Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number

Candidate Number

Physics

Advanced
Unit 4: Physics on the Move

Wednesday 11 June 2014 – Afternoon
Time: 1 hour 35 minutes

Paper Reference
WPH04/01

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

Turn over ▶

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 The nucleus of one of the isotopes of uranium is represented by ${}^{238}_{92}U$.

The number of neutrons in the nucleus is

☐ **A** 92

☐ **B** 146

☐ **C** 238

☐ **D** 330

(Total for Question 1 = 1 mark)

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2 The picture is of a child's spinning top.

The spinning top has a diameter of 22 cm and spins at a rate of 6.5 revolutions per second.
The speed of a point on the outer edge of the spinning top is

☐ **A** 0.11 m s^{-1}

☐ **B** 0.21 m s^{-1}

☐ **C** 4.5 m s^{-1}

☐ **D** 9.0 m s^{-1}

(Total for Question 2 = 1 mark)

P 4 2 9 2 8 A 0 2 2 4

3 The unit of magnetic flux density is the tesla T.
The unit T could also be written as

☒ **A** kg A s^{-2}

☒ **B** N A^{-1} m^{-1}

☒ **C** N C^{-1} m^{-1}

☒ **D** Wb m^{-1}

(Total for Question 3 = 1 mark)

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4 In the particle accelerator called the Linac, the particles gain kinetic energy because

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

☒ **B** mass is converted to energy due to $\Delta E = c^2\Delta m$.

☒ **C** the tubes increase in length.

☒ **D** they are in an electric field.

(Total for Question 4 = 1 mark)

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5 A 520 µF capacitor is charged so that the potential difference across it increases at a constant rate from 0 V to 4.5 V in 25 s.

The current that is charging the capacitor is

☒ **A** 0.18 µA

☒ **B** 4.6 µA

☒ **C** 47 µA

☒ **D** 94 µA

(Total for Question 5 = 1 mark)

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6 An electron of charge e and mass m accelerates from rest through a potential difference V. The electron's final velocity will be

☒ **A** $\dfrac{eV}{m}$

☒ **B** $\dfrac{2eV}{m}$

☒ **C** $\sqrt{\dfrac{2eV}{m}}$

☒ **D** $\sqrt{\dfrac{eV}{m}}$

(Total for Question 6 = 1 mark)

7 Which of the following **cannot** be used as a unit of electric field strength?

☒ **A** $\mathrm{N\,A^{-1}\,s^{-1}}$

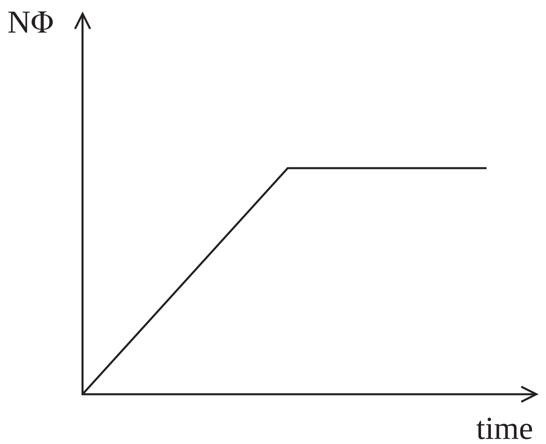
☒ **B** $\mathrm{N\,C^{-1}}$

☒ **C** $\mathrm{J\,C^{-1}\,m^{-1}}$

☒ **D** $\mathrm{J\,C\,m^{-1}}$

(Total for Question 7 = 1 mark)

8 The graph shows how the flux linkage NΦ through a coil varies with time.



The e.m.f. induced in the coil over the same period of time

☒ **A** increases and then becomes constant.

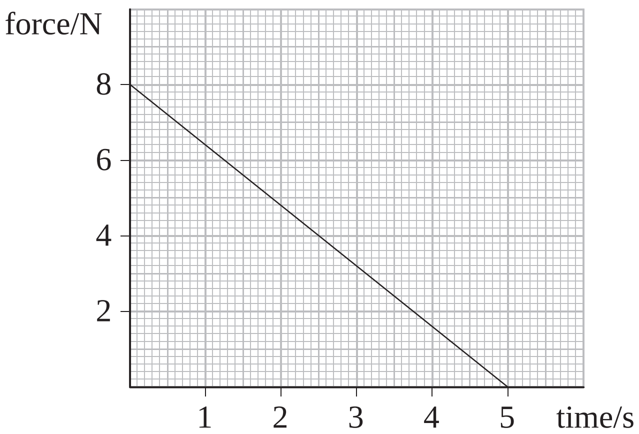
☒ **B** is constant and then becomes zero.

☒ **C** is zero and then increases.

☒ **D** decreases and then becomes zero.

(Total for Question 8 = 1 mark)

9 A model glider of mass 1.5 kg is launched using a large catapult. The glider starts from rest and the graph shows how the force on the glider varies with time.



The velocity of the glider after 5 s is

☒ **A** 2.4 m s^{-1}

☒ **B** 13 m s^{-1}

☒ **C** 20 m s^{-1}

☒ **D** 27 m s^{-1}

(Total for Question 9 = 1 mark)

10 In particle physics the mass of a particle is often given in GeV/c^2. If a particle has a mass M in kg, its mass in GeV/c^2 is

☒ **A** $\dfrac{Me}{c^2 \times 10^9}$

☒ **B** $\dfrac{Mc^2e}{10^9}$

☒ **C** $\dfrac{M}{ec^2 \times 10^9}$

☒ **D** $\dfrac{Mc^2}{e \times 10^9}$

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

***11** Rutherford carried out experiments in order to determine the structure of atoms. Alpha particles were directed at thin metal foils.

Describe how these alpha-scattering experiments provided evidence for the existence and properties of the nucleus.

(5)

(Total for Question 11 = 5 marks)

12 A particle Ω^- with strangeness –3 can be produced by the interaction of a K^- meson with a proton.

$$K^- + p = \Omega^- + K^+ + K^0$$

Strangeness is conserved in the interaction. Using the information given in the table below, deduce the quark composition of all the particles in the interaction.

(4)

Type of quark	Charge	Strangeness
u	+2/3	0
d	–1/3	0
s	–1/3	–1

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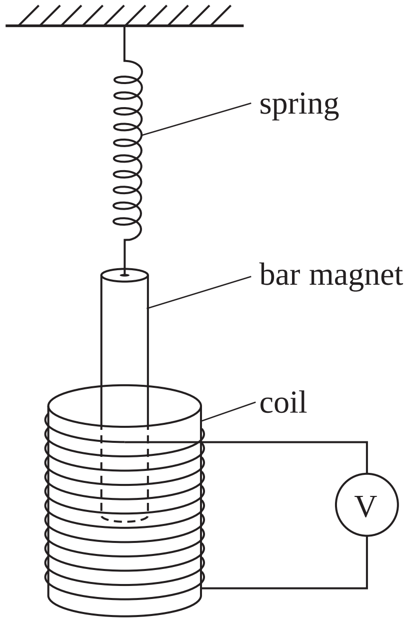
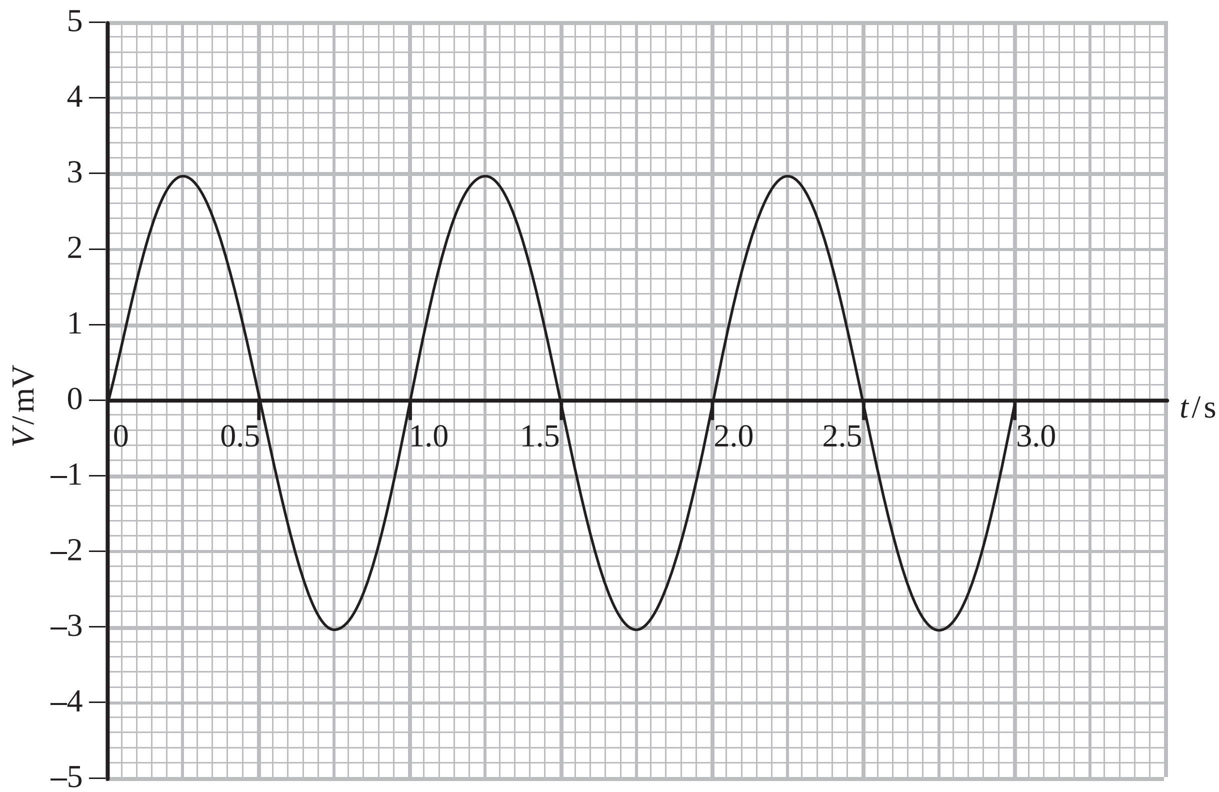
(Total for Question 12 = 4 marks)

***13** A bar magnet is suspended vertically from the bottom of a spring as shown in the diagram.



One pole of the magnet is inside a coil of wire which is connected to a high resistance voltmeter. The magnet is displaced vertically and released.
The graph, on the next page, shows the variation of the voltmeter reading V with time t.



Explain why the voltmeter reading varies as shown.

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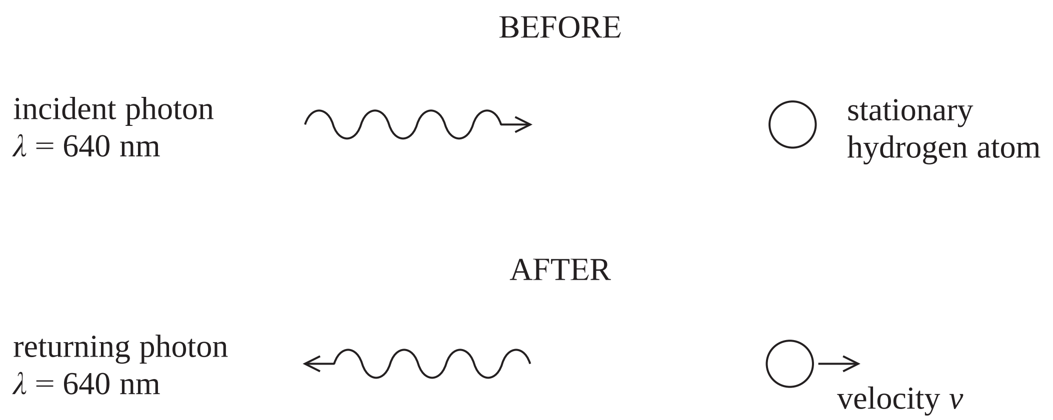
(Total for Question 13 = 5 marks)

14 A photon of visible light is incident on a stationary hydrogen atom. A photon returns in the opposite direction with the same wavelength when measured to 2 significant figures. The hydrogen atom moves with a velocity v as shown in the diagram.

mass of hydrogen atom = 1.67×10^{-27} kg



(a) Use the principle of conservation of momentum and the equation $\lambda = h/p$ to calculate the speed of the hydrogen atom after the interaction with the photon.

(4)

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Speed = ...

(b) The data given in this interaction is inconsistent with another conservation law. Explain this inconsistency and describe the effect of recording the wavelengths of the photons to more significant figures.

(4)

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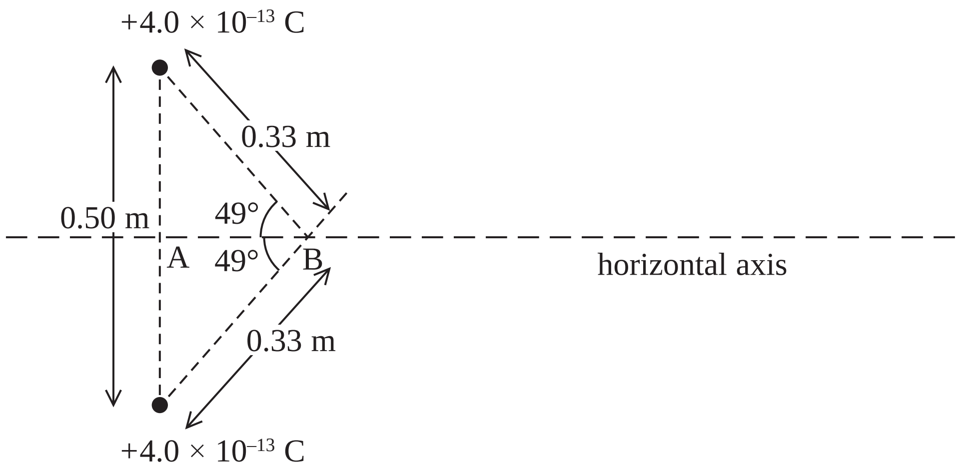
(Total for Question 14 = 8 marks)

15 Two small point charges are separated by a short distance as shown in the diagram.



(a) Calculate the resultant electric field strength at B, a distance of 0.33 m from each charge.

(4)

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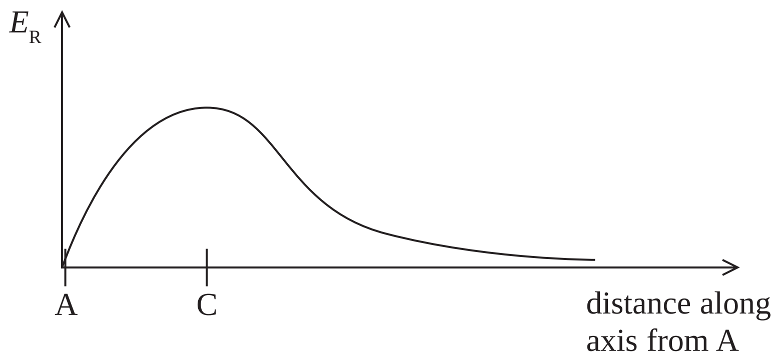
Resultant electric field strength = ...

(b) The graph shows how the resultant electric field strength E_R varies with distance along the horizontal axis from point A. A maximum occurs at point C.



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

Explain why E_R is zero at A and decreases with distance at large distances from A.

(2)

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(c) The electric field strength at C is 0.044 N C^{-1}.
A positive ion enters the electric field travelling along the axis towards the right. The ion has a speed of 1500 m s^{-1} at point A.

(i) Calculate the maximum acceleration of the ion as it passes through the field.

mass of ion = 6.6×10^{-27} kg

charge on ion = 3.2×10^{-19} C

(3)

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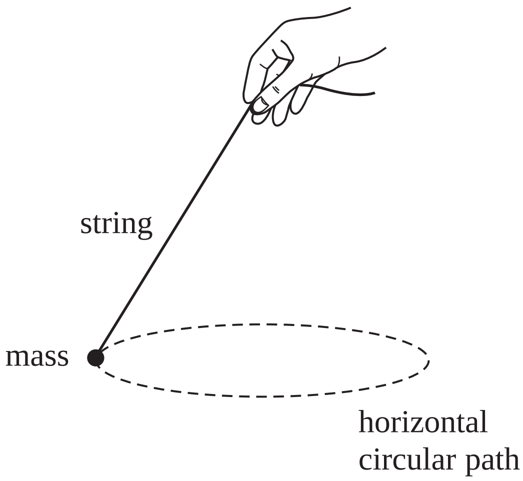
Maximum acceleration = ...

(ii) Sketch a graph to show how the speed of the ion varies as it travels along the axis from A until it is well beyond C. Mark positions A and C on the graph.

(3)

(Total for Question 15 = 12 marks)

16 (a) A student holds a piece of string with a small spherical mass attached to the other end. She rotates the mass at a constant angular velocity, in a horizontal circular path which is below her hand.



Explain why it is not possible for the student to rotate the mass so that the string is horizontal.

(2)

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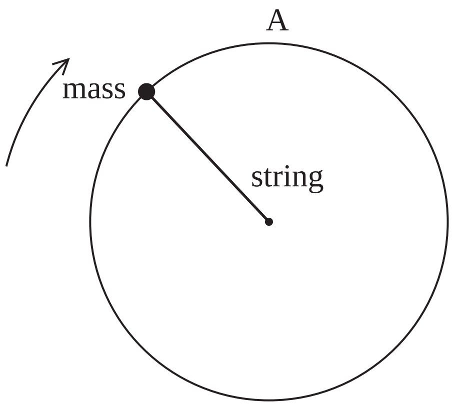
(b) The student now rotates the mass in a vertical plane as shown in the diagram.



(i) The string has a length of 25.0 cm and is attached to a mass of 204 g. It is rotated in a vertical circle with the string remaining taut at all times. When the mass is at the top of the circle it is moving with an angular velocity of 9.90 rad s^{-1}.

Calculate the tension in the string at this position.

(4)

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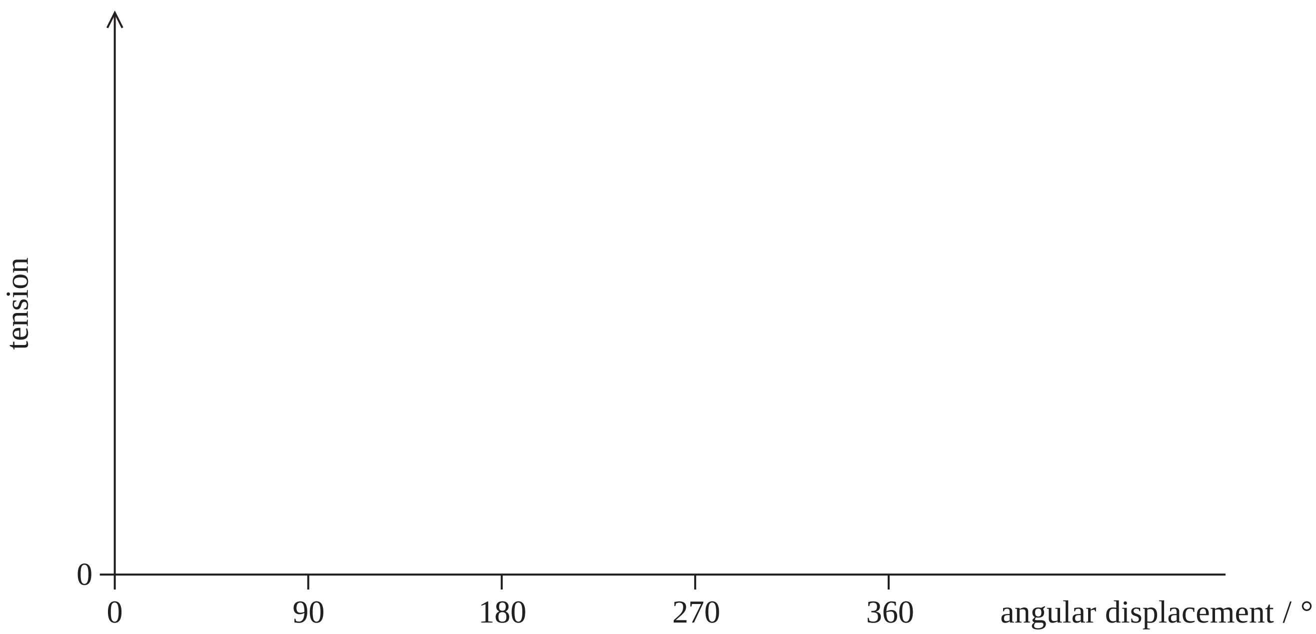
Tension = ...

(ii) As the mass completes one circuit of the vertical circle, its position can be identified by the angle it has moved through (its angular displacement). One complete revolution means that the mass has moved through an angle of 360°.

On the axes below sketch a graph of how the tension in the string varies as it completes a full circle starting from A.

(4)



(Total for Question 16 = 10 marks)

17 Particle detectors often use magnetic fields to deflect particles so that properties of the particles can be measured.

(a) State what is meant by a magnetic field.

(2)

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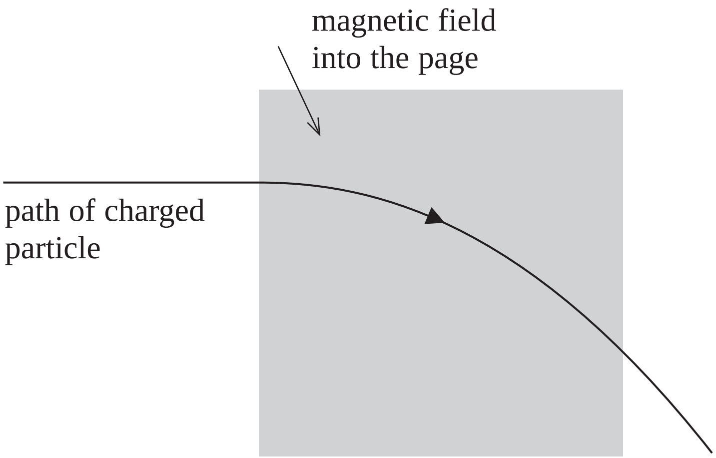
(b) A moving charged particle of mass *m*, charge *q* and velocity *v* enters a uniform magnetic field of flux density *B*.



(i) State the charge on the particle.

(1)

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(ii) Describe and explain the shape of the particle's path in the magnetic field.

(2)

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(iii) The radius of the path in the magnetic field is r. By considering the magnetic force acting on the particle show that the following equation is correct.

$$r = \frac{mv}{Bq}$$

(2)

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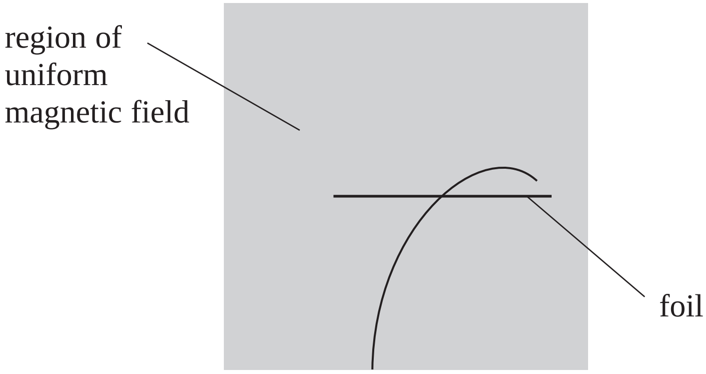
(c) A thin metal foil is placed in the same magnetic field. Another charged particle enters the magnetic field and its path is shown.



(i) Add an arrow to show the direction of travel of the particle and give your reasons.

(3)

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(ii) The radii of the two sections of the path are 8.4 cm and 6.1 cm.

Determine the ratio of the final momentum of the particle to the initial momentum of the particle, as it passes through the foil.

(2)

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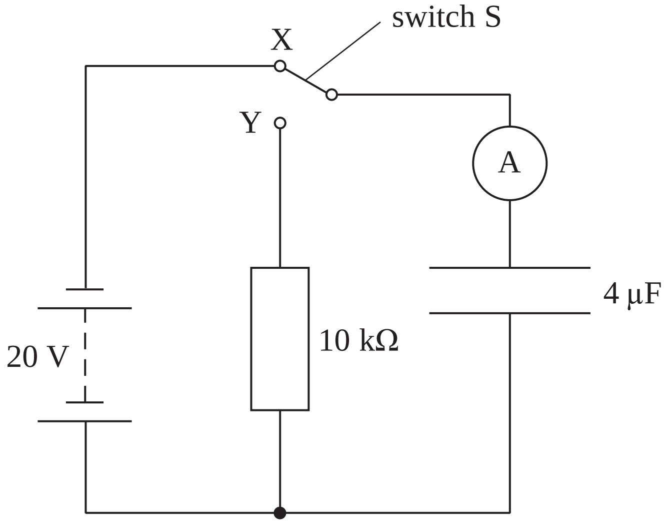
Ratio = ...

(Total for Question 17 = 12 marks)

18 A student sets up the circuit as shown in the diagram.



(a) (i) She moves the switch S from X to Y.

Describe what happens to the capacitor.

(2)

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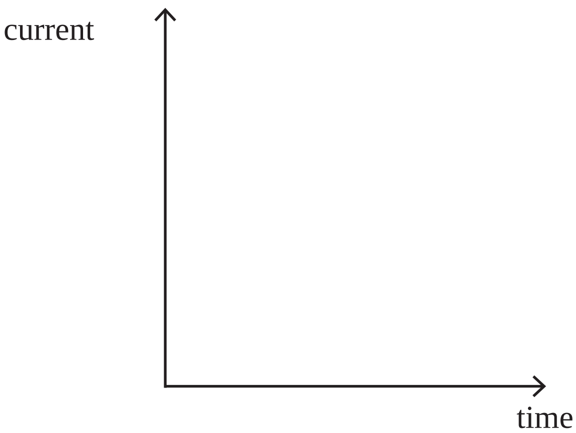
(ii) On the axes below, sketch a graph to show how the current in the ammeter varies with time. Take $t = 0$ as the time when the switch touches Y. Indicate typical values of current and time.

(3)



(iii) Describe and explain what happens when the switch is moved back to X.

(3)

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(b) The student wants to use this circuit to produce a short time delay of 0.20 s after the switch moves from X to Y.

Calculate the value of the potential difference across the capacitor after this time interval.

(3)

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Potential difference = ...

(c) The development of ultracapacitors which have much higher values of capacitance than traditional capacitors allows for capacitors to be used instead of batteries for storing energy.

The picture shows a Formula 1 racing car going around a curved section of a racing track.

Racing cars have to go through large changes in speed in order to go around the corners on the racing tracks. All racing cars have a kinetic energy recovery system which recovers the moving vehicle's kinetic energy when it is braking. The recovered energy can now be stored in ultracapacitors for later use when the car is accelerating.

A particular racing car has a mass of 800 kg and is travelling at 30 m s^{-1}. It uses an ultracapacitor of capacitance 2600 F charging to a potential difference of 2.5 V.

Calculate the ratio of the energy stored on the fully charged ultracapacitor to the kinetic energy of the car.

(3)

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Ratio = ...

(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS

TOTAL FOR PAPER = 80 MARKS

P 4 2 9 2 8 A 0 2 0 2 4

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

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	$\varepsilon = -\mathrm{d}(N\phi)/\mathrm{d}t$

Particle physics

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

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