Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | Candidate Number

Physics

Advanced

Unit 4: Physics on the Move

Tuesday 13 January 2015 – 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.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

1/1/1/1/1/1/
P 4 5 0 3 8 A 0 1 2 8

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 A particle moving in a circular path completes 7.5 revolutions in 9.0 s.
Its angular velocity in rad s^{-1} is

☒ **A** 0.83

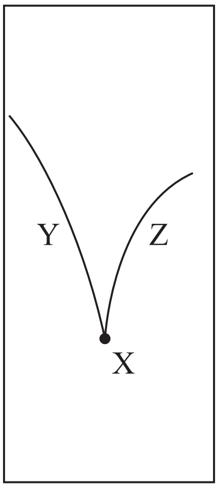
☒ **B** 5.2

☒ **C** 68

☒ **D** 420

(Total for Question 1 = 1 mark)

2 A moving pion decays into two particles Y and Z. This decay occurs at point X in a particle detector and the tracks observed are shown.



Which of the following is a valid conclusion from these tracks?

☒ **A** Momentum has not been conserved.

☒ **B** The pion is a neutral particle.

☒ **C** Y and Z have different masses.

☒ **D** Z is a negatively charged particle.

(Total for Question 2 = 1 mark)

3 Select the row of the table that correctly identifies what happens in an elastic collision.

	Momentum	Total energy	Kinetic energy
☒ **A**	conserved	conserved	conserved
☒ **B**	conserved	conserved	not conserved
☒ **C**	conserved	not conserved	conserved
☒ **D**	not conserved	conserved	not conserved

(Total for Question 3 = 1 mark)

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4 A current-carrying wire is placed into a magnetic field. If the magnetic force experienced by the wire balances the weight of the wire, the wire will float.

The direction of the magnetic field is from west to east.

For the wire to float, it is placed

☒ **A** parallel to the magnetic field so the current flows from east to west.

☒ **B** parallel to the magnetic field so the current flows from west to east.

☒ **C** perpendicular to the magnetic field so the current flows from north to south.

☒ **D** perpendicular to the magnetic field so the current flows from south to north.

(Total for Question 4 = 1 mark)

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5 Two capacitors of capacitance 1000 μF and 10 μF are charged so that they store the same amount of energy. The potential difference (p.d.) across the 1000 μF capacitor is V_1 and the p.d. across the 10 μF capacitor is V_2.

The value of $\left(\frac{V_1}{V_2}\right)^2$ is

☒ **A** 1×10^{-4}

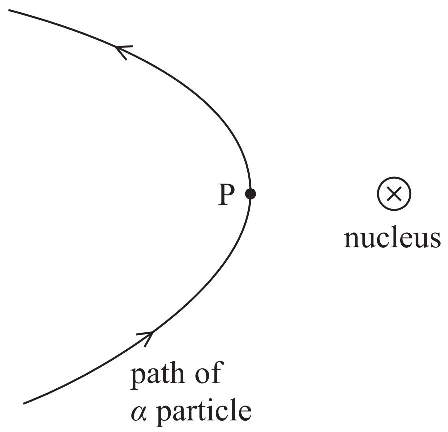
☒ **B** 1×10^{-2}

☒ **C** 1×10^{2}

☒ **D** 1×10^{4}

(Total for Question 5 = 1 mark)

6 The diagram shows the path of an α particle that is being deflected by the nucleus of an atom. The point P on the path is the point of closest approach of the α particle to the nucleus.



Which statement about the α particle on this path is correct?

- ☒ **A** Its acceleration is least at P.
- ☒ **B** Its speed is least at P.
- ☒ **C** Its total energy is greatest at P.
- ☒ **D** Its momentum is greatest at P.

(Total for Question 6 = 1 mark)

7 Which of the following is **not** a unit of electric field strength?

- ☒ **A** J C m^{-1}
- ☒ **B** $\text{J C}^{-1}\text{ m}^{-1}$
- ☒ **C** $\text{N A}^{-1}\text{ s}^{-1}$
- ☒ **D** N C^{-1}

(Total for Question 7 = 1 mark)

8 A capacitor is charged to a potential difference of 12 V and stores a charge of 600 μC. What would the potential difference across the plates have to be in order for the capacitor to store 50% more charge?

- ☒ **A** 3 V
- ☒ **B** 9 V
- ☒ **C** 18 V
- ☒ **D** 24 V

(Total for Question 8 = 1 mark)

9 Which of the following is **not** a valid conclusion from Rutherford's alpha scattering experiment?

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

☒ **B** The nucleus contains protons.

☒ **C** The nucleus must be charged.

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

(Total for Question 9 = 1 mark)

---

10 A particle Z has kinetic energy E and momentum p. A second particle X has twice the mass and half the momentum of particle Z.

The kinetic energy of X is

☒ **A** $2E$

☒ **B** $\frac{E}{4}$

☒ **C** $\frac{E}{8}$

☒ **D** $\frac{E}{16}$

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 The table gives the quark structure of three particles.

The up quark has a charge of +2/3*e* and the down quark has a charge of –1/3*e*.

Particle	Quarks
neutron n	udd
pion π^-	d$\bar{u}$
delta Δ^-	ddd

(a) Show that udd is a possible combination of quarks for the neutron.

(1)

....

....

(b) State, in terms of quark structure, why the Δ^- is classed as a baryon and the π^- a meson.

(2)

....

....

(c) Another particle in the delta family, the Δ^{++}, is also composed of up and/or down quarks. Its decay is shown by

$$\Delta^{++} \rightarrow p + \pi$$

Deduce the quark content of the Δ^{++} and the charge on the pion.

(2)

....

Quark content of Δ^{++} ....

....

Charge on pion ....

(Total for Question 11 = 5 marks)

12 An electron is accelerated through a potential difference of 3000 V.

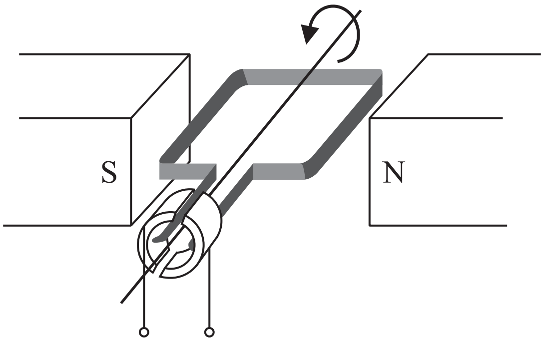
Calculate the de Broglie wavelength associated with this electron.

(4)

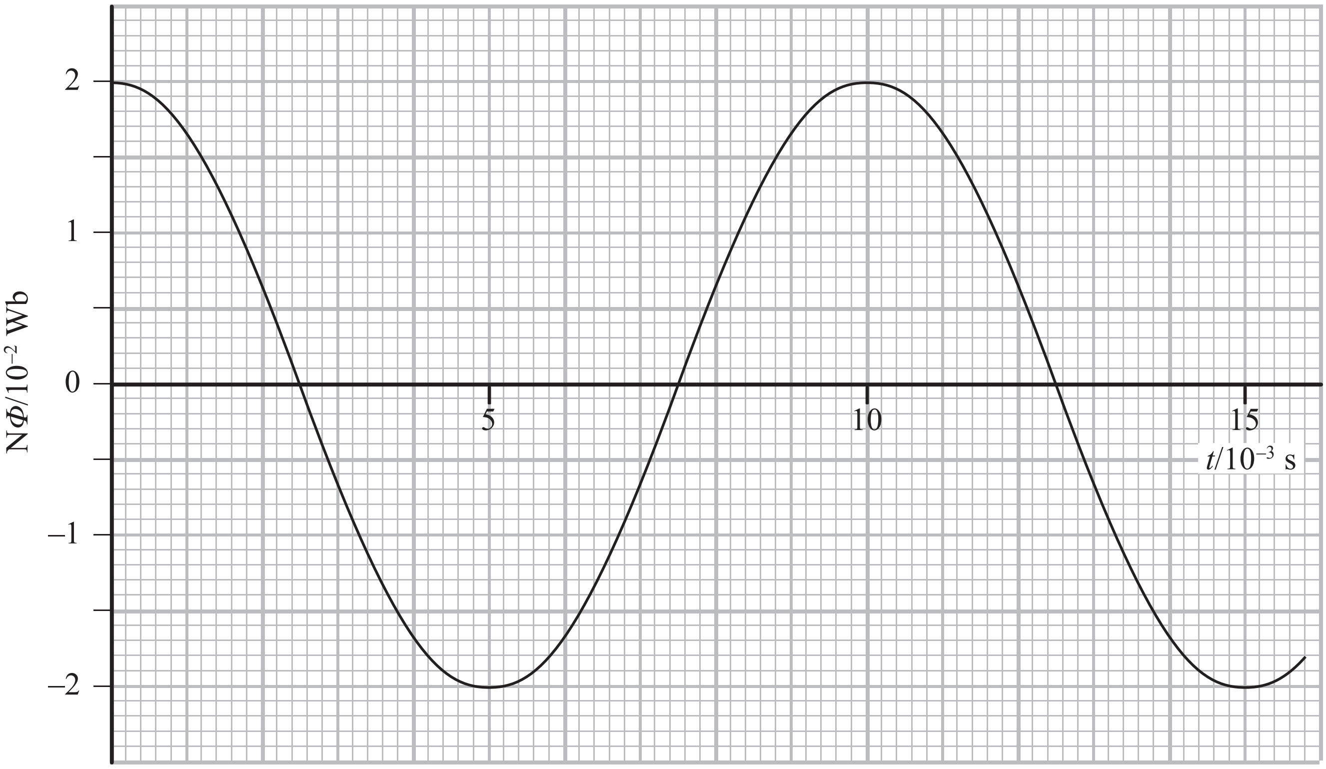
Wavelength = ...

(Total for Question 12 = 4 marks)

13 The diagram shows a simple generator. It has a flat coil of negligible resistance which can be rotated in a magnetic field. The coil has 500 turns and an area of 2.5×10^{-3} m^2.



The graph shows the variation of the magnetic flux linkage $N\Phi$ with time t as the coil is rotated at a steady frequency in a uniform magnetic field.



(a) Determine the frequency of rotation of the coil.

(2)

Frequency = ...

(b) Determine the magnetic flux density of the field.

(2)

Magnetic flux density = ...

(c) Determine the maximum e.m.f. induced in the coil.

(3)

Maximum e.m.f. = ...

(Total for Question 13 = 7 marks)

14 When an object moves in a circular path at constant speed, a resultant force is required.

(a) State why a resultant force is required and the direction of this force.

(2)

....

....

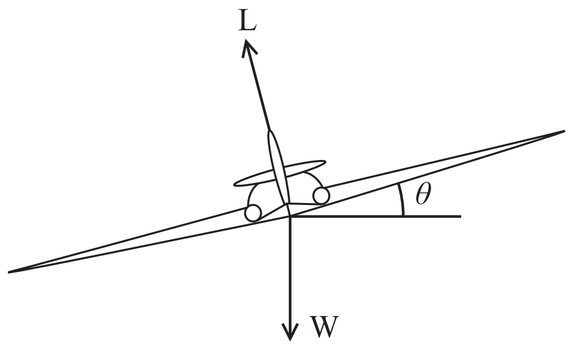
....

....

....

(b) When an aeroplane is flying there is an upward force called lift which acts at right angles to the wings. When the aeroplane is flying in a straight line, the lift force is equal to the weight of the aeroplane.

The diagram shows an aeroplane that is moving in a horizontal circle at constant speed.



*(i) Explain, in terms of forces, why the aeroplane is able to fly in a circular path.

(2)

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....

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....

....

(ii) The aeroplane has a mass of 2.4×10^6 kg and is flying in a horizontal circle at a speed of 85 m s^{-1} when θ is 25°.

By considering both the horizontal and vertical motion, calculate the radius of the circular path of the aeroplane.

(4)

Radius = ...

(Total for Question 14 = 8 marks)

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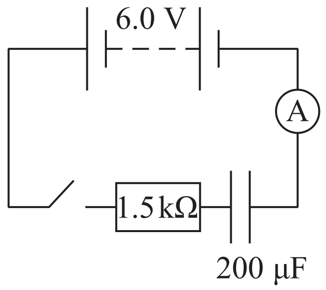
15 A student was investigating the charge and discharge of a capacitor.

He set up the following circuit.



(a) Calculate the time constant for the circuit.

(2)

....

....

....

Time constant = ...

(b) The student wanted to plot a current-time graph as the capacitor charged, but found that the current changed too rapidly for him to take readings.

Instead, he modelled the experiment using a spreadsheet. The switch was closed at time $t = 0$ s. V is the potential difference across the capacitor.

	A	B	C	D	E
1	t/s	I/mA	ΔQ/μC	Q/μC	V/V
3	0.0	4.00	400	400	2.00
4	0.1	2.67	267	667	3.33
5	0.2	1.78	178	844	4.22
6	0.3	1.19	119	963	4.81
7	0.4	0.79	79	1042	5.21
8	0.5	0.53	53	1095	5.47
9	0.6	0.35	35	1130	5.65
10	0.7	0.23	23	1153	5.77
11	0.8	0.16	16	1169	5.84
12	0.9	0.10	10	1179	5.90
13	1.0	0.07	7	1186	5.93

Explain how the value in cell B5 is calculated.

(2)

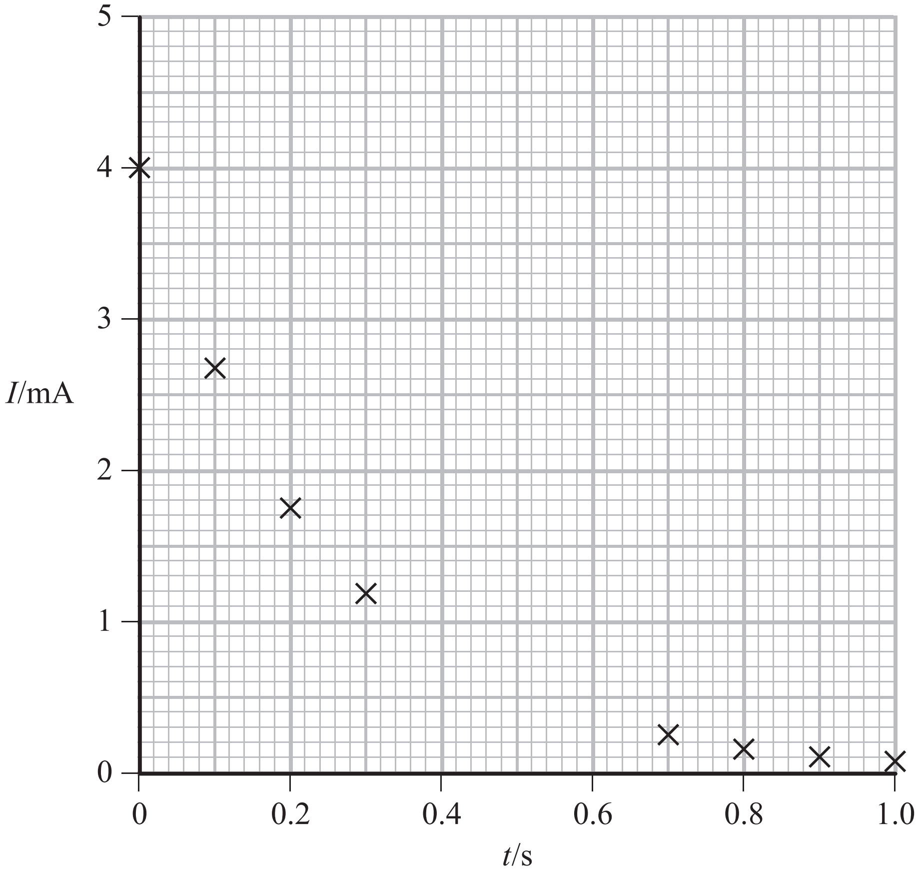
....

....

....

P 4 5 0 3 8 A 0 1 4 2 8

(c) Some of the data from the spreadsheet has been plotted on a graph of current I against time t.



(i) Plot the missing points and draw a line of best fit.

(2)

(ii) Use the graph to determine a second value for the time constant.

(2)

....

....

....

....

Time constant = ...

(iii) Suggest how the student might change his spreadsheet to give a more accurate model of the charging of the capacitor.

(1)

....

....

*(d) An alternative method of determining the time constant is to use a straight line graph.

State and explain the variables that the student should plot and how he should determine the time constant from this graph.

(3)

(Total for Question 15 = 12 marks)

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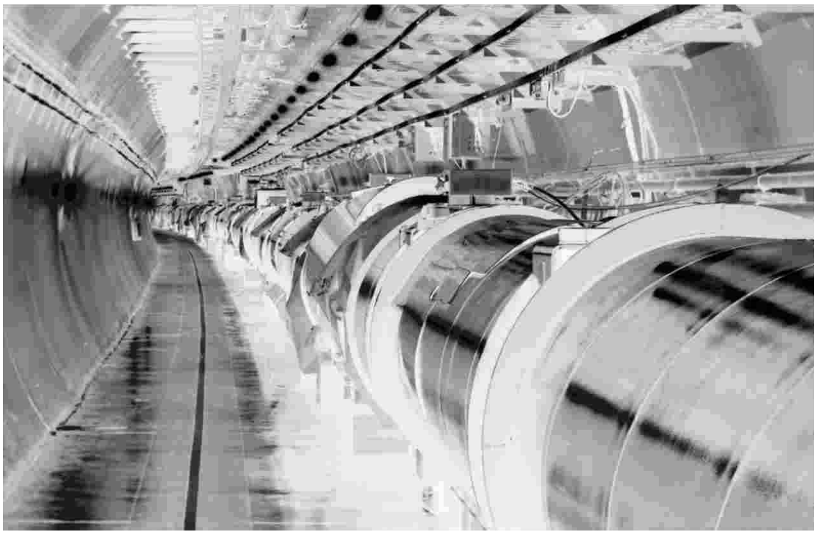
16 The photograph shows the circular tunnel of the Large Hadron Collider (LHC), which is an underground particle accelerator. The circumference of the tunnel is 27 km.



*(a) In the LHC, a magnetic field allows charged particles to move at a constant speed in a horizontal circular path of the required radius.

By reference to the force acting on the charged particles, explain how this is achieved.

(4)

(b) In practice the LHC uses electric fields to accelerate the particles so that their momentum gradually increases.

State and explain how the magnetic field in the LHC must change as the momentum of the particles increases.

(2)

....

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....

(c) (i) Collisions between particles in high-energy physics experiments often result in the production of an electron-positron pair.

Calculate the minimum energy, in joules, required to produce an electron-positron pair.

(2)

....

....

....

Minimum energy = ... J

(ii) By converting your minimum energy into MeV, give the rest mass of the electron in MeV/c^2.

(3)

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....

....

Rest mass of electron = ... MeV/c^2

(Total for Question 16 = 11 marks)

17 (a) State the principle of conservation of momentum.

(2)

....

....

....

....

(b) State the relationship between the resultant force acting on an object and the momentum of the object.

(1)

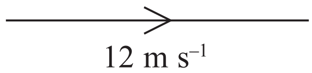
....

....

(c) A car is travelling due east with a velocity of 12 m s^{-1}. The driver of the car changes direction to travel due north with a velocity of 15 m s^{-1}.

(i) The initial velocity is shown in the diagram.
Complete the vector diagram to represent the change in velocity. You do not need to draw it exactly to scale.

(2)



(ii) Determine the change in velocity of the car.

(3)

Magnitude of change of velocity = ...

Direction of change of velocity = ...

(iii) The mass of the car is 1500 kg and the change in velocity took 4.0 s.

Calculate the average force that was needed.

(2)

Force = ...

(Total for Question 17 = 10 marks)

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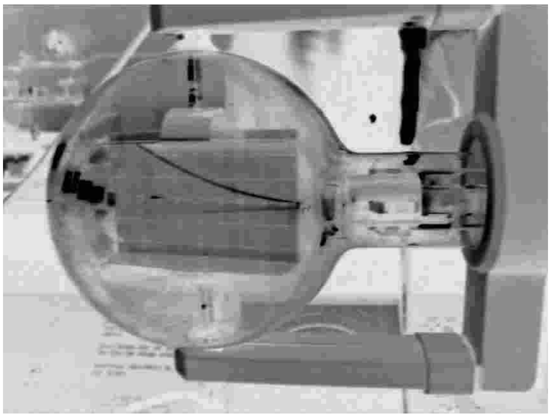
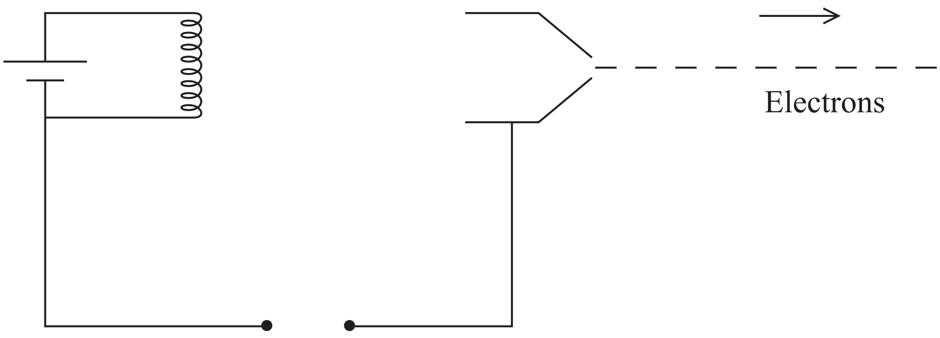
18 A teacher is using an electron beam tube to demonstrate the deflection of electrons in a uniform electric field.



A potential difference (p.d.) of 4800 V is applied between the cathode and anode of the tube. The cathode is heated and electrons are emitted from its surface. These electrons are then accelerated from rest and pass through a hole in the anode.



(a) State the name of the process by which electrons are emitted from the cathode.

(1)

....

(b) Show that the speed v of the electrons as they leave the anode is about 4×10^7 m s^{-1}.

(3)

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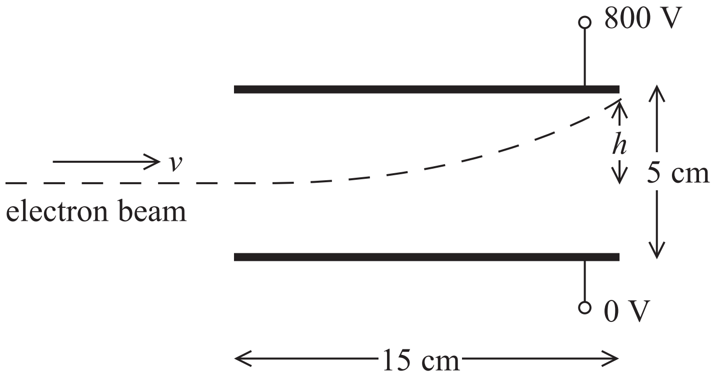
(c) After leaving the anode, the electrons follow a parabolic path as they pass between a pair of parallel plates with a p.d. of 800 V between them. There is a uniform electric field between the plates.



(i) Calculate the force due to the electric field that acts on an electron while it is between the plates.

(3)

....

....

....

....

....

Force = ...

(ii) An electron experiences an upward acceleration *a* as it travels between the plates.
Its vertical displacement *h* after a time *t* is given by

$$h = \frac{1}{2}at^2$$

Calculate the value of *h* as the electron leaves the plates.

(4)

....

....

....

....

....

....

....

....

....

....

h = ...

(d) (i) Keeping the p.d. between the cathode and anode at 4800 V, the p.d. between the parallel plates is decreased.
Draw the new path of the electrons on the diagram in (c). Label this path A.

(1)

(ii) Keeping the p.d. between the parallel plates at 800 V, the p.d. between the cathode and anode is decreased.
Draw the new path of the electrons on the diagram in (c). Label this path B.

(1)

(Total for Question 18 = 13 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

List of data, formulae and relationships

Acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$	(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	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
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	$E_{el} = \frac{1}{2}F\Delta x$

P 4 5 0 3 8 A 0 2 6 2 8

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	$\frac{1}{R} = \frac{1}{R_1} \quad \frac{1}{R_2} \quad \frac{1}{R_3}$

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	$\lambda = h/p$