Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number

Candidate Number

Physics

Advanced
Unit 4: Physics on the Move

Monday 8 January 2018 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
WPH04/01

You must have:
Ruler

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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Pearson

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 Some of Rutherford's alpha scattering experiments used radium as a source of alpha particles.

Which of the following nuclei would be produced by alpha emission from $^{226}_{88}Ra$?

☐ **A** $^{228}_{92}U$

☐ **B** $^{230}_{90}Th$

☐ **C** $^{222}_{86}Rn$

☐ **D** $^{224}_{84}Po$

(Total for Question 1 = 1 mark)

2 Which of the following is **not** a lepton?

☐ **A** electron

☐ **B** neutrino

☐ **C** pion

☐ **D** positron

(Total for Question 2 = 1 mark)

3 A capacitor of capacitance C stores a charge Q when the potential difference across it is V.

Which of the following expressions is the energy stored on the capacitor?

☐ **A** $\frac{1}{2}CV$

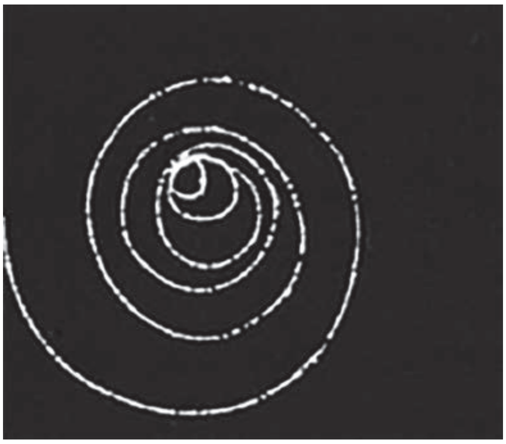
☐ **B** $\frac{1}{2}\frac{C^2}{Q}$

☐ **C** $\frac{1}{2}C^2V$

☐ **D** $\frac{1}{2}\frac{Q^2}{C}$

(Total for Question 3 = 1 mark)

4 The photograph shows the track of a positron in a particle detector. There is a magnetic field perpendicular to the plane of the track.



Which of the following is **not** a correct statement?

☒ **A** The energy of the positron is decreasing.

☒ **B** The magnetic field acts into the page.

☒ **C** The positron is gaining mass.

☒ **D** The speed of the positron is decreasing.

(Total for Question 4 = 1 mark)

5 The potential difference across a charged capacitor is V_0. The capacitor discharges through a fixed resistor. After a time equal to the time constant, the potential difference has reduced to V.

Which of the following is a correct expression for V?

☒ **A** $V = \frac{V_0}{2}$

☒ **B** $V = \frac{V_0}{e}$

☒ **C** $V = \frac{V_0}{\ln 2}$

☒ **D** $V = \frac{V_0}{\ln e}$

(Total for Question 5 = 1 mark)

6 Baryons and mesons are types of particles that consist of quarks.

Which row of the table shows a possible quark composition for a baryon and for a meson?

	Baryon	Meson
☒ **A**	$c\,\bar{u}$	$u\,\bar{c}\,d$
☒ **B**	$u\,c\,d$	$c\,u$
☒ **C**	$c\,\bar{u}$	$u\,c\,d$
☒ **D**	$u\,c\,d$	$c\,\bar{u}$

(Total for Question 6 = 1 mark)

7 Which of the following is a unit of the permittivity of free space ε_0?

☒ **A** $C^2\,m^2\,N^{-1}$

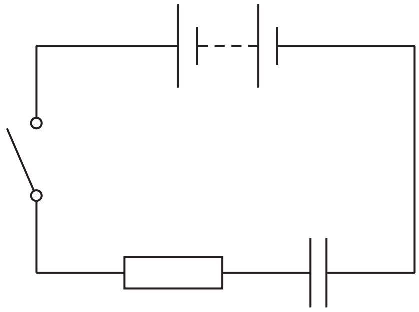
☒ **B** $C^2\,m^{-2}\,N^{-1}$

☒ **C** $C^{-2}\,m^2\,N^{-1}$

☒ **D** $C^{-2}\,m^{-2}\,N$

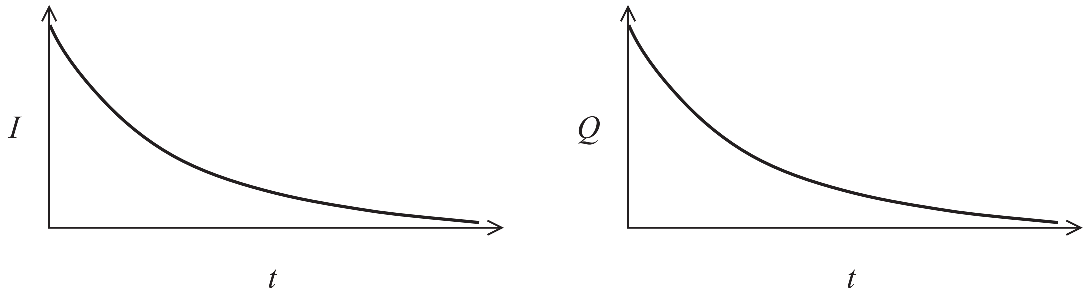
(Total for Question 7 = 1 mark)

8 The following circuit is used to charge a capacitor.

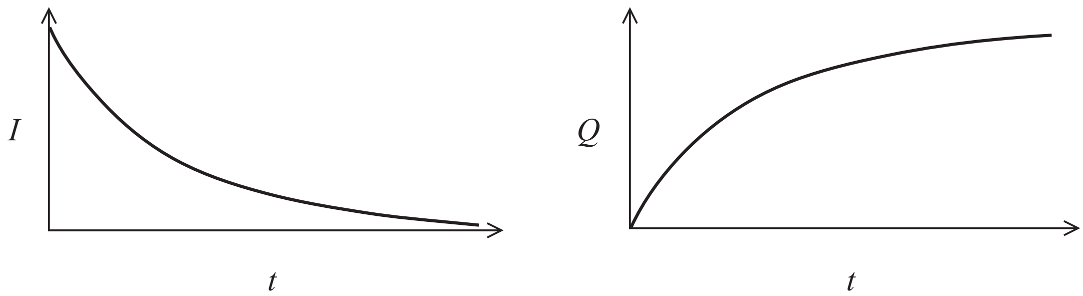


Which of the following pairs of graphs shows the variation of the current I in the resistor with time t and the variation of charge Q stored on the capacitor with t?

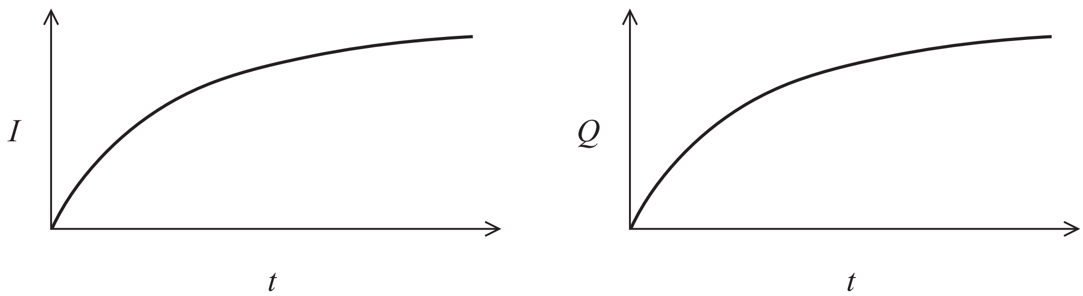
☒ **A**



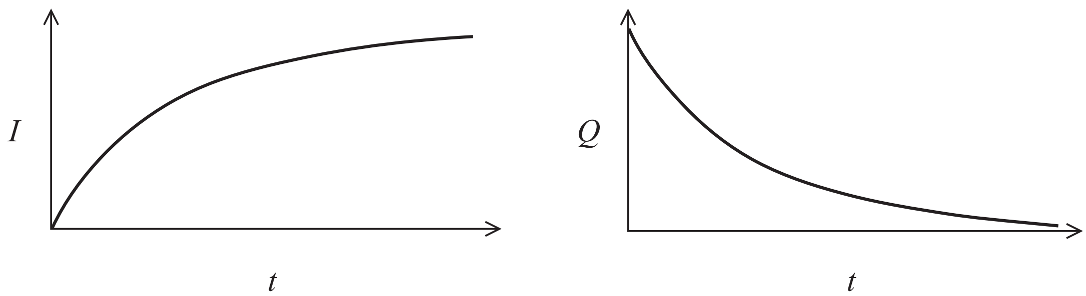
☒ **B**



☒ **C**



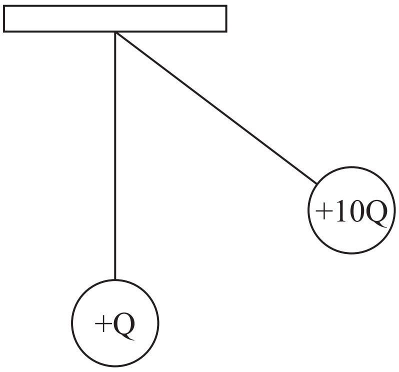
☒ **D**



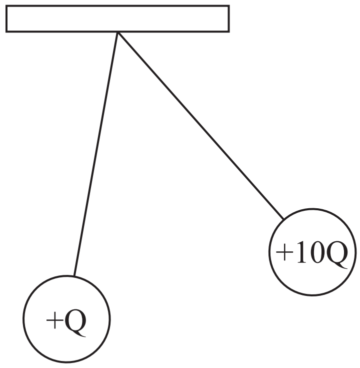
(Total for Question 8 = 1 mark)

9 Two charged spheres of equal mass are suspended with insulating threads of equal length. One sphere has a charge of +Q and the other has a charge of +10Q.

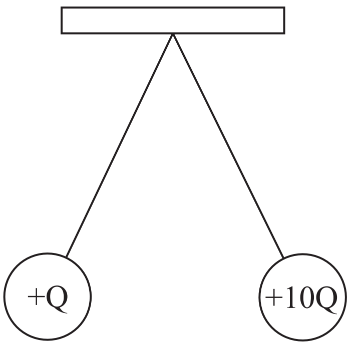
Which of the following shows the arrangement of these spheres when they are in equilibrium?



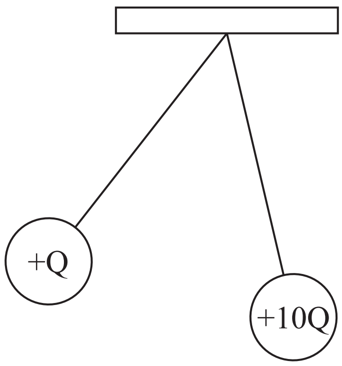
A



B



C



D

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

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P 5 1 9 4 8 R A 0 6 2 8

10 A student is investigating how the magnetic flux through a coil varies with its angle, in radians, to a magnetic field.

Which of the following gives the equivalent angle in radians for an angle of 40°?

☒ **A** $\dfrac{40 \times \pi}{360}$

☒ **B** $\dfrac{40 \times 2\pi}{360}$

☒ **C** $\dfrac{40 \times 360}{2\pi}$

☒ **D** $\dfrac{40 \times 360}{\pi}$

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 (a) A K^0 particle decays producing a pion, a muon and a neutrino.

Complete the nuclear equation to show the charges on the particles.

(1)

$$K^0 \rightarrow \pi + \mu + \bar{\nu}_\mu$$

(b) Ordinary matter is made up of protons, neutrons and electrons. At the time they were discovered, these particles were not thought to be made up of any other particles.

Explain how the proton, neutron and electron are described in the current standard model of matter.

(3)

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(Total for Question 11 = 4 marks)

12 The diagrams below represent the path of an electron in a vacuum.

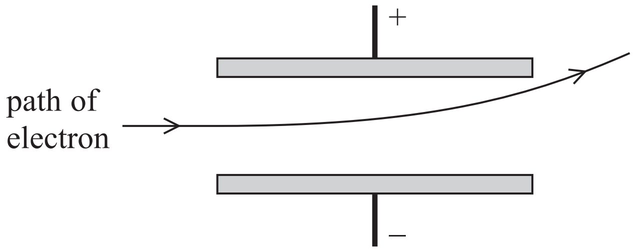

Diagram 1

No magnetic field
Potential difference across plates

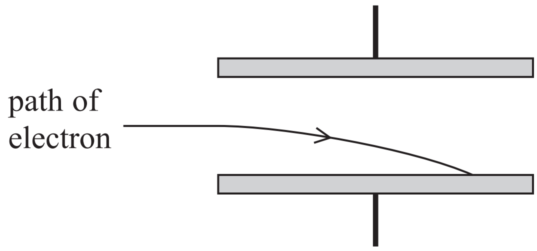

Diagram 2

Magnetic field into page
No electric field

Using both fields at the same time, it is possible to balance the forces so that the path of the electron is not deviated.

For such an electron, its velocity v is given by the equation

$$v = \frac{V}{dB}$$

where V is the potential difference across the plates, d is the separation of the plates and B is the magnetic flux density.

Show that this equation is correct.

(4)

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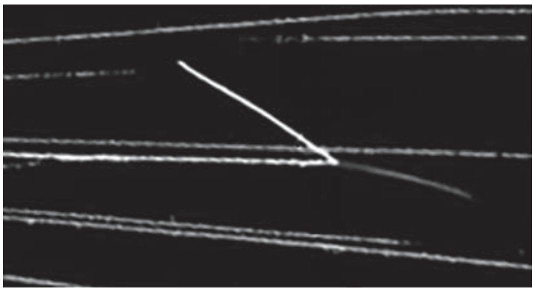
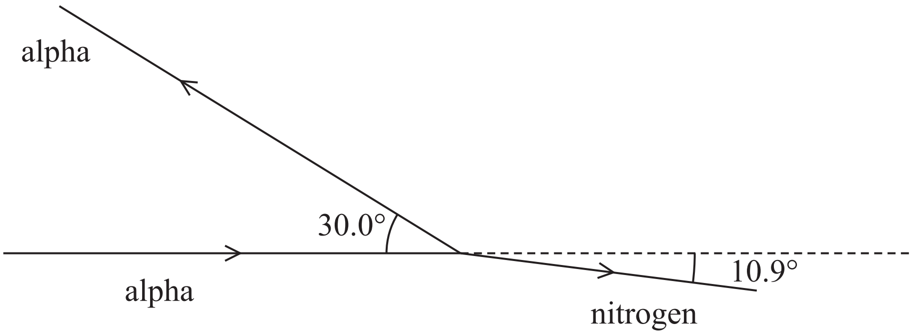
(Total for Question 12 = 4 marks)

13 In the 1920s Patrick Blackett investigated the interaction of alpha particles with different atomic nuclei. The diagram shows an alpha particle interacting with a stationary nitrogen nucleus.



The alpha particle rebounded off the nitrogen nucleus. The nitrogen nucleus recoiled in the other direction.

The directions of the paths are shown in the diagram.



The initial speed of the alpha particle was $1.20 \times 10^{7}\,\mathrm{m\,s^{-1}}$ and the speed of the alpha particle after the interaction was $6.93 \times 10^{6}\,\mathrm{m\,s^{-1}}$.

mass of alpha particle = $4.00\,u$

mass of nitrogen nucleus = $14.00\,u$

(a) Show that the speed of the nitrogen nucleus after the interaction was about $5.2 \times 10^{6}\,\mathrm{m\,s^{-1}}$.

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(b) Determine whether this interaction was elastic.

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(Total for Question 13 = 7 marks)

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14 When an X-ray photon interacts with an atomic nucleus, pair production can occur. In pair production the photon energy produces an electron and a positron.

For this to occur, the wavelength of the X-ray photon must be less than a certain value.

(a) Show that the maximum wavelength of the X-ray photon is about 1×10^{-12} m.

(4)

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(b) State why two electrons cannot be produced by pair production.

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(c) After production, the positron and the electron move off in different directions.

Suggest what happens to the electron and the positron after this.

(2)

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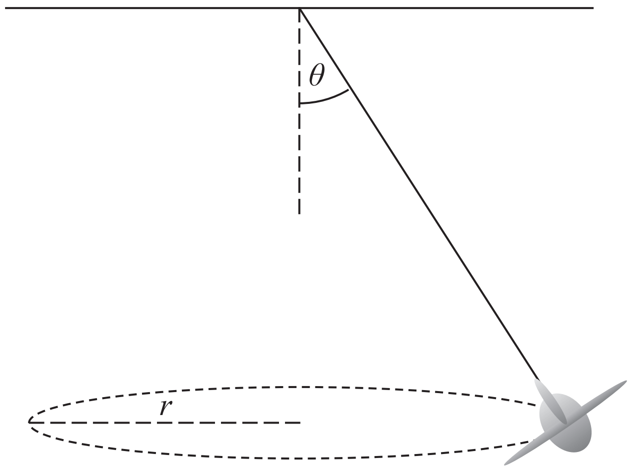
(Total for Question 14 = 7 marks)

15 The diagram represents a toy aeroplane on the end of a string.



The toy aeroplane follows a horizontal path of radius r and the string is at an angle θ to the vertical.

(a) (i) Complete a free-body force diagram for the toy aeroplane. Ignore any forces due to the air.

(2)

(ii) The toy aeroplane completes 36 revolutions in one minute.

Calculate the speed of the toy aeroplane.

(2)

$r = 40\,\text{cm}$

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Speed = ...

P 5 1 9 4 8 R A 0 1 4 2 8

(iii) By considering the vertical and horizontal components of tension, show that the angle θ is independent of the mass of the toy aeroplane.

(3)

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(b) Suggest how a value for θ can be determined experimentally.

(2)

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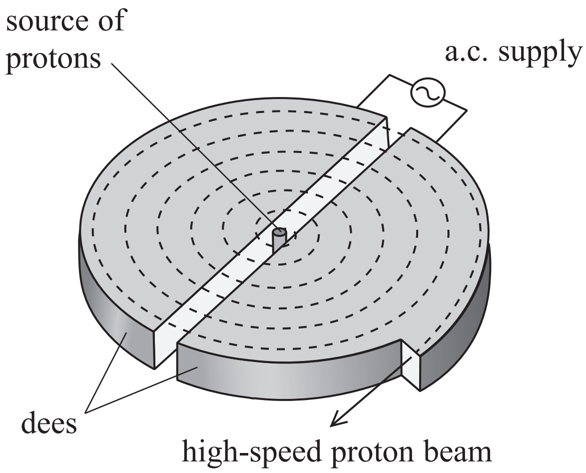
(Total for Question 15 = 9 marks)

16 A cyclotron at the TRIUMF national laboratory in Canada produces beams of protons with energies from 20 MeV up to 520 MeV.

A simplified diagram of a cyclotron is shown.



*(a) Explain how the cyclotron accelerates the protons to follow the path shown.

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(b) (i) Calculate the momentum, in N s, of protons with a kinetic energy of 20 MeV.
You may ignore any relativistic effects.

(3)

Momentum = ... N s

(ii) The TRIUMF cyclotron can produce beams of protons of different energies. This is done by extracting protons at different distances from the centre of the cyclotron.

Calculate the radius used to extract protons with a kinetic energy of 20 MeV.

(2)

magnetic flux density = 0.41 T

Radius = ...

(iii) Beams of protons can be used to probe the structure of matter.

Determine whether the wavelength of 20 MeV protons is suitable for investigating nuclei of diameter 1.3×10^{-14} m.

(3)

(Total for Question 16 = 13 marks)

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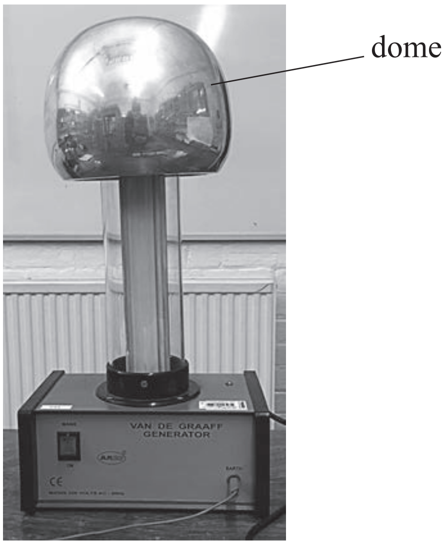
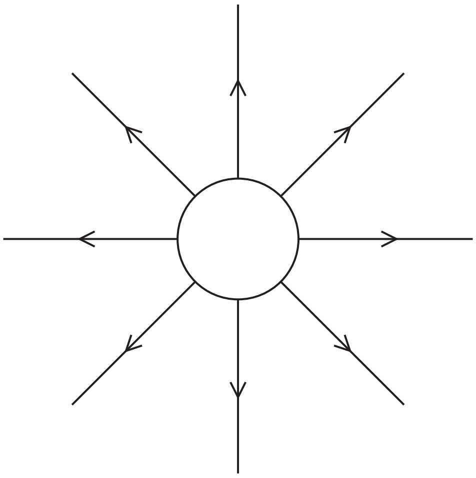
17 The photograph shows a Van de Graaff generator used in a school.



In the Van de Graaff generator, charge is transferred to a hollow metal dome which is insulated from the ground.

(a) The dome may be treated as a positively charged sphere with the charge distributed evenly on its outside surface.

The electric field outside the sphere is the same as if all the charge were concentrated at the centre of the sphere. The diagram shows the electric field for a positively charged conducting sphere.



(i) Suggest why there are no field lines inside the sphere.

(1)

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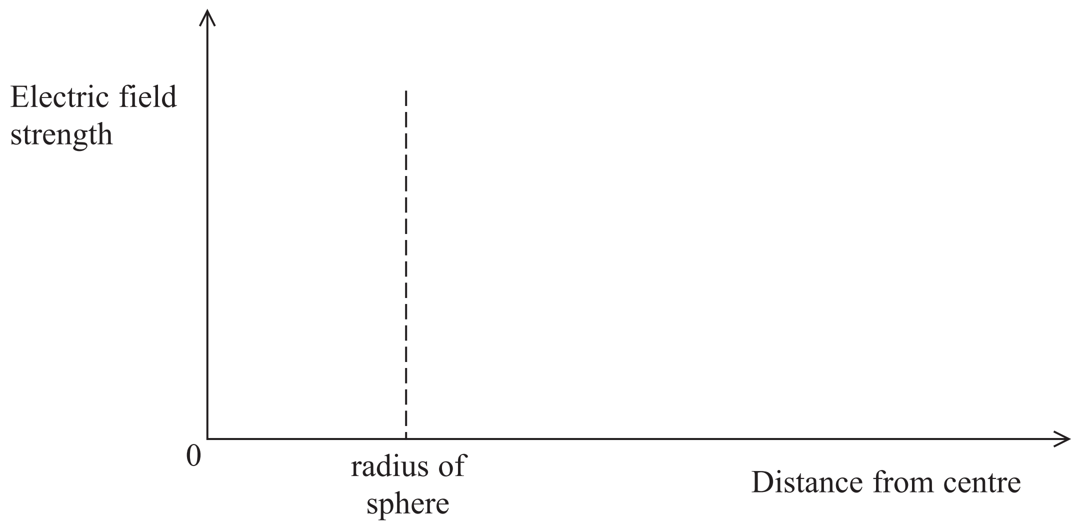
(ii) Sketch a graph to show how the electric field strength varies with distance from the centre of the sphere.

(2)



(b) (i) The capacitance of a conducting sphere of radius r is given by

$$C = 4\pi\varepsilon_0 r$$

The dome of the Van de Graaff generator behaves as a conducting sphere of radius 12 cm. The charge on the dome is 1.5×10^{-6} C.

Calculate the potential difference between the dome and the Earth.

(3)

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Potential difference = ...

(ii) The dome of the Van de Graaff generator is connected to Earth through a resistor of resistance R.

Calculate the time taken for the Van de Graaff generator to lose 70% of its charge.

(3)

$R = 9.1 \times 10^{11}\ \Omega$

Time taken = ...

(Total for Question 17 = 9 marks)

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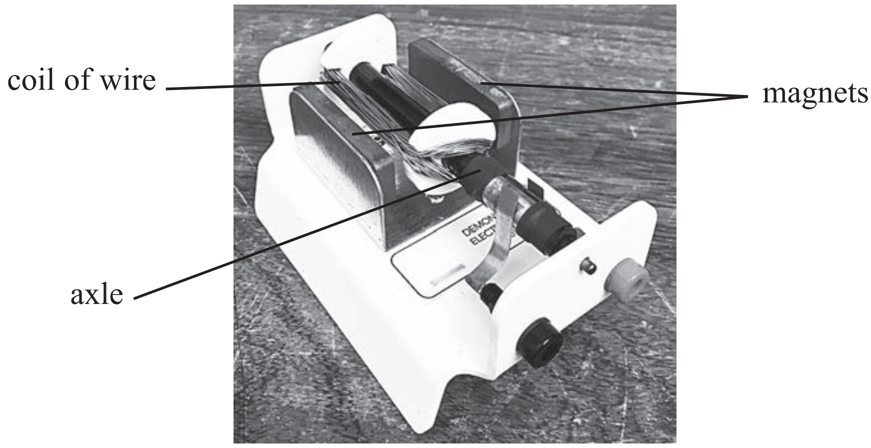
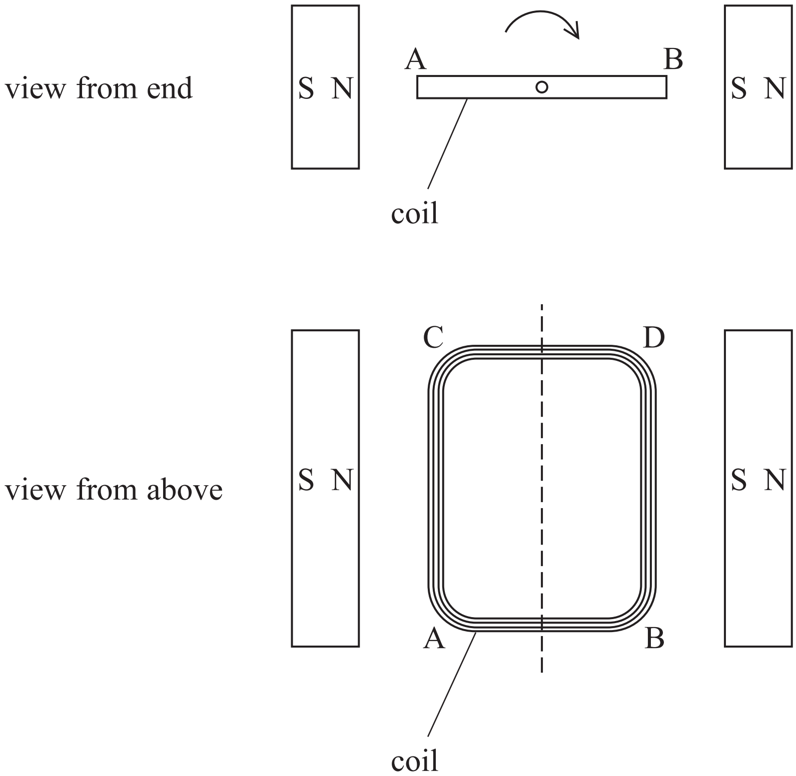
18 The photograph shows a demonstration electric motor.



A coil of wire is mounted on an axle so that it can rotate freely. Magnets are placed either side of the coil to provide a magnetic field.

When there is a current in the coil, the coil rotates.

The diagrams represent the coil and magnets viewed from the end and from above.



Number of turns on coil = 32 Length AC of the coil = 4.8 cm Magnetic flux density = 0.074 T

(a) The coil rotates clockwise as seen from the end AB in the diagram.

Explain the direction of the current in the coil.

(2)

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(b) Calculate the maximum force on the side AC when the current in the coil is 0.29 A.

(2)

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Maximum force = ...

(c) When the coil is rotating the average current in the coil is less than the current in the coil if it is held stationary. This is because of the production of a back e.m.f..

*(i) Explain how the back e.m.f. is produced by the motion of the coil.

(3)

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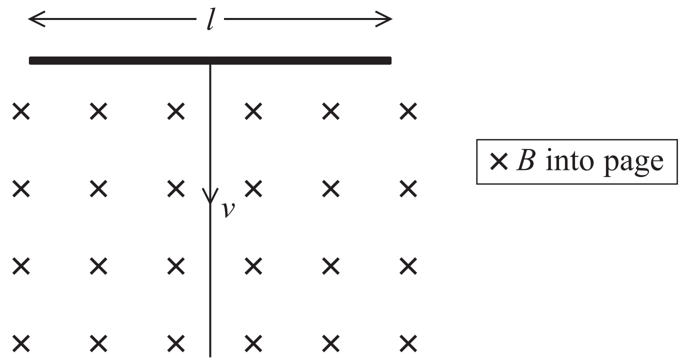
(ii) A wire of length l is moving at speed v through a magnetic field of magnetic flux density B, as shown.



Show that the e.m.f. ε produced is given by

$$\varepsilon = Blv$$

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(iii) The coil of the motor rotates at 9.0 rotations per second.

Calculate the maximum e.m.f. produced across the side AC of the coil.

(3)

width AB of coil = 2.4 cm

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Maximum e.m.f. = ...

(iv) The current in the coil varies as the coil rotates because the back e.m.f. is not constant.

Suggest why the back e.m.f. is not constant.

(2)

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(d) The average current in the coil can be measured with an ammeter.

Suggest a method for measuring how the current varies over time.

(2)

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(Total for Question 18 = 17 marks)

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

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	$E_{el} = \frac{1}{2}F\Delta x$

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	$hf = \phi + \frac{1}{2}mv^2_{max}$

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	$Q = Q_0 e^{-t/RC}$
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	$\lambda = h/p$