Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Monday 12 January 2026

Morning (Time: 1 hour 45 minutes)

Paper reference **WPH14/01**

Physics

International Advanced Level

UNIT 4: Further Mechanics, Fields and Particles

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.*
- **Show all your working out** in calculations and **include units** where appropriate.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In the question marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- The list of data, formulae and relationships is printed at the end of this booklet.

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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P 7 9 1 4 6 A 0 1 3 6

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 Which row of the table gives the number of neutrons and the number of protons in a nucleus of Gadolinium $^{150}_{64}Gd$?

		Neutrons	Protons
☒	**A**	64	150
☒	**B**	86	150
☒	**C**	86	64
☒	**D**	150	64

(Total for Question 1 = 1 mark)

2 Which of the following is a scalar quantity?

☒ **A** electric field strength

☒ **B** electric potential

☒ **C** impulse

☒ **D** magnetic flux density

(Total for Question 2 = 1 mark)

3 Which of the following is a reason why high energy electrons are used to study the structure of nucleons?

☒ **A** to ionise the nucleons

☒ **B** to produce individual quarks

☒ **C** to allow elastic collisions

☒ **D** to provide energy to produce new particles

(Total for Question 3 = 1 mark)

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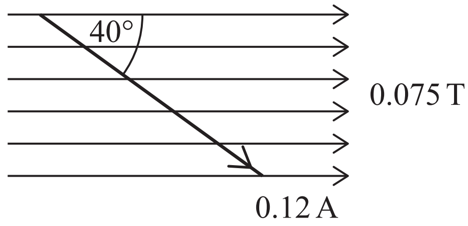
4 A wire carries a current of 0.12 A. The wire is placed in a uniform magnetic field of flux density 0.075 T.

The angle between the wire and the direction of the magnetic field is 40°, as shown.



The length of wire in the field is 4.6 cm.

Which of the following expressions gives the force, in newtons, on the wire?

☒ **A** $0.075 \times 0.12 \times 0.046$

☒ **B** $0.075 \times 0.12 \times 0.046 \times \cos 40°$

☒ **C** $0.075 \times 0.12 \times 0.046 \times \sin 40°$

☒ **D** $0.075 \times 0.12 \times 0.046 \times \tan 40°$

(Total for Question 4 = 1 mark)

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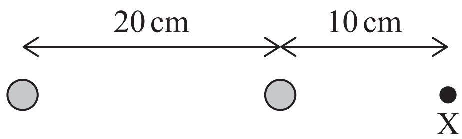
5 Two protons are 20 cm apart in a vacuum. Point X is 10 cm from one of the protons, as shown.



Which of the following expressions gives the electric field strength, in $N\,C^{-1}$, at point X?

☒ **A** $8.99 \times 10^{9} \times 1.6 \times 10^{-19} \left(\frac{1}{0.3} - \frac{1}{0.1}\right)$

☒ **B** $8.99 \times 10^{9} \times 1.6 \times 10^{-19} \left(\frac{1}{0.3} + \frac{1}{0.1}\right)$

☒ **C** $8.99 \times 10^{9} \times 1.6 \times 10^{-19} \left(\frac{1}{(0.3)^2} - \frac{1}{(0.1)^2}\right)$

☒ **D** $8.99 \times 10^{9} \times 1.6 \times 10^{-19} \left(\frac{1}{(0.3)^2} + \frac{1}{(0.1)^2}\right)$

(Total for Question 5 = 1 mark)

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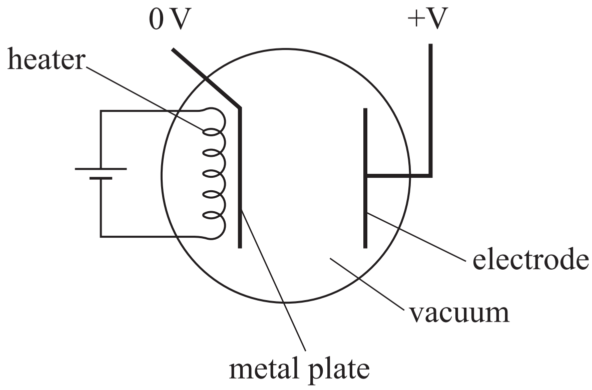
6 A vacuum tube is a type of diode. A metal plate in the vacuum tube is heated to release electrons, as shown.



A potential difference (p.d.) is applied between the metal plate and the electrode. Electrons are accelerated towards the electrode and there is a current I between the metal plate and the electrode.

Which of the following changes would increase I?

☒ **A** reverse the p.d. applied to the heater

☒ **B** increase the p.d. applied to the heater

☒ **C** reverse the p.d. between the metal plate and the electrode

☒ **D** decrease the p.d. between the metal plate and the electrode

(Total for Question 6 = 1 mark)

7 In the early 20th century, scientists investigated the structure of the atom by directing alpha particles at thin gold foils.

Which of the following is **not** a conclusion from the observations made during these investigations?

☒ **A** Most of the atom is empty space.

☒ **B** Most of the mass of the atom is in the nucleus.

☒ **C** There is a concentration of charge in the nucleus.

☒ **D** The nucleus consists of protons and neutrons.

(Total for Question 7 = 1 mark)

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8 A linac accelerates charged particles to high speeds. The charged particles move in a straight line along a series of tubes called ‘drift tubes’.

An alternating potential difference (p.d.) of constant frequency is applied between the drift tubes.

Which of the following is correct?

☒ **A** Each drift tube is the same length.

☒ **B** There is an electric field inside each drift tube.

☒ **C** The particles do not accelerate when they are inside the drift tubes.

☒ **D** The applied p.d. changes polarity when particles are between the drift tubes.

(Total for Question 8 = 1 mark)

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9 An alpha particle and a proton enter a region of uniform magnetic field. The particles are deflected into circular paths.

The alpha particle and the proton have the same initial velocity.

Which of the following is equal to the ratio $\dfrac{\text{radius of path of alpha particle}}{\text{radius of path of proton}}$?

☒ **A** $\dfrac{1}{4}$

☒ **B** $\dfrac{1}{2}$

☒ **C** 2

☒ **D** 4

(Total for Question 9 = 1 mark)

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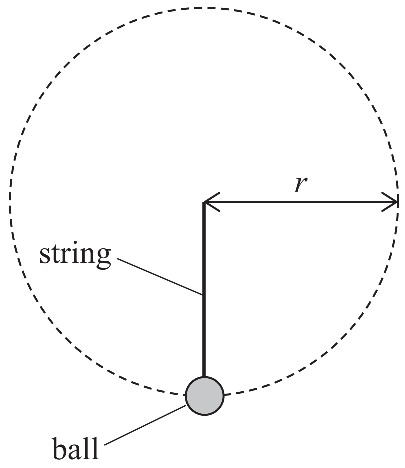
10 A ball of mass m is attached to a string. The ball is made to move in a vertical circle, as shown.



The ball moves in a circle of radius r. Its speed at the bottom of the circle is v.

There is a tension in the string.

Which of the following expressions gives the tension in the string when the ball is at the bottom of the circle?

☒ **A** $mg - \frac{mv^2}{r}$

☒ **B** mg

☒ **C** $\frac{mv^2}{r} - mg$

☒ **D** $\frac{mv^2}{r} + mg$

(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 An alpha particle is moving at right angles to a uniform magnetic field in a vacuum.

Calculate the magnetic flux density of the uniform magnetic field.

force on alpha particle = 9.2×10^{-14} N
speed of alpha particle = 1.2×10^{7} m s^{-1}

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Magnetic flux density = ...

(Total for Question 11 = 2 marks)

12 A carousel is a popular theme park ride. The riders sit on model horses, as shown.

(Source: © Alchemy / Alamy Stock Photo)

The carousel rotates and the riders move in a horizontal circle. The carousel takes 15 s to complete one revolution.

(a) Show that the angular velocity of the carousel is about $0.4\,\text{rad}\,\text{s}^{-1}$.

(2)

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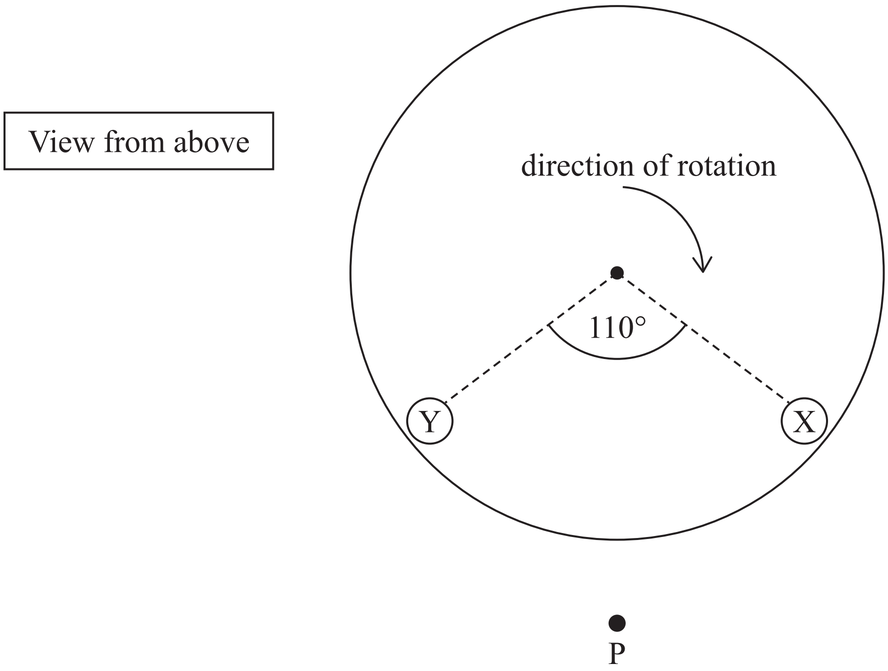
(b) The carousel is rotating. Two riders are at positions Y and X on the carousel, as shown.



As the carousel rotates, the rider at X passes directly in front of the fixed point P. The rider at Y passes the fixed point P a short time t later.

Calculate the time t.

(3)

t = ...

(Total for Question 12 = 5 marks)

13 In the upper atmosphere, high energy cosmic rays interact with nuclei to produce pions. The pions decay into muons.

(a) Muons are leptons. Pions are mesons.

State one difference between the structure of leptons and the structure of mesons.

(1)

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(b) Muons are unstable particles.

The particle equation shows a muon decaying into an electron, a muon neutrino and an electron anti-neutrino.

$$\mu^- \rightarrow e^- + v_\mu + \overline{v}_e$$

Deduce whether the conservation of charge and the conservation of lepton number apply to this decay.

(4)

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(Total for Question 13 = 5 marks)

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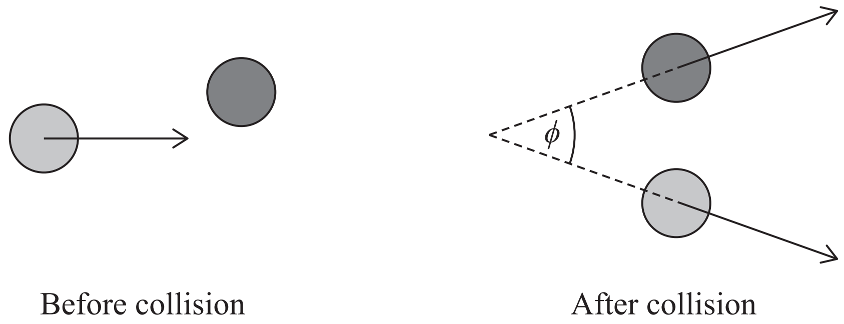
14 A student investigated the collision of two spheres.

(a) The diagram shows the spheres before and after the collision.



After the collision, the spheres move apart at an angle ϕ.

Describe how the angle ϕ can be determined experimentally.

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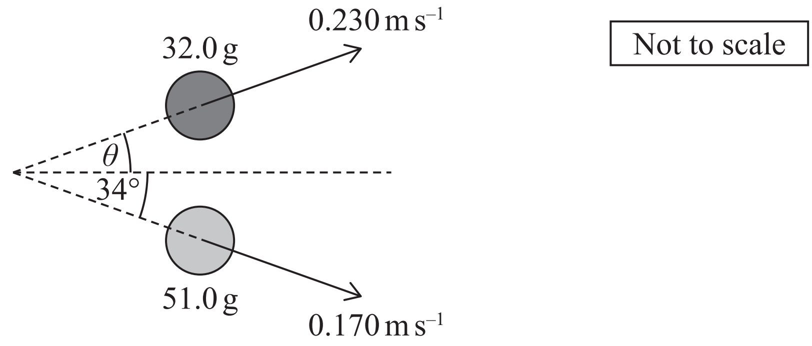
(b) The student rolled a sphere of mass 51.0 g with a velocity u into a stationary sphere of mass 32.0 g.

After the collision, the spheres began to move apart, as shown.



(i) The collision was elastic.

Show that u is about $0.25\,\mathrm{m\,s^{-1}}$.

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(ii) The student determined that θ was 43°.

Deduce whether the student was correct.

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(Total for Question 14 = 8 marks)

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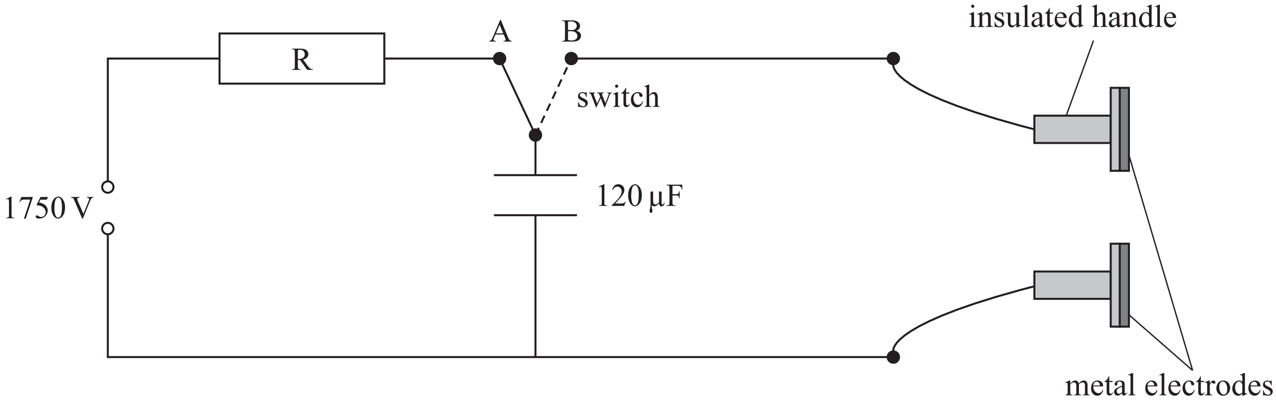
15 Defibrillators save lives by delivering energy to restart a heart that has stopped.

A defibrillator includes a capacitor and a pair of metal electrodes.
The capacitor is charged by connecting it to a large potential difference. The electrodes are connected across the chest of the person and the capacitor discharges.

A switch is used to charge or discharge the capacitor, as shown.



(a) To charge the capacitor, the switch is connected to A.

To restart a heart, the energy stored in the capacitor needs to be at least 150 J.

Deduce whether this circuit will provide enough energy to restart a heart.

(3)

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(b) The electrodes are held on the person's chest by insulated handles.

The switch is moved to position B. The capacitor is then partially discharged across the person's chest.

The initial discharge current is 20.0 A. The discharge is stopped when the discharge current is 8.0 A.

chest resistance of person = 87.5 Ω

(i) Calculate the time taken for the current to decrease to 8.0 A.

(2)

Time taken = ...

(ii) Determine the charge on the capacitor when the discharge is stopped.

(3)

Charge = ...

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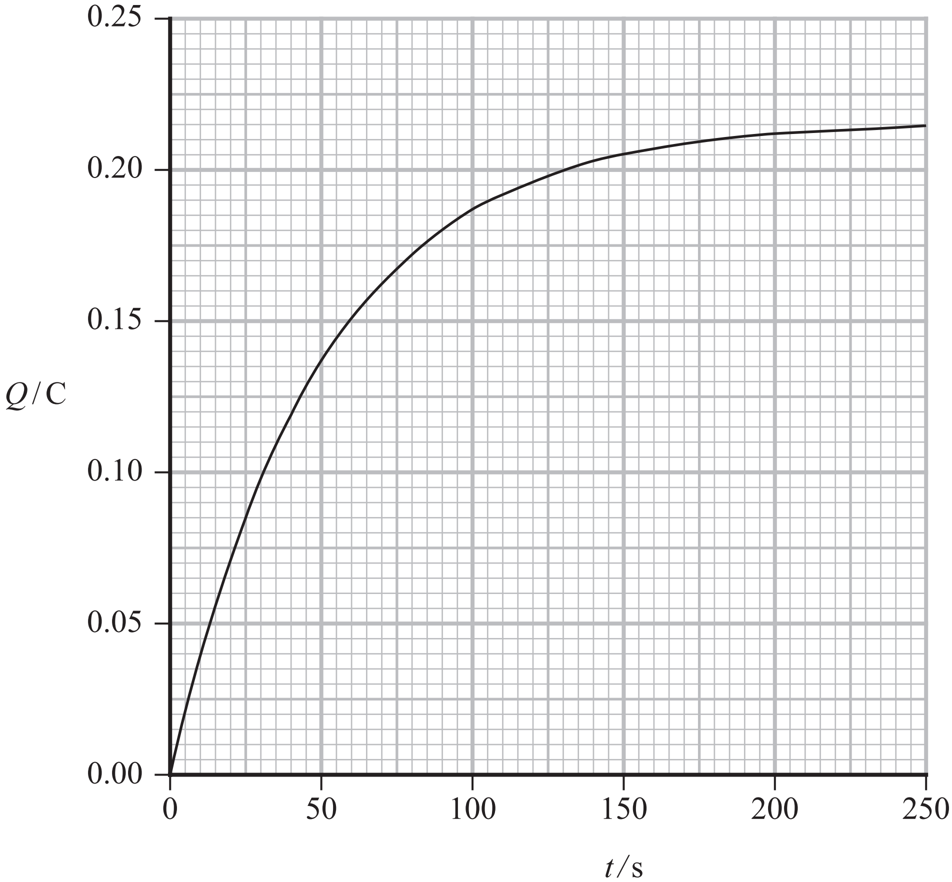
(c) The capacitor must be recharged before the defibrillator can be used again.

During the charging process, the charge Q on the capacitor varies with time t as

$$Q = Q_0 - Q_0 e^{-\frac{t}{RC}}$$

where Q_0 is the charge on the capacitor when it is fully charged.

The graph shows how Q varies with t as the capacitor is being charged.



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Determine the resistance of resistor R in the charging circuit.

(4)

Resistance = ...

(Total for Question 15 = 12 marks)

16 When a high energy photon passes through a strong electric field, pair production can occur. In pair production, the high energy photon creates a particle-antiparticle pair.

An example of pair production is given by the equation

$$\gamma \rightarrow e^{-} + e^{+}$$

where a photon creates an electron-positron pair.

(a) State two differences between an electron and a positron.

(2)

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(b) A high energy photon has an energy of 1.2 MeV.

Deduce whether this photon has sufficient energy to create an electron-positron pair.

(3)

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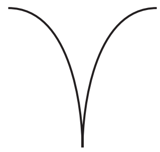
*(c) The tracks shown were produced by particles in a particle detector. There was a uniform magnetic field perpendicular to the plane containing the tracks.



Explain how these tracks could provide evidence for a photon creating a particle-antiparticle pair.

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(Total for Question 16 = 11 marks)

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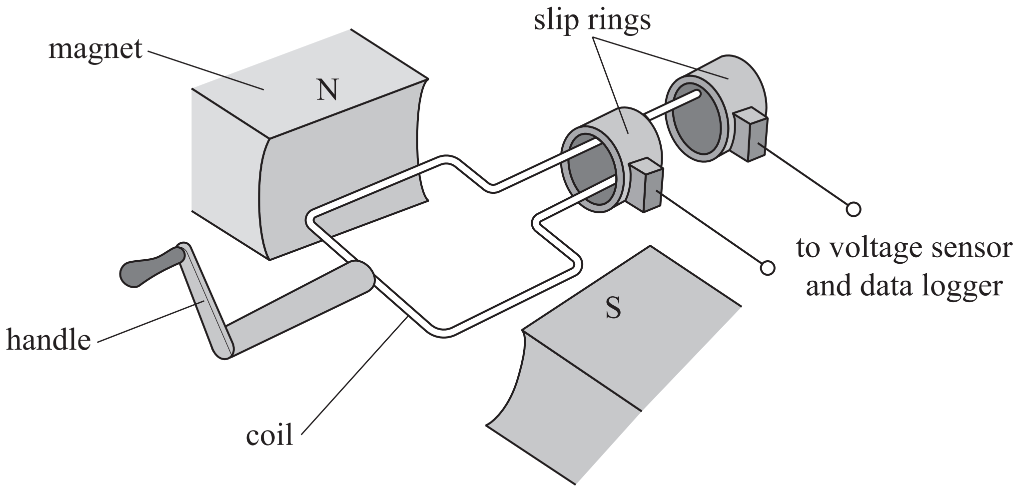
17 A teacher showed a simple alternating current generator to her class.

The generator consists of a coil in a magnetic field. The handle is used to rotate the coil. The teacher connected a voltage sensor to a pair of 'slip rings', as shown.



The voltage sensor was connected to a data logger.

(a) Initially the plane of the coil was horizontal and parallel to the magnetic field.

The teacher rotated the handle at constant speed.

(i) Sketch a graph of e.m.f. against time for two complete rotations of the handle, as shown on the data logger.

(3)

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(ii) The teacher doubled the speed of rotation of the coil.

Explain how this affected the graph shown on the data logger.

(3)

(b) The magnetic flux density in the region between the magnets was 0.90 T. The teacher rotated the coil with a constant angular velocity ω equal to 1.57 rad s^{-1}.

The maximum induced e.m.f. ε_{max} is given by the formula

$$\varepsilon_{max} = \phi\omega$$

where ϕ is the maximum flux linked with the coil.

Calculate ε_{max}.

width of coil = 9.5 cm
length of coil = 12.0 cm

(4)

ε_{max} = ...

(c) Explain how Lenz's law applies to the motion of the coil.

(2)

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(Total for Question 17 = 12 marks)

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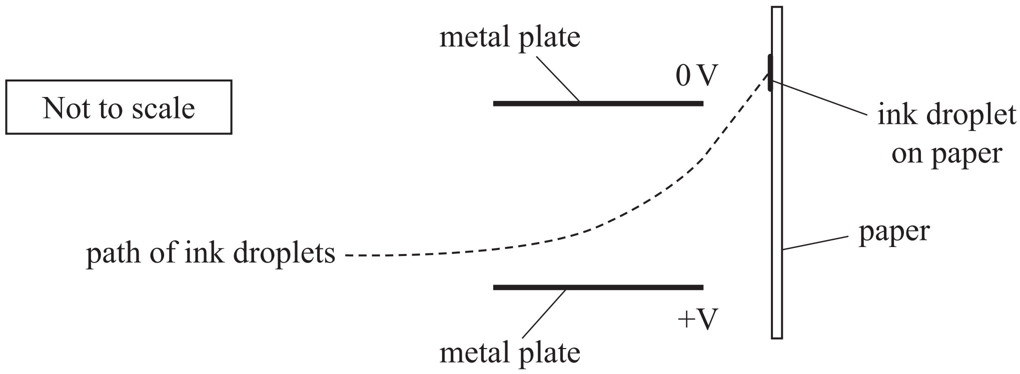
18 An inkjet printer produces tiny drops of ink called droplets. As the droplets are produced, they gain positive charge. Each ink droplet can be considered to be a positive point charge.

(a) The diagram represents a positive point charge.

Draw field lines to show the electric field around the point charge.

(2)

(b) The charged droplets pass through the uniform electric field between two metal plates and are deflected, as shown.



The potential difference across the metal plates is 45.0 V and the distance between the metal plates is 3.00×10^{-4} m.

An ink droplet is between the plates for a time of 8.6×10^{-5} s. The charge on the ink droplet is $+1.40 \times 10^{-10}$ C and the mass of the ink droplet is 2.90×10^{-10} kg.

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(i) Calculate the vertical component of the velocity of the ink droplet just after it leaves the plates.
Ignore gravitational forces.

(5)

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Vertical component of velocity = ...

(ii) The horizontal component of the velocity of the ink droplet is $15.2\,\mathrm{m\,s^{-1}}$.

The ink droplet collides with the paper and comes to rest.
The minimum horizontal impulse needed for the ink droplet to stick to the paper is $4.2 \times 10^{-9}\,\mathrm{N\,s}$.

Deduce whether the horizontal impulse on the paper will be enough for the ink droplet to stick to the paper.

(3)

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(Total for Question 18 = 10 marks)

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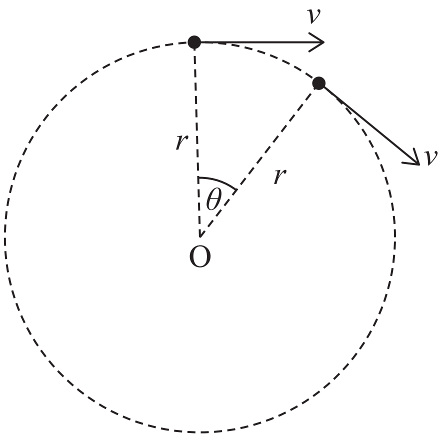
19 In the Bohr model of a hydrogen atom, an electron moves in a circular orbit around a proton.

(a) A particle orbits a point O, in a circular path of radius r, as shown.

The particle moves at a constant speed v. The dots represent two positions, an angle θ apart.



The acceleration of the particle is a.

Derive the equation $a = \frac{v^2}{r}$

Your answer should include a vector diagram.

(5)

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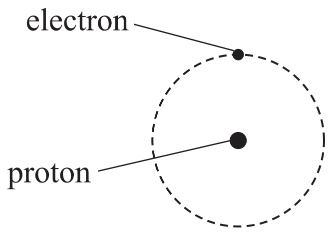
(b) The diagram below shows the Bohr model of a hydrogen atom.



In the Bohr model, the electron orbits at a distance of 5.30×10^{-11} m from the proton.

The electron has kinetic energy due to its motion and potential energy due to its electrostatic attraction to the proton.

(i) Determine the kinetic energy of the electron as predicted by the Bohr model.

(5)

Kinetic energy = ...

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(ii) Determine the potential energy of the electron as predicted by the Bohr model.

(3)

Potential energy = ...

(c) Suggest what would happen if an electron radiated energy when in orbit around a proton.

(2)

(Total for Question 19 = 15 marks)

TOTAL FOR SECTION B = 80 MARKS
TOTAL FOR PAPER = 90 MARKS

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List of data, formulae and relationships

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

Unit 1

Mechanics

Kinematic equations of motion

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

Momentum

$$p = mv$$

Moment of force

$$\text{moment} = Fx$$

Work and energy

$$\Delta W = F\Delta s$$

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

$$\Delta E_{grav} = mg\Delta h$$

Power

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

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Efficiency

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

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

Materials

Density $\rho = \frac{m}{V}$

Stokes' law $F = 6\pi\eta r v$

Hooke's law $\Delta F = k\Delta x$

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

Young modulus $E = \frac{\sigma}{\varepsilon}$ where

Stress $\sigma = \frac{F}{A}$

Strain $\varepsilon = \frac{\Delta x}{x}$

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Unit 2

Waves

Wave speed	$v = f\lambda$
Speed of a transverse wave on a string	$v = \sqrt{\dfrac{T}{\mu}}$
Intensity of radiation	$I = \dfrac{P}{A}$
Refractive index	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
	$n = \dfrac{c}{v}$
Critical angle	$\sin C = \dfrac{1}{n}$
Diffraction grating	$n\lambda = d\sin\theta$

Electricity

Potential difference	$V = \dfrac{W}{Q}$
Resistance	$R = \dfrac{V}{I}$
Electrical power, energy	$P = VI$
	$P = I^2R$
	$P = \dfrac{V^2}{R}$
	$W = VIt$
Resistivity	$R = \dfrac{\rho l}{A}$
Current	$I = \dfrac{\Delta Q}{\Delta t}$
	$I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

Particle nature of light

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$
de Broglie wavelength	$\lambda = \dfrac{h}{p}$

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Unit 4

Further mechanics

Impulse	$F\Delta t = \Delta p$
Kinetic energy of a non-relativistic particle	$E_k = \frac{p^2}{2m}$
Motion in a circle	$v = \omega r$
	$T = \frac{2\pi}{\omega}$
	$a = \frac{v^2}{r}$
	$a = r\omega^2$
Centripetal force	$F = ma = \frac{mv^2}{r}$
	$F = mr\omega^2$

Electric and magnetic fields

Electric field	$E = \frac{F}{Q}$
Coulomb's law	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$
	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$
	$E = \frac{V}{d}$
Electrical potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
Capacitance	$C = \frac{Q}{V}$
Energy stored in capacitor	$W = \frac{1}{2}QV$
	$W = \frac{1}{2}CV^2$
	$W = \frac{1}{2}\frac{Q^2}{C}$
Capacitor discharge	$Q = Q_0 e^{-t/RC}$

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Resistor-capacitor discharge $I = I_0 e^{-t/RC}$

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

$$\ln Q = \ln Q_0 - \frac{t}{RC}$$

$$\ln I = \ln I_0 - \frac{t}{RC}$$

$$\ln V = \ln V_0 - \frac{t}{RC}$$

In a magnetic field $F = Bqv \sin \theta$

$$F = BIl \sin \theta$$

Faraday's and Lenz's laws $\mathscr{E} = \frac{-\mathrm{d}(N\phi)}{\mathrm{d}t}$

Nuclear and particle physics

In a magnetic field $r = \frac{p}{BQ}$

Mass-energy $\Delta E = c^2 \Delta m$

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