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 18 May 2020

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.*
- Candidates may use a scientific calculator.
- 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.

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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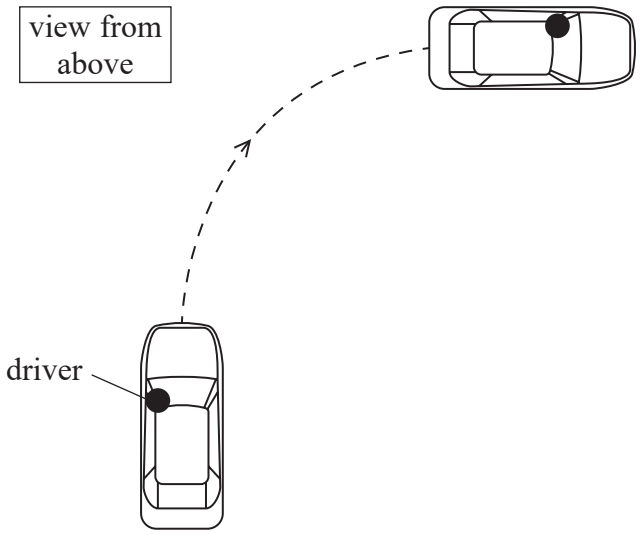
SECTION A

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 driver steers a car to the right as shown. The driver remains at the same position in the car as the car changes direction.



Which of the following does the driver experience as the car moves in the circular path?

☒ **A** A force to his left and a force to his right.

☒ **B** A resultant force to his left.

☒ **C** A resultant force to his right.

☒ **D** No resultant force.

(Total for Question 1 = 1 mark)

2 Which of the following is **not** a valid conclusion from large-angle alpha particle scattering experiments?

☒ **A** The nucleus contains neutrons.

☒ **B** The nucleus contains most of the mass of the atom.

☒ **C** The nucleus is charged.

☒ **D** The nucleus is very small compared to the atom.

(Total for Question 2 = 1 mark)

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3 An electron is emitted from a nucleus. The de Broglie wavelength of this electron is 2.43×10^{-12} m.

Which of the following expressions gives the speed of this electron in $m\,s^{-1}$?

☒ **A** $\dfrac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 2.43 \times 10^{-12}}$

☒ **B** $\dfrac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times (3.0 \times 10^{8})^2}$

☒ **C** $\dfrac{6.63 \times 10^{-34} \times 9.11 \times 10^{-31}}{2.43 \times 10^{-12}}$

☒ **D** $\dfrac{6.63 \times 10^{-34}}{1.66 \times 10^{-27} \times 2.43 \times 10^{-12}}$

(Total for Question 3 = 1 mark)

4 An alpha particle has momentum p. After passing through a few centimetres of air, the kinetic energy of the alpha particle is halved.

Which of the following is the new momentum of the alpha particle?

☒ **A** $\dfrac{p}{\sqrt{2}}$

☒ **B** $\dfrac{p}{2}$

☒ **C** $\sqrt{2}\,p$

☒ **D** $2p$

(Total for Question 4 = 1 mark)

5 Which of the following statements describes an inelastic collision?

☒ **A** Both momentum and kinetic energy are conserved.

☒ **B** Kinetic energy is not conserved.

☒ **C** Momentum is not conserved.

☒ **D** Neither momentum nor kinetic energy is conserved.

(Total for Question 5 = 1 mark)

6 A recently discovered chemical element has the symbol Og.

The number of neutrons in a nucleus of $^{294}_{118}Og$ is

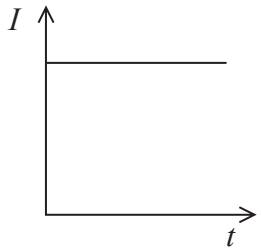
- ☒ **A** 412
- ☒ **B** 294
- ☒ **C** 176
- ☒ **D** 118

(Total for Question 6 = 1 mark)

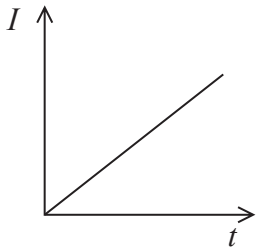
7 An uncharged capacitor is connected in series with a battery and a resistor.

Which of the following graphs shows the variation of current I with time t as the capacitor charges?

A



B



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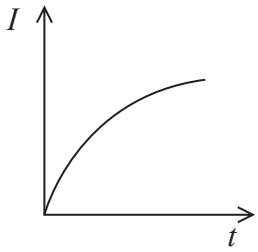
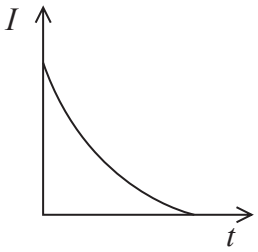


D



- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 7 = 1 mark)

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8 A boy falls through a small height h. He is brought to rest in a time t after his feet touch the ground. His feet exert an average force F_1 on the ground.

A girl with the same mass falls through a height $2h$. She is brought to rest in a time $2t$ after her feet touch the ground. Her feet exert an average force F_2 on the ground.

The value of F_1 / F_2 is

☒ **A** $\frac{1}{2}$

☒ **B** $\frac{1}{\sqrt{2}}$

☒ **C** $\sqrt{2}$

☒ **D** 2

(Total for Question 8 = 1 mark)

9 A cyclotron is a type of particle accelerator.

Which of the following is the reason why particles gain kinetic energy in a cyclotron?

☒ **A** A magnetic field causes circular motion.

☒ **B** An electric field accelerates the particles.

☒ **C** Mass is converted to energy.

☒ **D** There is a vacuum inside the cyclotron.

(Total for Question 9 = 1 mark)

10 A coil of N turns and cross-sectional area A is perpendicular to a magnetic field of flux density B. The magnetic flux linkage is X.

A second coil with $N/2$ turns and cross-sectional area $3A$ is perpendicular to a magnetic field of flux density $2B$.

Which of the following gives the magnetic flux linkage with the second coil?

☒ **A** $\frac{2X}{3}$

☒ **B** $\frac{3X}{2}$

☒ **C** X

☒ **D** $3X$

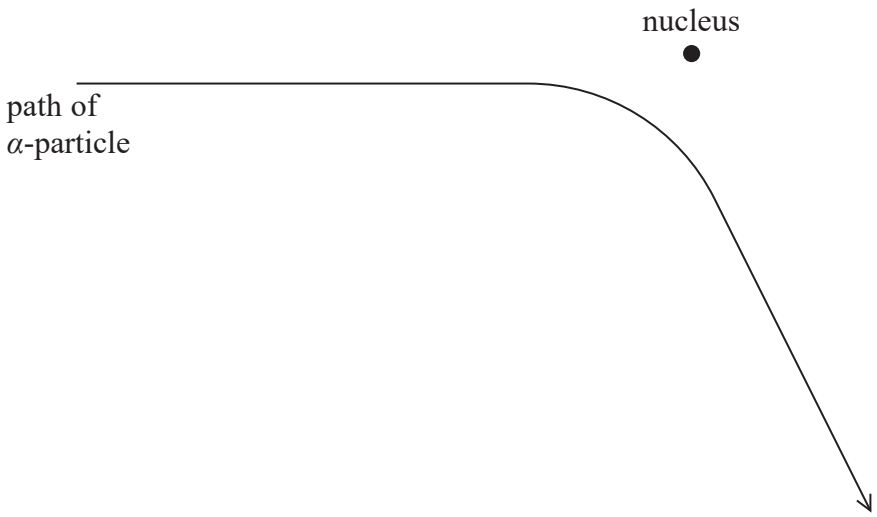
(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

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



(i) Draw an arrow on the diagram 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.

(1)

(ii) The foil is replaced by a metal with a greater proton number.

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

(2)

(b) Under certain circumstances a proton can decay into a neutron, positron and neutrino as shown.

$$p \rightarrow n + e^{+} + \nu_e$$

The neutrino ν_e produced in the decay is uncharged.

Explain why the neutrino must be uncharged. Your answer should refer to the equation.

(2)

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(Total for Question 11 = 5 marks)

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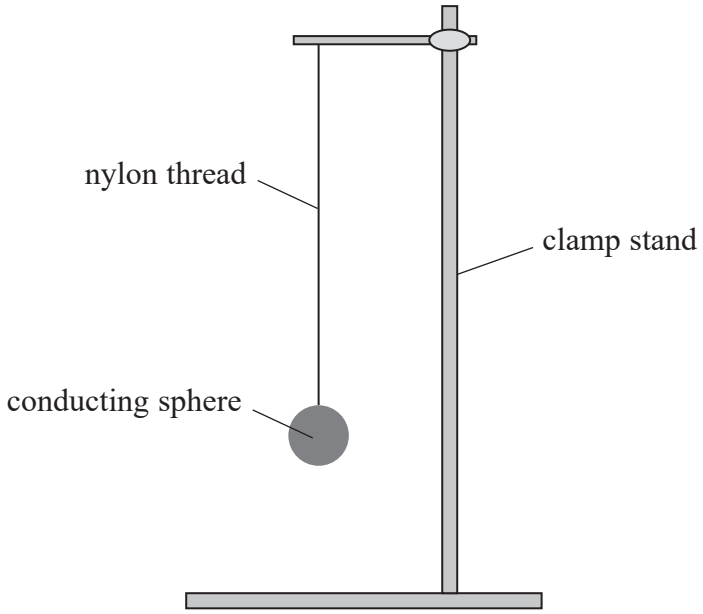
12 A teacher is demonstrating the electric field around a charged sphere. She hangs a small conducting sphere from a nylon thread as shown.



(a) Nylon is an insulator.

Suggest why an insulator is used to suspend the sphere.

(1)

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(b) Sketch the electric field around a positively charged sphere.

(2)

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(c) A conducting sphere acts as a capacitor with a capacitance C where

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

and r is the radius of the sphere.

The sphere has a radius of 3.0 cm and is at a potential of +1500 V.

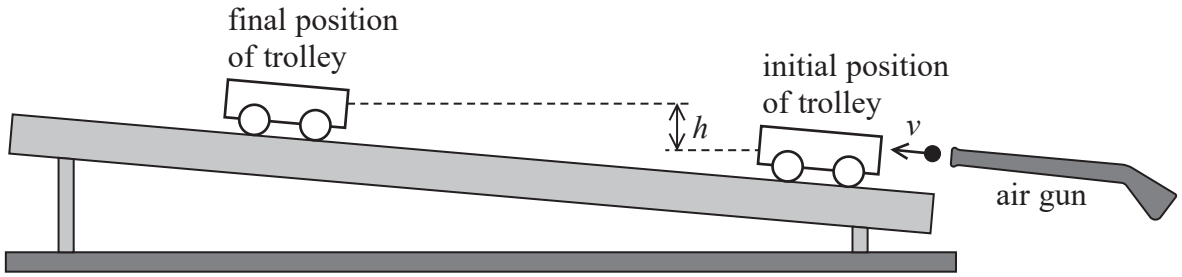
Calculate the electric field strength E at a point 7.0 cm from the surface of the sphere.

(4)

E = ...

(Total for Question 12 = 7 marks)

13 The diagram shows an experiment to determine the speed at which a pellet is fired from an air gun. The pellet moves parallel to the track and hits the trolley. The trolley and pellet move off together along the track, before coming to rest. The change in vertical height of the trolley is *h*.



The pellet was fired into the trolley, and *h* measured, several times. A mean value of *h* was calculated.

(a) State why the experiment should be repeated and a mean value for *h* calculated.

(1)

.....

(b) (i) The mean value of *h* was 0.16 m.

Show that the speed of the trolley immediately after being hit by the pellet was about 2 m s^{-1}. Assume that resistive forces were negligible.

(2)

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(ii) Calculate the speed of the pellet immediately before it hit the trolley.

mass of trolley = 0.125 kg
mass of pellet = 1.88×10^{-3} kg

(3)

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Speed of pellet = ...

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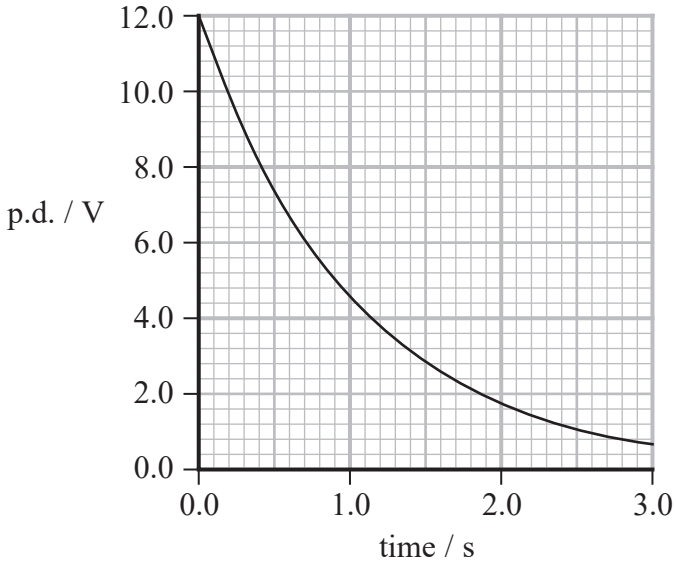
(iii) Determine by calculation whether the collision between the pellet and the trolley was elastic.

(3)

(Total for Question 13 = 9 marks)

14 A capacitor was charged to a potential difference (p.d.) of 12.0 V and then discharged through a 220 kΩ resistor.

A data logger recorded the p.d. across the capacitor. The graph shows how the p.d. varied with time.



(a) Explain why using a data logger to record the p.d. and time is more appropriate than a person using a voltmeter and stopwatch.

(3)

(b) The time constant T of the circuit is given by the equation $T = RC$

(i) Show that T has units of seconds.

(2)

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(ii) Show that the time constant of the circuit is about 1 s.

(3)

(iii) Calculate the capacitance C of the capacitor.

(2)

C = ...

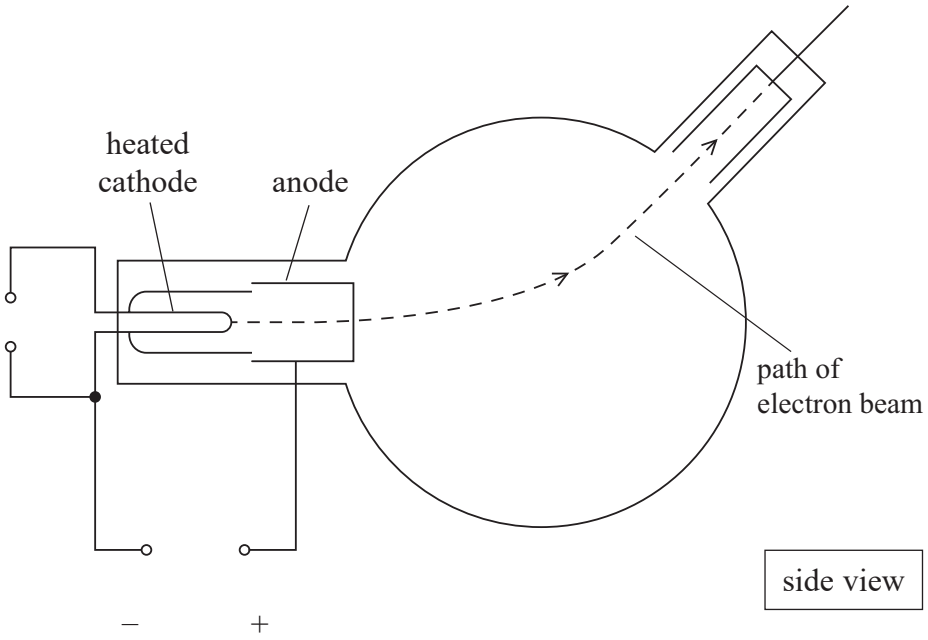
(iv) Determine the time taken for the capacitor to transfer 50% of its initial stored energy as it discharges.

(3)

Time to transfer 50% of initial stored energy = ...

(Total for Question 14 = 13 marks)

15 The diagram shows an electron beam tube of a type first used by Perrin to demonstrate that electrons have negative charge.



(a) Describe how the electron beam is produced.

(2)

(b) There is a potential difference of 225 V between the cathode and the anode.

Show that the speed of the electrons leaving the anode is about $9 \times 10^6\,m\,s^{-1}$.

(2)

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(c) The electron beam follows the path shown. A horizontal magnetic field of flux density B is applied in the direction into the page.

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

$$r = \frac{p}{Be}$$

(2)

(ii) The diameter of the circular path is 15.5 cm.

Calculate the value of B.

(2)

$B =$ .....

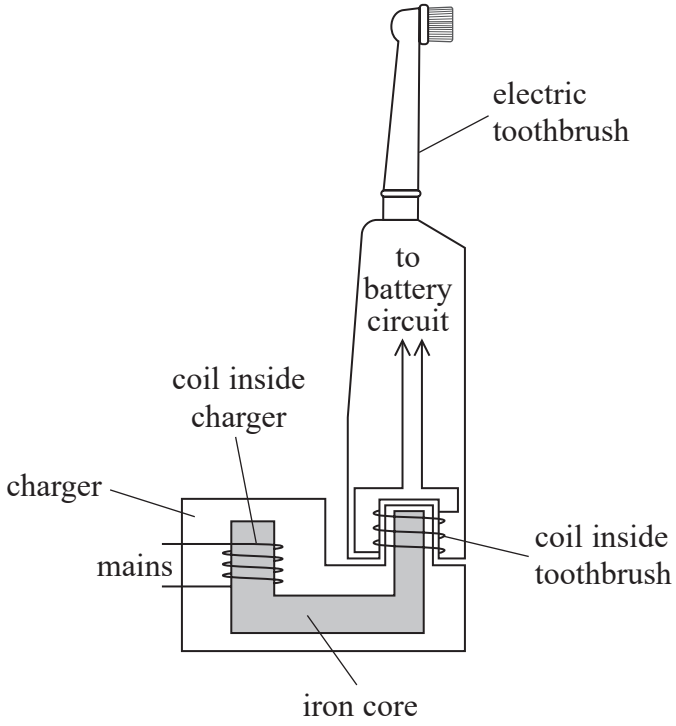
(iii) State why the weight of the electrons can be ignored.

(1)

(Total for Question 15 = 9 marks)

16 The electric toothbrush shown contains a rechargeable battery. The battery is charged by placing the toothbrush onto the charger, with no electrical contact between the toothbrush and the charger.





The charger contains a coil wrapped around an iron core. The coil is plugged into the mains supply. The toothbrush also contains a coil that sits around the iron core when the toothbrush is placed on the charger.

*(a) Describe how this arrangement enables the battery to be charged.

(4)

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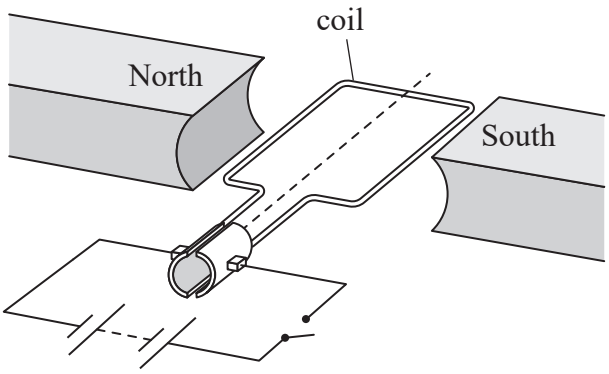
*(b) An electric motor in the toothbrush causes the brush to oscillate at high speed.

The diagram shows a simple electric motor.



The switch is closed.
Explain why the coil starts to rotate.

(4)

(c) In one type of toothbrush the distance between the two sides of the coil is 6.5 mm.
The coil makes 5.5×10^3 rotations every minute.
Calculate the speed v of the side of the coil.

(3)

v = ...

(Total for Question 16 = 11 marks)

17 In 2018 two new particles were discovered. The particles each consist of three quarks and were called Σ_{b1} and Σ_{b2}.

The Σ_{b1} particle consists of one bottom quark and two up quarks. The Σ_{b2} particle consists of one bottom quark and two down quarks.

Quark	up	down	bottom
Charge / e	$+\frac{2}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$

(a) Determine the charge on each Σ_b particle.

(2)

Σ_{b1} .....

Σ_{b2} .....

(b) Each Σ_b particle has a mass of 6.097 GeV/c^2.

(i) Calculate the mass m of one of these particles in kg.

(3)

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m = ... kg

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(ii) A Σ_{b1} particle meets its antiparticle. The particles annihilate and two identical high energy photons are produced.

Calculate the frequency f of these photons.

(3)

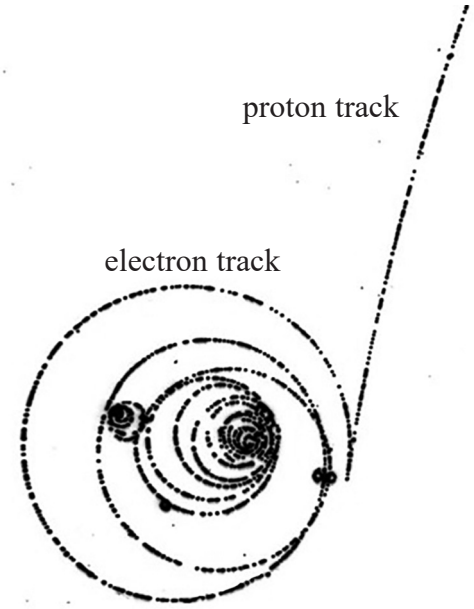
$f =$ .....

(iii) Calculate the momentum p of each photon.

(3)

$p =$ .....

(c) The bubble chamber photograph below shows a neutron decaying into a proton and an electron, in a region of uniform magnetic field.



(i) State the direction of the magnetic field.

(1)

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(ii) Explain why the proton track is much less curved than the electron track.

(2)

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(iii) Explain why the radius of the electron track gradually decreases.

(2)

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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	$g = 9.81$ m s^{-2}	(close to Earth's surface)
Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}	
Coulomb's law constant	$k = 1/4\pi\varepsilon_0$ $= 8.99 \times 10^9$ N m^2 C^{-2}	
Electron charge	$e = -1.60 \times 10^{-19}$ C	
Electron mass	$m_e = 9.11 \times 10^{-31}$ kg	
Electronvolt	1 eV $= 1.60 \times 10^{-19}$ J	
Gravitational constant	$G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}	
Gravitational field strength	$g = 9.81$ N kg^{-1}	(close to Earth's surface)
Permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}	
Planck constant	$h = 6.63 \times 10^{-34}$ J s	
Proton mass	$m_p = 1.67 \times 10^{-27}$ kg	
Speed of light in a vacuum	$c = 3.00 \times 10^8$ m s^{-1}	
Stefan-Boltzmann constant	$\sigma = 5.67 \times 10^{-8}$ W m^{-2} K^{-4}	
Unified atomic mass unit	$u = 1.66 \times 10^{-27}$ 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	$P = VI$ $P = I^2R$ $P = V^2/R$ $W = VIt$
	$\%\ \text{efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}} \times 100$
	$\%\ \text{efficiency} = \dfrac{\text{useful power output}}{\text{total power input}} \times 100$
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	$\dfrac{1}{R} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3}$

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	$Q = Q_0e^{-t/RC}$
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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