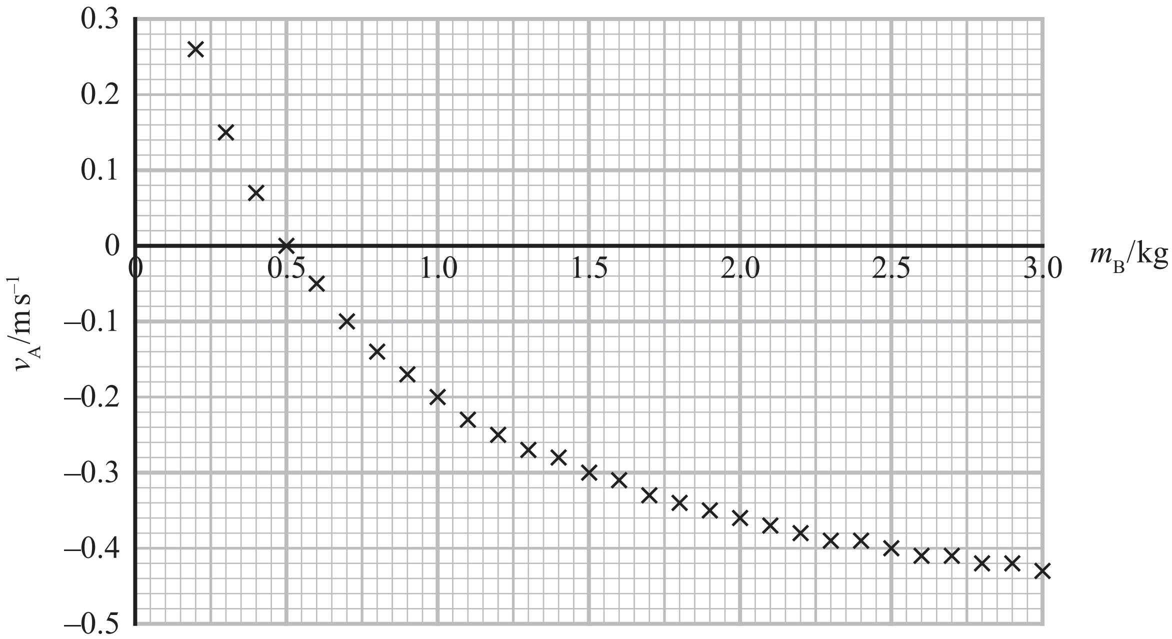


Glider A had mass $m_A = 0.50\,kg$ and moved towards glider B at a speed of $0.60\,m\,s^{-1}$. Glider B was initially at rest.

The gliders collided and the velocity v_A of glider A after the collision was measured.

The process was carried out for various masses m_B of glider B. The mass and initial speed of glider A were kept the same.

The results are shown on the graph.



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(a) Describe the motion of glider A and glider B after the collision

(i) when $m_B < m_A$

(1)

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(ii) when $m_B = m_A$

(1)

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(iii) when $m_B > m_A$.

(1)

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(b) (i) Calculate the velocity v_B of glider B after the collision when $m_B = 1.4\,\text{kg}$. Do not assume that the collision is elastic.

(4)

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v_B = ...

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(ii) Determine whether the collision was elastic when $m_B = 1.4$ kg.

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(Total for Question 14 = 10 marks)

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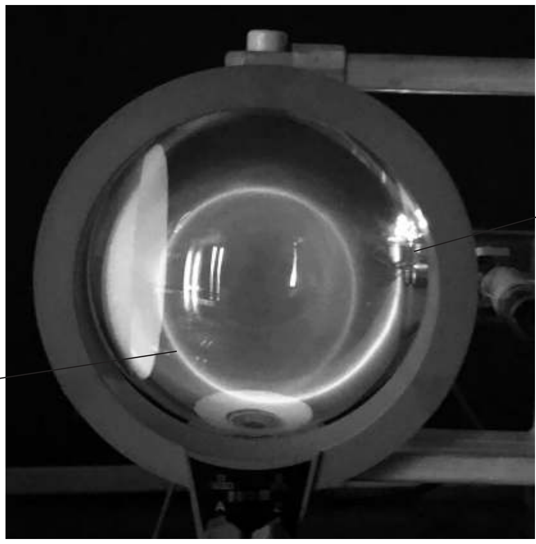
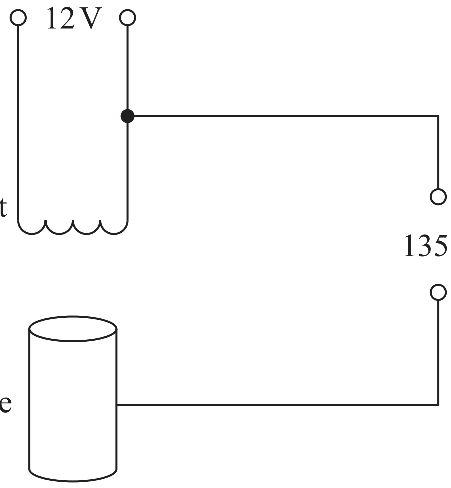
15 The photograph shows the path of an electron beam in a fine beam tube.



The fine beam tube contains helium gas at very low pressure. When electrons strike the helium atoms the resulting excitation is responsible for the glow tracing the path of the electron beam.

The electron beam is emitted downwards from an electron gun.

(a) The electron gun contains a heated filament above an anode as shown. There is a potential difference of 135 V between the anode and the filament.



(i) Describe how the electron beam is produced.

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(ii) Show that the speed of the electrons leaving the electron gun is about $7 \times 10^6\,\mathrm{m\,s^{-1}}$.

(2)

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(b) The electron beam follows the path shown in the photograph. A horizontal magnetic field is applied in the direction into the page.

(i) Show that a particle of momentum p follows a circular path of radius r given by

$$r = p/BQ$$

where Q is the charge on the particle and B is the magnetic flux density.

(2)

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(ii) Calculate B.

diameter of circular path = 7.3 cm

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B = ...

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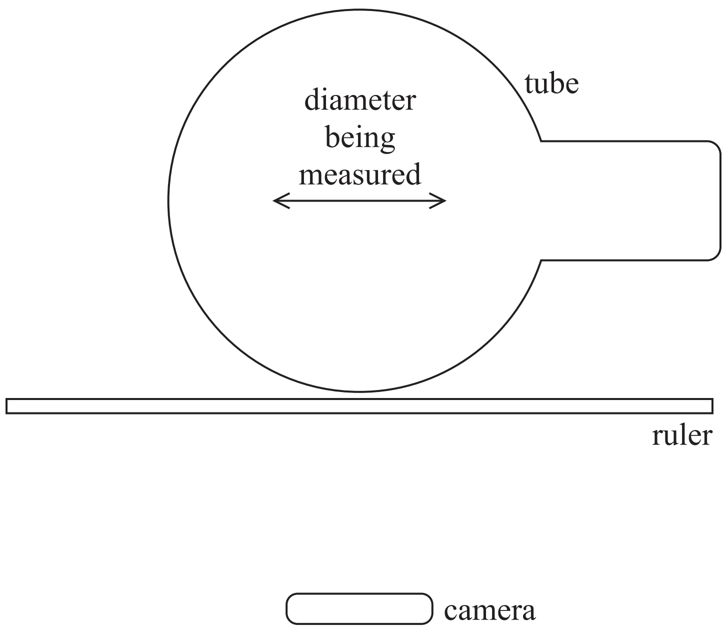
(c) The diameter of the circular path was measured by holding a metre rule in front of the tube and taking a photograph, as shown.



Discuss the suitability of this method.

(2)

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(d) Suggest why the electron beam continues along a path of decreasing diameter with decreasing intensity.

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(Total for Question 15 = 12 marks)

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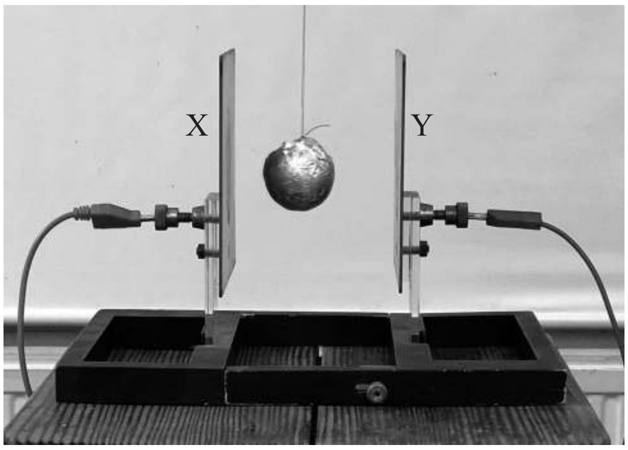
16 The photograph shows an arrangement for investigating charge, known as the "shuttling ball".

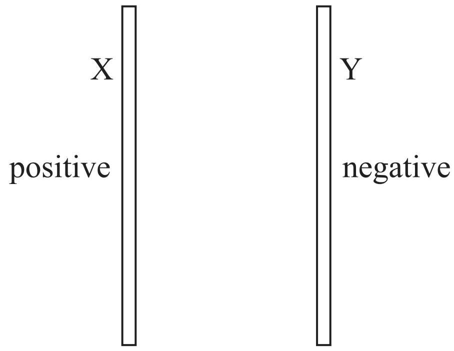


A ball coated in conducting material is suspended, on a very long insulating thread, between metal plates.

A potential difference (p.d.) is applied across the plates so that plate X is positively charged and plate Y is negatively charged. When the ball is touched against plate Y it gains a negative charge and is attracted to plate X. When the ball touches plate X the charge is transferred, the ball becomes positively charged and is attracted to plate Y. The ball continually moves between the plates. Assume that the presence of the ball does not affect the field of the plates.

(a) (i) Sketch the field between the plates on the diagram below.

(2)



(ii) Explain why the charged ball experiences a horizontal force of constant magnitude while it is between the plates.

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(b) The ball is initially at rest touching plate Y. After it leaves plate Y the ball accelerates uniformly from plate Y to plate X.

mass of ball = 2.7 g

(i) Show that the acceleration is about $0.2\,\mathrm{m\,s^{-2}}$.

distance between plates = 9.5 cm
p.d. between plates = 5000 V
charge on ball = 11 nC

(4)

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(ii) Calculate the momentum of the ball as it reaches plate X.

diameter of ball = 4.0 cm

(3)

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Momentum = ...

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(iii) The ball is in contact with plate X for 0.95 ms.
Calculate the average force acting on the ball during this time.
Assume that the ball hits the plate and leaves the plate at the same speed.

(3)

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Average force = ...

(Total for Question 16 = 14 marks)

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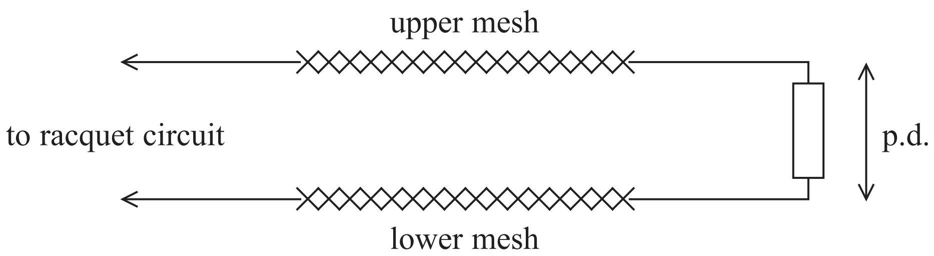
17 The photograph shows an electronic 'fly zapper' racquet.

The racquet has two metal meshes. When a fly is between the meshes, the user presses a button and a potential difference (p.d.) of 1500 V is applied between the meshes for a short time. This p.d. causes a current in the fly, stunning it.

A student thought that the racquet must contain a capacitor. To investigate this, he connected a resistor with a high resistance between the meshes.



The student pressed the button and used a data logger to record how the p.d across the resistor varied with time. The student obtained the following graph.

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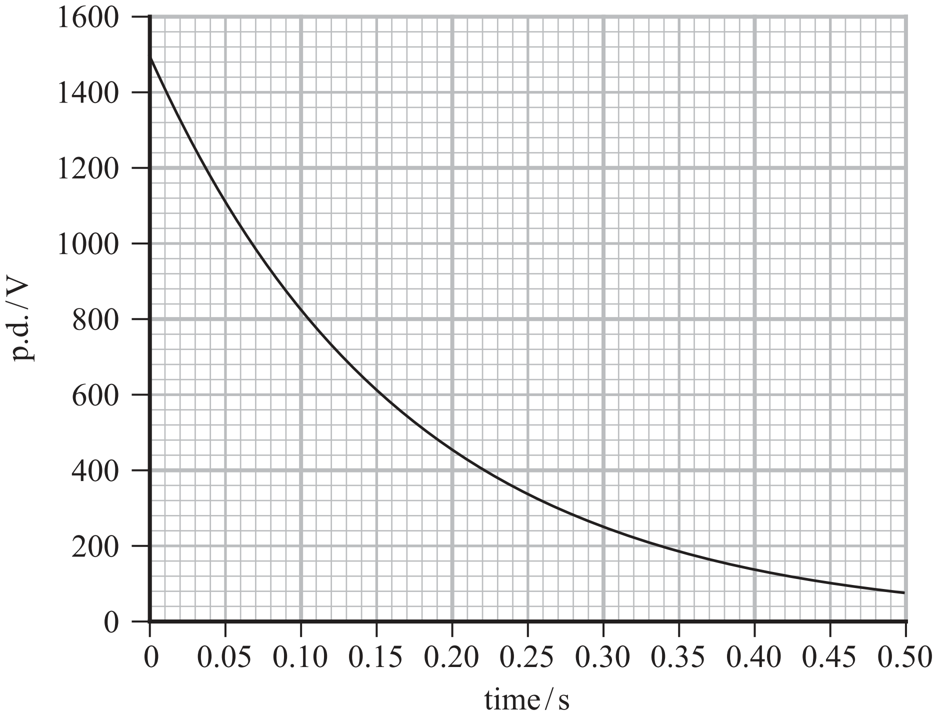

(a) Describe how a graph of p.d. against time can be used to show that the racquet contained a capacitor. Your answer should not include calculations.

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(b) (i) Show that the capacitor has a capacitance of about 10 nF. Use values from the graph.

resistance of resistor = 12 MΩ

(4)

(ii) To ensure safety for humans, the maximum allowed stored charge for a fly zapper is 45 μC.

Show that this racquet operates within the safe limit.

(2)

(iii) Calculate the energy stored on the fully charged capacitor.

(2)

Energy = ...

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(c) The p.d. falls to about 5% of its initial value in less than half a second.

Explain why the measurements were made using a data logger rather than a digital voltmeter and a timer.

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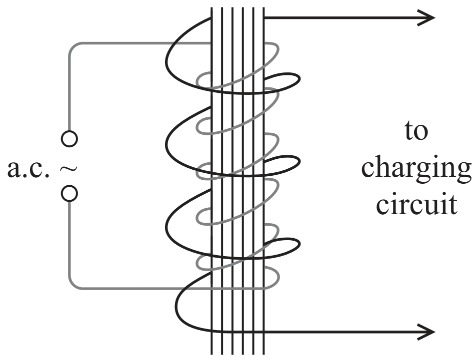
*(d) The capacitor is charged using a 5 V battery.

A circuit in the racquet produces a small alternating p.d. This circuit is connected to a coil wound around an iron core. A second coil around the core is connected to the capacitor charging circuit, as shown in the diagram.



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Explain how this arrangement causes a current in the capacitor charging circuit.

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(Total for Question 17 = 16 marks)

TOTAL FOR SECTION B = 70 MARKS
TOTAL FOR PAPER = 80 MARKS

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List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \mathrm{m\ s^{-2}}$	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}\ \mathrm{J\ K^{-1}}$	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^{9}\ \mathrm{N\ m^2\ C^{-2}}$	
Electron charge	$e = -1.60 \times 10^{-19}\ \mathrm{C}$	
Electron mass	$m_e = 9.11 \times 10^{-31}\ \mathrm{kg}$	
Electronvolt	$1\ \mathrm{eV} = 1.60 \times 10^{-19}\ \mathrm{J}$	
Gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\ m^2\ kg^{-2}}$	
Gravitational field strength	$g = 9.81\ \mathrm{N\ kg^{-1}}$	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\ m^{-1}}$	
Planck constant	$h = 6.63 \times 10^{-34}\ \mathrm{J\ s}$	
Proton mass	$m_p = 1.67 \times 10^{-27}\ \mathrm{kg}$	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}\ \mathrm{m\ s^{-1}}$	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}\ \mathrm{W\ m^{-2}\ K^{-4}}$	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$	

Unit 1

Mechanics

Kinematic equations of motion	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
Forces	$\Sigma F = ma$ $g = F/m$ $W = mg$
Work and energy	$\Delta W = F\Delta s$ $E_k = \frac{1}{2}mv^2$ $\Delta E_{grav} = mg\Delta h$

Materials

Stokes' law	$F = 6\pi\eta rv$
Hooke's law	$F = k\Delta x$
Density	$\rho = m/V$
Pressure	$p = F/A$
Young modulus	$E = \sigma/\varepsilon$ where Stress $\sigma = F/A$ Strain $\varepsilon = \Delta x/x$
Elastic strain energy	$E_{el} = \frac{1}{2}F\Delta x$

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Unit 2

Waves

Wave speed	$v = f\lambda$
Refractive index	${}_1\mu_2 = \sin i / \sin r = v_1/v_2$

Electricity

Potential difference	$V = W/Q$
Resistance	$R = V/I$
Electrical power, energy and efficiency	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$

$$\%\ \text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100$$

$$\%\ \text{efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100$$

Resistivity	$R = \rho l/A$
Current	$I = \Delta Q/\Delta t$ $I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Quantum physics

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$

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Unit 4

Mechanics

Momentum	$p = mv$
Kinetic energy of a non-relativistic particle	$E_k = p^2/2m$
Motion in a circle	$v = \omega r$ $T = 2\pi/\omega$ $F = ma = mv^2/r$ $a = v^2/r$ $a = r\omega^2$

Fields

Coulomb's law	$F = kQ_1Q_2/r^2$ where $k = 1/4\pi\varepsilon_0$
Electric field	$E = F/Q$ $E = kQ/r^2$ $E = V/d$
Capacitance	$C = Q/V$
Energy stored in capacitor	$W = \frac{1}{2}QV$
Capacitor discharge	$Q = Q_0e^{-t/RC}$
In a magnetic field	$F = BIl \sin\theta$ $F = Bqv \sin\theta$ $r = p/BQ$
Faraday's and Lenz's laws	$\varepsilon = -d(N\phi)/dt$

Particle physics

Mass-energy	$\Delta E = c^2 \Delta m$
de Broglie wavelength	$\lambda = h/p$

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