ANDERSON JUNIOR COLLEGE

2017 JC2 Preliminary Examination

PHYSICS Higher 2 9749/01

Paper 1 Multiple Choice **Tuesday 19 September 2017**

1 hour

Additional Materials: Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

Write your name, class index number and PDG on the Answer Sheet in the spaces provided.
Shade and write your NRIC/FIN.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this question paper.
The use of an approved scientific calculator is expected, where appropriate.

Data

speed of light in free space	c =	3.00×10^{8} m s^{-1}
permeability of free space	μ_0 =	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0 =	8.85×10^{-12} F m^{-1}
		$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e =	1.60×10^{-19} C
the Planck constant	h =	6.63×10^{-34} J s
unified atomic mass constant	u =	1.66×10^{-27} kg
rest mass of electron	m_e =	9.11×10^{-31} kg
rest mass of proton	m_p =	1.67×10^{-27} kg
molar gas constant	R =	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A =	6.02×10^{23} mol^{-1}
the Boltzmann constant	k =	1.38×10^{-23} J K^{-1}
gravitational constant	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g =	9.81 m s^{-2}

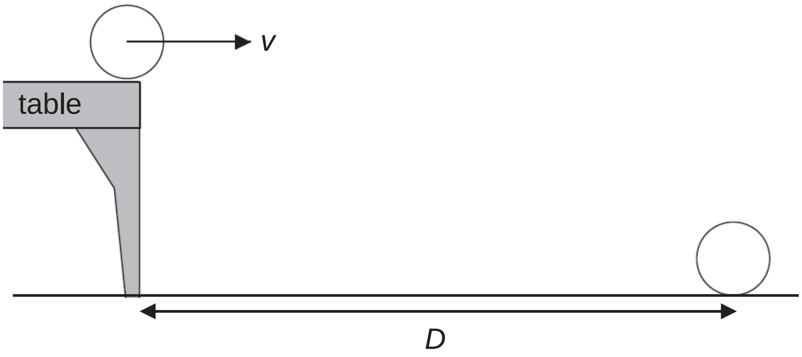
Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\mathrm{K} = T/^\circ\mathrm{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm\omega\sqrt{x_o{}^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 What is equivalent to 2000 picovolts?

A 0.002 μJ C **B** 0.02 GV **C** 0.2×10^{4} TV **D** 2×10^{-15} MJ C^{-1}

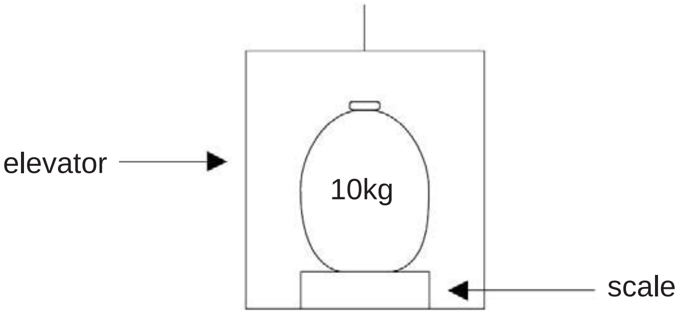
2 A ball rolls off a horizontally table with velocity *v*. It lands on the ground a time *T* later at a distance *D* from the foot of the table as shown in the diagram below. Air resistance is negligible.



A second heavier ball rolls off the table with velocity *v*. Which one of the following is correct for the heavier ball?

	Time to land	Distance from table
A	*T*	*D*
B	*T*	less than *D*
C	less than *T*	*D*
D	less than *T*	less than *D*

3 An elevator is used to either raise or lower sacks of potatoes. In the diagram, a sack of potatoes of mass 10 kg is resting on a scale that is resting on the floor of an accelerating elevator. The scale reads 12 kg.



Which of the following is the best estimate for the acceleration of the elevator?

A 2.0 m s^{-2} downwards.

B 2.0 m s^{-2} upwards.

C 1.2 m s^{-2} downwards.

D 1.2 m s^{-2} upwards.

4 Two similar spheres, each of mass *m* and travelling with speed *v*, are moving towards each other.

The spheres have a head-on elastic collision.

Which statement is correct?

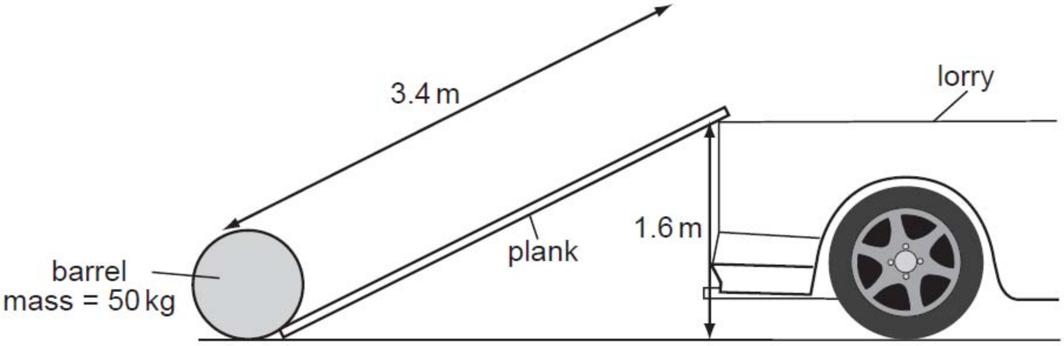
A The spheres stick together on impact.

B The total kinetic energy after impact is mv^2.

C The total kinetic energy during collision is mv^2.

D The total momentum before impact is 2*mv*.

5 A barrel of mass 50 kg is loaded onto the back of a lorry 1.6 m high by pushing it up a smooth plank 3.4 m long.



What is the minimum work done?

A 80 J **B** 170 J **C** 780 J **D** 1700 J

6 A ball is falling at terminal speed in still air. The forces acting on the ball are upthrust, viscous drag and weight.

What is the order of increasing magnitude of these three forces?

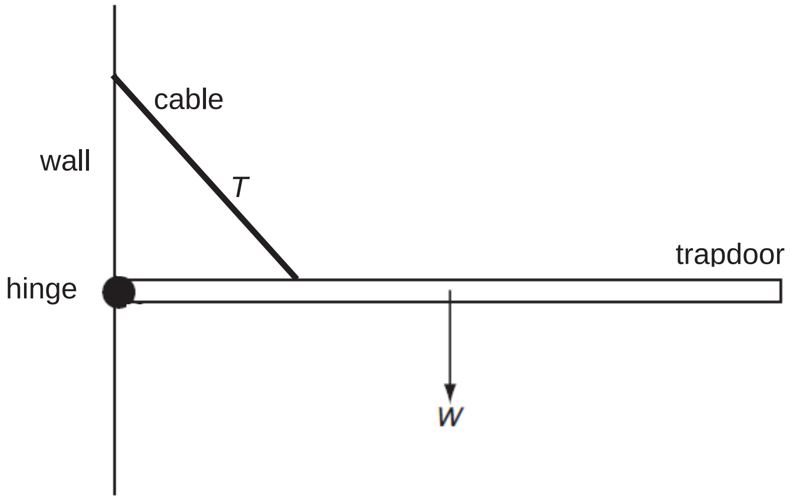
A viscous drag → weight → upthrust

B viscous drag → upthrust → weight

C weight → viscous drag → upthrust

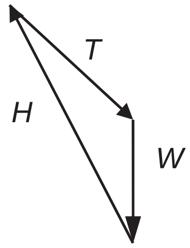
D upthrust → viscous drag → weight

7 A hinged trapdoor is held closed in the horizontal position by a cable. Three forces act on the trapdoor: weight *W* of the door, tension *T* in the cable and a force *H* at the hinge.

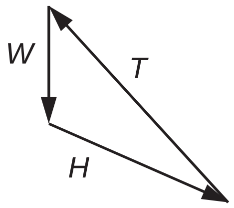


Which vector triangle could represent the forces acting on the trapdoor?

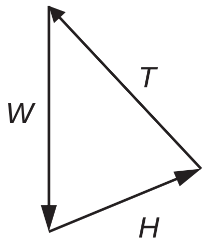
A



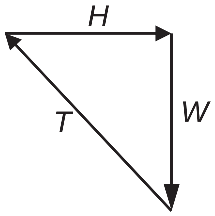
B



C

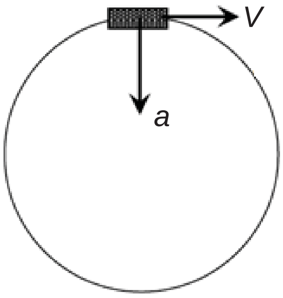


D

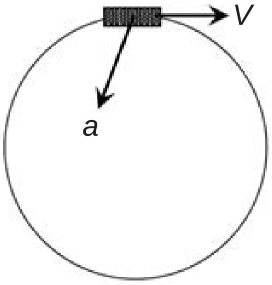


8 A drone is performing a vertical circular path stunt for its audience on the ground. Which diagram shows the resultant acceleration *a* acting on the drone at the instant where its velocity is *V* and speeding up?

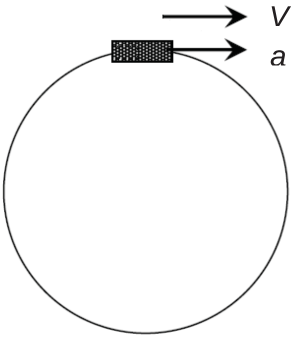
A



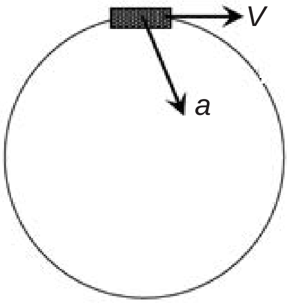
B



C



D



9 A CD-ROM is spinning about its central axis at a constant speed. At a point that is 0.030 m from the centre of the disc, the centripetal acceleration is 120 m s^{-2}. What is the linear speed of a point that is 0.050 m from the centre of the disc?

A 1.90 m s^{-1} **B** 2.24 m s^{-1} **C** 3.16 m s^{-1} **D** 6.32 m s^{-1}

10 A spacecraft orbiting a planet in uniform circular motion has an antenna detached gently from it. Neglecting air resistance, which statement best describes the motion of this detached antenna?

A It will move off in a straight line away from the planet.

B It will take a parabolic path into the planet.

C It will drop straight down into the planet.

D It will continue to orbit in uniform circular motion.

11 Water has a higher specific heat capacity than iron. If the same amount of heat is given to equal masses of water and iron that are initially at the same temperature, which of the following is true?

A The iron is now warmer than the water.

B The water is now warmer than the iron.

C The temperature of the iron rises faster than the water but both reach the same final temperature.

D The temperature of the water rises faster than the iron but both reach the same final temperature.

12 When a gas is heated uniformly inside a sealed rigid cylinder, which of the following does not change?

A The average number of molecules hitting the cylinder wall per second.

B The average force acting on the gas molecules by the cylinder wall.

C The average distance between the gas molecules.

D The average speed of the gas molecules.

13 A sample of an ideal gas may (i) expand at constant pressure or (ii) expand at constant temperature. What is the net flow of heat into the gas from the exterior?

A Negative in each case.

B Positive in each case.

C Zero for (i) and positive for (ii).

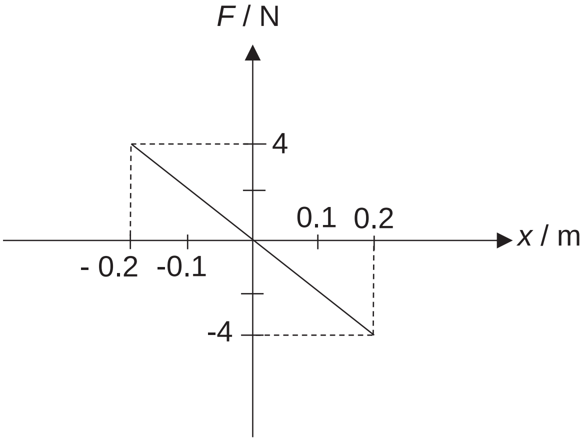
D Positive for (i) and zero for (ii).

14 A student is investigating the specifications of a camera shutter. He used a camera to photograph a simple pendulum bob that is moving in front of a horizontal scale. The extreme positions of the bob were at 600 mm and 700 mm marks.

The photograph showed that the bob moved from the 650 mm mark to the 675 mm mark when the shutter was opened. If the period of the pendulum was 2 s, what is the time that the shutter has remained opened?

A 1 s **B** 0.50 s **C** 0.25 s **D** 0.167 s

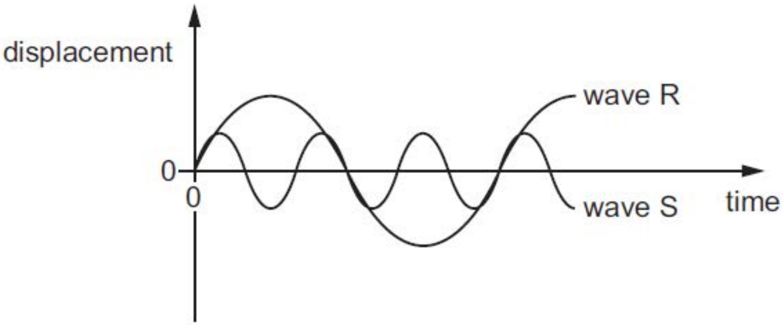
15 A body of mass 0.20 kg is subjected to a force *F* which varies with its displacement *x* from a fixed point as shown below.



What is the maximum speed of its motion in m s^{-1}?

A 2.0 **B** 10 **C** 20 **D** 100

16 The diagram shows two waves R and S.

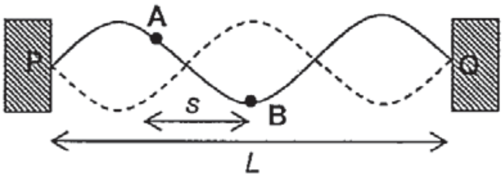


Wave R has an amplitude of 8 cm and a period of 30 ms.

What are the amplitude and the period of wave S?

	amplitude / cm	period / ms
A	2	10
B	2	90
C	4	10
D	4	90

17 A guitar string of length L is stretched between two fixed points **P** and **Q** and made to vibrate transversely as shown.



Two particles **A** and **B** on the string are separated by a distance s. The maximum kinetic energies of **A** and **B** are K_A and K_B respectively.

Which of the following gives the correct phase difference and maximum kinetic energies of the particles?

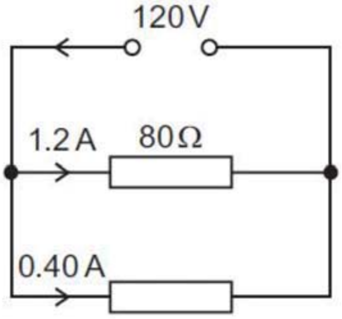
	Phase difference	Maximum kinetic energy
A	$\left(\frac{3s}{2L}\right)\times 360°$	$K_A < K_B$
B	$\left(\frac{3s}{2L}\right)\times 360°$	same
C	180°	$K_A < K_B$
D	180°	same

18 Monochromatic light of wavelength 5.30×10^{-7} m is incident normally on a diffraction grating. The first order maximum is observed at an angle of 15.4° to the direction of the incident light.

What is the angle between the first and second order diffraction maxima?

A 7.7° **B** 15.4° **C** 16.7° **D** 32.1°

19 The electromotive force of a power supply is 120 V. It delivers a current of 1.2 A to a resistor of resistance 80 Ω and a current of 0.40 A to another resistor, as shown.



What is the internal resistance of the power supply?

A 15 Ω **B** 20 Ω **C** 60 Ω **D** 75 Ω

20 There is a current in a resistor for an unknown time.

Which two quantities can be used to calculate the energy dissipated by the resistor?

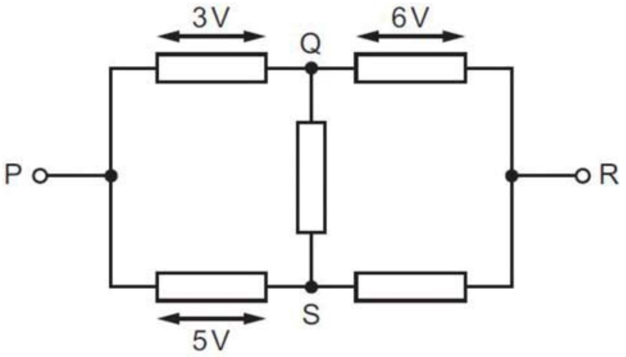
A The current in the resistor and the potential difference across the resistor.

B The resistance of the resistor and the current in the resistor.

C The total charge passing through the resistor and the potential difference across the resistor.

D The total charge passing through the resistor and the resistance of the resistor.

21 There is a current from P to R in the resistor network shown.



The potential difference (p.d.) between P and Q is 3 V.

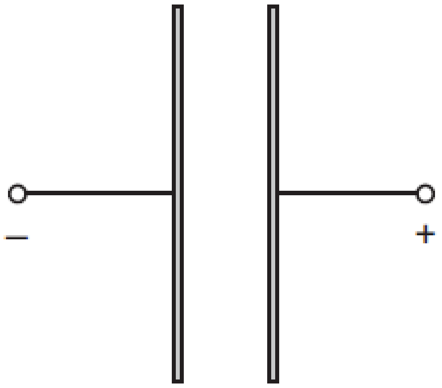
The p.d. between Q and R is 6 V.

The p.d. between P and S is 5 V.

Which row in the table is correct?

	p.d. between Q and S	p.d. between S and R
A	2 V	4 V
B	2 V	10 V
C	3 V	4 V
D	3 V	10 V

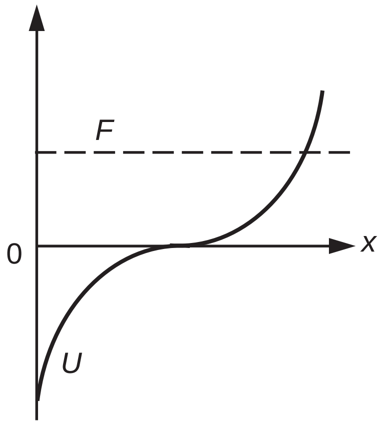
22 Two oppositely-charged parallel plates are arranged as shown.



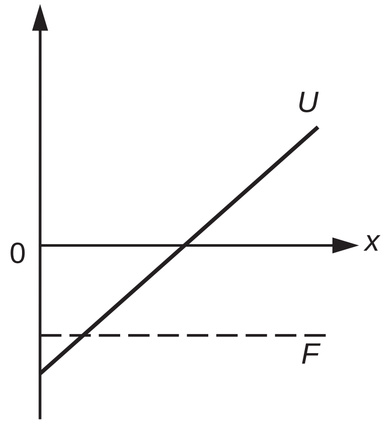
An electron is released from rest from the surface of the negatively-charged plate. The electron travels from the negatively-charged plate towards the positively-charged plate.

Which graph shows how the force F and electric potential energy U of the electron vary with its distance x from the negative plate?

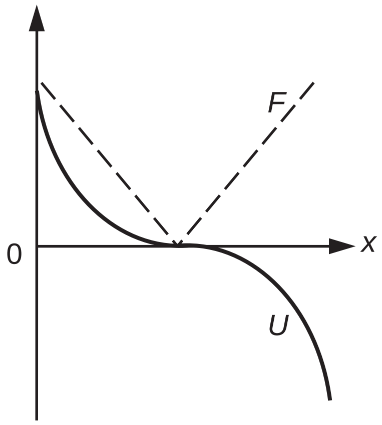
A



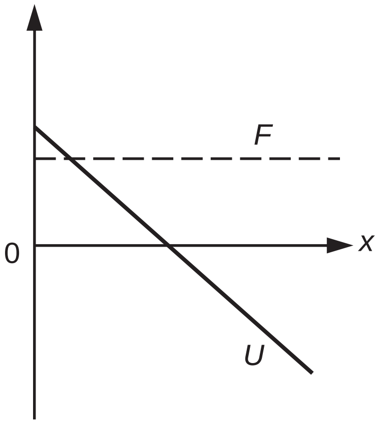
B



C



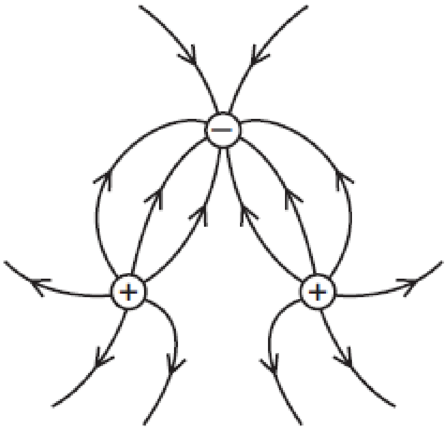
D



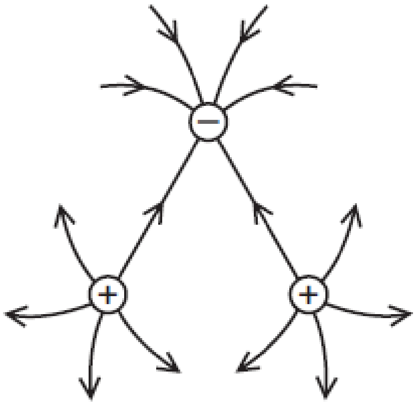
23 Two positive charges and one negative charge, all of equal magnitude, are set at the corners of an equilateral triangle.

Which diagram best represents the electric field surrounding the charges?

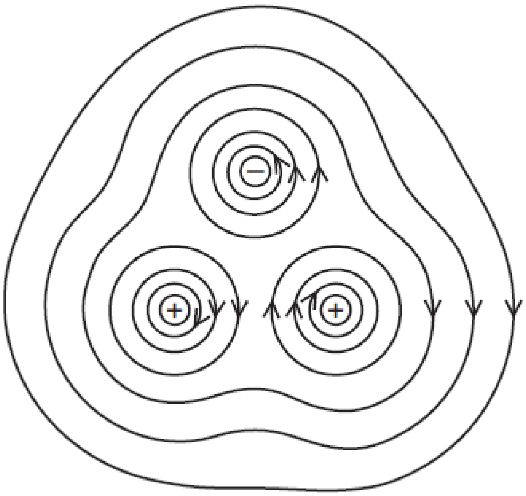
A



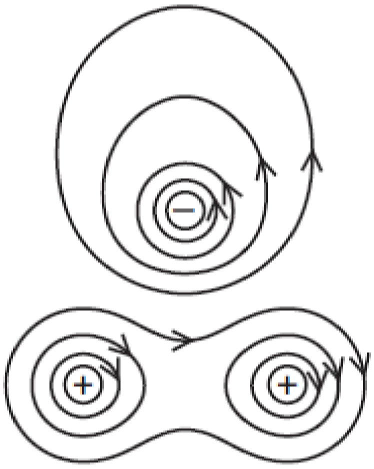
B



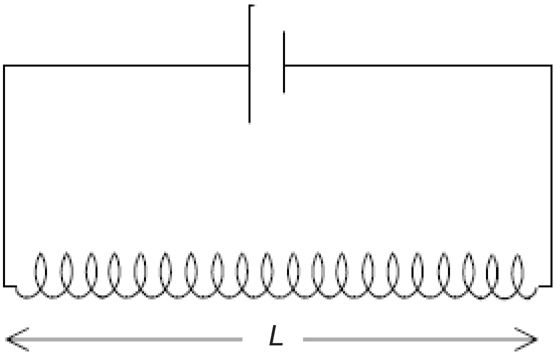
C



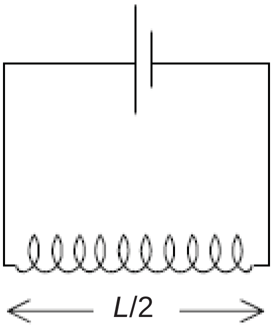
D



24 The diagram shows a long solenoid of length *L* connected to a battery of negligible internal resistance. The magnetic field strength at the centre of the solenoid is *T*.



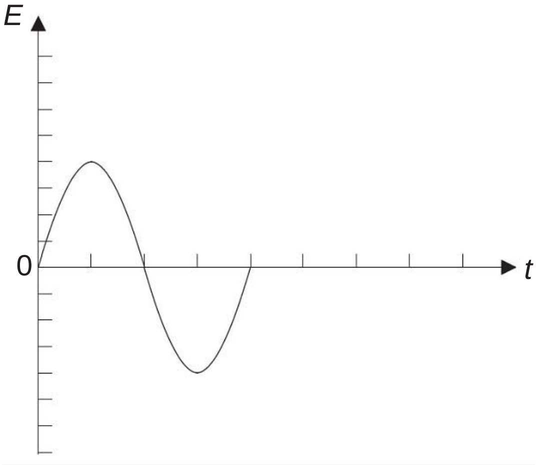
The solenoid is now disconnected from the battery and cut in half and one of the halves is reconnected to the battery as shown below.



What is the best estimate of the field strength at the centre of this solenoid?

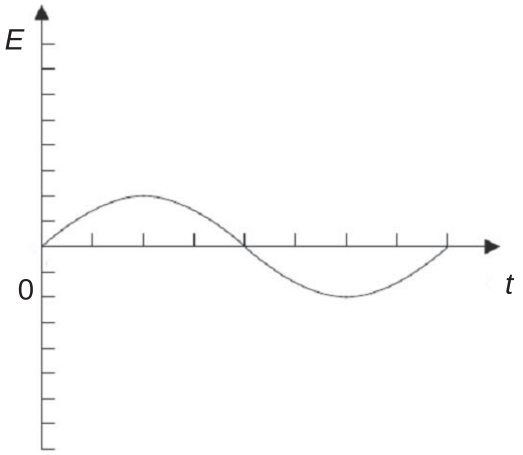
A 0.5*T* **B** *T* **C** 2*T* **D** 4*T*

25 When a coil is rotated in a uniform magnetic field at a certain frequency, the variation with time *t* of the induced e.m.f. *E* is shown below.

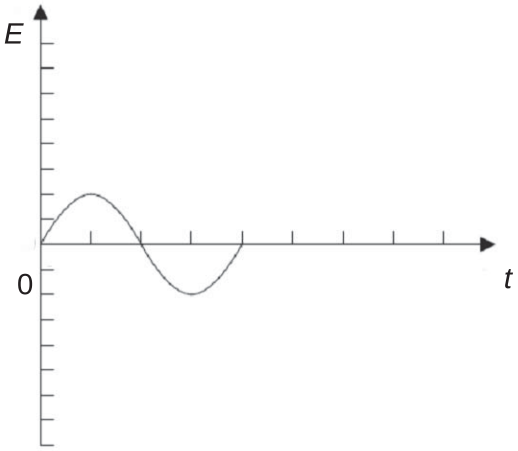


The frequency of rotation of the coil is reduced to **one half** of its initial value. Which **one** of the following graphs correctly shows the new variation with time *t* of the induced e.m.f. *E*?

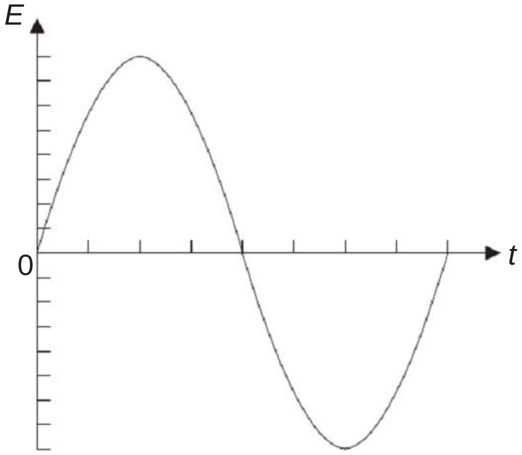
A



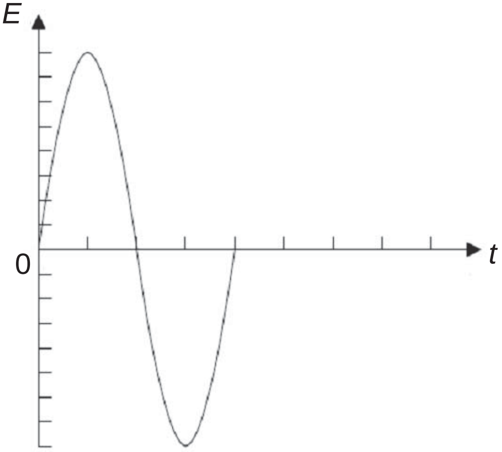
B



C



D

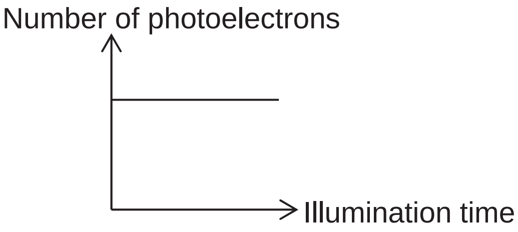


26 An a.c. supply is connected to a resistor. If the r.m.s. voltage output of the supply is doubled, by what factor would the power dissipated in the resistor increase?

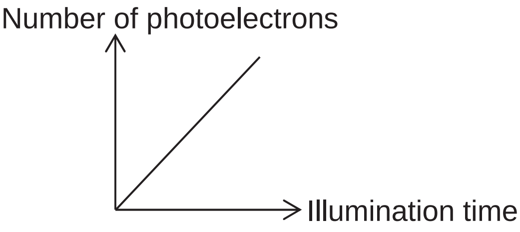
A 1 **B** $\sqrt{2}$ **C** 2 **D** 4

27 When electromagnetic radiation of frequency *f* falls on a particular metal surface, photoelectrons are emitted. Which graph is obtained when the intensity of the electromagnetic radiation is kept constant?

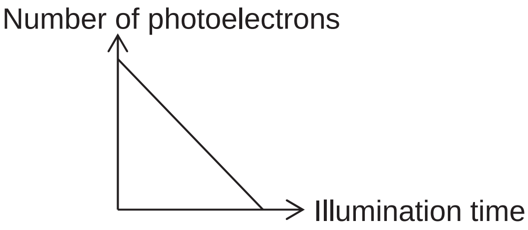
A



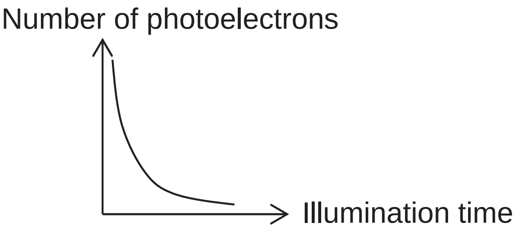
B



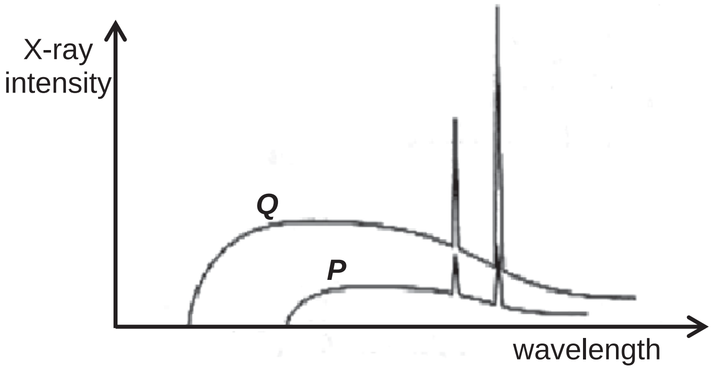
C



D



28 X-ray spectra are taken from two X-ray tubes P and Q. The intensity of the X-rays is plotted against the wavelength in both cases and is shown below.



What deduction can be made from these plots?

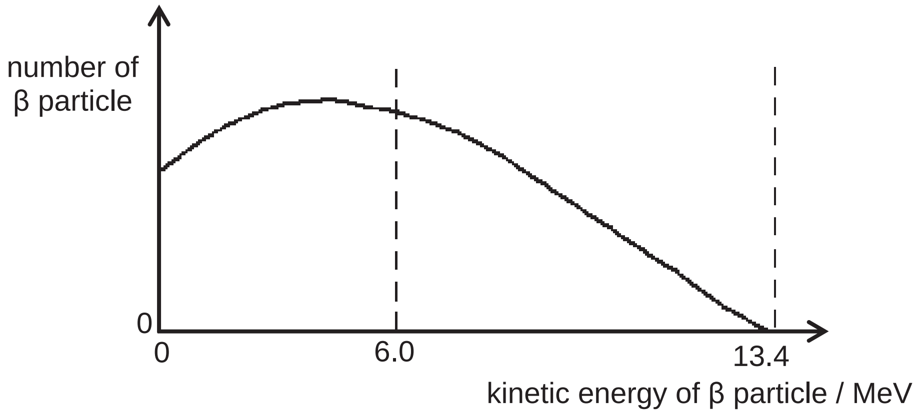
A X-ray tube Q has the higher voltage applied to it and the target material in both tubes are different.

B X-ray tube Q has the higher voltage applied to it and the target material in both tubes is the same.

C X-ray tube P has the higher voltage applied to it and the target material in both tubes is the same

D X-ray tube P has the higher voltage applied to it and the target material in both tubes are different.

29 The beta spectrum for ^{12}B decay is as shown below.



The kinetic energy of an emitted β particle is 6.0 MeV. What is the approximate energy of the associated neutrino?

A 6.0 MeV

B 7.4 MeV

C 9.7 MeV

D 13.4 MeV

30 Nuclide X decays with a half-life of 15 days to stable nuclide Y. At a particular time, *t*, the ratio of the number of nuclides X to the number of nuclides Y in a sample is 1:1.

How long after time *t* will the ratio in the sample be 1:3?

A 15 days

B 30 days

C 45 days

D 60 days

End of Paper

Name: ______________________________ (   )   PDG: ______/ 16

ANDERSON JUNIOR COLLEGE

2017 JC2 Preliminary Examination

PHYSICS   Higher 2   9749/02

Paper 2 Structured Questions   **Tuesday 12 September 2017**

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class index number and PDG in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, glue or correction fluid.

The use an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	
2	
3	
4	
5	
6	
7	
Significant Figure	
Total (80 marks)	

This document consists of **22** printed pages

Data

speed of light in free space	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$
	$(1/(36\pi)) \times 10^{-9}\ \text{F m}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ \text{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\ \text{J s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\ \text{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\ \text{kg}$
molar gas constant	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\ \text{J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ \text{N m}^{2}\ \text{kg}^{-2}$
acceleration of free fall	$g = 9.81\ \text{m s}^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\dfrac{Gm}{r}$
temperature	$T/\text{K} = T/°\text{C} + 273.15$
pressure of an ideal gas	$p = \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm\omega\sqrt{{x_o}^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to long straight wire	$B = \dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \dfrac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{\ln 2}{t_{\frac{1}{2}}}$

1 In 2010, an iron cannon and some iron cannon balls were discovered offshore in the United Kingdom after sitting on the seabed for a few hundred years.

(a) An experiment is performed to determine the density ρ of an iron cannon ball. The average of the measurements, with their uncertainties, are shown in Fig 1.1.

Mass, m / kg	Diameter, d / cm
79.72 ± 0.01	26.7 ± 0.1

Fig 1.1

(i) Show that the density of iron, ρ is 7999 kg m^{-3}.

[1]

(ii) Calculate the actual uncertainty in ρ.

actual uncertainty in ρ =…………………….. kg m^{-3} [2]

(iii) State the value of ρ and its actual uncertainty to the appropriate number of significant figures.

ρ = ……………………±……………………..kg m^{-3} [1]

(b) One possible way to raise the iron cannon from the seabed is to use a lifting bag, which may be attached to the iron cannon and then partially inflated with air, as shown in Fig. 1.2.

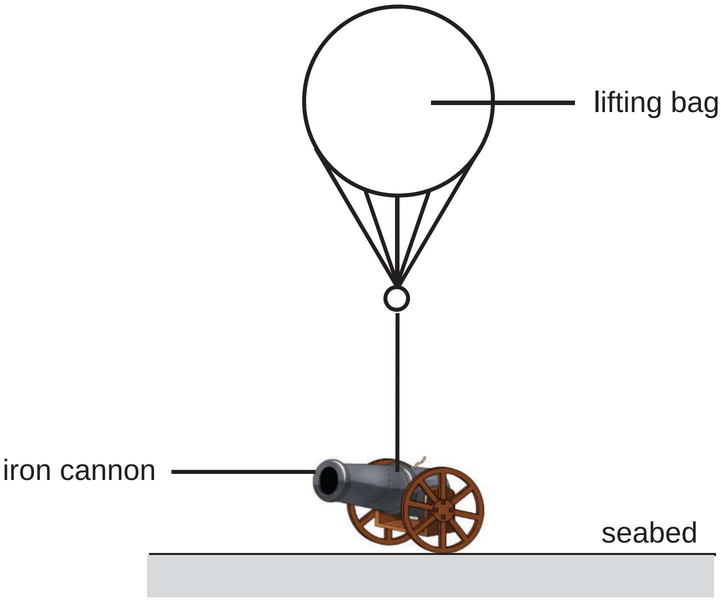


Fig. 1.2

(i) The submerged iron cannon of mass 800 kg is attached to a lifting bag of negligible volume and mass. Using the data in part **(a)(i)**, estimate the initial acceleration of the cannon when 0.70 m^3 of air is suddenly released into the bag. The density of the seawater is 1050 kg m^{-3}.

acceleration = ……………………………m s^{-2} [3]

(ii) Explain why air has to be released continuously from the lifting bag as the iron cannon rises from the seabed to the surface so that a constant speed of ascent is maintained.

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…………………………………………………………………………….………….... [3]

2 **(a)** Gas, R, is trapped in a vessel by a column of liquid PQ as shown in Fig 2.1 below. Length of the liquid column can be increased by adding more liquid to PQ.

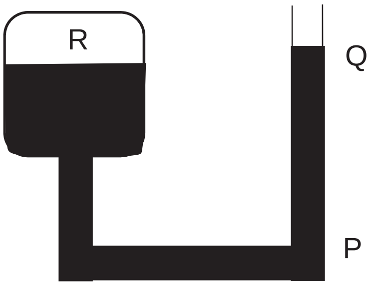

Fig 2.1

Using the kinetic theory, explain how the pressure of the gas R is increased,

(i) when the volume of R remain unchanged and its temperature increases.

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……………………………………………………………………………………………[3]

(ii) when the temperature of R remain unchanged and its volume decreased slightly.

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……………………………………………………………………………………………..

……………………………………………………………………………………………[2]

(b) There is about one hydrogen atom per cm^3 in outer space, where the temperature (in the shade) is about 3.5 K. The mass of a hydrogen atom is 1 *u*.

Calculate

(i) the rms speed of these atoms.

rms speed = …………………………….. m s^{-1} [3]

(ii) the pressure exerted by these atoms.

pressure = ………………………………… Pa [3]

3 **(a)** A mass of 170 g oscillates with simple harmonic motion. Fig. 3.1 shows the variation with time *t* of the displacement *y* of the mass.

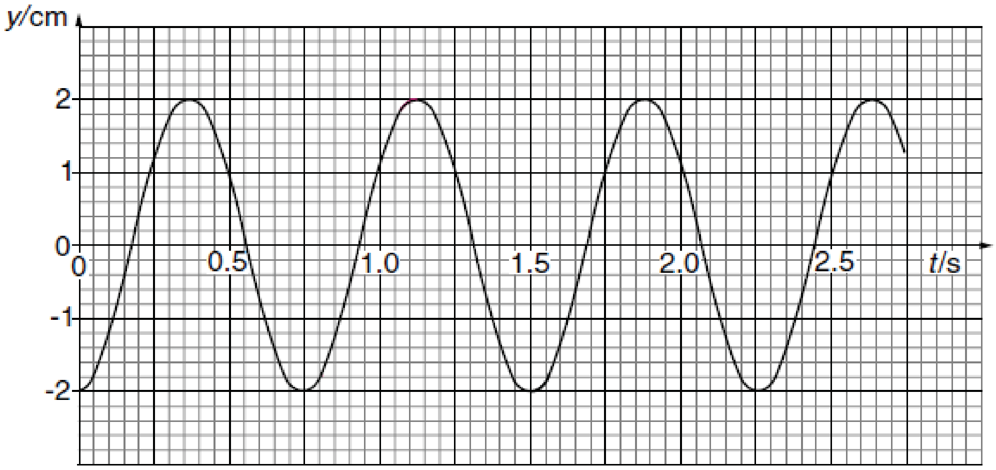

Fig. 3.1

(i) Explain what is meant by *simple harmonic motion*.

………………………………………………………………………………………………..

………………………………………………………………………………………………..

……………………………………………………………………………………………. [2]

(ii) On Fig. 3.2, draw a graph showing the variation with displacement y of the potential energy E_p of the mass

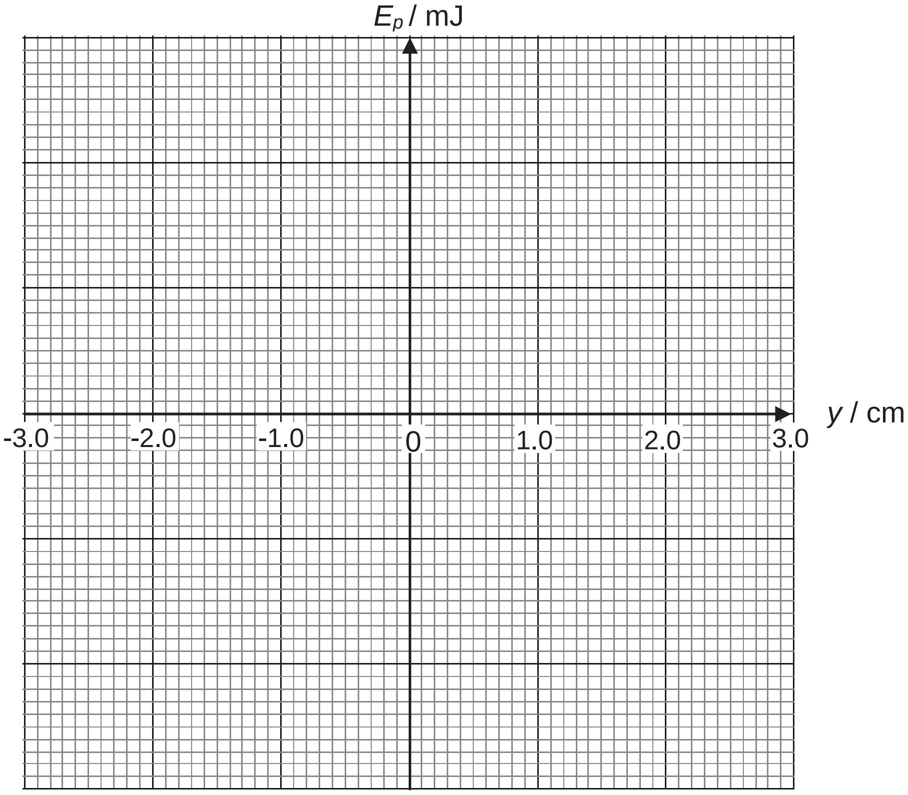

Fig. 3.2

.

[3]

(b) The drums of an automatic washing machine are suspended from the casing by springs, at the top and bottom, as shown in Fig. 3.3. The inner drum rotates within the outer drum at variable speeds according to the washing programme.

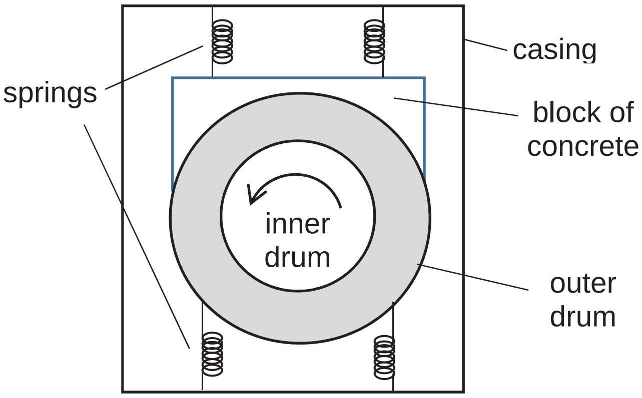

Fig. 3.3

The total mass of the drums is 20 kg. A block of concrete of mass 20 kg is added to the outer drum. The natural period of oscillation of the system is 1.6 s. The period of oscillation T of the system is given by $T = 2\pi\sqrt{\frac{M}{k}}$, where M is the total mass of the load in the system and k is the effective spring constant of the springs.

When the washing machine enters the spin part of the washing programme, it starts from rest and its rotational speed increases gradually. As the speed increases, the system is observed to oscillate with increasing amplitude which reaches a maximum value of 5.0 cm before decreasing again at higher speeds.

(i) Calculate the number of revolutions per second of the drum when the maximum amplitude of oscillation is observed.

number of revolutions per second = ……………........... [1]

(ii) Explain

1. why the system oscillates when the inner drum is rotated,

……………………………………………………………………………………..................

……………………………………………………………………………………………….... [1]

2. and why the amplitude reaches a maximum.

……………………………………………………………………………………..................

……………………………………………………………………………………………….... [1]

(iii) On Fig. 3.4, sketch a graph showing how the amplitude varies with frequency of rotation of the inner drum.

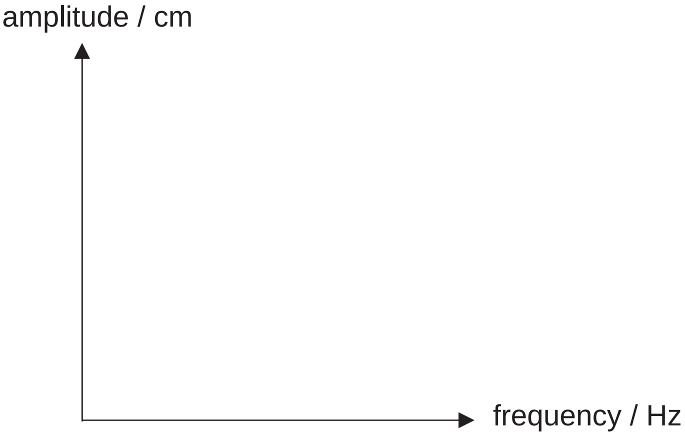

Fig. 3.4 [2]

(iv) State and explain one effect on the machine without the block of concrete fixed to the drum.

……………………………………………………………………………………..................

……………………………………………………………………………………..................

……………………………………………………………………………………………….... [2]

4 **(a)** A cell of e.m.f. *E* = 3.0 V and internal resistance *r* = 0.50 Ω is connected to three bulbs X, Y and Z as shown in the circuit of Fig. 4.1.

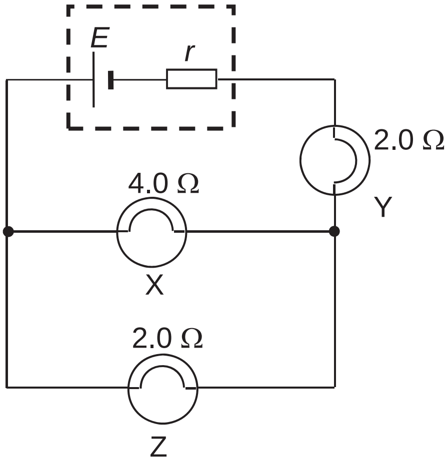

Fig. 4.1

(i) Calculate the effective resistance of the three bulbs in the circuit of Fig. 4.1.

effective resistance = …………………………….Ω [2]

(ii) List the light bulbs X, Y and Z in order of *increasing* brightness.

in order of increasing brightness: ……………………………. [1]

(b) The circuit of Fig. 4.1 was connected to a potentiometer that is made up of a 6.0 V battery in series with a resistance R = 1.0 Ω and a uniform wire **AB** of length 100.0 cm and resistance 2.0 Ω (see Fig. 4.2).

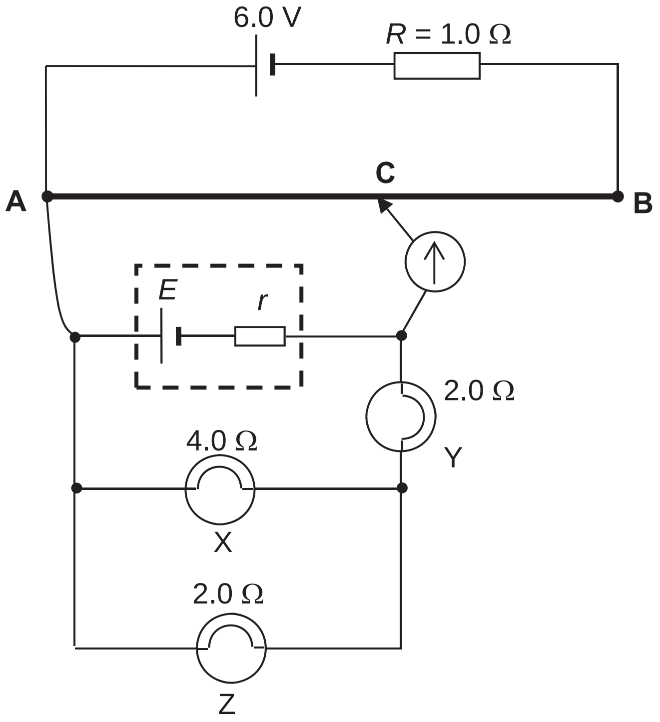

Fig. 4.2

(i) Show that the potential difference across **AB** is 4.0 V when the galvanometer shows null deflection

. [1]

(ii) Determine the balance length **AC**.

balance length **AC** = …………………………….cm [3]

(iii) Explain how, if at all, the balance length **AC** will be affected if bulb X is replaced by a bulb of lower resistance.

………………………………………………………………………………………

………………………………………………………………………………………

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………………………………………………………………………………………

……………………………………………………………………………………… [2]

5 **(a)** A current-carrying solenoid XY is placed near to a small coil, as shown in Fig. 5.1.

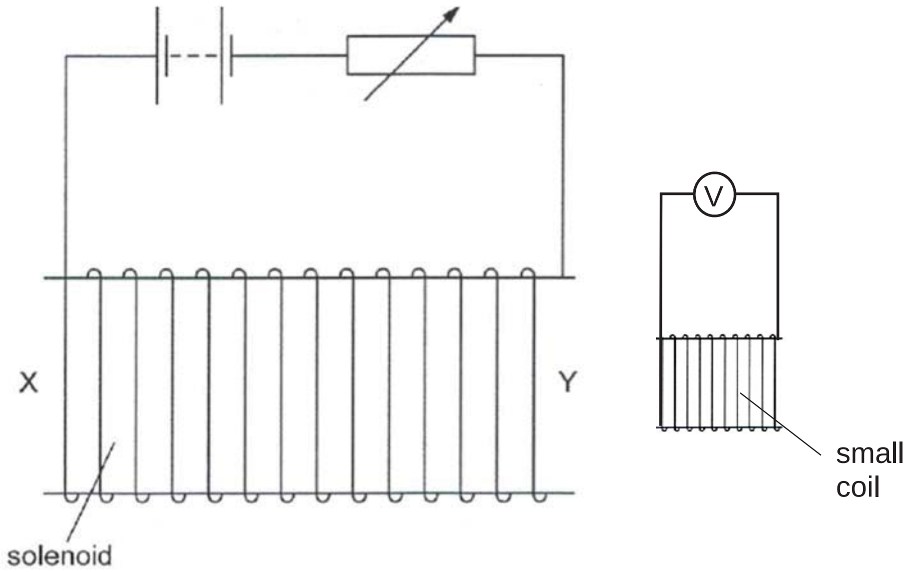

Fig. 5.1

The small coil is connected to a sensitive voltmeter.

(i) State the direction, XY or YX, of the magnetic field in the solenoid.

direction = …………………………… [1]

(ii) The resistance of the variable resistor is changed so that the current in the solenoid increases.

1. State Faraday's law of electromagnetic induction and use it to explain why a reading is recorded on the voltmeter.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………[2]

2. State Lenz's law and hence explain the direction of the induced current in the small coil.

On Fig. 5.1, mark the direction of this induced current.

………………………………………………………………………………………...........

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………………………………………………………………………………………[3]

(iii) The current in the solenoid is now made to vary as shown in Fig. 5.2.

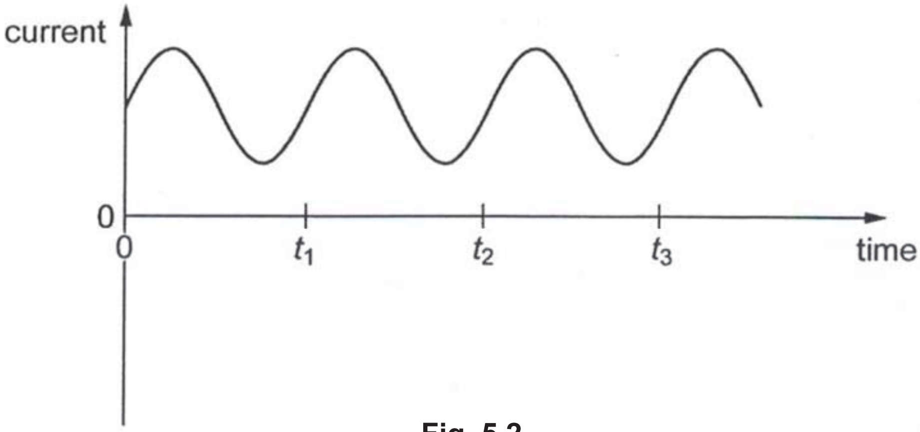

Fig. 5.2

On Fig. 5.3, show the variation with time of the e.m.f. induced in the small coil.

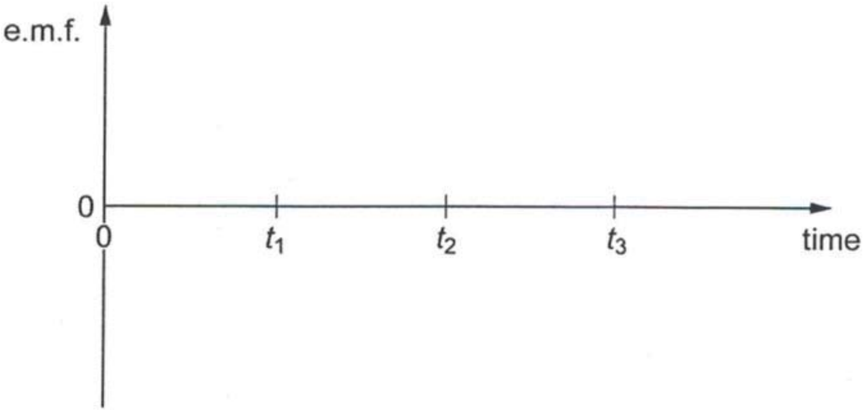

Fig. 5.3

[2]

(b) Fig. 5.4 is the circuit diagram for a half-wave rectifier.

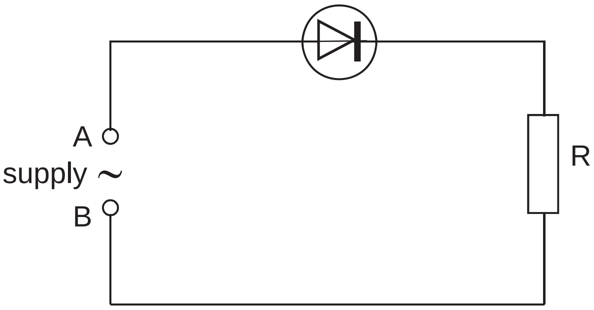

Fig. 5.4

The supply to the diode is rated as 50 Hz, 6.0 V, 1.5 W. Fig. 5.5 shows the trace of the variation with time of the potential at terminal A with respect to B when an oscilloscope is connected across the supply.

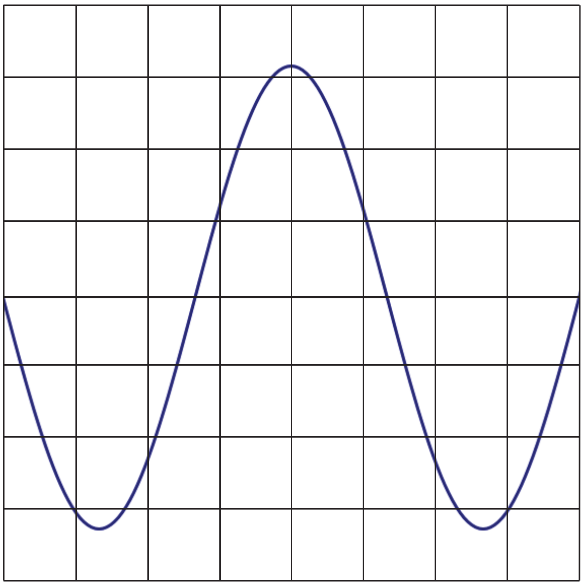

Fig. 5.5

(i) Determine the r.m.s. current the supply can provide when it is operating at 6.0 V.

r.m.s. current = …………………………….A [1]

(ii) On Fig. 5.6, draw a line to represent the corresponding trace seen on the oscilloscope across the load resistor R. [1]

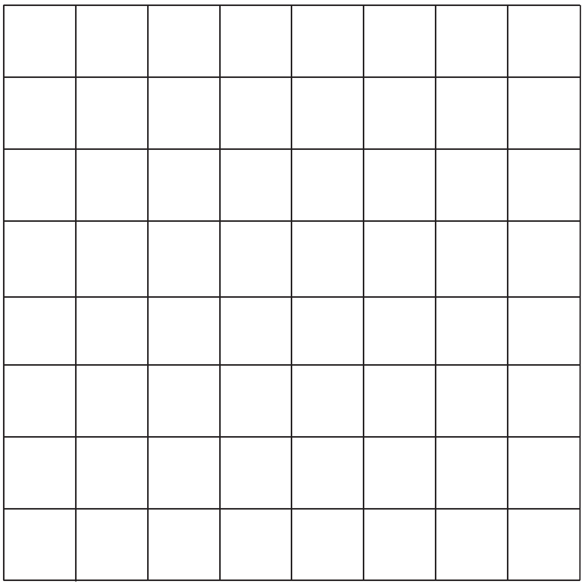

Fig. 5.6

6 **(a)** A parallel beam of electrons, all travelling at the same speed, is incident normally on a carbon film. The scattering of the electrons by the film is observed on a fluorescent screen, as illustrated in Fig. 6.1.

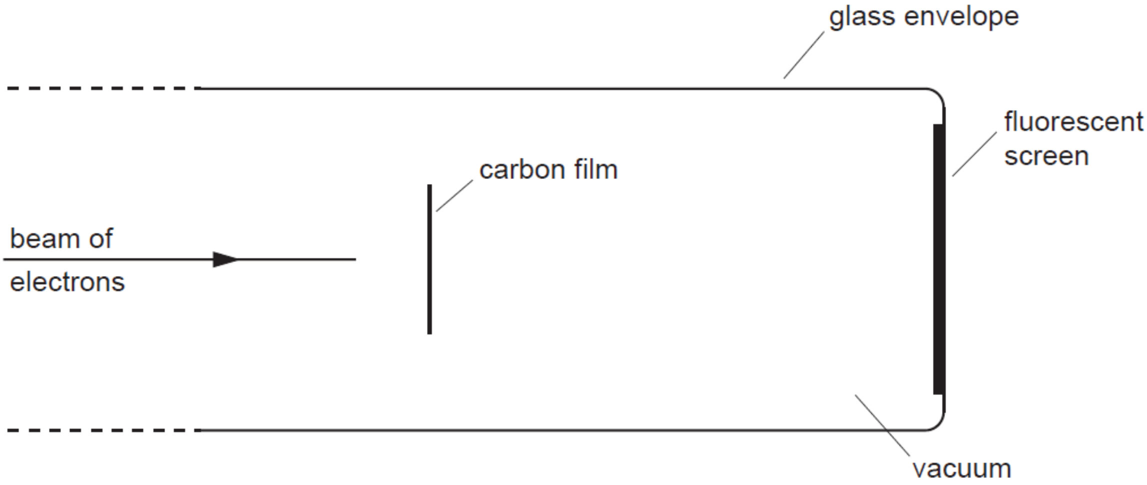

Fig. 6.1

(i) Assuming that the electrons behave as **particles**, predict what would be seen on the screen.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(ii) In this experiment, the electrons do **not** behave as particles.

Describe briefly the pattern that is actually observed on the screen.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(b) The Heisenberg Uncertainty principle (HUP) for position and momentum can be written in the form

$$\Delta p \Delta x \geq h$$

where Δp is the uncertainty in momentum, Δx is the uncertainty in the position of a particle and h is the Planck constant.

(i) Calculate the uncertainty in momentum when an electron of mass 9.11×10^{-31} kg travelling at 3.00×10^{7} m s^{-1} passes through a narrow slit of width 1.00×10^{-10} m (comparable to the spacing of atoms in a crystal).

uncertainty in momentum = ... kg m s^{-1} [2]

(ii) Compare this uncertainty in momentum to the original momentum of the electron and state its significance.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

7 The article below is based on articles on the Internet.

Read the article and then answer the questions that follow.

Use of ultrasonic sound waves on biological cells

Ultrasonic sound waves (ultrasound) are produced and detected using an ultrasound transducer. Ultrasound transducers are capable of sending an ultrasound and then the same transducer can detect the sound and convert it to an electrical signal to be diagnosed.

To produce an ultrasound, a piezoelectric crystal has an alternating current running through it. The piezoelectric crystal grows and shrinks depending on the voltage applied across it. Running an alternating current through it causes it to vibrate at a high speed and to produce an ultrasound.

Ultrasound have frequencies outside the audible range of the human ear, that is, greater than about 20 kHz.

When an ultrasound passes through a medium, its wave energy is absorbed. The rate at which energy is absorbed by unit mass of the medium is known as the dose-rate. The dose-rate is measured in W kg^{-1}. The total energy absorbed by unit mass of the medium is known as absorbed dose. This is measured in J kg^{-1} or, as in this question, kJ kg^{-1}.

Under certain circumstances, biological cells may be destroyed by ultrasound. The effect on a group of cells is measured in terms of the survival fraction (*SF*).

$$SF = \frac{\text{number of cells surviving after exposure}}{\text{number of cells before exposure}}$$

For any particular absorbed dose, it is found that the survival fraction changes as the dose-rate increases. Fig. 7.1 shows the variation with dose-rate of the survival fraction for samples of cells in a liquid. The absorbed dose for each sample of cells was 240 kJ kg^{-1}.

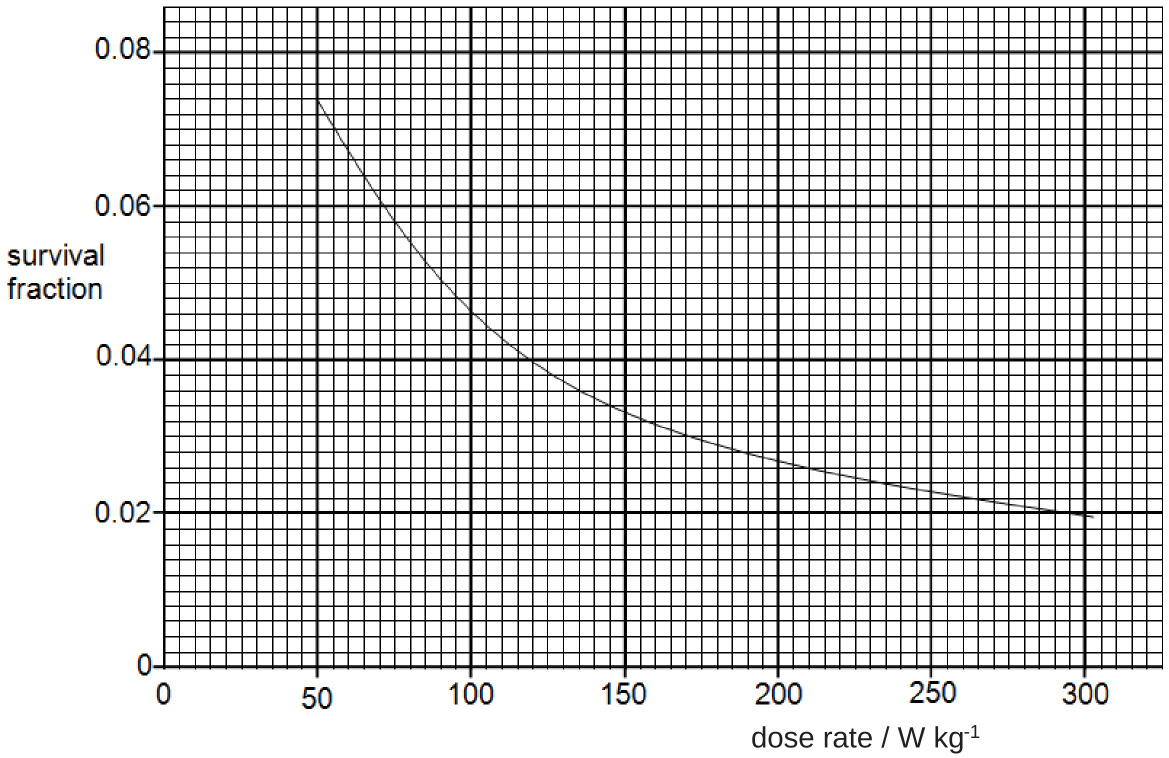

Fig. 7.1

(a) **(i)** State the transformation of energy that occurs in an ultrasound transducer.

………………………………………………………………………………………................ [1]

(ii) State one difference between ultrasound and light.

…………………………………………………………………………………….....................

…………………………………………………………………………………….....................

…………………………………………………………………………………….....................

…………………………………………………………………………………………….... [2]

(b) **(i)** Use Fig. 7.1 to state the survival fraction for a dose-rate of 200 W kg^{-1}.

survival fraction = ... [1]

(ii) Calculate the exposure time for an absorbed dose of 240 kJ kg^{-1} and at a dose-rate of 200 W kg^{-1}.

exposure time = ………………….... s [2]

(c) Survival fraction depends not only on dose-rate but also on absorbed dose. Fig. 7.2 shows the variation with dose-rate of $\log_{10}(SF)$ for different values of absorbed dose.

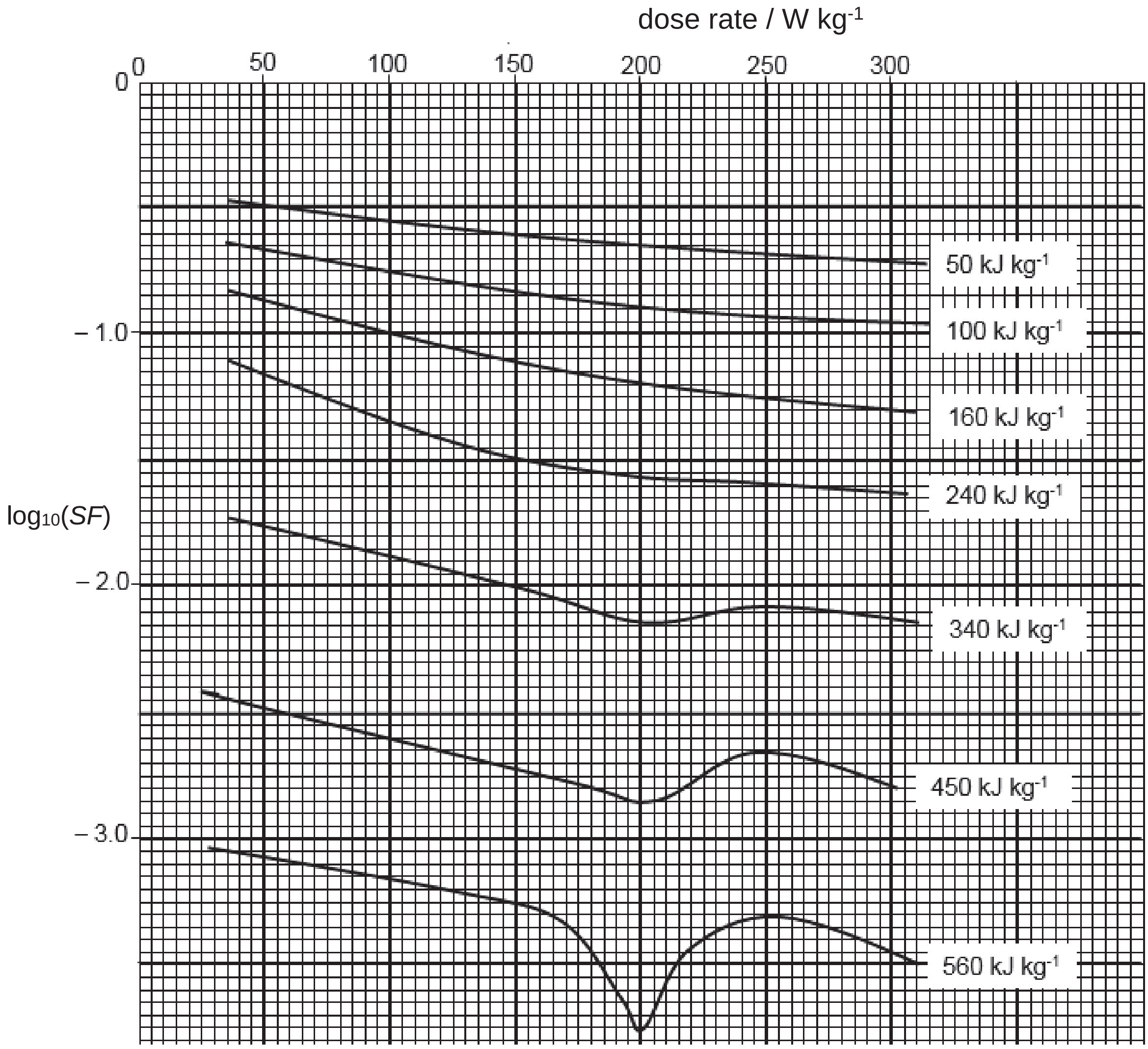

Fig. 7.2

The line with absorbed dose of 240 kJ kg^{-1} represents the data given in Fig. 7.1, but with survival fraction plotted on a logarithmic scale.

(i) Suggest why the survival fraction is plotted on a logarithmic scale.

………………………………………………………………………………………..................

……………………………………………………………………………………….............. [1]

(ii) Use Fig. 7.2 to complete the table of Fig. 7.3 for a dose-rate of 200 W kg^{-1}.

absorbed dose / kJ kg^{-1}	$\log_{10}(SF)$
50	
100	
160	
240	
340	
450	
560	

Fig. 7.3

[3]

(iii) Use Fig. 7.3 to calculate the survival fraction for an absorbed dose of 160 kJ kg^{-1} at a dose-rate of 200 W kg^{-1}.

SF = ………………… [1]

(d) Use the table of Fig. 7.3 to plot, on the axes of Fig. 7.4, a graph to show how the variation with absorbed dose of $\log_{10}(SF)$ for the dose-rate of 200 W kg^{-1}. [3]

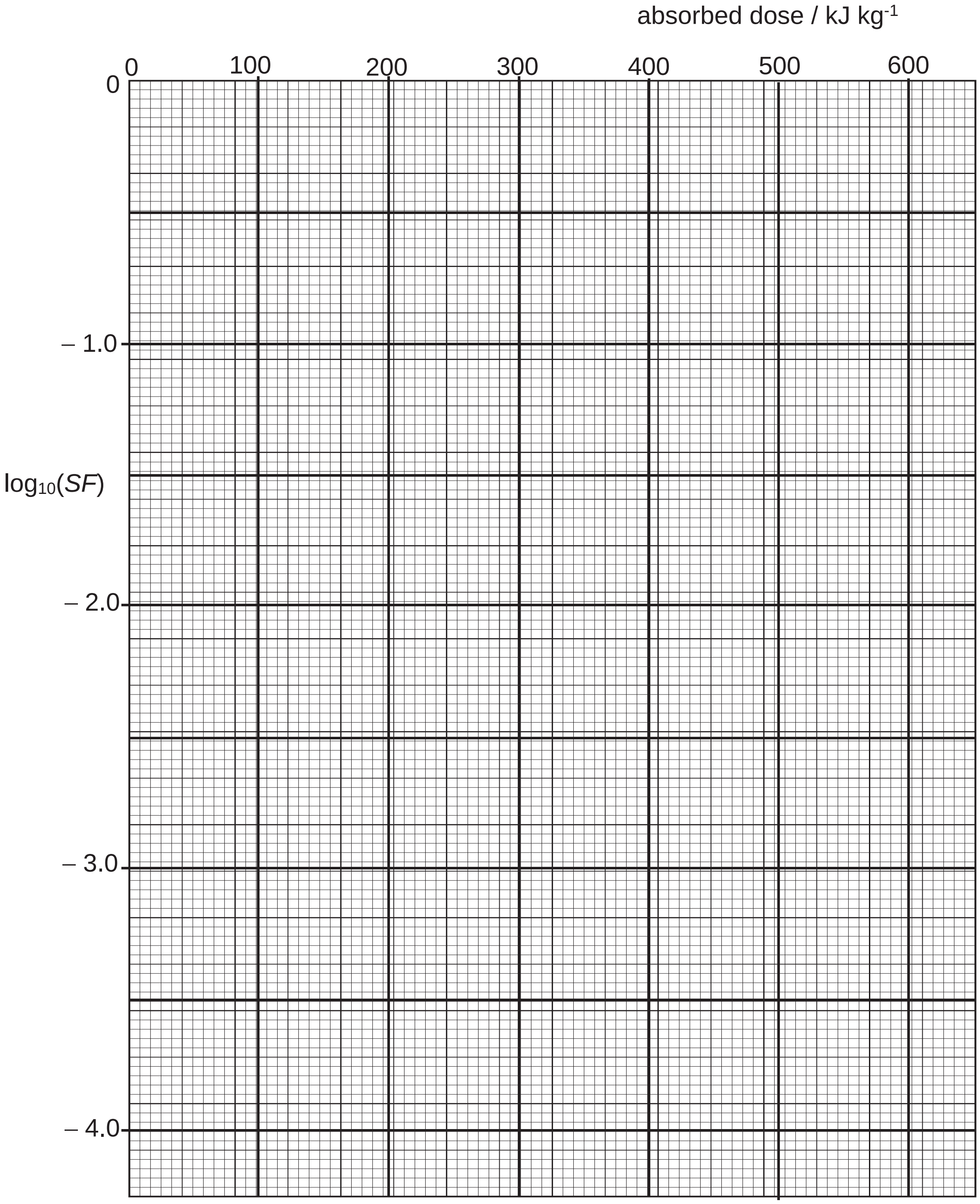

Fig. 7.4

(e) Theory suggests that at a dose-rate of 200 W kg^{-1}, two separate effects may give rise to cell destruction. According to this theory, one of the effects becomes apparent only at higher absorbed doses. State the evidence provided for this theory by

(i) Fig. 7.2,

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(ii) Fig 7.4.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(f) The theory outlined in **(e)** suggests that the resultant survival fraction $(SF)_R$ due to two independent effects which have survival fractions $(SF)_1$ and $(SF)_2$ is given by the expression

$$(SF)_R = (SF)_1 \times (SF)_2$$

(i) Suggest how the graph in Fig. 7.4 may be used to determine $(SF)_R$ for an absorbed dose of 560 kJ kg^{-1}.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(ii) With reference to the graph in Fig. 7.4, discuss how it is possible to determine separate values of $(SF)_1$ and $(SF)_2$ for the absorbed dose of 560 kJ kg^{-1}.

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……………………………………………………………………………………………………

…………………………………………………………………………………………………… [3]

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ANDERSON JUNIOR COLLEGE

2017 JC2 Preliminary Examination

PHYSICS Higher 2
9749/03

Paper 3 Longer Structured Questions **Thursday 14 September 2017**

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class index number and PDG in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

You are advised to spend one and half hours on Section A and half an hour on Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Paper 3 (80 marks)	
1	
2	
3	
4	
5	
6	
7	
8	
9	
Significant Figure	
Total (80 marks)	

This document consists of **21** printed pages and **1** blank page.

[Turn Over

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gravitational constant	$G = 6.67 \times 10^{-11}\ \mathrm{N\ m^{2}\ kg^{-2}}$
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temperature	$T/\mathrm{K} = T/{}^\circ\mathrm{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm\omega\sqrt{x_o{}^2 - x^2}$
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magnetic flux density due to a long solenoid	$B = \mu_o nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer **all** the questions in this section.

1 Fig. 1.1 shows a trolley of mass 0.80 kg, on a bench surface, connected to a mass *M* by a string. The mass *M* is released and the trolley moves along the surface. Fig. 1.2 shows the variation of the velocity *v* of the trolley with time *t* for the motion from A to B.

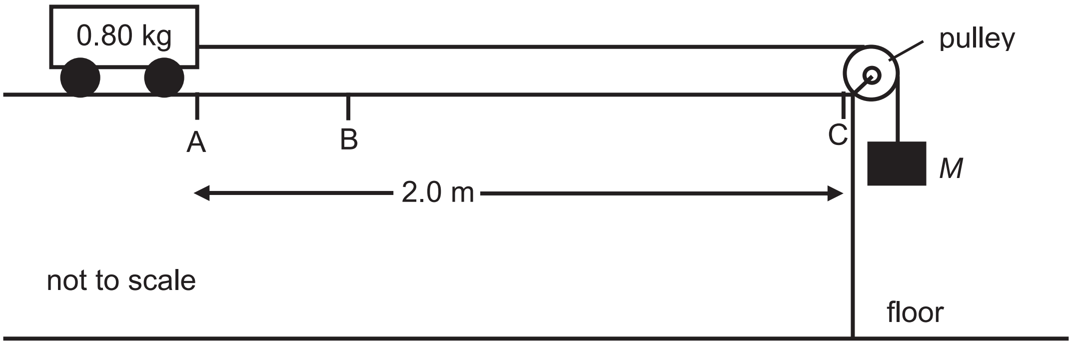


Fig. 1.1

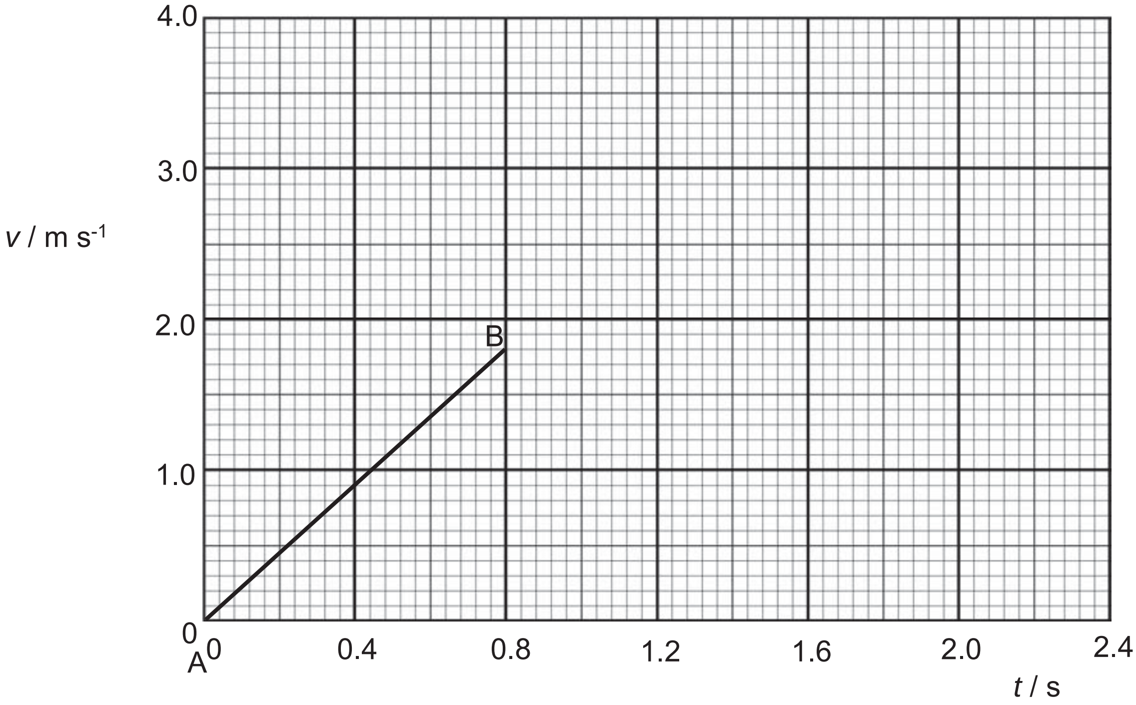


Fig. 1.2

(a) Calculate the acceleration of the trolley between A and B.

acceleration = ……………………………m s^{-2} [1]

(b) Show that the distance from A to B is 0.72 m.

[1]

(c) When the trolley reaches B the mass *M* has just reached the floor.

(i) Ignoring any resistive forces, calculate the time it takes the trolley to travel from B to C.

time = …………………………………..s [2]

(ii) On Fig. 1.1, complete the graph for the trolley moving from B and coming to rest at the pulley at C. [2]

(iii) Using energy considerations, determine the mass *M*.

M = ……………………………………..kg [2]

2 Bodies A and B of mass *2M* each are located at a distance *D* from one other as shown in Fig. 2.1.

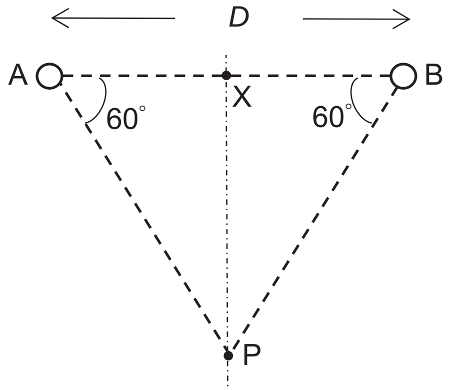


Fig. 2.1

(a) **(i)** Determine the net gravitational potential ϕ_P at P, in terms of *M, D* and the gravitational constant *G*, due to masses A and B.

ϕ_P = ………………………….. [2]

[Turn Over

(ii) A stationary mass *m* is released at P and it moves to point X under the influence of gravitational field by A and B. Determine the speed of the mass, v_x, when it reaches X in terms of *m, G*, *M* and *D*.

v_x = ……………………….. [2]

(b) Electrical charges of +*2Q* and -*Q* were induced in bodies A and B respectively and it was assumed that the electrical charges were evenly distributed on the surfaces of A and B.

Taking direction towards B as positive, sketch on the axes provided below,

(i) the variation with distance from A of the gravitational field strength and gravitational potential between AB.

Label your graphs *g* for gravitational field strength and ϕ for gravitational potential respectively.

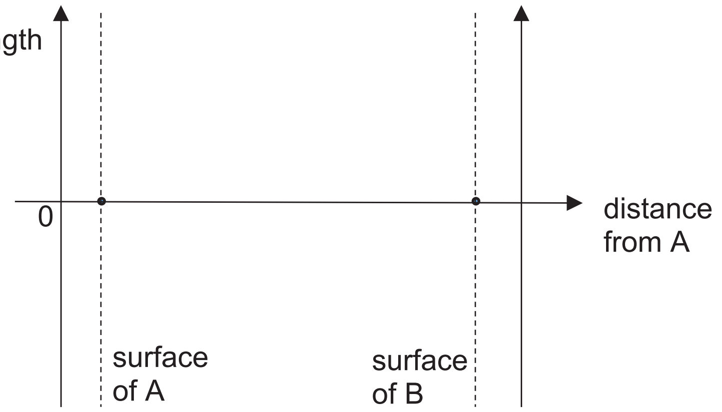


Fig 2.2

[2]

(ii) the variation with distance from A of the electric field strength and electric potential between AB.

Label your graphs *E* for electric field strength and *V* for electric potential respectively.

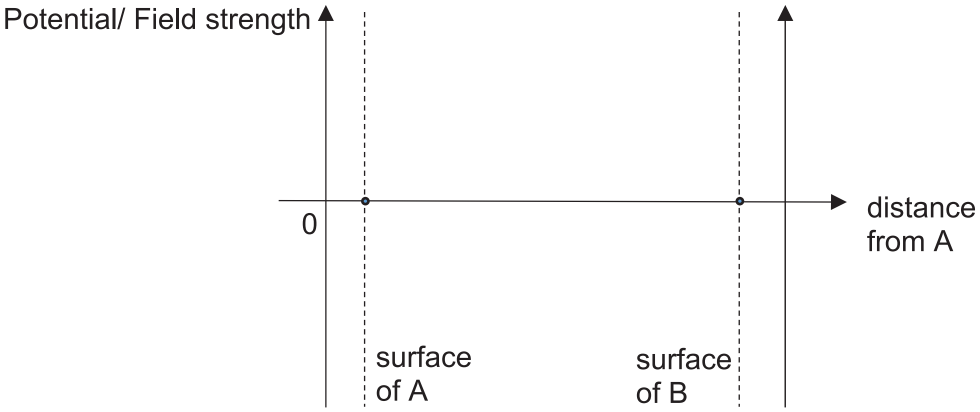


Fig 2.3

[2]

(iii) At point R in Fig 2.4 below, a body of mass *M* and charge +*Q* is being released from rest.

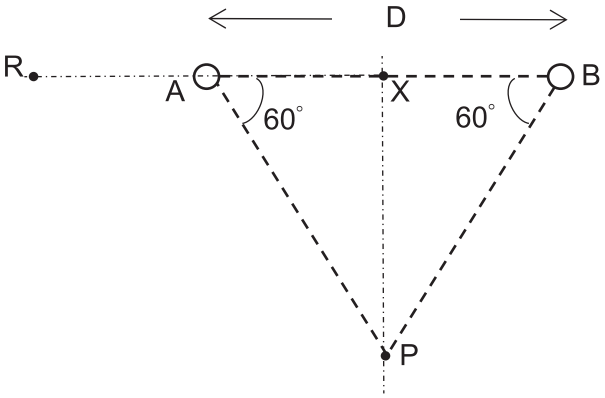


Fig 2.4

Suggest with a reason the direction of the body's subsequent motion.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………[2]

3 In a heat engine, the working substance is an ideal monatomic gas with 3.0 moles of molecules. The gas undergoes a cycle of thermodynamic processes ABCDA as it drives the engine as shown in Fig 3.1.

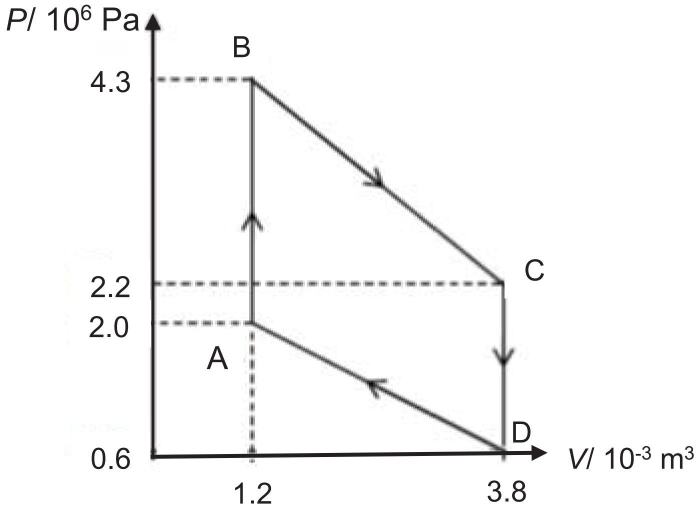


Fig 3.1

(a) Determine the thermodynamic temperature of the gas at B.

temperature = ……………………………… K [2]

(b) Determine the change in internal energy of the gas in process BC.

change in internal energy = ………………………………... J [2]

(c) Determine the work done by the gas in process BC.

work done by gas = ……………………………….. J [2]

(d) Determine the heat absorbed by the gas in process BC.

heat absorbed = ……………………………….. J [2]

4 **(a)** Light is an example of transverse electromagnetic wave.

Light can be polarized. Explain how this gives evidence for light being a transverse wave.

……..

…………………………………………………………………………………………...........[1]

(b) Fig. 4.1 shows an ideal polarizer A arranged so that its polarizing direction is vertical. Polariser B is oriented with its plane parallel to that of A and with its polarizing direction at 45° to the vertical.

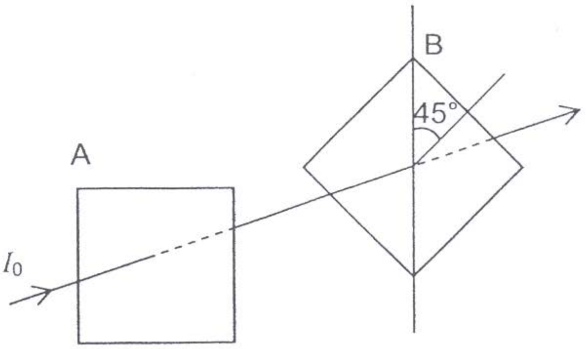


Fig. 4.1 a

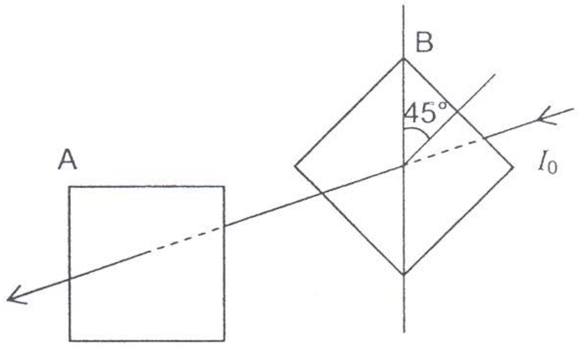


Fig. 4.1b

A beam of vertically-polarised light, of initial intensity I_o, passes through the polarisers in turn. Determine the intensity and the orientation of the emergent beam when the beam passes through the polarizer system

(i) in the direction from A to B (Fig. 4.1a),

intensity = ……………………………………….

orientation =……………………………………….

[3]

(ii) in the direction from B to A (Fig. 4.1b).

intensity = ……………………………………….

orientation = ……………………………………….

[2]

5 **(a)** State what is meant by the *diffraction* of a wave.

……………………………………………………………………………………………………..

……………………………………………………………………………………………..........[1]

(b) Two identical point sources of monochromatic light of wavelength 600 nm are placed at a distance of 40 m from a slit and at a separation of 10 mm, as shown in Fig 5.1. The images of the point sources of monochromatic light are formed on a screen situated 25 mm away from the slit.

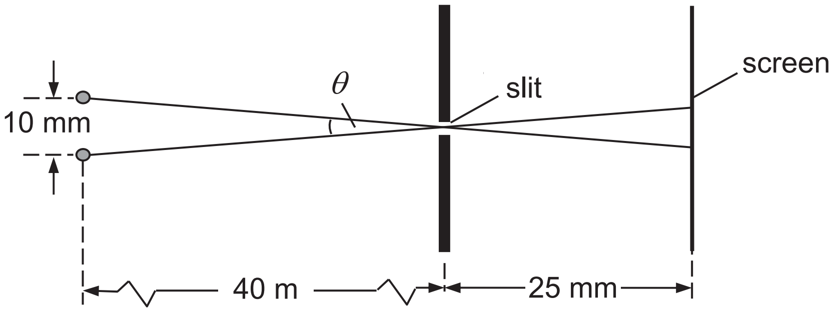


Fig. 5.1

(i) Calculate the angle subtended θ at the slit by the two sources.

θ = ……………………rad [1]

(ii) If the slit has a width of 1.5 mm, discuss whether or not the two images will be resolved.

……………………………………………………………………………………...................

……………………………………………………………………………………...................

……………………………………………………………………………………………....[3]

(c) An arrangement for demonstrating the interference of light is shown in Fig. 5.2.

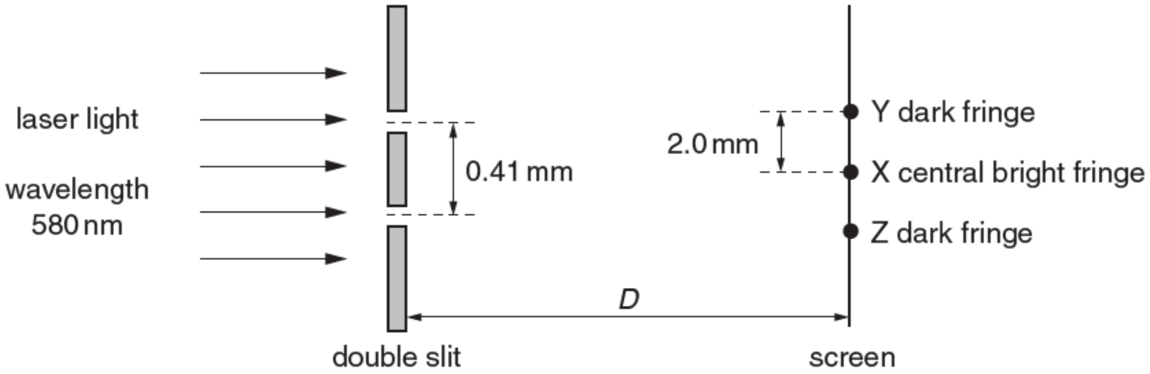


Fig. 5.2 (not to scale)

The wavelength of the light from the laser is 580 nm. The separation of the slits is 0.41 mm. The perpendicular distance between the double slit and the screen is *D*.

Coherent light emerges from the slits and an interference pattern is observed on the screen. The central bright fringe is produced at point X. The closest dark fringes to point X are produced at points Y and Z. The distance XY is 2.0 mm.

(i) Explain why a bright fringe is produced at point X.

…………………………………………………………………………………………...................

…………………………………………………………………………………………...................

…………………………………………………………………………………………...................

…………………………………………………………………………………………... [2]

(ii) State the difference in the distances, in nm, from each slit to point Y.

distance = …………………… nm [1]

(iii) Calculate the distance *D*.

D = …………………… m [2]

6 A long, straight wire Z carrying a direct current of 2.0 A flows in the direction as shown in Fig. 6.1.

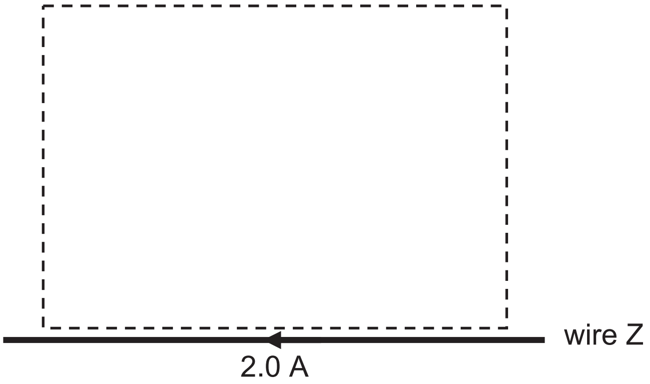


Fig. 6.1

(a) Using symbols X or ⊙ to represent the direction of magnetic field into or out of the paper respectively, draw on Fig. 6.1 the pattern of magnetic field produced by wire Z in the region indicated by the dotted box.

[2]

(b) A positive ion is projected from point P with an initial velocity *v* in a direction perpendicular to wire Z as shown in Fig. 6.2.

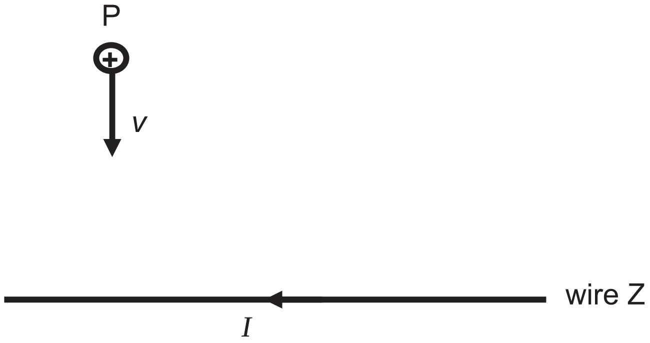


Fig. 6.2

Describe and explain the subsequent path of the ion, shortly after leaving P, due to the effect of the wire's magnetic field.

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

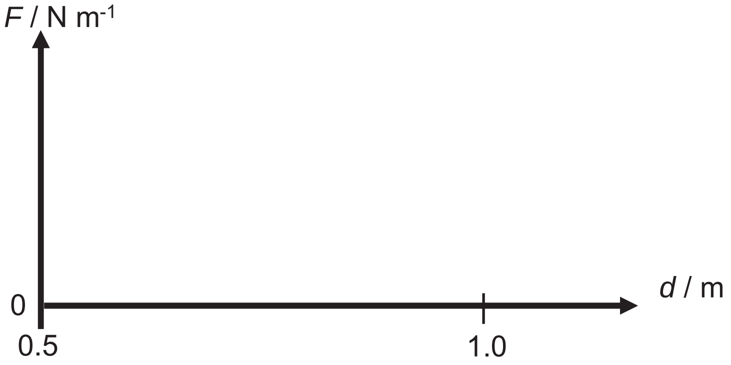
……………………………………………………………………………………………...........[3]

(c) A similar wire Y is placed parallel to wire Z. The separation *d* between the two wires is 1.0 m. Wire Y is carrying a current of 1.0 A in the same direction as wire Z.

(i) Calculate the resultant magnetic flux density at the mid-point between the two wires.

magnetic flux density = ……………………………T [2]

(ii) Wire Y moves towards wire Z such that the separation *d* of the two wires decreases from 1.0 m to 0.5 m. Wire Y is maintained parallel to wire Z throughout the motion. Sketch the variation with separation *d* of the force per unit length *F* experienced by wire Y due to the magnetic field of wire Z.



[2]

7 A π^0 meson is a sub-atomic particle.
A stationary π^0 meson, which has mass 2.4×10^{-28} kg, decays to form two γ-ray photons.
The nuclear equation for this decay is

$$\pi^0 \rightarrow \gamma + \gamma.$$

(a) Explain why the two γ-ray photons will move off in opposite directions with equal energies.

…………………………………………………………………………………………………..

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…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

……………………………………………………………………………………………........[3]

(b) Determine, for each γ-ray photon,

(i) the energy,

energy = ... J [2]

(ii) the wavelength,

wavelength = ... m [2]

(iii) the momentum.

momentum = ... N s [2]

Section B

Answer **one** question in this section.

8 **(a)** Define

(i) resistance

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(ii) the ohm

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(b) Sketch the I–V characteristics of a metallic conductor at constant temperature on Fig. 8.1 and a filament lamp on Fig. 8.2. [2]

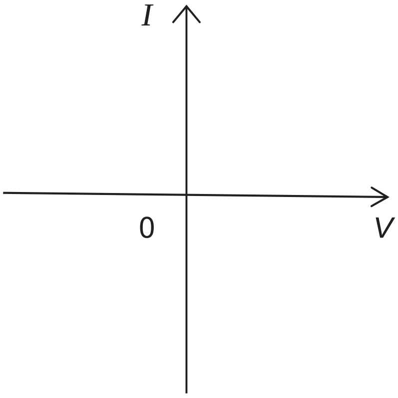

Fig. 8.1

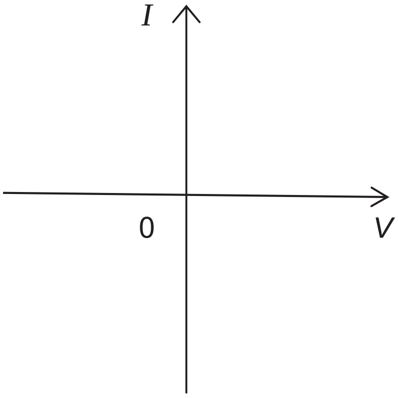

Fig. 8.2

(c) State and explain the difference between how the resistance of a filament lamp and the resistance of a semiconductor vary with temperature.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[3]

(d) A copper wire of diameter 1.4 mm connects to the tungsten filament wire of a light bulb of diameter 0.020 mm. A current of 0.42 A flows through both of the wires. Copper has 8.0×10^{28} electrons per cubic metre and tungsten can be assumed to have 3.4×10^{28} electrons per cubic metre.

(i) The filament is 2.0 m long when uncoiled and has a resistivity of $5.5 \times 10^{-8}\ \Omega$ m.

Calculate the power dissipated in the filament bulb.

power dissipated = ……………………………W [2]

(ii) The drift speed of electrons in the copper wire is 0.021×10^{-3} m s^{-1}.

1. Determine the drift speed of electrons in the tungsten filament.

drift speed = ……………………………m s^{-1} [2]

2. Explain, in microscopic terms, why the copper wire stays cool although the tungsten filament reaches a high temperature.

……………………………………………………………………………………...................

……………………………………………………………………………………...................

……………………………………………………………………………………...................

……………………………………………………………………………………...................

……………………………………………………………………………………...................

……………………………………………………………………………………... [3]

(iii) State one important property of a conductor used to make heating elements.

……………………………………………………………………………………... [1]

(e) A thermistor has resistance 3900 Ω at 0 °C and resistance 1250 Ω at 30 °C. The thermistor is connected into the circuit of Fig. 8.3 in order to monitor temperature changes.

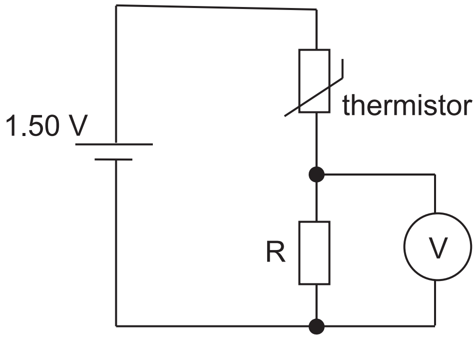

Fig. 8.3

The battery of e.m.f. 1.50 V has negligible resistance and the voltmeter has infinite resistance.

(i) The voltmeter is to read 1.00 V at 0 °C. Show that the resistance of resistor R is 7800 Ω.

[1]

(ii) The temperature of the thermistor is increased to 30 °C. Determine the reading on the voltmeter.

reading = ...V [2]

(iii) The voltmeter in Fig. 8.3 is replaced with one having a resistance of 7800 Ω. Calculate the reading on this voltmeter for the thermistor at a temperature of 0 °C.

reading = ...V [2]

9 **(a)** State and explain two relations in which the Planck constant *h* is the constant of proportionality.

1. ……………………………………………………………………………………………………

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

2. ……………………………………………………………………………………………………

……………………………………………………………………………………………………..

……………………………………………………………………………………………………..

…………………………………………………………………………………………..........[4]

(b) Experiments are conducted to investigate the photoelectric effect.

(i) It is found that, on exposure of a metal surface to light, either electrons are emitted immediately or they are not emitted at all.

Suggest why this observation does not support a wave theory of light.

……………………………………………………………………………………...................

……………………………………………………………………………………...................

……………………………………………………………………………………...................

……………………………………………………………………………………….... [3]

(ii) Data for the wavelength λ of the radiation incident on the metal surface and the maximum kinetic energy E_k of the emitted electrons are shown in Fig. 9.1.

λ /nm	E_k /10^{-19} J
650	-
240	4.44

Fig. 9.1

1. Without any calculation, suggest why no value is given for E_k for radiation of wavelength 650 nm.

……………………………………………………………………………………...................

……………………………………………………………………………………….... [1]

2. Use data from Fig. 9.1 to determine the work function energy of the surface.

work function energy = ... J [2]

(iii) Radiation of wavelength 240 nm gives rise to a maximum photoelectric current I. The intensity of the incident radiation is maintained constant and the wavelength is now reduced.

State and explain the effect of this change on

1. the maximum kinetic energy of the photoelectrons,

....

....

.... [2]

2. the maximum photoelectric current I.

....

....

.... [2]

(c) Some electron energy levels in atomic hydrogen are illustrated in Fig. 9.2.

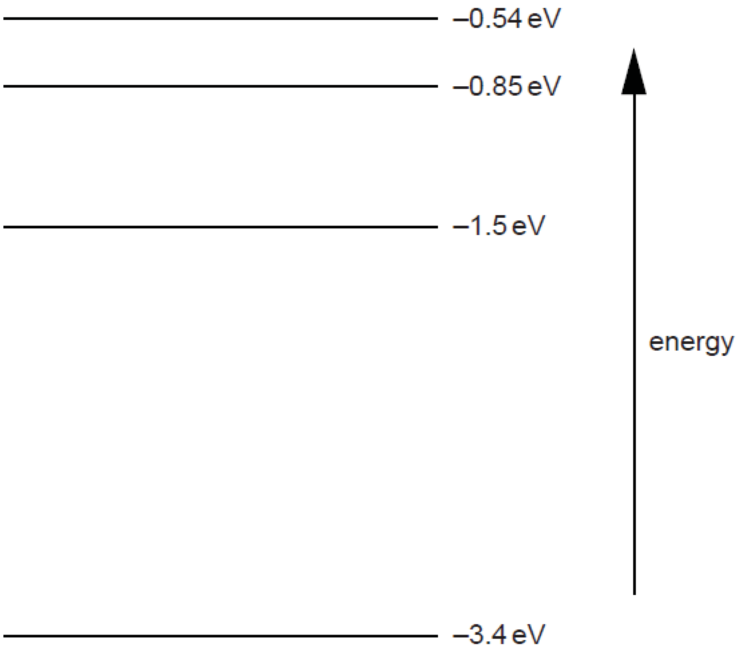

Fig. 9.2

The longest wavelength produced as a result of electron transitions between two of the energy levels shown in Fig. 9.2 is 4.0×10^{-6} m.

(i) On Fig. 9.2,

1. draw, and mark with the letter L, the transition giving rise to the wavelength of 4.0×10^{-6} m, [1]

2. draw, and mark with the letter S, the transition giving rise to the shortest wavelength. [1]

(ii) Calculate the wavelength for the transition you have shown in **(i) part 2**.

wavelength = ……………………………m [2]

(iii) Photon energies in the visible spectrum vary between approximately 3.66 eV and 1.83 eV.

Determine the energies, in eV, of photons in the visible spectrum that are produced by transitions between the energy levels shown in Fig. 9.2.

photon energies = ……………………………eV [2]

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ANDERSON JUNIOR COLLEGE

2017 JC2 Preliminary Examination

PHYSICS Higher 2 9749/04

Paper 4 Practical **Friday 25 August 2017**

2 hours 30 minutes

Candidates answer on the Question Paper.
Additional Materials: As listed on the Confidential Instructions

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READ THESE INSTRUCTIONS FIRST

Write your name, class index number and PDG in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose mark if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory where appropriate in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
Paper 4 (55 marks)	
1	
2	
3	
4	
Total (55 marks)	

This document consists of **16** printed pages and **0** blank page.

1 In this experiment, you will investigate how the period of torsional oscillations of a bar magnet suspended above a fixed bar magnet changes with the separation between the two magnets.

(a) **(i)** Fix one of the magnets to the bench top using Blu-tack.

(ii) Suspend a second magnet using a stirrup and thread so that it lies in a horizontal plane about 50 cm below the point of suspension. The distance *d* between the bottom of the suspended magnet and the top of the fixed magnet should initially be about 5 cm. The base of the stand should be as far as possible from the fixed bar magnet. The arrangement is shown in Fig. 1.1.

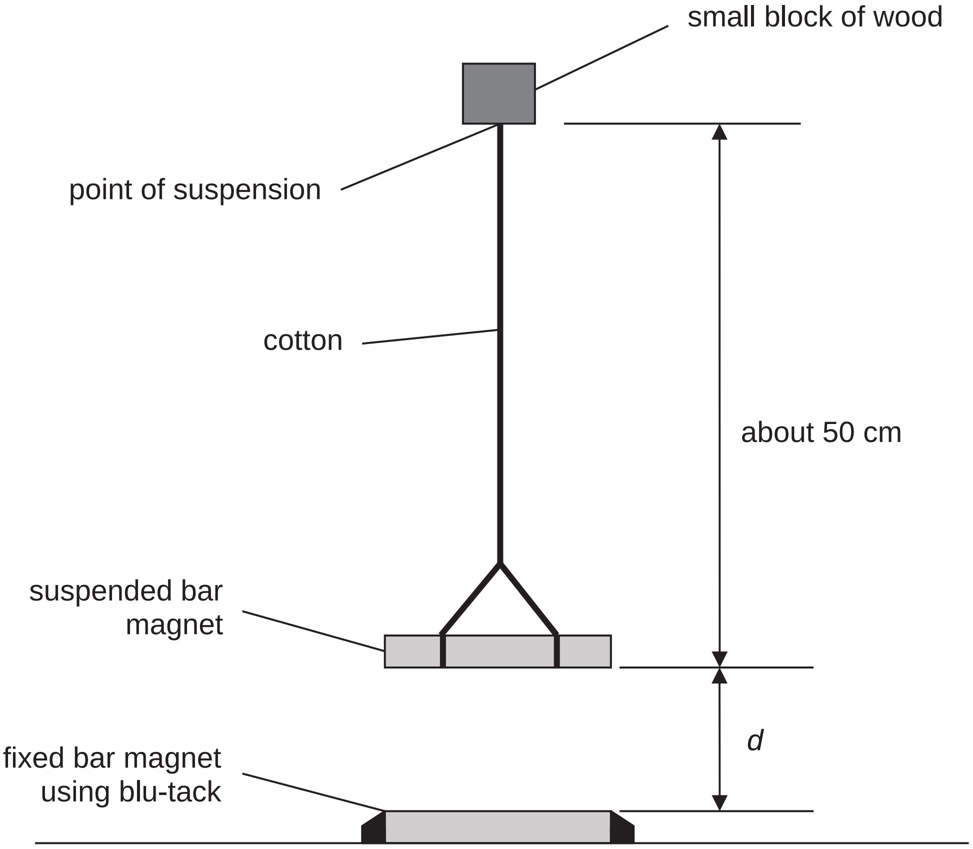


Fig. 1.1

(b) **(i)** Measure and record distance *d*.

d = ……………………………… [1] M1

(ii) Estimate the percentage uncertainty in *d*, showing your working.

percentage uncertainty =……………………………… [1] A1

(iii) Gently rotate the suspended magnet and release it so that it performs small torsional oscillations in a horizontal plane, as shown in Fig. 1.2.

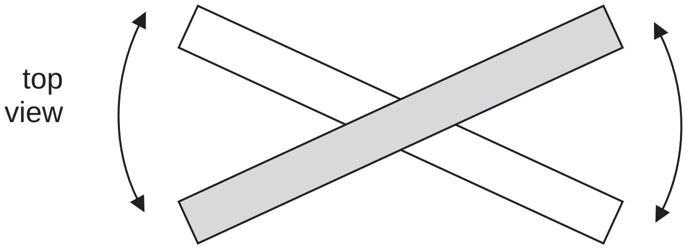


Fig.1.2

Make and record measurements to determine the period *T* of these oscillations.

T = ……………………………… [2]

M2	
A2	

(c) It is suggested that period *T* is proportional to separation *d*.

Change *d* to a value between 3 cm to 10 cm and take another set of measurements to investigate this suggestion.
State and explain whether or not you agree with this suggestion.

Present your measurements and calculated results clearly.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………… [5]

M3	
A3	
A4	
A5	
A6	

For Examiner's Use

(d) Explain why, in practice, it may be difficult to measure the period *T* directly for a separation *d* = 1 cm.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

A7	

(e) A student suggests that the period of torsional oscillations *T* depends on the mass distribution of the oscillating body about its axis of rotation.

Suggest changes that could be made to the setup in Fig. 1.1 to study the student's claim when two lumps of plasticine of equal mass are provided.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [3]

PL1	
PL2	
PL3	

[Total: 13 marks]

2 This investigation considers how the force required to maintain equilibrium of a horizontal rule depends on the position of a mass suspended from the rule.

(a) **(i)** Suspend a metre rule horizontally using two loops of string and a newton-meter, as shown in Fig. 2.1. The strings must be vertical.

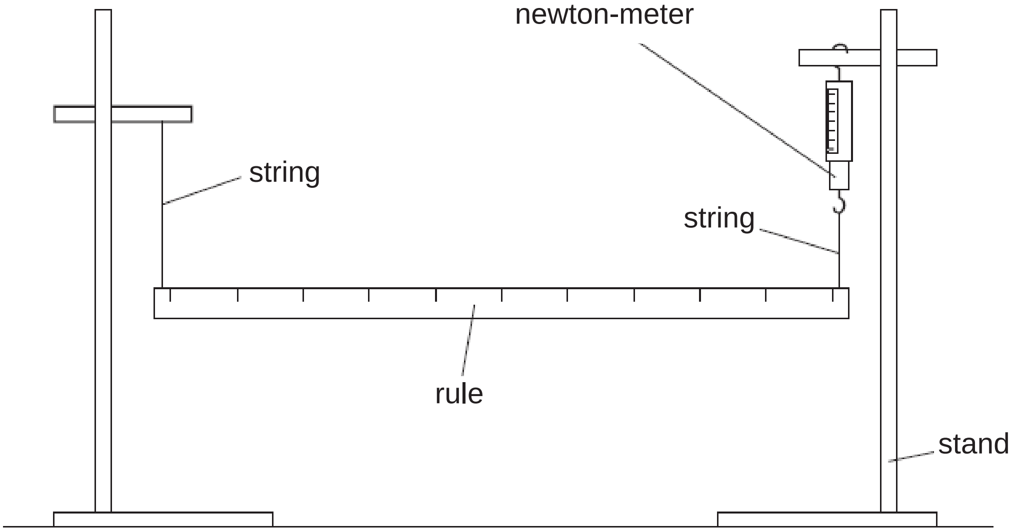


Fig. 2.1

(ii) Suspend the 50 g mass at a distance *d* from the newton-meter using a loop of string. You will need to adjust the position of the clamps to ensure that the rule remains horizontal. The arrangement should now be as shown in Fig. 2.2.

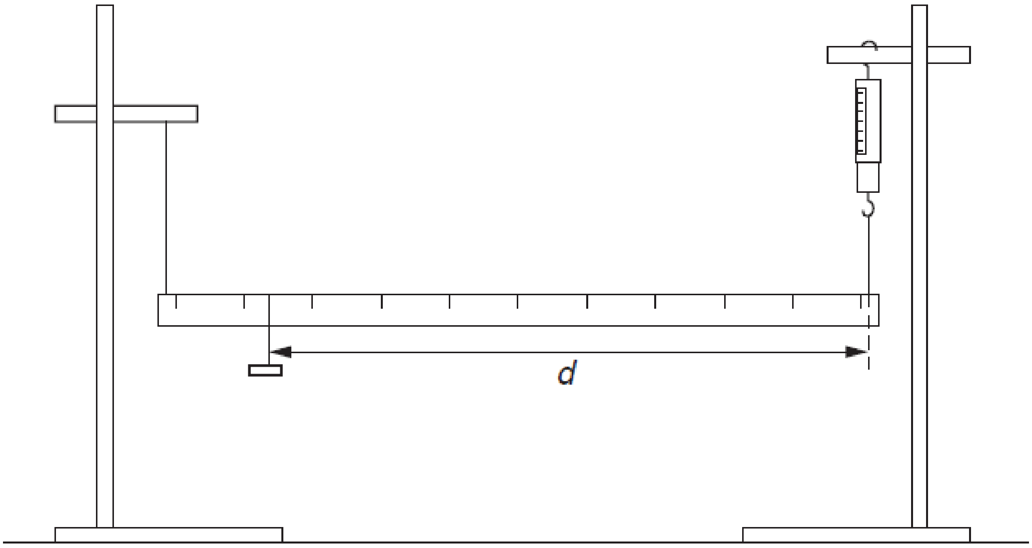


Fig. 2.2

(b) **(i)** Measure and record the value of *d* and the reading *F* from the newton-meter.

d =……..………..…

F =……..………..….[1]

M1

(ii) Slide the suspended mass to a new position on the rule and repeat **(b)(i)**. Record at least five more readings of *d* and *F*. You should ensure when you are taking readings that the rule is horizontal and that the newton-meter does not go off scale.

M2	
M3	
M4	

[3]

(iii) Explain how you ensured that the rule was horizontal when the measurements were taken.

…………………………………………………………………………………………………….

…………………………………………………………………………………………………….

…………………………………………………………………………………………………[1]

A1	

(c) Plot your values from **(b)(ii)** on Fig. 2.3.

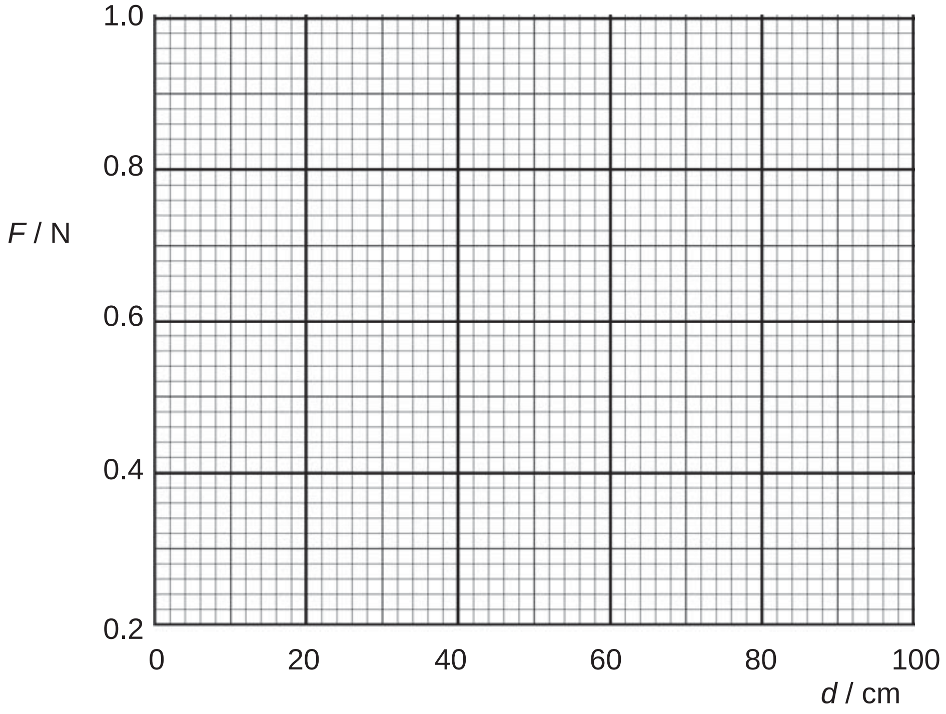


Fig. 2.3

P1	
P2	

[2]

For Examiner's Use

(d) The equation that relates F and d is

$$F = \frac{-Wd}{L} + \frac{mg}{2} + W$$

where W is the weight of the suspended mass, m is the mass of the rule, L = 0.980 m, and g = 9.81 m s^{-2}.

Use your graph of Fig. 2.3 to determine value for m. Include appropriate unit.

A2	
A3	
A4	

m =……..………..….[3]

[Total: 10 marks]

3 In this experiment, you will determine the resistivity of a metal in the form of a wire.

(a) **(i)** Measure and record the diameter *d* of the wire attached to the metre rule.

d = ……………………………… [1]

M1

(ii) Calculate the cross-sectional area *A* of the wire.

A =…………………………m^2 [1]

A1

(b) **(i)** Use the wire attached to the metre rule, one of the voltmeters and one of the two identical resistors of resistance *R* to set up the partial circuit shown in Fig. 3.1. The value of *R* is 10 Ω.

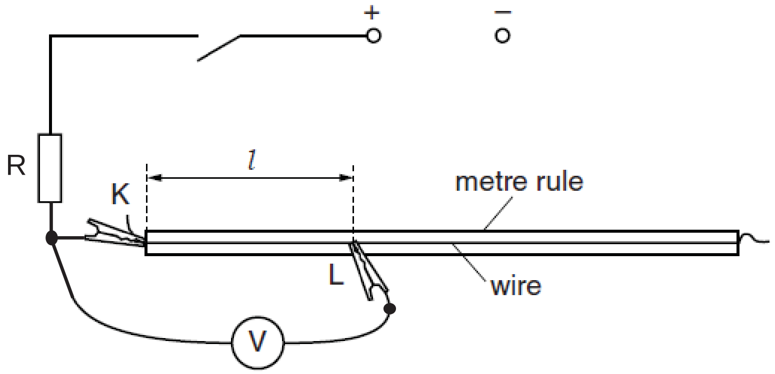


Fig. 3.1

There are two crocodile clips, one labelled K and the other labelled L.
Place K and L so that the distance *l* between them is approximately 30 cm.

(ii) Measure and record the distance *l* between K and L.

l = ……………………………………

(iii) Use the other resistor and the other voltmeter to complete the circuit shown in Fig. 3.2.

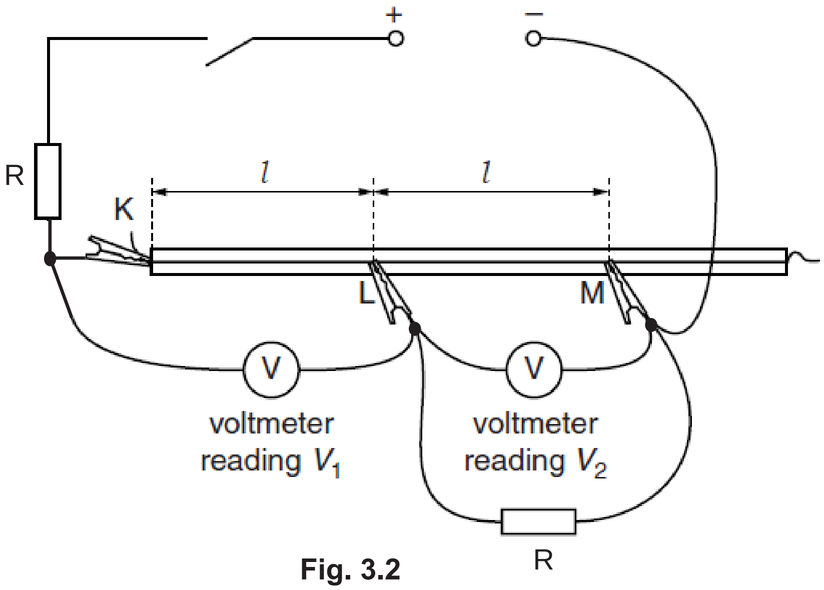


Fig. 3.2

(iv) Place the crocodile clip M at a distance l from L. The value of l should be the same as in **(b)(ii)**.

(c) **(i)** Switch on the power supply.

(ii) Record the voltmeter readings V_1 and V_2 as shown in Fig. 3.2.

V_1 = ……………..…… V

V_2 = ……………..…… V

(iii) Switch off the power supply.

(d) Change l and repeat **(b)(ii)**, **(b)(iv)** and **(c)** for further sets of readings of l, V_1 and V_2. For each set of readings, distances KL and LM should **both** be l.

[7]

M2	
M3	
P1	
P2	
P3	
A2	

(e) Theory suggests that V_1, V_2 and l are related by the expression

$$\frac{V_1}{V_2} = P\,l + Q$$

where P and Q are constants.

Plot a suitable graph to determine the values of P and Q.

A3	
A4	
A5	

P = ……..…………..…………

Q = ………………..………… [3]

For Examiner's Use

P4	
P5	
P6	
A7	

[3]

(f) Comment on any anomalous data or results you may have obtained.
Explain your answer.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

M4

(g) The quantity P is given by the expression

$$P = \frac{\rho}{AR}$$

where ρ is the resistivity of the material of the wire.

(i) Use values from **(a)(ii)**, **b(i)** and **(e)** to find a value for ρ.

ρ = …………………………… [1]

A6

(ii) In the expression $\frac{V_1}{V_2} = P\,l + Q$, Q is independent of R.

The experiment is repeated with a smaller value of R.

On the graph grid on page 11, sketch a second graph to represent the new results. Label it Z. [1]

(h) **(i)** State one significant source of error.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

A8

(ii) Suggest one improvement that could be made to the experiment to address the source of error identified in **(h)(i)**. You may suggest the use of other apparatus or a different procedure.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

A9

[Total: 20 marks]

Please turn over for question 4.

4 A student is interested in 'bungee jumping', where a person attached to an elastic cord falls from a height and travels downwards through a distance before moving upwards. Different cords are used for different people. A schematic diagram is shown in Fig. 4.1.

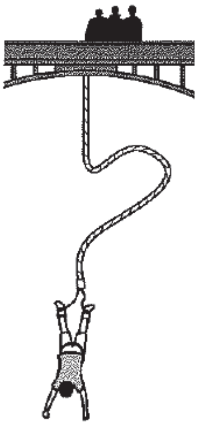


Fig 4.1

The student models 'bungee jumping' in the laboratory by using elastic cords of unstretched length 50.0 cm with different spring constants. An object is attached to each cord.
The student investigates the relationship between the maximum distance h fallen by the object and the spring constant k of the elastic cord.

It is suggested that the relationship between h and k is

$$\frac{1}{2}k(h - L)^2 = mgh$$

where L is the unstretched length of the cord, m is the mass of the object and g is the acceleration of free fall.

Design a laboratory experiment to test the relationship between h and k.
Explain how your results could be used to plot a graph with $\frac{(h-L)^2}{h}$ on the y-axis and to determine the value of g. You should draw a labelled diagram to show the arrangement of your apparatus.

In your account you should pay particular attention to

(a) the procedure to be followed,
(b) the measurements to be taken,
(c) the control of variables,
(d) the analysis of the data,
(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

[12]

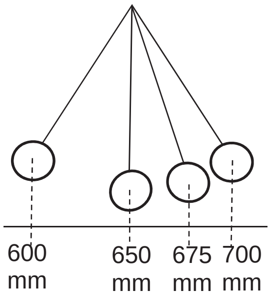
2017 AJC JC2 H2 Physics Prelim Solutions
Paper 1 (30 marks)

Answer

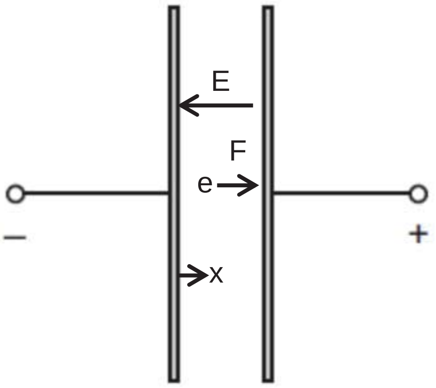
1	2	3	4	5	6	7	8	9	10
D	A	B	B	C	D	B	D	C	D
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	C	B	D	A	C	C	C	A	C
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A	D	A	C	A	D	B	B	B	A

No	Answer & Solution
1	**Ans: D** $2000\text{ pV} = 2000 \times 10^{-12}\text{ V}$ $= 2 \times 10^{-9}\text{ V}$ $= 2 \times 10^{-15} \times 10^{6}\text{ V}$ $= 2 \times 10^{-15} \times \text{M V}$ p.d. = work done per unit charge, hence V is equivalent to J C^{-1}
2	**Ans : A** For the projectile motion, horizontal speed is constant, *v*. Vertical speed is zero initially and acceleration is *g*, downwards. Let the height of the table be *h*. Using $s = ut + \frac{1}{2}at^2$ $h = 0 + \frac{1}{2}gT^2$ $T = \sqrt{\frac{2h}{g}}$ *T* is independent of mass. Range, *D* = *vT*. Since both *v and T* are independent of mass, *D* will remain the same.
3	**Ans : B** The scale reads the contact force between the sack and scale. Since the scale reading is larger than the mass, the upward contact force must be larger than the downward weight. The sack experiences a net force and acceleration upwards. (12 – 10) x 9.81 = 10 x acceleration acceleration = 1.962 ≈ 2.0 m s^{-2}.
4	**Ans : B** For elastic collision, total KE is conserved OR relative speed of approach equals to relative speed of separation. Total KE before impact = $\frac{1}{2}mv^2 + \frac{1}{2}mv^2 = mv^2$ Thus, total KE after impact = mv^2. Answer C is wrong because during collision, KE is not conserved. It is converted to elastic PE then back to KE. Answer D is wrong because total momentum before impact = mv + m(-v) = 0

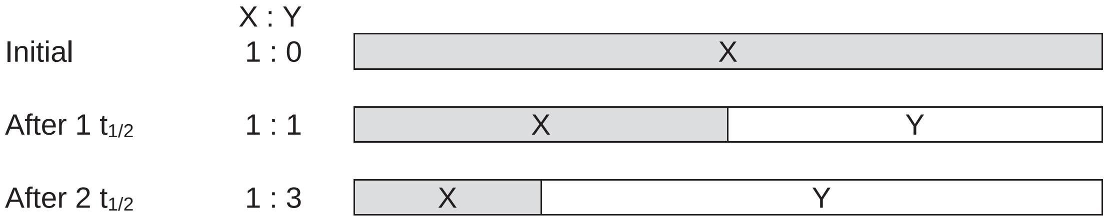
	Answer A is wrong because when the spheres stick together, it is already a perfectly inelastic collision. Also note that relative speed of approach = $u_1 – u_2$ = v – (-v) = 2v (non-zero). If the spheres stick together, they will share the same speed and relative speed of separation will be zero.
5	**Ans : C** Work done is minimum if the force applied is just enough to overcome the barrel's weight on its way up the plank, with no change in speed. The barrel gains GPE without any gain in KE. Minimum work = Gain in GPE = mgh = 50 x 9.81 x 1.6 = 784.8 J ≈ 780 J Alternative method : Work done = Force x distance = mg sin θ x d = 50 x 9.81 x (1.6/3.4) x 3.4 = 784. 8 J
6	**Ans: D** Upthrust = weight of air displaced (smallest force as density of air is very small). Viscous drag is proportional to speed which increases as ball falls. At terminal speed, downward weight of ball is a constant which is balanced by upward drag and upthrust. Hence, weight > viscous drag > upthrust.
7	**Ans: B** For equilibrium, all three forces must meet at a common point, which is a point below trapdoor along the line of action of *W*. Hence option C and D are wrong as direction of *H* is wrong. Tension must act away from the door, hence direction of *T* is wrong. So option A is also wrong.
8	**Ans: D** The vertical component of the acceleration is the centripetal acceleration which is present since the particle is performing circular motion. The horizontal component of the acceleration causes the speed of the object to increase.
9	**Ans: C** $a = v^2/r$, So $v = \sqrt{ar} = \sqrt{120 \times 0.030} = 1.897$ Since ω is constant and ω = v/r Hence $\omega = \frac{v_1}{r_1} = \frac{v_2}{r_2}$ $v_2 = \frac{v_1}{r_1} \times r_2 = \frac{1.897}{0.030} \times 0.050 = 3.16 \text{ m s}^{-1}$ OR $a = \omega^2 r$ $\omega = \sqrt{(120/0.030)}$ $= 63.25 \text{ rads}^{-1}$ v = r ω = 0.050 (63.25) $= 3.16 \text{ ms}^{-1}$

10	Ans: D The antenna will have the same speed as the space-craft and is still bound in orbit. There is still gravitational force acting on it which causes it to move in circular motion.
11	Ans: A Let the amount of added heat be Q. So, $Q = mc_w \Delta T_w$ ……………. (1) {heat added to water} $Q = mc_i \Delta T_i$ ……………. (2) {heat added to iron} Eqn. (1) = (2), $\frac{c_w}{c_i} = \frac{\Delta T_i}{\Delta T_w}$ Since cw > ci, ΔTi > ΔTw → the final temperature of iron is going to be higher than the water's final temperature.
12	**Ans: C** The total volume of the cylinder is not changed. Neither is the total number of molecules. Hence, the average space given to each molecule remains constant. This implies that the average distance between molecules is unchanged.
13	**Ans: B** $\Delta U = Q + W$ in case (i), W –ve, ΔU +ve (PV $\uparrow \Rightarrow$ T$\uparrow$), $\therefore$Q +ve in case (ii), ΔU = 0 since T is constant. W is -ve, thus Q is positive and heat is gained.
14	**Ans : D** Taking the initial position at 650 mm mark, $x = x_0 \sin \omega t = x_0 \sin\left[\left(\frac{2\pi}{T}\right)t\right]$ $25 = 50 \sin\left[\left(\frac{2\pi}{2}\right)t\right]$ $t = 0.167$ s 
15	**Ans : A** At x = 0.2 m, $a = -\omega^2 x$ $20 = -\omega^2(-0.2)$ $\omega = 10$ rad s^{-1} $v_{max} = \omega x_o = 10 \times 0.2 = 2.0$ m s^{-1}

16	**Ans: C** 3 x (Period of S) = 30. Hence Period of S= 10 ms At t = $\frac{1}{4}$ x period of S = 2.5 ms, amplitude of S = displacement of R. $y = y_o \sin \omega t = y_o \sin [(2\pi/T)t]$ $= 8 \sin [(2\pi/30)x2.5] = 4$ cm
17	**Ans: C** Since particles A and B are at two sides of a node of a stationary wave, they are anti-phase. Hence phase difference is 180° Maximum KE is proportional to amplitude. Since amplitude of A < amplitude of B, $K_A < K_B$
18	**Ans: C** For diffraction grating: $n \lambda = d \sin\theta$ or $\sin\theta = n \lambda /d$ for n=1, $\sin (15.4) = \lambda /d$ ……….(1) for n=2, $\sin \theta_2 = 2\lambda /d$ …………..(2) (2)/(1): $\sin \theta_2 = 2 \sin (15.4)$ $\theta_2 = 32.8°$ Angle between first and second maxima = 32.8 – 15.4 = 16.7°
19	**Ans : A** Terminal p.d. = 1.2 x 80 = 96 V ---(1) Terminal p.d. = 120 – (1.2+0.40) r ---(2) Equating (1) and (2), r = 15 Ω <u>Alternative method:</u> Let r be the internal resistance of supply and X the resistance of the lower resistor. p.d. across 80 Ω resistor = p.d. across the lower resistor, $X = \frac{1.2 \text{ x } 80}{0.40} = 240\ \Omega$ total current = 1.2 + 0.40 = 1.6 A = supply voltage/total resistance $1.6 = \frac{120}{r + \left(\frac{80 \text{ x } 240}{80 + 240}\right)}$ $r = 15\ \Omega$
20	**Ans : C** Energy = QV
21	**Ans : A** Let $V_R = 0$ V. $V_Q = 6$ V $V_P – V_Q = 3 \text{ V} \Rightarrow V_P = 9$ V $V_P – V_S = 5 \text{ V} \Rightarrow V_S = 4$ V Hence, $V_{QS} = 6 – 4 = 2$ V and $V_{SR} = 4 – 0 = 4$ V

22	**Ans: D**  2 parallel plates, so E is constant → F is constant and in the same direction as x, as shown in the diagram. Potential V increases linearly with x. Since electron is negatively charged, from U = qV, U of electron decreases linearly with x.
23	**Ans: A** Efield lines radiates out of positive charges and enters the negative charge. Efield lines of like charges should repel each other.
24	**Ans: C** As the number of coils is halved, solenoid length is also halved, hence *n* does not change. As $I = V/R$ where $R = \rho L/A$, since *L* is halved, *R* will be halved and I will be twice as before. Hence *T* will be twice.
25	**Ans : A** The peak value of the induced e.m.f. , $E_0 = (2\pi f)BAN$ and T=1/f When f is halved, E_0 will halve but T will double.
26	**Ans : D** Power dissipated across a resistor, $P = V_{rms}^2/R$ When V_{rms} is doubled with R unchanged, P will increase 4 times
27	**Ans : B** The number of photoelectrons emitted per second ($\frac{N}{t}$) is directly proportional to the intensity of incident radiation. Since the intensity of radiation is constant, the number of photoelectrons varies proportional with time.
28	**Ans : B** $eV = hc/\lambda_{min}$ higher V means smaller λ_{min} so Q has the higher voltage applied same characteristic X-ray indicates same target material
29	**Ans : B** Based on COE and COM, the kinetic energy of the daughter nuclei is negligible hence the total energy released is shared between β particle and neutrino. Since the highest possible KE of β particle is 13.4 MeV, i.e. when neutrino has zero KE, hence the total energy released by the reaction is also 13.4 MeV, and this value is fixed for this particular reaction. Thus, when an emitted β particle has KE of 6.0 MeV, the associated neutrino must have 13.4 – 6.0 = 7.4 MeV of energy.

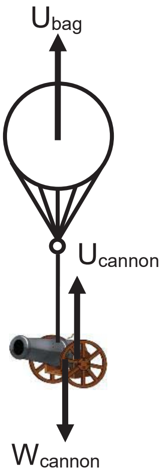
30 **Ans : A**



1 half-life after time t, the number of nuclides of X will reduced by ½ and the number of nuclides of Y will increase by ½. The ratio will then become 1:3.

2017 AJC H2 Phy Prelim Solutions

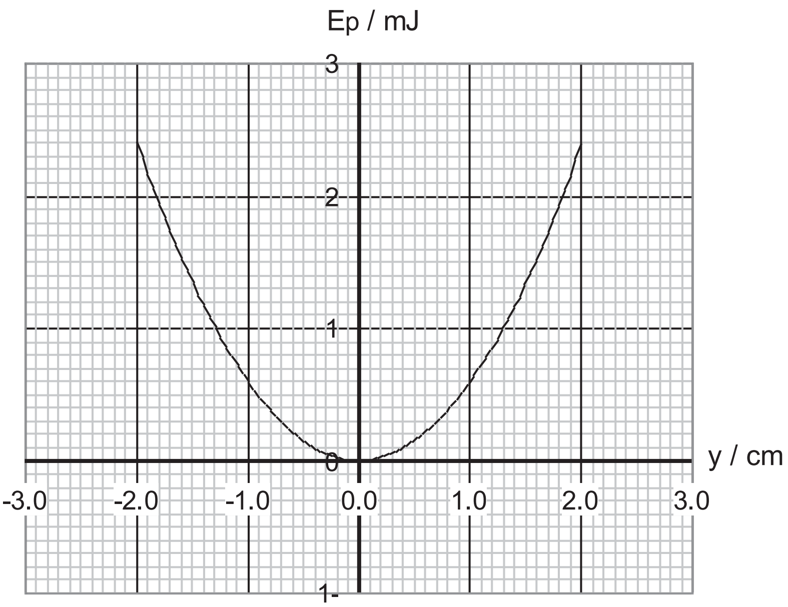
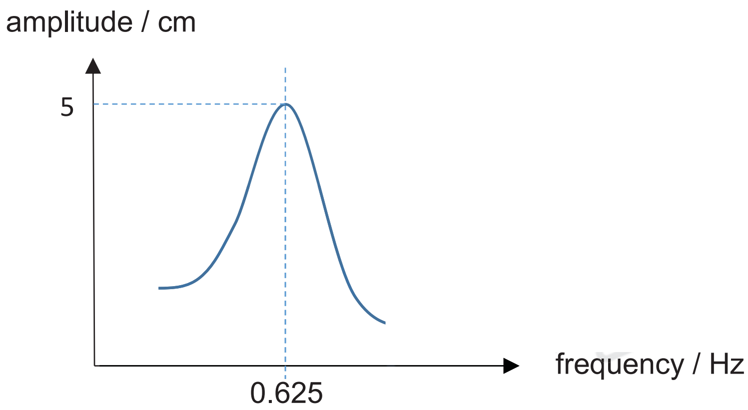
Paper 2 (80 marks)

1ai	Density $\rho = \frac{\text{mass}}{\text{volume}} = \frac{79.72}{\frac{4}{3}\times\pi\times\left(\frac{26.7\times10^{-2}}{2}\right)^{3}}$ $= 7998.9 \approx 7999$ kg m^{-3}
1aii	$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 3\left(\frac{\Delta d}{d}\right) = \frac{0.01}{79.72} + 3\left(\frac{0.1}{26.7}\right)$ $\Delta\rho = 90.87 \approx 90$ kg m^{-3} (to 1 s.f.)
1aiii	$\rho = (8000 \pm 90)$ kg m^{-3}
1bi	 From Newton's 2nd Law Ubag + Ucannon – Wcannon = ma ρ seaVairg + ρ seaVcannong – mg = ma $(1050 \times 0.70 \times 9.81) + (1050 \times \frac{800}{7999} \times 9.81) - 800 \times 9.81 = 800 \times a$ a = 0.49 m s-2
1biv	As the bag and cannon rises, pressure drops due to smaller depth of water, so volume of the lifting bag will increase. (Since temperature is relatively constant), upthrust due to lifting bag increases. For a constant speed of ascent, net force acting on the cannon must be zero. Hence air has to be released to keep the volume of the lifting bag and thus upthrust constant.
2ai	Increasing temperature causes the KE and hence <u>speed of the gas molecules to increase</u>. Constant gas volume and higher speed of the molecules will result in <u>greater frequency of collision</u> and <u>greater change in momentum per collision</u>. These will result in greater average force on the container

	and hence increased pressure.
2aii	When the temperature is kept constant, the speed at which the molecules move remain unchanged. But reducing the volume, causes the frequency of collision to increase due to the lesser space for the gas molecules to move in. Pressure increases due to the increased frequency of collision by the gas molecules.
2bi	Assuming internal PE is zero (or gas is ideal), $\frac{1}{2}mv^2 = \frac{3}{2}kT$ $v_{rms} = \sqrt{\frac{3kT}{m}}$ Given m is 1*u* = 1.66 x 10^{-27} kg, $v_{rms} = \sqrt{\frac{3(1.38 \, x 10^{-23})(3.5)}{1.66 \, x10^{-27}}}$ V_{rms} = 295 m s^{-1}
2bii	Since there is 1 H atom per cm^3, density ρ = 1.66x 10^{-27} kg cm^{-3} = 1.66 x 10^{-21} kg m^{-3} $P = \frac{1}{3}\rho v_{rms}^2 = \frac{1}{3}(1.66 \times 10^{-21})(295)^2$ *P* = 4.8 x 10^{-17} Pa OR *PV = NkT* *P*(1 x 10^{-6}) = (1)(1.38 x 10^{-23})(3.5) *P* = 4.8 x 10^{-17} Pa

3ai	Simple harmonic motion is the motion of a body such that its acceleration is proportional to its displacement from a fixed point and is always directed towards that point.
3aii	Correct shape – smooth curve ($E_p \propto x^2$), symmetrical about EPE axis, max EPE at max displacement (± 2.0 cm), zero E_p at zero displacement Correct value of max EPE = 2.4 ± (0.1) mJ Scale marked, appropriate choice of scale Note: Max EPE = Max KE= $\frac{1}{2}m(\omega x_0)^2 = \frac{1}{2}m\left(\frac{2\pi}{T}\right)^2 x_0{}^2 = 0.5(0.170)\left(\frac{2\pi}{2.25/3}\right)^2(0.020)^2 = 2.4\,\text{mJ}$

2017 AJC H2 Phy Prelim Solutions
Paper 2 (80 marks)

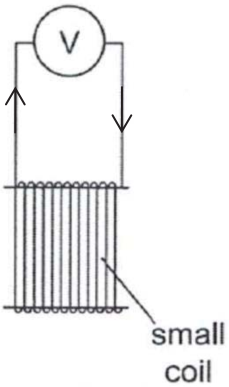
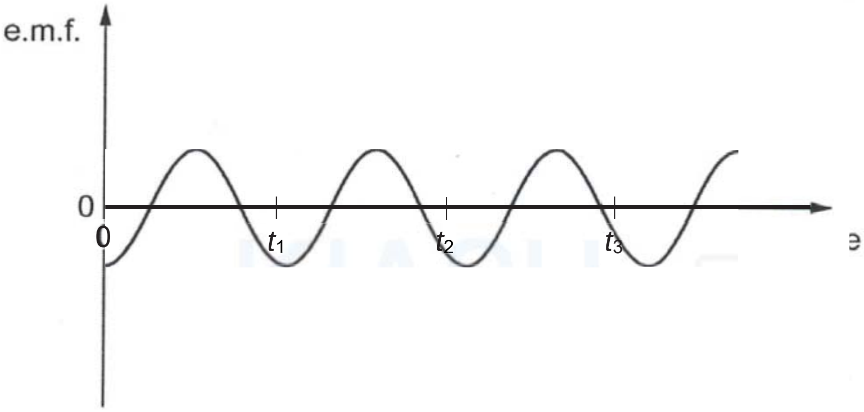
	
3bi	$\frac{1}{1.6} = 0.625$
3bii1	The rotating drum exerts a periodic force on the system. As a result, the system undergoes forced oscillation.
3bii2	The amplitude reaches a maximum value when the period of the force exerted by the inner drum is 1.6 s, which is the natural period of the system
3biii	 Correct label of resonant frequency 0.625 Hz and max amplitude of 5 cm. Correct shape
3biv	Without the concrete, the machine's centre of mass is higher This will result in less stability of the washing machine when the machine is

	spinning at high speeds. OR Without the concrete, the mass of the system is smaller, hence period of oscillation is shorter. This will lead to excessive large amplitude of vibration in spin mode as machine spins at high speed.

4ai	$R_{eff} = \left(\frac{1}{4.0} + \frac{1}{2.0}\right)^{-1} + 2.0$ $= 3.33\ \Omega$
4aii	X, Z, Y. The brightness of the bulbs depends on the power dissipated in them. Comparing bulbs X and Z, since they are in parallel, the voltage drop across them is the same, and using $P = V^2/R$, we conclude that bulb Z is brighter than bulb X. Next, use $P = I^2R$ to compare between bulbs Y and Z, and bulb Y is brighter as the current through Y is larger.
4bi	Using the potential divider principle on the upper circuit, $V_{AB} = 6.0\left(\frac{2.0}{1.0 + 2.0}\right)$ $= 4.0\ \text{V}$
4bii	At null deflection, terminal p.d. of the lower circuit = $3.0\left(\frac{3.33}{3.33 + 0.50}\right) = 2.608\ \text{V}$ $\frac{L_{AC}}{L_{AB}} = \frac{V_{AC}}{V_{AB}}$ $\frac{L_{AC}}{100.0} = \frac{2.608}{4.0} \Rightarrow L_{AC} = 65.2\ \text{cm}$
4biii	With a lower resistance bulb used for X, the effective resistance of the three bulbs (in a(i)) will decrease. Hence, the terminal potential difference across the cell in the lower circuit decreases. The balance length AC must be **shorter** for null deflection to occur.

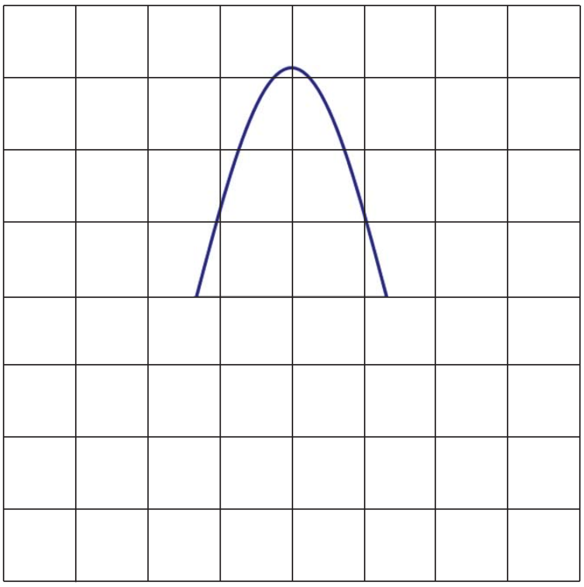
5ai	Direction is $X \rightarrow Y$

2017 AJC H2 Phy Prelim Solutions
Paper 2 (80 marks)

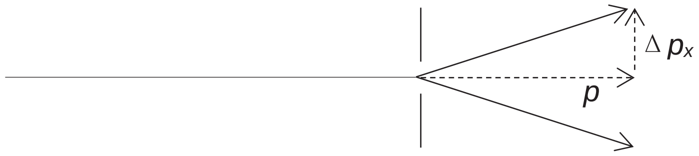
5aii1.	The e.m.f. induced in a conductor is proportional to the rate of change of magnetic flux linkage. Flux in solenoid is increasing. Hence, flux in small coil is also increasing, so e.m.f. induced.
5aii2.	The direction of the induced e.m.f. is such that it tends to produce effects to oppose the change causing it. The magnetic field set up in the small coil will oppose/be in opposite direction to the increasing field in solenoid. Direction of induced current marked correctly on diagram (Induced current is in the clockwise direction through the voltmeter.) 
5aiii	 cosine curve about time axis correct frequency (ignore phase) $I = I_0\sin\omega t + A$ where $A > 0$ Since $B \propto I$, $\varepsilon = -\frac{d(NBA)}{dt} = -NA\frac{dB}{dt}$ Hence, $\varepsilon \propto -\cos\omega t$

2017 AJC H2 Phy Prelim Solutions

Paper 2 (80 marks)

5bi	$\mathrm{I} = \frac{\mathrm{P}}{\mathrm{V}} = \frac{1.5}{6.0} = 0.25\ \mathrm{A}$
5bii	

6a i	screen will be uniformly bright
6a ii	Concentric bright rings spacing between rings increases and intensity of rings decreases radially outwards
6b i	$\Delta p_x = \frac{h}{\Delta x}$ $= \frac{6.63 \times 10^{-34}}{1.00 \times 10^{-10}}$ $= 6.63 \times 10^{-24}\ kgms^{-1}$
6b ii	$p = mv = (9.11 \times 10^{-31})(3.00 \times 10^{7}) = 2.73 \times 10^{-23}$ kg m s^{-1} comparison of Δp_x with value of p to show significance: e.g.

	$\frac{6.63x10^{-24}}{2.73x10^{-23}}x100\% = 24\%$ Δp_x *is* 24% *of* p **or** $\Delta p_x \approx 0.24\ p$ This means there is a high uncertainty in the angle which the electron can be scattered (or the angle which the electron can be scattered is significant) **or** there is high uncertainty in the direction that the electron will emerge (or the emerging electron can be travelling in a significant range of directions) *Note for understanding:*  Before the slit, uncertain about the electron position hence more certain about its momentum, ie. direction travelling towards slit. At the slit, greater certainty of the electron vertical position (ie. Δ x small), then there will be greater uncertainty in momentum vertically (Δp_x *high), ie. not so sure about its direction after passing through the slit.*

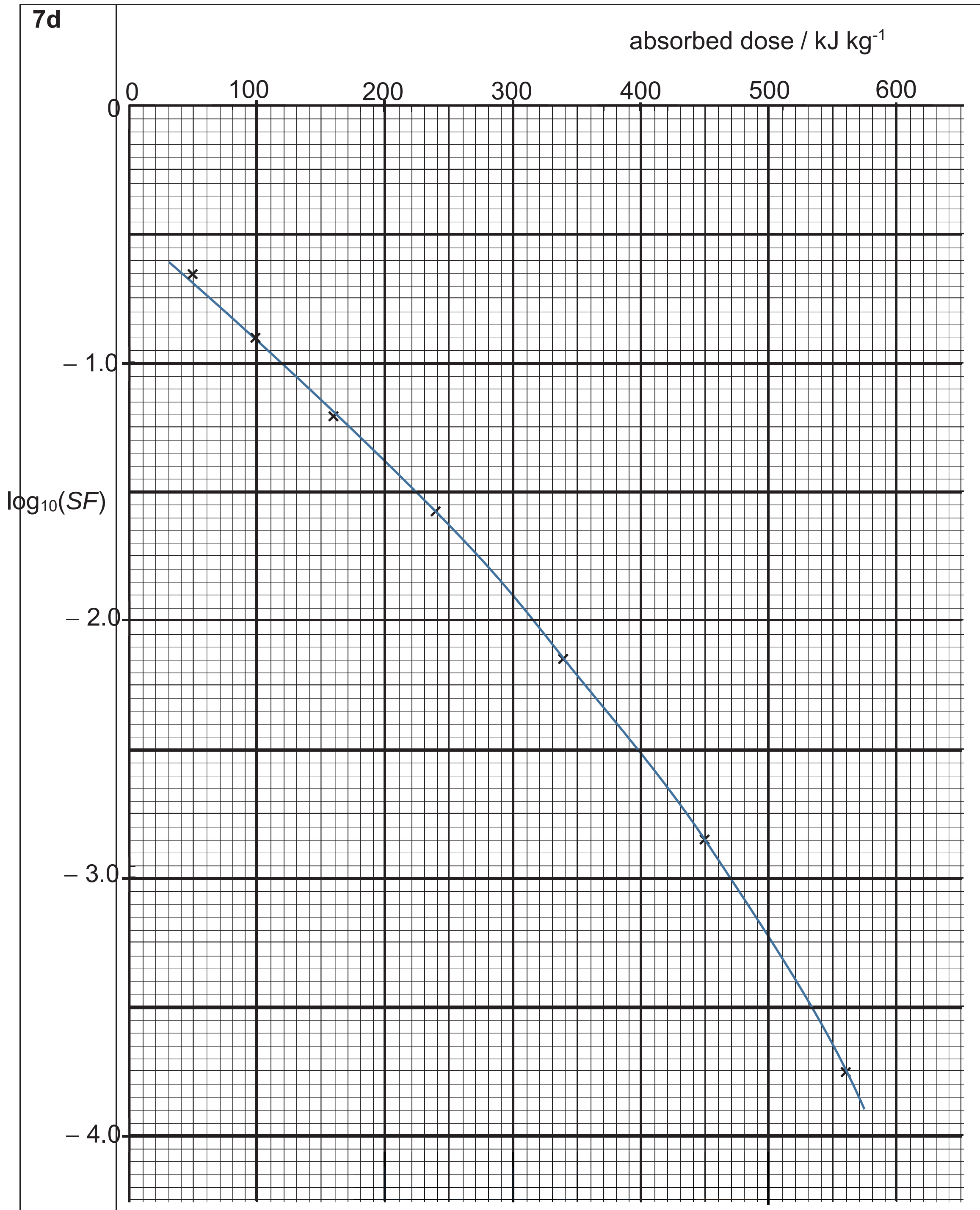
7ai	Electrical energy to (mechanical energy) to sound energy OR Sound energy to (mechanical energy) to electrical energy
7aii	Ultrasound is a wave in which the displacements of the particles in the wave are along the direction of transfer of energy of the wave and Light is a wave in which the directions of the oscillations of electric field and magnetic field are perpendicular to each other and at right angles to the direction of transfer of energy of the wave. Or ultrasound is longitudinal and light is transverse Or ultrasound needs medium for propagation but light can propagation in vacuum Or ultrasound cannot be polarised and light can be polarised.

2017 AJC H2 Phy Prelim Solutions

Paper 2 (80 marks)

<table>
<tr><td></td><td></td></tr>
<tr><td>7bi</td><td>0.027</td></tr>
<tr><td>7bii</td><td>Exposure time = $\frac{\text{absorbed dose}}{\text{dose - rate}} = \frac{240 \times 10^3}{200}$
= 1200 s</td></tr>
<tr><td>7ci</td><td>Plotting <i>SF</i> on a logarithmic scale allows separation of the curves at small values of <i>SF</i> to be increased.</td></tr>
<tr><td>7cii</td><td>
<table>
<tr><th>absorbed dose / kJ kg^{-1}</th><th>$\log_{10}(SF)$</th></tr>
<tr><td>50</td><td>– 0.65</td></tr>
<tr><td>100</td><td>–0.90</td></tr>
<tr><td>160</td><td>–1.18 OR –1.20</td></tr>
<tr><td>240</td><td>–1.55 OR –1.58</td></tr>
<tr><td>340</td><td>–2.13 OR –2.15</td></tr>
<tr><td>450</td><td>–2.85</td></tr>
<tr><td>560</td><td>–3.75 OR –3.78</td></tr>
</table>

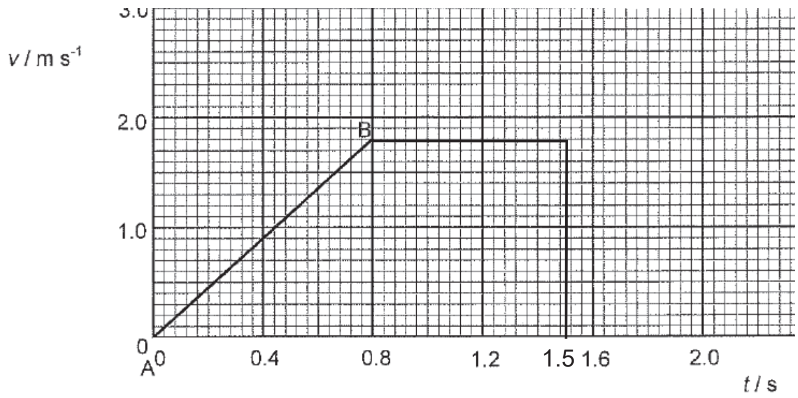
3 marks for all (7) answers recorded correctly
2 mark for at least 4 answers recorded correctly
1 mark for at least 2 answers recorded correctly
.</td></tr>
<tr><td>7ciii</td><td>$\log_{10}(SF)$ = –1.18 OR –1.20
<i>SF</i> = 0.0661 or 0.0631</td></tr>
</table>

7d	 2 marks for all points plotted correctly (accuracy up to half of a small square) 1 mark for at least 4 points plotted correctly (accuracy up to half of a small square) 1 mark for best fit curve (number of points on either side of curve differ by 1)
7ei	There are dips in the curves at (about) 200 W kg^{-1} for the higher absorbed doses.
7eii	The curve is almost linear at low doses,

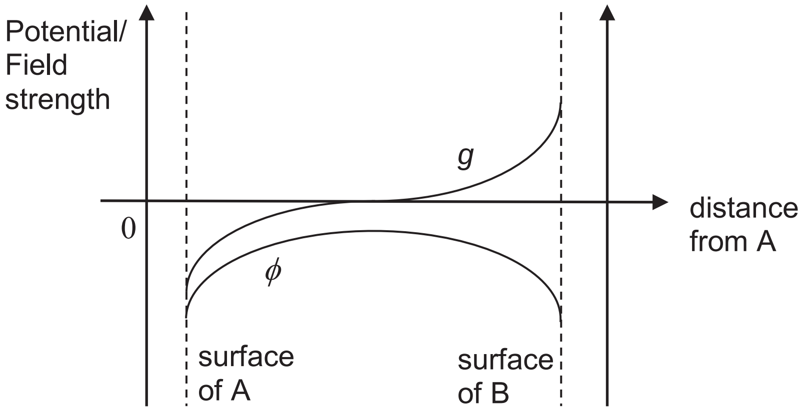
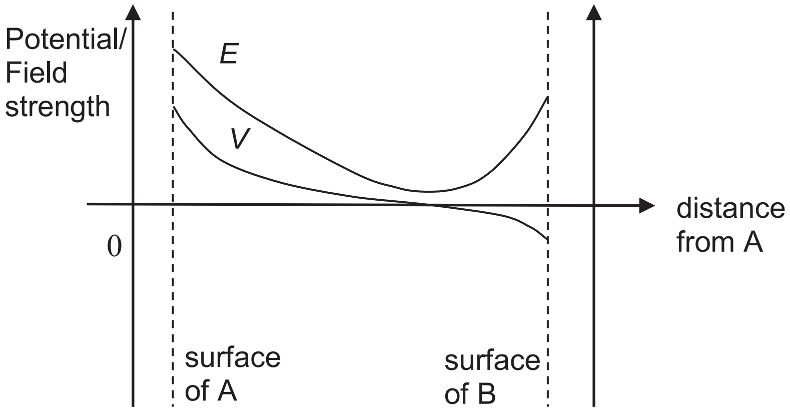
	and the curve becomes steeper at higher doses
7fi	The value of $\log_{10}$ $(SF)_R$ for the absorbed dose of 560 kJ kg^{-1}can be determined from Fig. 7.4 as the graph is $\log_{10}(SF)_R$ vs absorbed dose. $(SF)_R$ is then calculated from it.
7fii	$\log_{10} (SF)_R = \log_{10} [(SF)_1 \times (SF)_2] = \log_{10} (SF)_1 + \log_{10} (SF)_2$ The linear part of Fig. 7.4 could represent the effects due to $(SF)_1$. The linear part is extrapolated to determine the value of $\log_{10}$ $(SF)_1$ at 560 kJ kg^{-1} and hence $(SF)_1$ The value of $\log_{10}$ $(SF)_2$ is determined by subtracting the value of $\log_{10}$ $(SF)_1$ from the value of $\log_{10}$ $(SF)_R$ at 560 kJ kg^{-1}. Hence, $(SF)_2$ can be determined.

2017 AJC prelim Physics H2P3 Solutions

Paper 3 (80 marks)

1a	Acceleration = gradient of graph = 1.80 / 0.80 = 2.25 ≈ 2.3 m s^{-2}
1b	Distance = area under the graph = (1.80 x 0.80) / 2 = 0.72 m
1ci	Time = distance BC / speed = (2.0 – 0.72) / 1.8 = 0.71 s
1cii	Straight horizontal line until 1.5 s Steep line to zero speed (ignore gradient) 
1ciii	KE gain by trolley and M = GPE loss by M ½ x (0.80 + M) x 1.8^2 = M x 9.81 x 0.72 M = 0.24 kg

2ai	At P, $\phi_p = -\frac{2GM}{D} - \frac{2GM}{D}$ $\phi_p = -\frac{4GM}{D}$
2aii	From P to X, Gain in KE = Lost in GPE $\frac{1}{2} m v_x^2 = [-\frac{4GM}{D} - (-\frac{2GM}{D/2} - \frac{2GM}{D/2})]m$ $\frac{1}{2} v_x^2 = \frac{4GM}{D}$ $v_x = \sqrt{\frac{8GM}{D}}$

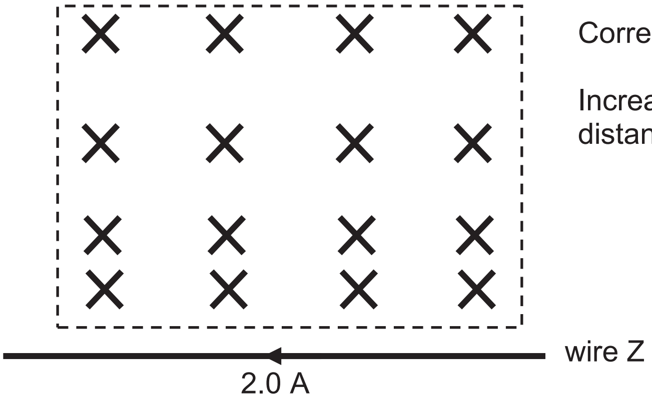
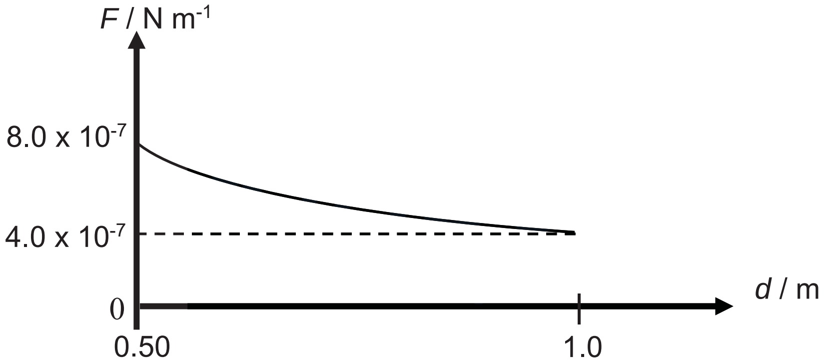
2bi	 *g* – cuts horz axis at centre, positive and negative values. ϕ - symmetrical about centre and all values are negative.
2bii	 E – All values positive, turning point to the right hand side of centre. V – cuts horz axis to the right of the centre pt. Positive and –ve value. Gradient is non-zero at horz intercept.
2biii	Body will move towards the left (away from A) as resultant g-field is much weaker than resultant E-field, direction of motion will be influenced by E-field. Or as repulsive electric force by A on mass at R is larger than attractive force by B on mass at R; and the attractive gravitational force by both A and B on mass at R is negligible as compared to net replusive electric force.

3a	At B, pV = nRT $(4.3 \times 10^6)(1.2 \times 10^{-3}) = 3.0 \times 8.31 \times T$ T = 207 K = 210 K
3b	At C, pV = nRT $(2.2 \times 10^6)(3.8 \times 10^{-3}) = 3.0 \times 8.31 \times T$ $\therefore T = 335$ K For monatomic ideal gas, Internal energy, *U* = total KE of all molecules, since PE = 0 $\therefore U = 3/2\ nRT$ $\therefore$ change in internal energy, $\Delta U = 3/2\ nR\Delta T$ or $3/2\ Nk\Delta T$ From B to C, $\Delta U = 3/2\ nR\Delta T$ $= 3/2 \times 3.0 \times 8.31 \times (335 - 207)$ OR $\Delta U = 3/2\ NK\Delta T$ $= 3/2 \times 3.0 \times (6.02 \times 10^{23}) \times (1.38 \times 10^{-23}) \times (335 - 207)$

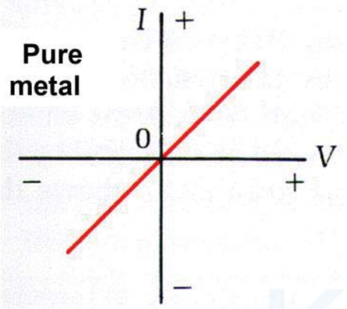
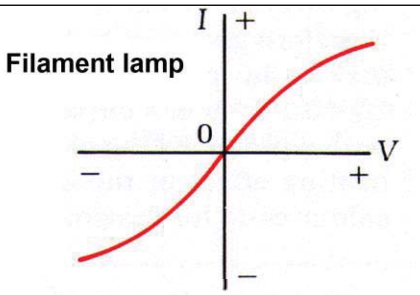
	$\Delta U = 4790$ J = 4800 J
3c	Work done from B to C = area under graph from B to C WD by gas = ½ (4.3 +2.2) x 10^6 x (3.8 – 1.2) x 10^{-3} = + 8450 J (gas expansion) = +8500 J
3d	By 1st Law of Thermodynamics, for process BC, $\Delta U = Q + WD$ $\therefore$ 4790 = Q + (−8450) $\therefore$ heat absorbed by gas in process BC, Q = 13240 J = + 1.32 x 10^4 J

4a	Only transverse wave can be polarized.
4bi	Use Malus' law, Intensity $I = I_o \cos^2 \theta$ Intensity $I = I_o \cos^2 \theta = I_o \cos^2 45° = I_o/2$ Emergent beam is polarised at 45° clockwise from vertical
4bii	Intensity $I = (I_o \cos^2 45°) \cos^2 45° = I_o/4$ Emergent beam is polarised vertically

5a	**Diffraction** is the spreading of waves when they pass through an opening or round an obstacle. (Diffraction effects are the greatest when the width of the opening is comparable with the wavelength of the waves.)
5bi	Angle subtended $\theta = (10 \times 10^{-3})/40 = 2.5 \times 10^{-4}$ rad
5bii	Rayleigh's criterion for two images to be just resolved is when one central peak (central maximum) falls at the first dark fringe (first minimum) for the second diffraction pattern, i.e the minimum angular separation of the 2 images is $\theta_{min} \approx \lambda/b$. $\theta_{min} \approx \lambda/b = (600 \times 10^{-9}) / (1.5 \times 10^{-3})$ $= 4.0 \times 10^{-4}$ rad. Since angle subtended θ is smaller than the θ_{min}, therefore the images observed cannot be resolved
5ci	waves (from slits) overlap (at point X) path difference (from slits to X) is zero or phase difference (between the two waves) is zero so constructive interference gives bright fringe
5cii	difference in distances = $\lambda / 2$ = 580 / 2 = 290 nm
5ciii	$\lambda = ax / D$ $D = [0.41 \times 10^{-3} \times (\mathbf{2 \times 2.0 \times 10^{-3}})] / 580 \times 10^{-9}$ = 2.8 m

6a	 Correct direction of B Increasing spacing with increasing distance from wire Z (at least 3 rows)
b	Ion moves (or spirals /curves) anticlockwise (or towards the right) with decreasing radius. By FLHR, magnetic force is directed to the right perpendicular to v at point P. Hence ion is deflected to the right. As radius of curvature is inversely proportional to magnetic flux density, radius decreases as magnetic flux density increases as ion approaches wire Z. NOTE: (Student only needs to describe the path for particle approaching wire. If students discussed beyond that, marks can only be awarded if there is sound physics. If student extends to discuss particle reaches a closest approach from wire and moves away from wire, the radius of curvature should increase as magnetic flux density decreases.)
ci	$B = B_Z - B_Y$ $= \frac{\mu_0 I_Z}{2\pi r} - \frac{\mu_0 I_Y}{2\pi r}$ $= \frac{(4\pi x\ 10^{-7})}{2\pi(0.5)}(2.0 - 1.0)$ $= 4.0 \times 10^{-7}$ T
cii	 Correct trend as F $\propto \frac{1}{d}$ *F* at 0.50 m is twice the amount at 1.0 m. (values not required)

7 a	By conservation of momentum, since initial momentum of meson is zero as it is stationary, total final momentum of the photons is zero, hence the photons must be equal in magnitude and opposite in direction. Since photons have equal momentum, ρ , they have same wavelength (ie. same frequency) and hence equal energy, E.
7b i	2 (Energy of photon) = Energy released = m c^2 Energy of photon = $(\frac{2.4 \times 10^{-28}}{2})(3.00 \times 10^{8})^2$ = 1.08×10^{-11} J
7b ii	E = hc / λ $\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (1.08 \times 10^{-11})$ $= 1.84 \times 10^{-14}$ m
7b iii	λ = h / p $p = (6.63 \times 10^{-34}) / (1.84 \times 10^{-14})$ $= 3.6 \times 10^{-20}$ N s **OR** E = pc $1.08 \times 10^{-11} = p\,(3.00\times 10^{8})$ $p = 3.6 \times 10^{-20}$ N s

8ai	The **resistance** of a conductor is the ratio of the potential difference across it to the current flowing through it.
8aii	The **ohm** is the resistance of a conductor in which the current is 1 ampere when a potential difference of 1 volt is applied across it.
8b	 
8c	When the temperature increases, the resistance of a filament lamp increases while the resistance of a semiconductor decreases. For a filament lamp, there is little increase in the number of charge carriers/electrons. The increase in amplitude of vibration of the atoms causes the resistance to increase with temperature. For a semiconductor, the increase in the number of charge carriers/electrons is more significant than the increase in amplitude of vibration of the atoms. This causes the resistance to decrease with temperature.

8di	Use $R = \frac{\rho l}{A}$ $= \frac{(5.5 \text{ x } 10^{-8})(2.0)}{\left(\frac{\pi(0.020 \text{ x } 10^{-3})^2}{4}\right)}$ $= 350\ \Omega$ power dissipated = $I^2R = (0.42)^2(350) = 62$ W
8dii1	<u>Mthd 1</u> Common current in both wires, so *nAv* for tungsten= *nAv* for copper. $v_{\text{tungsten}} = \frac{n_{\text{copper}} A_{\text{copper}} v_{\text{copper}}}{n_{\text{tungsten}} A_{\text{tungsten}}}$ $= \frac{(8.0)(1.4^2)(0.021 \text{ x } 10^{-3})}{(3.4)(0.02^2)}$ $= 0.24 \text{ m s}^{-1}$ <u>Mthd 2</u> Use $I = nAve$ $v_{\text{tungsten}} = \frac{I}{n_{\text{tungsten}} A_{\text{tungsten}} e}$ $= \frac{0.42}{(3.4 \text{ x } 10^{28})(\pi \frac{(0.02 \text{ x } 10^{-3})^2}{4})(1.60 \text{ x } 10^{-19})}$ $= 0.25 \text{ m s}^{-1}$ *Note that v is the drift speed and not the actual speed of the electrons.*
8dii2	The higher speed of the electrons in tungsten means that they have a much greater kinetic energy than those in copper. As the electrons collide with the fixed atoms, energy is lost to these atoms, resulting in a rise in temperature.
8diii	Any one – high resistivity, high melting point, should not oxidise at high temperature (to ensure long life), non-corrosive
8ei	<u>Mthd 1</u> resistance of thermistor at 0 °C = 3900 Ω using potential divider principle, $\left(\frac{R}{R + 3900}\right) \text{x} 1.50 = 1.00$ R = 7800 Ω <u>Mthd 2</u> p.d. across thermistor = 1.50 – 1.00 = 0.50 V resistance of thermistor at 0 °C = 3900 Ω common current in circuit = $\frac{1.00}{R} = \frac{0.50}{3900}$ R = 7800 Ω
8eii	<u>Mthd 1</u> resistance of thermistor at 30 °C = 1250 Ω using potential divider principle, $\text{voltmeter reading} = \left(\frac{7800}{7800 + 1250}\right) \text{x} 1.50$ $= 1.29 \text{ V}$

	Mthd 2 resistance of thermistor at 30 °C = 1250 Ω common current, I in circuit = $\frac{1.50}{R+1250}=\frac{1.50}{7800+1250}=\frac{1.50}{9050}$ voltmeter reading = IR = 1.29 V
8eiii	resistance of thermistor at 0 °C = 3900 Ω effective resistance of R and voltmeter = 7800/2 = 3900 Ω (same as thermistor's) voltmeter reading = p.d. across X = 1.50/2 = 0.750 V

9 a 1.	photon is a packet/quantum of energy of electromagnetic radiation (photon) energy = h × frequency
2.	every particle has an (associated) wavelength wavelength = h / p , where p is the momentum (of the particle)
9bi	for a wave, electron can 'collect' energy continuously for a wave, electron will always be emitted / electron will be emitted at all frequencies after a sufficiently long delay
9bii 1.	either wavelength is longer than threshold wavelength or frequency is below the threshold frequency or photon energy is less than work function
9bii 2.	$hc / \lambda = \phi + E_k$ $(6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / (240 \times 10^{-9}) = \phi + 4.44 \times 10^{-19}$ $\phi = 3.8 \times 10^{-19}$ J (allow 3.9×10^{-19} J)
9biii1.	photon energy larger so (maximum) kinetic energy is larger
9biii2.	fewer photons (per unit time) so (maximum) current is smaller
9ci1.	arrow from –0.54 eV to –0.85 eV, labelled L
2.	arrow from –0.54 eV to –3.4 eV , labelled S (two correct arrows, but only one label – allow 2 marks) (two correct arrows, but no labels – allow 1 mark)
9cii	$E = hc / \lambda$ $(3.4 - 0.54) \times 1.6 \times 10^{-19} = (6.63 \times 10^{-34} \times 3.00 \times 10^{8}) / \lambda$ $\lambda = 4.35 \times 10^{-7}$ m
9ciii	–1.50 → –3.4 = 1.9 eV –0.85 → –3.4 = 2.55 eV (allow 2.6 eV) –0.54 → –3.4 = 2.86 eV (allow 2.9 eV)

JC2 Prelim Question 1 MS

Q1	Answer	Mark	Code
(b)(i) **MMO**	***Measurement of d*** Value of *d* with unit and to nearest 1 mm.	1	**M1**
(b)(ii) **ACE**	***Estimating uncertainties*** Percentage uncertainty in *d* calculated correctly to 2 s.f using sensible value of Δd (e.g. 2 mm ≤ Δd ≤ 4 mm).	1	**A1**
(b)(iii) **MMO** **ACE**	***Calculation of T*** Evidence of repeated readings for raw time and NT > 10 s Correct calculation of *T* to 3 s.f. with unit.	1 1	**M2** **A2**
(c) **PDO** **ACE**	3.0 cm ≤ 2nd *d* ≤ 10.0 cm 2nd T calculated correctly Higher/lower 2nd *d* , higher/lower 2nd *T* Two values of *k* calculated correctly with correct units Valid conclusion relating to the calculated values of *k*, testing against a stated criterion.	1 1 1 1 1	**M3** **A3** **A4** **A5** **A6**
(d) **ACE**	Oscillations are too quick to timed accurately. OR Magnets may stick together in this small separation.	1	**A7**
(e) **APLE**	<u>Placed each lump at equal distance from the axis of rotation</u> of (top) bar magnet and measure the period <u>Vary the distance between the 2 masses</u> <u>*d* between the magnets kept the same</u>	1 1 1	**PL1** **PL2** **PL3**

JC2 Prelim Question 2 MS

Q2	Answer	Mark	Code
(b)(i) **MMO**	***Measurement of F*** Values of *F* to 0.01 N and *d* to 0.1 cm.	1	**M1**
(b)(ii) **MMO**	***Set up apparatus from a diagram and follow of written instructions*** 6 sets of readings with correct trend. Reasonable intervals between values of *d* (> 5cm) and range of *d* ≥ 80 cm. All values of *F* to 0.01 N and *d* to 0.1 cm.	1 1 1	**M2** **M3** **M4**
(b)(iii) **ACE**	***Evaluation on keeping rule horizontal*** Use metre rule to measure distance from the bench at two different points on the rule to ensure the rule is horizontal.	1	**A1**
(c) **PDO**	***Graph*** Points correctly plotted. Line of best fit	1 1	**P1** **P2**
(d) **ACE**	***Value of m calculated correctly from y-intercept*** Y-intercept must read off to the nearest half small square or determine from y = mx + c using a point on the line. Correct calculation and unit of *m*. Values of *m* between 80 to 120 g.	1 1 1	**A2** **A3** **A4**

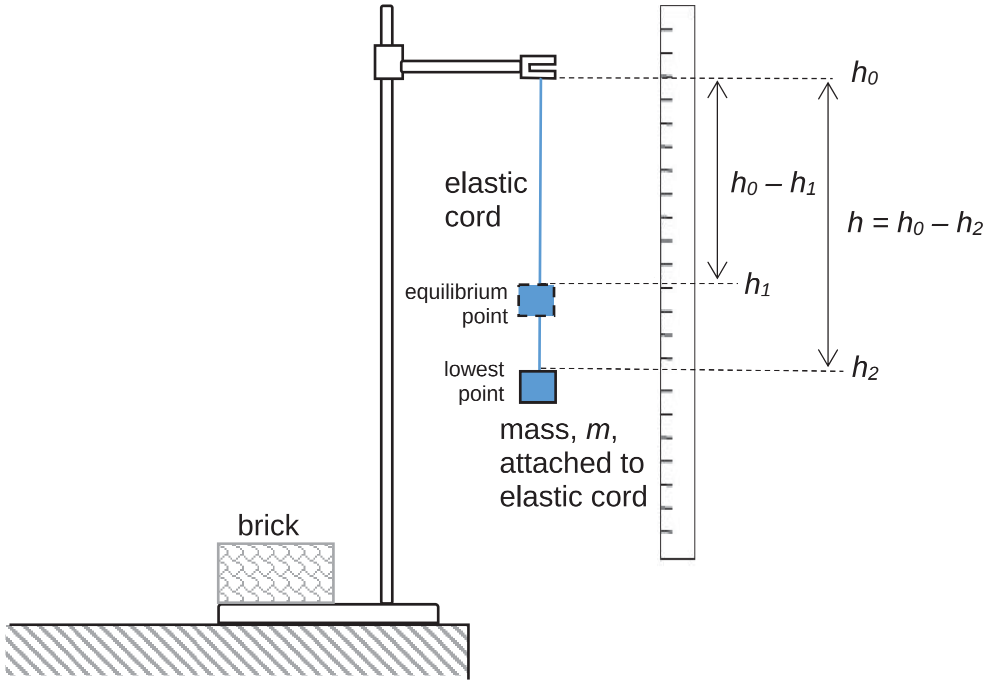
JC2 Prelim Question 3 MS

Q3	Answer	Mark	Code
(a)(i) **MMO**	***Measurement of d*** Record zero error and take repeated readings for *d*. Value of *d* in the range 0.15 mm ≤ *d* ≤ 0.25 mm, with unit to nearest 0.01 mm.	1	**M1**
(a)(ii) **ACE**	***Calculation of A*** Calculation of *A* in m^2 with same significant figure as *d.*	1	**A1**
(d) **MMO**	***Set up apparatus from a circuit diagram and follow of written instructions*** • Award 2 marks if the student has successfully collected 6 or more sets of data (l, V_1, V_2), with V_1>V_2, without assistance/intervention. • Award 1 mark if student has successfully collected 5 sets of data (l, V_1, V_2) , with V_1>V_2, without assistance/intervention. • Award zero mark if student has successfully collected 4 or fewer sets of data (l, V_1, V_2) without assistance/intervention. • Deduct 1 mark if student requires some assistance/intervention but has been able to do most of the work independently. Indicate the nature of any assistance. • Deduct 2 marks if student has been unable to collect data without substantial assistance/intervention. Minimum mark for **M2** = 0.	2	**M2**
(d) **MMO**	***Range of l*** Range of l ≥ 30 cm.	1	**M3**
(d) **PDO**	***Layout: Column headings (raw data & calculated quantities: l, V_1, V_2, V_1/V_2)*** Each column heading must contain an appropriate quantity and a unit. Ignore units in the body of the table. There must be some distinguishing mark between the quantity and the unit i.e. solidus is expected.	1	**P1**
(d) **PDO**	***Table of results: raw data (appropriate degree of precision)*** ALL values of l to nearest mm and V_1 & V_2 to nearest 0.001 V.	1	**P2**
(d) **PDO**	***Table of results: calculated quantities (appropriate no. of significant figures)*** Calculated values of V_1/V_2 should consistently be to the same no. of s.f. as the raw data. ALL values of V_1/V_2 are given to 3 s.f. for this mark to be awarded.	1	**P3**
(d) **ACE**	***Table of results: calculated quantities*** Correctly calculated values of V_1/V_2. Allow one slip in computation.	1	**A2**
(e) **ACE**	***Linearising Equation*** Linearising equation and deriving expressions that equate e.g. gradient to *P* and y-intercept to *Q*.	1	**A3**
(e) **PDO**	***Graph: Layout, choice of scale and labeling of axes*** Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Axes must be labelled with the quantity which is being plotted.	1	**P4**

Q3	Answer	Mark	Code
(e) **PDO**	**Graph: plotting of points** All observations must be plotted. Check any 3 points and put ticks if correct. Work to an accuracy of half a small square.	1	**P5**
(e) **PDO**	**Graph: trend line and ability to draw best fit line** Straight line of best fit – judge by scatter of points about the student's line. There must be a fair scatter of points on either side of the line.	1	**P6**
(e) **ACE**	***Interpretation of graph – gradient*** Gradient – the hypotenuse of the triangle must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square. Check for Δy/Δx (do not allow Δx/Δy). Value of *P* = candidate's gradient with correct unit m^{-1}.	1	**A4**
(e) **ACE**	***Interpretation of graph – intercept*** y-intercept – must be read off to nearest half a small square or determined from $y = mx + c$ using a point on the line. Value of *Q* = candidate's y-intercept and Q has no unit.	1	**A5**
(f) **MMO**	***Identification of anomaly*** Anomalous data/results, if any, must be identified. Appropriate justification must be given. Otherwise, comment of absence of anomalous data. Possible answer for anomalous point The point (x, y) is an anomalous point because it is far away from the best fit line. This could be due to the difficulty in clipping crocodile clips tightly to the wire attached to metre rule.	1	**M4**
(g)(i) **ACE**	***Drawing conclusions*** Value of ρ calculated correctly with unit Ω m. Range of ρ in the range of 1.0 – 20.0 x 10^{-7} Ω m.	1	**A6**
(g)(ii) **ACE**	***Interpretation of graph – underlying principles*** Steeper gradient with the same intercept and line is labelled Z.	1	**A7**
(h)(i) **ACE**	***Sources of errors*** Relevant point might be: 1. It is difficult to measure *l* because the crocodile clip has a broad width. This will affect the accuracy of *l*.	1	**A8**
(h)(ii) **ACE**	***Improvement*** Relevant point might be (correspond to sources of errors): 1. Replace the crocodile clip with a sliding jockey or a narrower clip to reduce the error in *l* measured.	1	**A9**

Suggested Solution to Q4

Diagram



Define problem

To test the relationship between *h* and *k*, and determine value of *g*.

Procedure

1. Setup the experiment as shown in the diagram above.
2. Measure and record mass, *m*, of the given object using an electronic balance.
3. Hang the elastic cord from clamp of the retort stand. Measure and record the initial height h_0 of mass *m* at its starting position using a metre rule.
4. Lower the attached mass m and allow it to come to rest.
5. Measure record the height h_1 of mass *m* at its equilibrium position using a meter rule, determine the spring constant *k* using $\dfrac{mg}{(h_0 - h_1) - L}$, where *L* is 50.0 cm.
6. Bring the mass *m* back to its initial height h_0 and drop it from rest.
7. Measure and record the lowest height reached by the mass, h_2 using a metre rule.
8. Determine the height fallen by the mass *m*, h using $h = h_2 - h_0$
9. Repeat the experiment using different elastic cords to obtain 6 sets of values for *h* and *k*.

Control of variables

1. Mass of object used is kept constant by using the same mass throughout the experiment.

Analysis

$$\frac{(h-L)^2}{h} = \frac{2mg}{k}$$

Plot a graph of $\dfrac{(h-L)^2}{h}$ against $\dfrac{1}{k}$ where the gradient is $2mg$ and y-intercept is zero.

Relationship is valid if the graph is a straight line passing through the origin.

Value of *g* can be determined from $\dfrac{gradient}{2m}$.

Safety and Accuracy

1. Take preliminary readings to locate approximate lowest height h_2 / to prevent object hitting surface
2. Ensure that the position of the metre rule is not shifted during the experiment by clamping it to a retort stand.
3. Use set square to ensure that metre rule is vertical
4. Use a set square as a marker, repeat the experiment a few times to better locate the lowest position of the mass h_2 / *OR*
   Use of video camera with slow motion or frame by frame playback to determine lowest position of mass m / OR
   Place a motion sensor directly beneath the mass m to record its displacement from the sensor. Lowest position of the mass could be read off from the datalogger.
5. Ensure that cord obeys Hooke's law and has not exceeded proportional limit by checking the L remains unchanged after the experiment.
6. Use sand tray to catch falling object to prevent mass / cord from hitting a person.
7. Use goggles / safety screen to prevent mass / cord from hitting a person
8. Use a heavy mass to stabilize the retort stand to prevent setup from toppling.