YISHUN INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

CG

INDEX NO

PHYSICS

9749/01

Paper 1 Multiple Choice

16 September 2022

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid/tape.
Write your name and class on the Answer Sheet in the spaces provided unless this has been done for you.

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.

Read the instructions on the Answer Sheet very carefully.

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

This document consists of **15** printed pages and **1** blank page.

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	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature,	T/K	=	T/°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	=	$v_0 \cos \omega t$
		=	$\pm \omega \sqrt{(x_0^2 - x^2)}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	B	=	$\frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_0 n I$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{1/2}}$

[Turn over

1 The mobility μ of electrons travelling through a metal conductor can be calculated using the equation

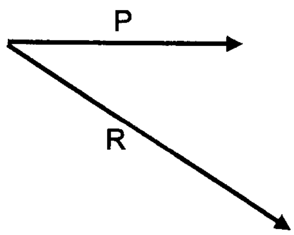
$$\mu = (\frac{e}{m})\tau$$

where e is the charge on an electron and m is its mass. The average time between the collisions of an electron with the atoms in the metal is τ.

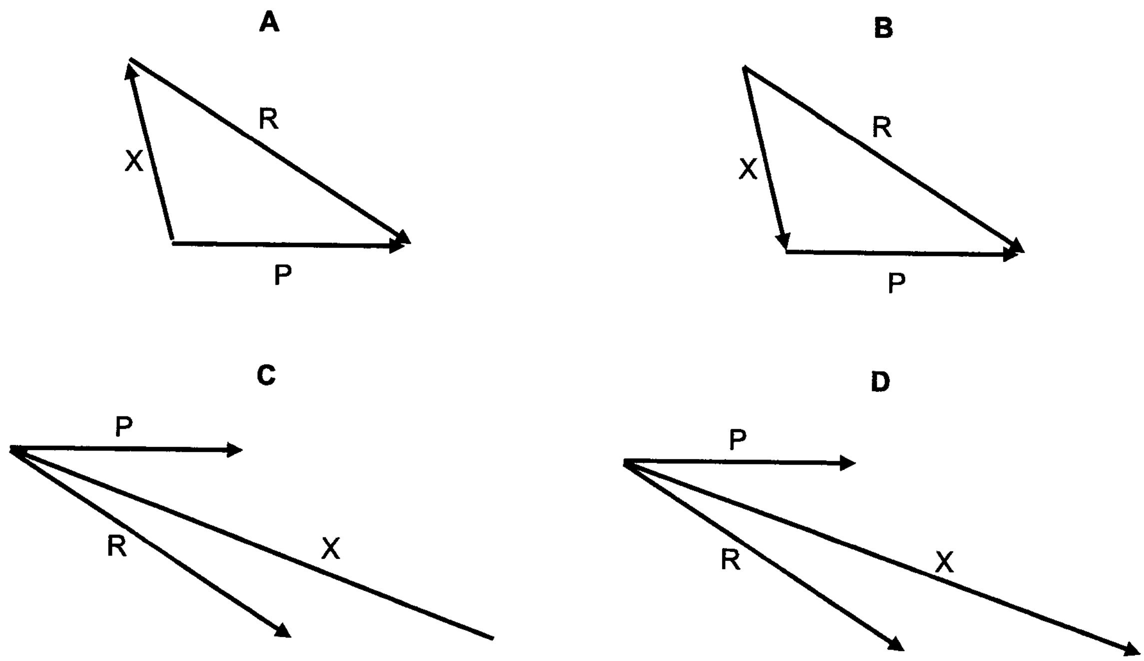
What are the SI base units of μ?

A C s kg^{-1} **B** C s kg **C** A s^2 kg^{-1} **D** A s^{-2} kg^{-1}

2 P and R are coplanar vectors.



If X = P – R, which diagram best represents vector X?



3 A train, initially at rest at a station, has a uniform acceleration of 0.20 m s^{-2} until it reaches a speed of 20 m s^{-1}.

It travels for a time at this constant speed and then has a uniform deceleration of 0.40 m s^{-2} until it comes to rest at the next station.

The distance between the two stations is 3000 m.

What is the time taken by the train to travel between the two stations?

A 75 s **B** 150 s **C** 230 s **D** 300 s

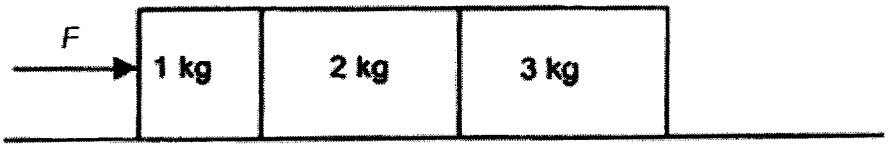
4 A person of mass 60 kg stands on an accurate bathroom scales, placed on the floor of an elevator (lift) which operates in a tall building.

At a certain instant the bathroom scales read 58 kg.

Which row could give the person's direction of movement and type of motion?

	direction	motion
A	downwards	constant speed
B	downwards	slowing down
C	upwards	constant speed
D	upwards	slowing down

5 Three boxes are pushed along a smooth surface by a force *F* as shown below. What is the force exerted by the 2 kg mass on the 1 kg mass?

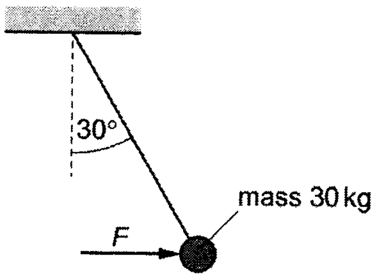


A $\frac{1}{3}F$ **B** $\frac{1}{2}F$ **C** $\frac{3}{4}F$ **D** $\frac{5}{6}F$

6 The table shows four different collisions between two blocks, each of mass 0.50 kg.
Which collision is perfectly elastic?

	before collision	after collision
A	$4.0\,m\,s^{-1}$ → [0.50 kg] ; $0.0\,m\,s^{-1}$ [0.50 kg]	$2.0\,m\,s^{-1}$ → [0.50 kg][0.50 kg]
B	$2.0\,m\,s^{-1}$ → [0.50 kg] ; ← $2.0\,m\,s^{-1}$ [0.50 kg]	$0.0\,m\,s^{-1}$ [0.50 kg][0.50 kg]
C	$2.0\,m\,s^{-1}$ → [0.50 kg] ; ← $1.0\,m\,s^{-1}$ [0.50 kg]	← $2.0\,m\,s^{-1}$ [0.50 kg] ; $3.0\,m\,s^{-1}$ → [0.50 kg]
D	$4.0\,m\,s^{-1}$ → [0.50 kg] ; $1.0\,m\,s^{-1}$ → [0.50 kg]	$1.0\,m\,s^{-1}$ → [0.50 kg] ; $4.0\,m\,s^{-1}$ → [0.50 kg]

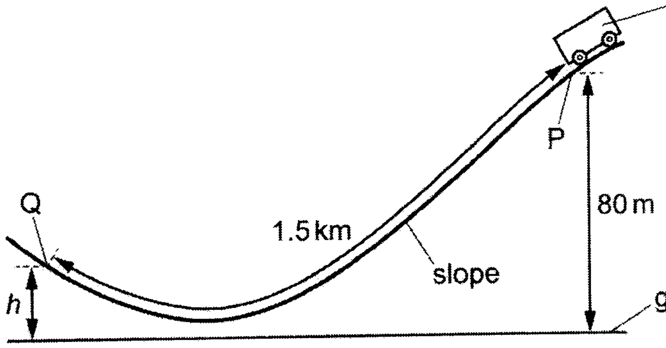
7 A mass of 30 kg is suspended from the end of a wire. A horizontal force F acts on the mass so that it is in equilibrium, with the wire at an angle of 30° to the vertical, as shown.



What is the magnitude F?

A 17 N **B** 150 N **C** 170 N **D** 510 N

8 A trolley of mass 600 kg initially at point P on a slope, at height of 80 m above ground level, as shown. The trolley is released from rest and moves along the slope, reaches a speed of 12.0 m s^{-1} at point Q, at height h above the ground level.

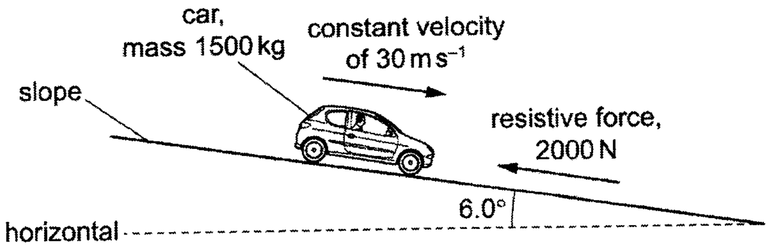


The total distance PQ moved by the trolley along the slope is 1.5 km. A constant resistive force of 200 N opposes the motion of the trolley on the slope.

What is the value of h?

A 3.5 m **B** 22 m **C** 29 m **D** 55 m

9 A car of mass 1500 kg travels at constant velocity of 30 m s^{-1} down a slope. The slope is at an angle of 6.0° to the horizontal, as shown.

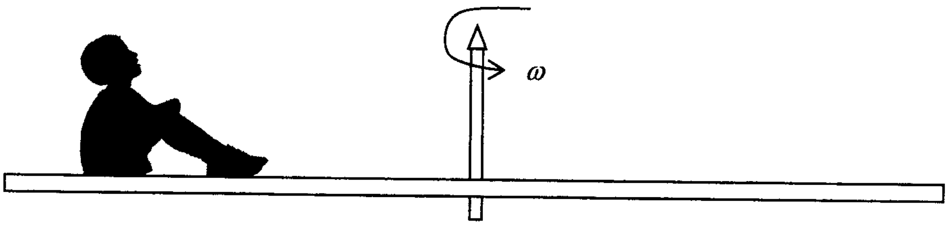


The magnitude of the total resistive force acting on the car is 2000 N.

What is the power output of the car's engine?

A 14 kW **B** 60 kW **C** 110 kW **D** 380 kW

10 The diagram shows a child sitting on a merry-go-round, which is turning with constant angular velocity ω.



Which statement correctly states and explains the direction of friction acting on the child in the position shown?

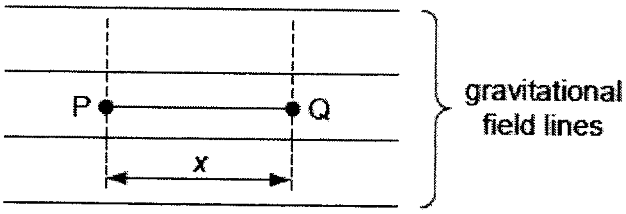
A Rightwards, to provide for centripetal force.

B Rightwards, to counter centripetal force.

C Leftwards, to provide for centripetal force

D Leftwards, to counter centripetal force.

11 A mass m is situated in space in a uniform gravitational field.



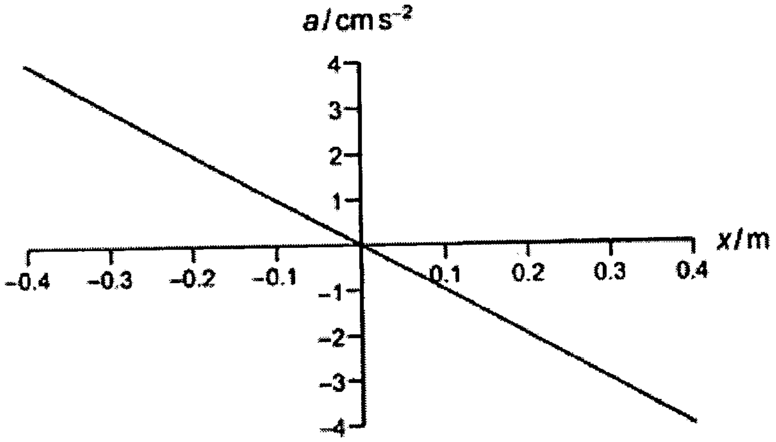
When the mass moves through a displacement x, from P to Q, it loses an amount of potential energy E.

Which row correctly specifies the magnitude and the direction of the acceleration due to the gravity in this field?

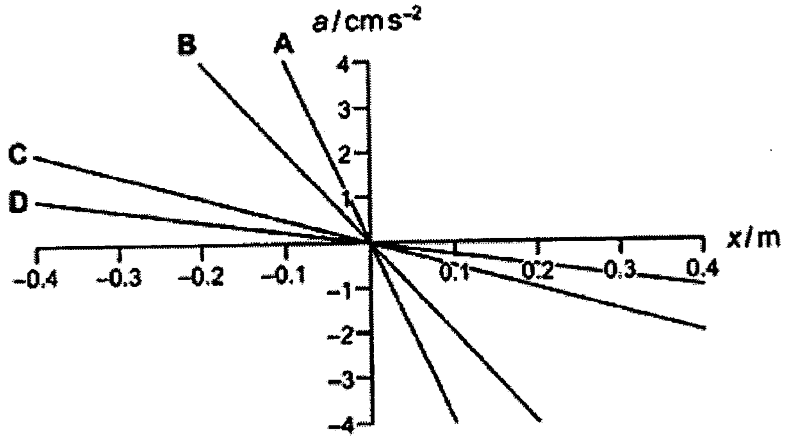
	magnitude	direction
A	$\frac{E}{x}$	→
B	$\frac{E}{x}$	←
C	$\frac{E}{mx}$	→
D	$\frac{E}{mx}$	←

[Turn over

12 The graph shows the variation of acceleration a with displacement x for an object undergoing simple harmonic motion.



The simple harmonic motion system is altered so that it has a period of oscillation twice that of before. Which line could be produced?



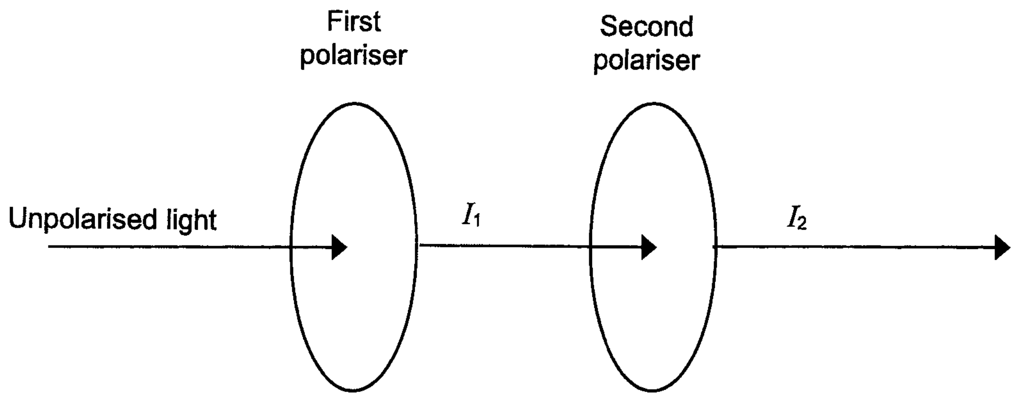
13 The frequency of a certain wave is 500 Hz and its speed is 340 m s^{-1}.

What is the phase difference between the motions of two points on the wave 0.17 m apart?

A $\frac{\pi}{4}$ rad **B** $\frac{\pi}{2}$ rad **C** $\frac{3\pi}{4}$ rad **D** π rad

[Turn over

14 Unpolarised light is incident upon two consecutive polarisers as shown below.



The second polariser has a fixed transmission axis which cannot be rotated. I_1 is the intensity after the first polariser, and I_2 is the intensity of light after the second polariser.

How would I_1 and I_2 be affected if the transmission axis of the first polariser was rotated?

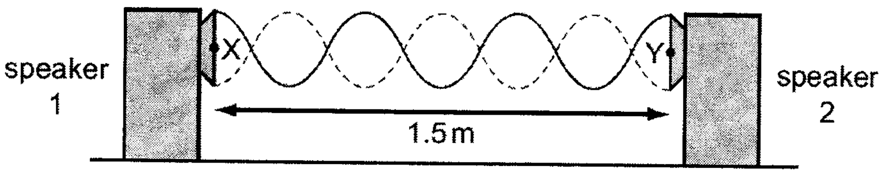
A Both would change.

B Only I_1 would change.

C Only I_2 would change.

D Neither would change.

15 A stationary wave is produced by two loudspeakers emitting sound of the same frequency.

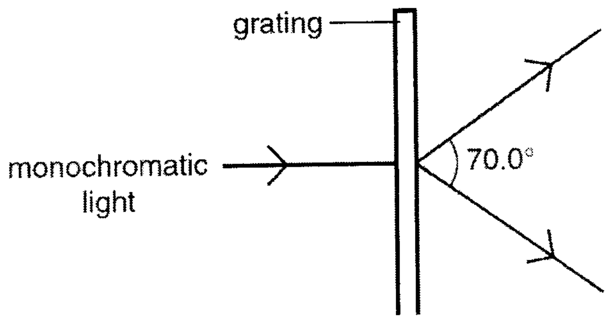


When a microphone is moved between X and Y, a distance 1.5 m, six nodes and seven antinodes are detected.

What is the wavelength of the sound?

A 0.50 m **B** 0.43 m **C** 0.25 m **D** 0.21 m

16 A diffraction grating is used to measure the wavelength of monochromatic light, as shown in the diagram below.



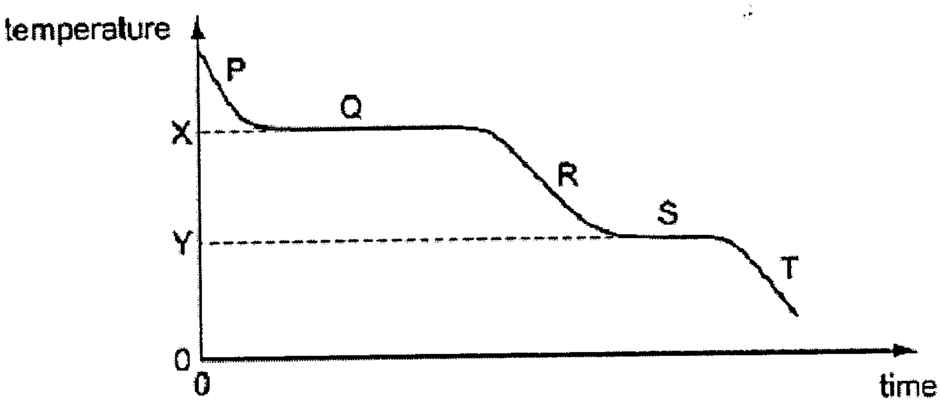
The diffraction grating has a line density of 1200 per mm. The angle between the first order diffraction maxima is 70.0°.

What is the wavelength of the light?

A 239 nm **B** 478 nm **C** 630 nm **D** 783 nm

17 A vapour in a container is at a high temperature and loses heat to its surroundings. The rate of heat loss is taken to be constant.

The graph shows how its temperature changes over the next few minutes.



Which feature of the graph indicates that the specific latent heat of vaporisation of the substance is greater than its specific latent heat of fusion?

A The gradient of the graph at P is greater than the gradient at R.

B The gradient of the graph at T is greater than the gradient at R.

C The length of the line Q is greater than the length of the line S.

D The value of X is greater than the value Y.

18 A fixed amount of gas is reduced in volume at a constant temperature.

What is the reason for the increase in pressure of the gas?

A The average distance travelled between collisions by the gas molecules is decreased.

B The average intermolecular attractive force between the gas molecules is increased.

C The average speed of the gas molecules is increased.

D The frequency of the collisions of the gas molecules with the walls of the container is increased.

19 An ideal gas undergoes an expansion in volume from 1.3×10^{-4} m^3 to 3.6×10^{-4} m^3 at a constant pressure of 1.3×10^5 Pa. During the expansion, 24 J of heat is supplied to the gas.

What is the overall change in the internal energy of the gas?

A decrease of 54 J

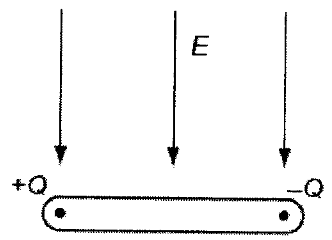
B decrease of 6 J

C increase of 6 J

D increase of 54 J

20 The diagram shows a light insulating rod with equal and opposite point charges at each end.

An electric field of strength E acts on the rod in a downwards direction.

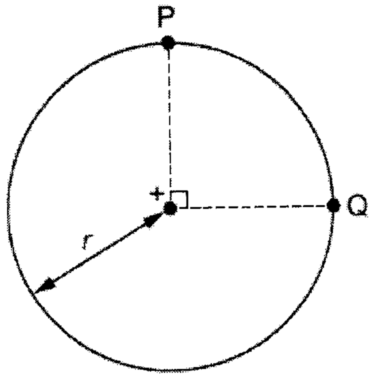


Which row is correct?

	resultant force	resultant torque
A	zero	clockwise
B	downwards	clockwise
C	zero	anti-clockwise
D	downwards	anti-clockwise

21 The diagram shows two points P and Q which lie 90° apart on a circle of radius r.

A positive point charge at the centre of the circle creates an electric field of magnitude E at both P and Q.



Which expression gives the work done in moving a unit positive charge from P to Q?

A 0 **B** $E \times r$ **C** $E \times \left(\frac{\pi r}{2}\right)$ **D** $E \times (\pi r)$

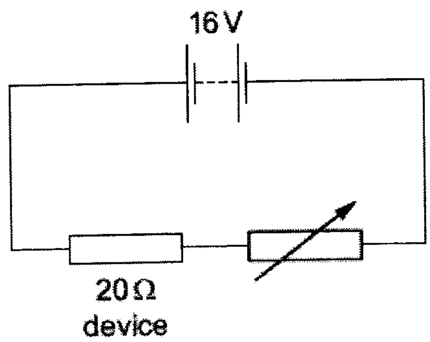
22 When there is a current of 5.0 A in a copper wire, the average drift velocity of the free electrons is 8.0×10^{-4} m s^{-1}.

What is the average drift velocity in a different copper wire that has twice the diameter and a current of 10.0 A?

A 4.0×10^{-4} m s^{-1} **B** 8.0×10^{-4} m s^{-1}

C 1.6×10^{-3} m s^{-1} **D** 3.2×10^{-3} m s^{-1}

23 An electrical device of fixed resistance 20 Ω is connected in series with a variable resistor and a battery of electromotive force (e.m.f.) 16 V and negligible internal resistance.

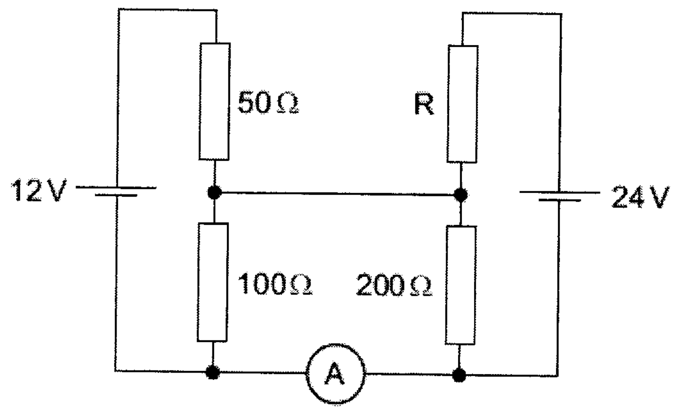


What is the resistance of the variable resistor when the power dissipated in the electrical device is 4.0 W?

A 16 Ω **B** 36 Ω **C** 44 Ω **D** 60 Ω

 [Turn over

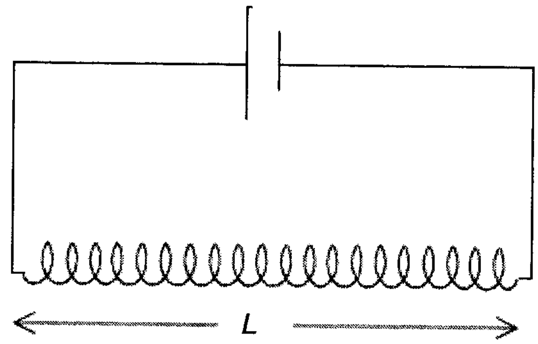
24 In the circuit shown, the ammeter reading is zero.



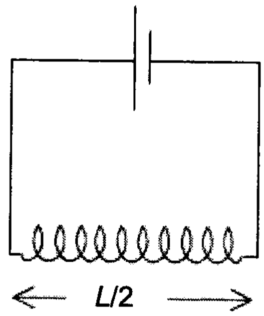
What is the resistance of resistor R?

A 100 Ω **B** 200 Ω **C** 400 Ω **D** 600 Ω

25 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 $0.25T$ **B** $0.5T$ **C** T **D** $2T$

26 An e.m.f is induced in a coil of wire that is rotating inside a magnetic field.

Which one of the following does not affect the magnitude of e.m.f induced in the coil?

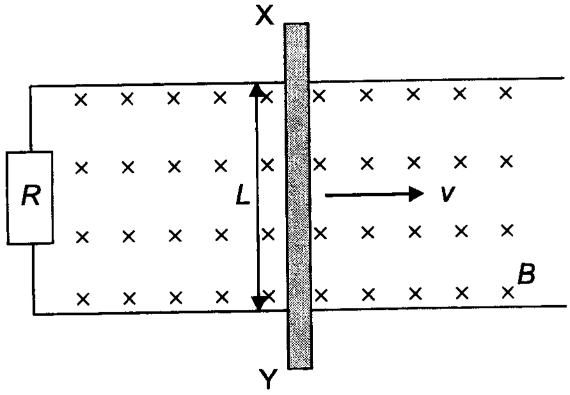
A the angular velocity of the coil

B the resistance of the coil

C the number of turns of the coil

D the magnetic flux density

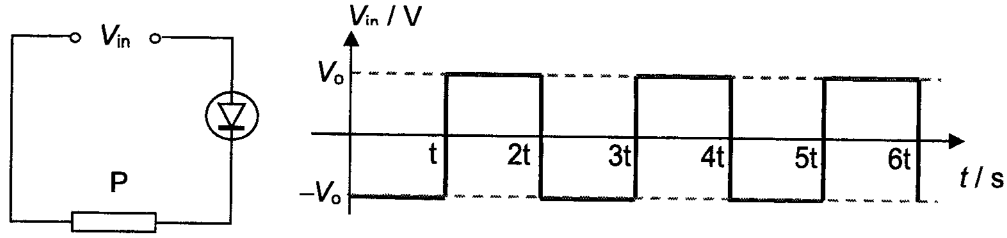
27 A metal rod slides along a wire frame, with negligible resistance, to the right with a speed of $v = 2.0$ m s^{-1} across a magnetic field B perpendicular to the plane of the frame as shown in the figure below.



If $L = 0.80$ m, $R = 6.0\ \Omega$ and $B = 3.5$ T, which end of the rod, X or Y, is at a higher potential and what is the power dissipated by R?

	End at higher potential	Power dissipated by R
A	X	5.2 W
B	X	5.6 W
C	Y	5.2 W
D	Y	5.6 W

28 A rectifier is connected in series with load P and an alternating voltage supply as shown in the figure.



What is the value of the r.m.s. voltage across load P?

A 0.18 V_o **B** 0.50 V_o **C** 0.71 V_o **D** 1.0 V_o

29 In the lungs, there are tiny sacs of air known individually as alveolus. The average diameter of an alveolus is 0.250 mm. Consider an oxygen molecule of mass 5.30×10^{-26} kg that is trapped in an alveolus.

What is the order of magnitude of the uncertainty in the velocity of this oxygen molecule?

A 10^{-5} m s^{-1}

B 10^{-8} m s^{-1}

C 10^{-10} m s^{-1}

D 10^{-12} m s^{-1}

30 The following represents a sequence of radioactive decays involving two α-particles and one β-particle.

$$^{217}_{85}\text{At} \xrightarrow{\alpha} \text{X} \xrightarrow{\alpha} \text{Y} \xrightarrow{\beta} \text{Z}$$

What is the nuclide Z?

A $^{213}_{85}\text{At}$ **B** $^{215}_{77}\text{Ir}$ **C** $^{209}_{82}\text{Pb}$ **D** $^{209}_{80}\text{Hg}$

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YISHUN INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME

CG

INDEX NO

PHYSICS

9749/02

Paper 2 Structured Questions

31 August 2022

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this page.
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 staples, paper clips, highlighters, glue or correction fluid/tape.

The use of 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	
Paper 2	
1	/12
2	/10
3	/6
4	/6
5	/10
6	/8
7	/8
8	/20
Penalty	
Paper 2 Total	
	/80

This document consists of **25** printed pages and **3** blank pages.

[Turn over

Data

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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}
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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	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature,	T/K	=	$T/°\text{C} + 273.15$
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	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega \sqrt{(x_o^2 - x^2)}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
magnetic flux density due to a 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	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

1 (a) A toy car moves up a ramp and travels across a gap to land on another ramp, as illustrated in Fig. 1.1.

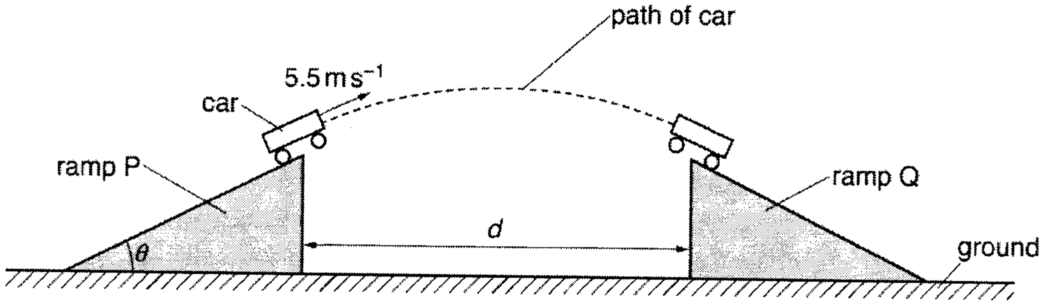

Fig 1.1

The car leaves ramp P with a velocity of 5.5 m s^{-1} at an angle θ to the horizontal. The car lands at the top of ramp Q. The tops of both ramps are at the same height and are distance d apart. Air resistance is negligible.

Taking θ = 33°, determine

(i) the time taken for the car to travel between the ramps

time = ... s [2]

(ii) the horizontal distance d between the tops of the ramps

d = ... m [2]

(iii) Calculate the ratio

$$\frac{\text{kinetic energy of the car at its maximum height}}{\text{kinetic energy of the car as it leaves ramp P}}$$

ratio = ... [2]

(b) A uniform beam AB of length 6.0 m is placed on a horizontal surface and then tilted at an angle of 31° to the horizontal, as shown in Fig. 1.2.

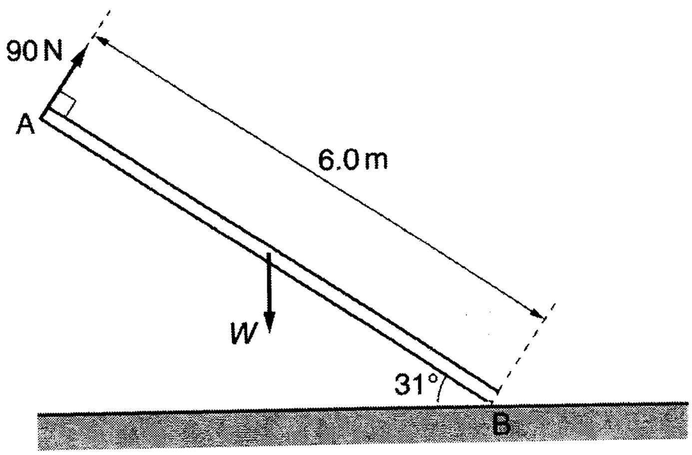

Fig 1.2

The beam is held in equilibrium by three forces that all act in the same plane. Two of the forces are shown in Fig. 1.2.

A force of 90 N acts perpendicular to the beam at end A. The weight *W* of the beam acts at its centre of gravity. The third force *F* acts at the end B of the beam by the ground.

(i) Draw the force *F* showing its direction.

[1]

(ii) Calculate weight *W* of the beam.

W = ... N [2]

(iii) Determine the magnitude of force *F*.

F = ... N [3]

[Total: 12]

2 A spring of length 5.0 cm is extended by a force. The variation with extension x of the force F is shown in Fig. 2.1.

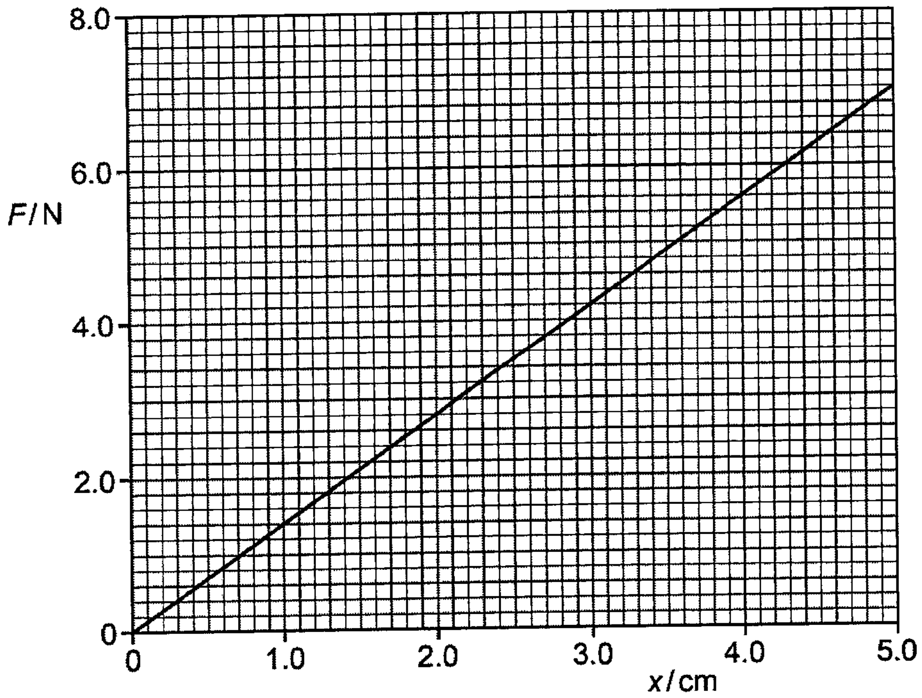

Fig. 2.1

(a) Describe how the graph in Fig. 2.1 shows that the spring obeys Hooke's law.

....

.... [1]

(b) Determine:

(i) the spring constant of the spring.

spring constant = ... N m^{-1} [1]

(ii) the elastic potential energy in the spring when x = 4.0 cm.

elastic potential energy = ... J [1]

(c) One end of the spring is attached to a fixed point. A cylinder that is submerged in a liquid is now suspended from the other end of the spring, as shown in Fig. 2.2.

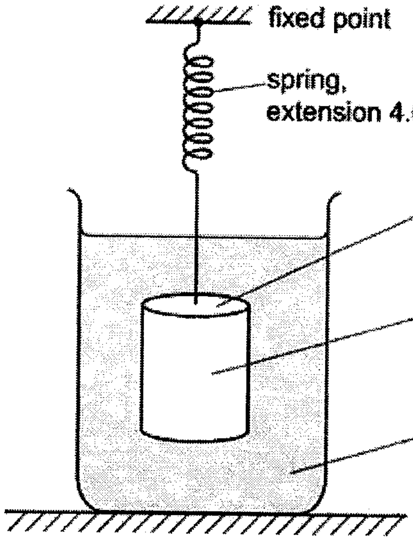

Fig. 2.2

The cylinder has a cross-sectional area 1.2×10^{-3} m^2 and weight 6.2 N. The cylinder is in equilibrium when the extension of the spring is 4.0 cm.

(i) Determine the upthrust acting on the cylinder.

upthrust = ... N [1]

(ii) Calculate the difference in pressure between the bottom face and the top face of the cylinder.

difference in pressure = ... Pa [2]

(d) State and explain the effect, if any, on the extension of the spring if the liquid in **(c)** is replaced by another liquid of greater density with the cylinder still fully submerged.

....

....

.... [2]

(e) The weight of the cylinder is given by

$$W = \pi r^2 h \rho g$$

where W is the weight of the cylinder, r is the radius of the cylinder, h is the height of the cylinder, ρ is the density of cylinder and g is the acceleration of free fall.

Data for the cylinder is shown in Table 2.3.

Table 2.3

quantity	magnitude	uncertainty
W/N	6.2	± 0.4
r/m	1.95×10^{-2}	$\pm 0.03 \times 10^{-2}$
ρ/kg m^{-3}	7800	± 300

The value of h can be determined using the data given above.

Determine the percentage uncertainty associated to h.

percentage uncertainty = ... % [2]

[Total: 10]

3 (a) By reference to the definition of gravitational potential, explain why gravitational potential is a negative quantity.

....

.... [2]

(b) Two stars A and B have their surfaces separated by a distance of 1.4×10^{12} m, as illustrated in Fig. 3.1.

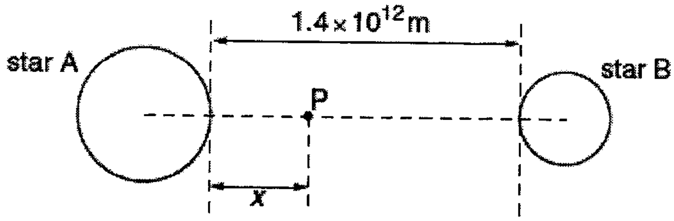

Fig. 3.1

Point P lies on the line joining the centres of the two stars. The distance x of point P from the surface of star A may be varied.

The variation with distance x of the gravitational potential ϕ at point P is shown in Fig 3.2.

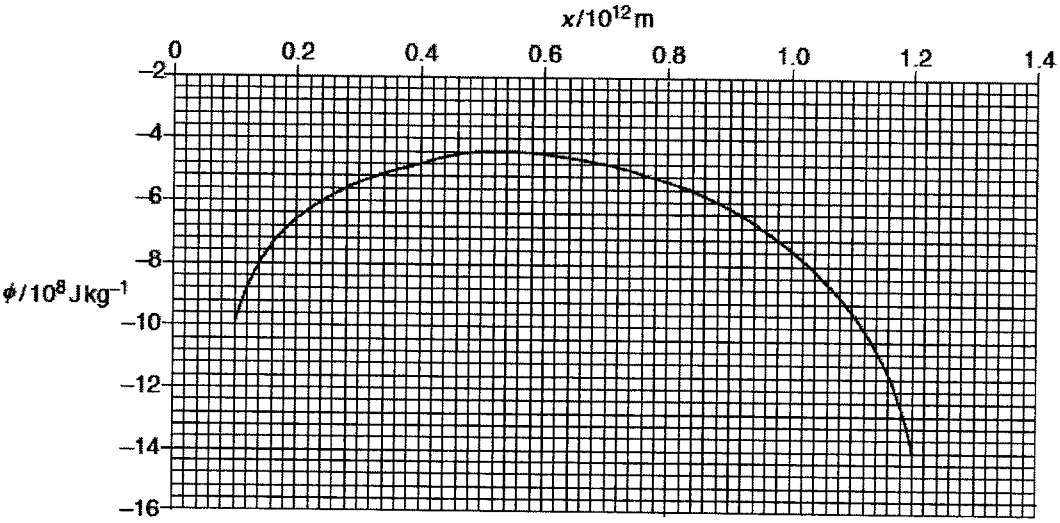

Fig. 3.2

A rock of mass 180 kg moves along the line joining the centres of the two stars, from star A towards star B.

(i) Using Fig. 3.2, state and explain the variation of the direction of the gravitational force experienced by the rock as it moves from $x = 0.1 \times 10^{12}$ m to $x = 1.2 \times 10^{12}$ m.

....

....

....

.... [2]

(ii) At a point where $x = 0.1 \times 10^{12}$ m, the speed of the rock is v.

Use data from Fig. 3.2, calculate the minimum value of v such that the rock is able to reach the point where $x = 1.2 \times 10^{12}$ m.

speed = ... m s^{-1} [2]

[Total: 6]

4 The piston in the cylinder of a car engine moves in the cylinder with simple harmonic motion. The piston moves between a position of maximum height in the cylinder to a position of minimum height, as illustrated in Fig. 4.1.

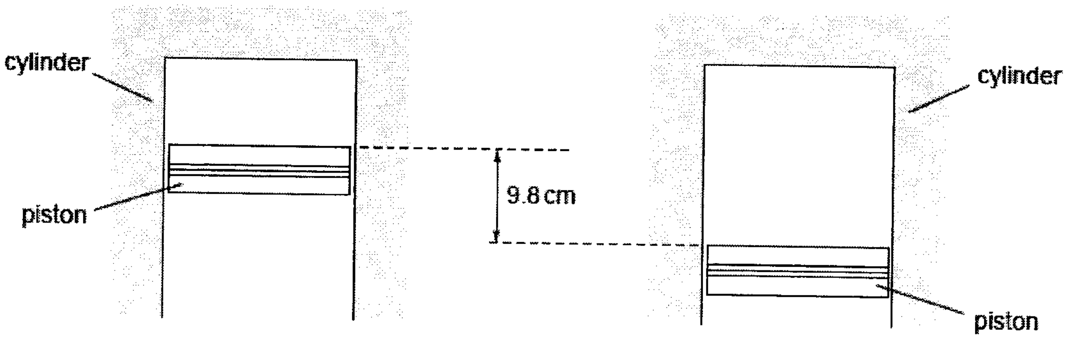

Fig. 4.1

The distance moved by the piston between the positions shown in Fig. 4.1 is 9.8 cm.

The mass of the piston is 640 g.

When the car is moving on the expressway, the piston completes 2700 oscillations in 1.0 minute.

(a) For the oscillations of the piston in the cylinder, determine

(i) the amplitude

amplitude = ... cm [1]

(ii) the frequency

frequency = ... Hz [1]

(iii) the speed of the piston when its top is 2.3 cm below its maximum height

speed = ... m s^{-1} [2]

(b) The acceleration of the piston varies.

Determine the resultant force on the piston that gives rise to its maximum acceleration.

force = ... N [2]

[Total: 6]

5 (a) State the first law of thermodynamics.

....

....

....

.... [1]

(b) A constant mass of an ideal gas has a volume of 3.49×10^3 cm^3 at a temperature of 21.0 °C. When the gas is heated, 565 J of thermal energy causes it to expand to a volume of 3.87×10^3 cm^3 at 53.0 °C. This is illustrated in Fig. 5.1.

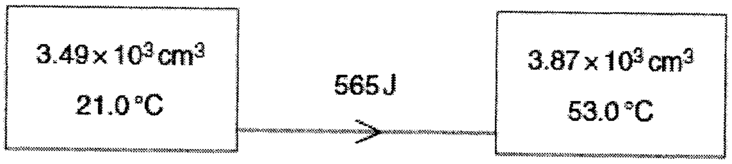

Fig. 5.1

(i) Show that the initial and final pressures of the gas are equal.

[2]

(ii) The pressure of the gas is 4.20×10^5 Pa.

For the heating of the gas, calculate the work done by the gas.

work done = ... J [2]

(iii) Hence determine the change in the internal energy of the gas.

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

(iv) Explain why the change in kinetic energy of the molecules of this ideal gas is equal to the change in internal energy.

....

....

....

....

.... [3]

[Total: 10]

6 (a) Define *magnetic flux density.*

....

....

.... [1]

(b) While inside a uniform magnetic field of magnetic flux density B, a particle of charge q and mass m has velocity of v and makes an angle of θ with the field as shown in Fig. 6.4.

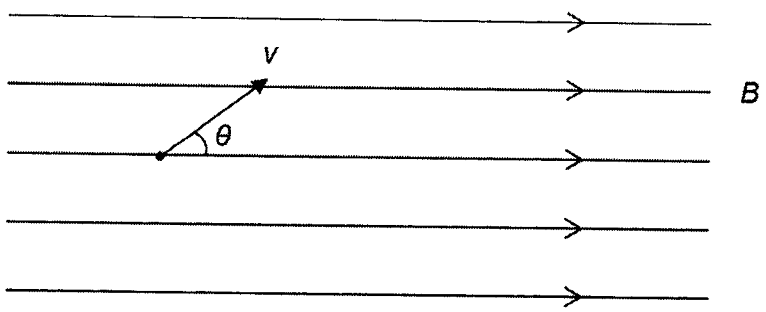

Fig. 6.4

(i) Explain why the particle will trace a helical path.

....

....

....

.... [2]

(ii) Show that the radius r of the helical path is given by the expression

$$r = \frac{m v \sin\theta}{B q}$$

[3]

(iii) Hence, or otherwise, show that the period of each cycle of the helical path is independent of θ.

[2]

[Total : 8]

7 **(a)** State Faraday's law of electromagnetic induction.

....

....

.... [1]

(b) A small coil is positioned so that its axis lies along the axis of a large bar magnet, as shown in Fig. 7.1.

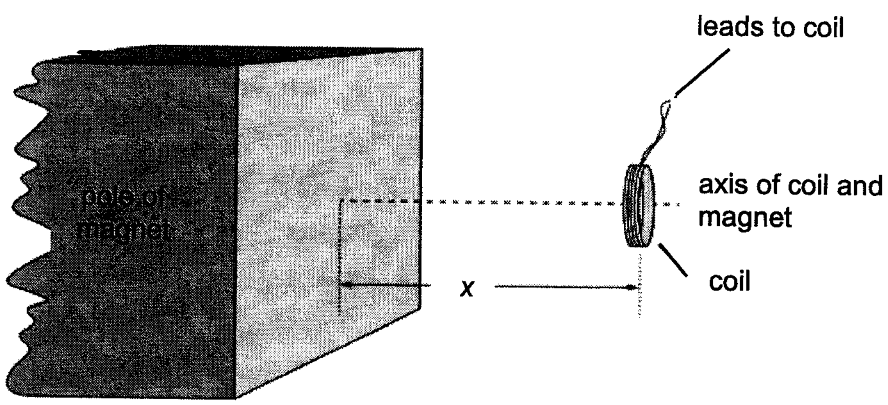

Fig. 7.1

The coil has a cross-sectional area of 0.40 cm^2 and contains 150 turns of wire. The average magnetic flux density B through the coil varies with the distance x between the face of the magnet and the plane of the coil, as shown in Fig. 7.2.

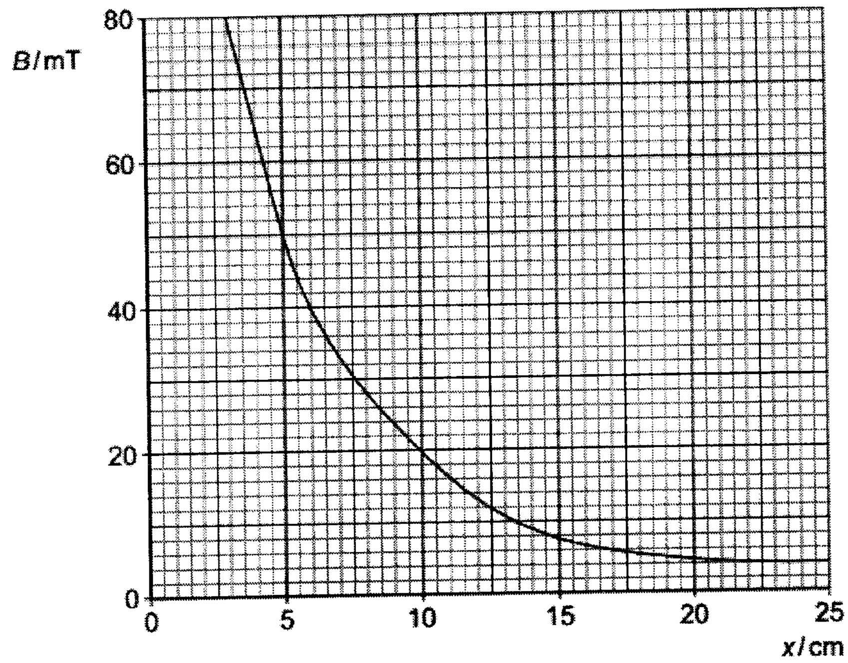

Fig. 7.2

The coil is moved along the axis of the magnet so that the distance x changes from $x = 5.0$ cm to $x = 15.0$ cm in a time of 0.30 s.

Calculate

(i) the change in magnetic flux linkage of the coil,

change in magnetic flux linkage = ... Wb [2]

(ii) the average e.m.f. induced in the coil.

induced e.m.f. = ... V [2]

(c) State and explain the variation, if any, of the speed of the coil so that the induced e.m.f. remains constant during the movement in **(b)(ii)**.

....

....

....

....

.... [3]

[Total : 8]

8 X-rays are a form of electromagnetic radiation, just like visible light and ultraviolet light are. Unlike light, however, X-rays have higher energy and can pass through many objects, including the human body.

Most X-ray wavelengths are between 0.01 nm to 10 nm.

Such rays can be produced in an X-ray tube, as shown in Fig. 8.1 below.

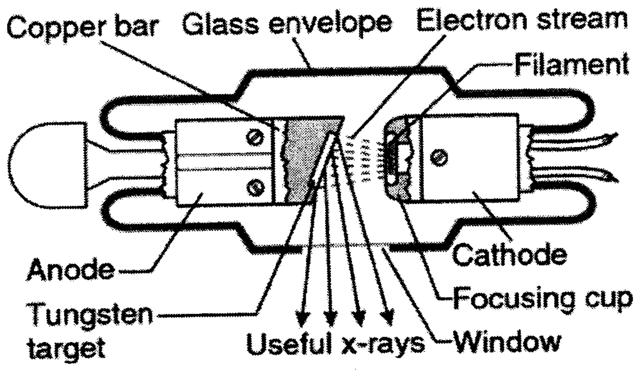

Fig. 8.1

Electrons are emitted at the cathode (C) in a process known as thermionic emission. The electrons then accelerate to the anode (A), thus hitting the target.

Specifications of a particular model of a commercial X-ray tube indicate that it produces a power of 4.0 kW whereas its power supply is 230V, 13A. The range of accelerating voltages is given as 40 – 115 kV.

Similar to other waves, X-rays suffer from attenuation. X-ray attenuation is the reduction in intensity of the X-rays as they are absorbed when travelling through matter. Bones absorb X-rays to a higher extent relative to muscle. That is why bones appear paler on X-ray film.

When X-rays travel through a given material, the intensity of the emergent beam can be calculated using the equation

$$I = I_0 e^{-\mu x}$$

where

I_0 = the intensity of the incident beam (in W m^{-2})

I = the intensity of the emergent beam (in W m^{-2})

μ = the linear absorption coefficient of a given material (in m^{-1})

x = the distance travelled through the material (in m)

(a) **(i)** Suggest why X-ray production is sometimes known as a reverse photoelectric effect process.

....

....

.... [1]

(ii) Determine the range of C-A currents in the X-ray tube above.

range of current = ... mA [2]

(iii) Typically, only 1% of the kinetic energy of the electrons is converted to X-rays. Suggest what happens to the rest of the kinetic energy.

....

....

.... [1]

(b) In the early part of the 20th century, Henry Moseley found that the energy E of the characteristic lines of the X-ray spectrum was related to the atomic number Z of the target material.

Mathematically, Moseley's law is written in the following form:

$$E = aE_1(Z - b)^2$$

where E is in keV and a, E_1 and b are constants.

For K_α lines, a = 0.75 and b = 1, whereas for L_α lines, a = 0.139 and b = 7.4.

Fig. 8.2 below shows the values of E for the L_α lines of different elements.

Element	Z	E (in keV)	$(Z - 7.4)^2$
Calcium	20	0.34	159
Manganese	25	0.64	
Zinc	30	1.01	511
Bromine	35	1.48	762
Zirconium	40	2.04	1063
Rhodium	45	2.70	1414

Fig. 8.2

The corresponding graph of E against $(Z - b)^2$ for L_α lines is shown in Fig. 8.3.

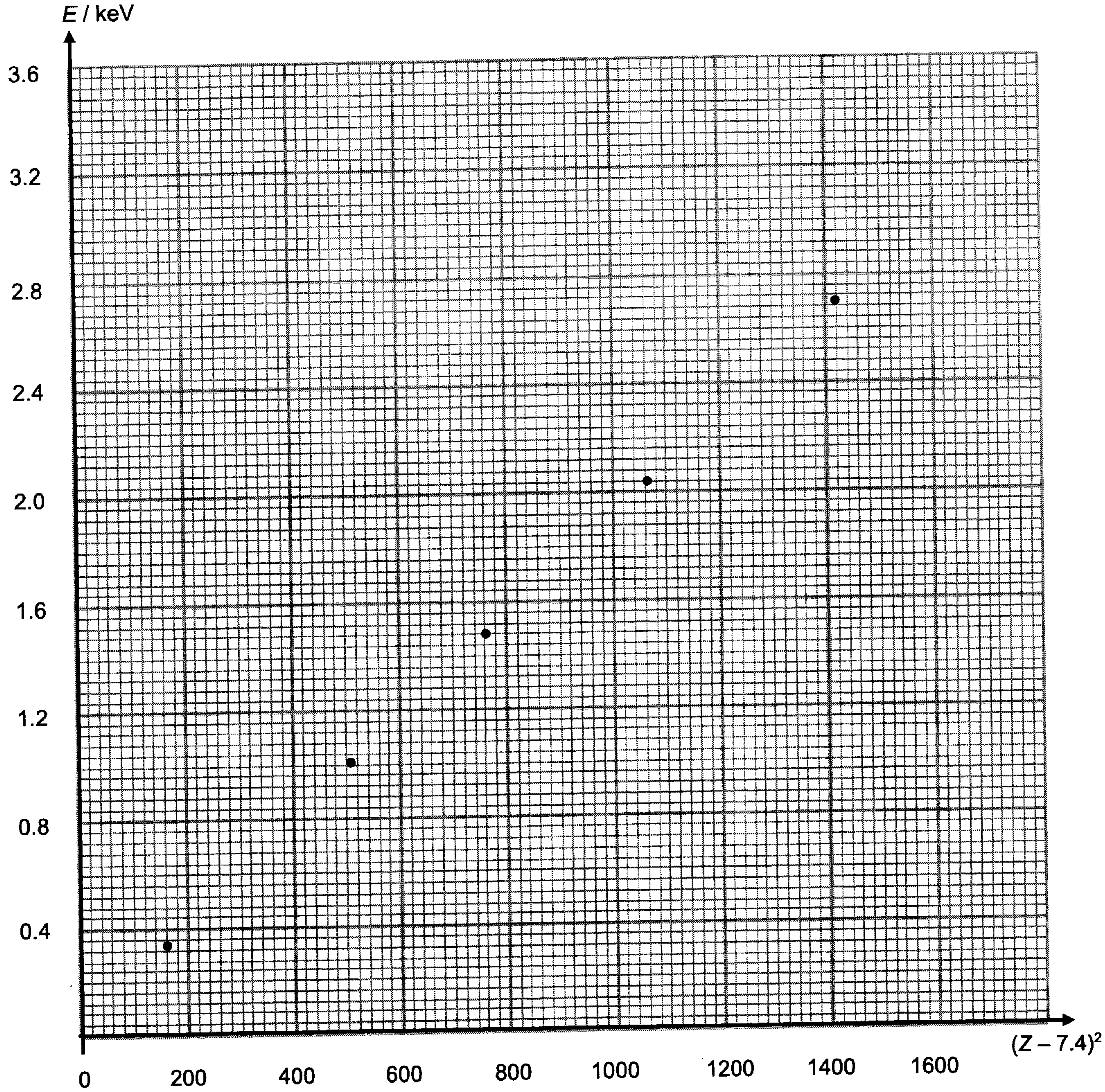
E / keV
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
200
400
600
800
1000
1200
1400
1600
(Z – 7.4)²

Fig. 8.3

(i) Complete Fig. 8.2 by filling up the missing value for manganese.

[1]

(ii) Plot the corresponding point on Fig. 8.3 and draw the corresponding best-fit line.

[2]

(iii) From the graph, determine the value of E_1.

E_1 = ... eV [2]

(iv) Based on the graph, suggest if the data is consistent with Moseley's law.

....

....

....

.... [2]

(v) The notation for the most stable isotope of tungsten is ${}^{184}_{74}W$. Deduce its corresponding value of E for its K_α line.

E = ... keV [2]

(vi) For rhodium, state and explain the value of the minimum accelerating voltage in the X-ray tube such that the L_α line will show up on its X-ray spectrum.

....

....

....

.... [2]

(c) The diagram of Fig. 8.4 shows the cross-section of a model arm, which is used in the investigation of the absorption of X-ray radiation.

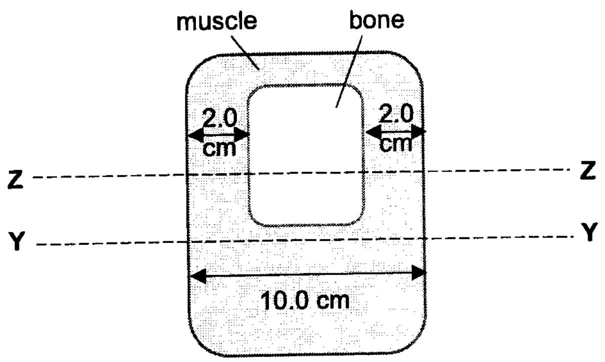

Fig. 8.4

Parallel X-ray beams are directed along the lines YY and ZZ. The linear absorption coefficients of the muscle and the bone are 0.30 cm^{-1} and 10 cm^{-1} respectively.

(i) Calculate the ratio

$$\frac{\text{Intensity of X-ray beam emerging from model}}{\text{Intensity of X-ray beam incident on model}}$$

for a parallel X-ray beam directed along the line

1. YY

ratio = ... [1]

2. ZZ

ratio = ... [2]

(ii) Hence, state and explain whether the X-ray images will have good contrast.

....

....

....

.... [2]

[Total : 20]

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JC 2 PRELIMINARY EXAMINATION
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INDEX NUMBER

PHYSICS

9749/03

Paper 3 Longer Structured Questions

13 September 2022

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this page.
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 staples, paper clips, highlighters, glue or correction fluid/tape.

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

Section A
Answer **all** questions.

Section B
Answer any **one** question.

You are advised to spend one and a 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	
Section A	
1	/12
2	/12
3	/10
4	/10
5	/10
6	/6
Section B	
7	/20
8	/20
Penalty	
	/80

This document consists of **23** printed pages and 1 blank page.

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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	=	$\rho g h$
gravitational potential,	ϕ	=	$-\frac{Gm}{r}$
temperature,	T/K	=	$T/°C + 273.15$
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	=	$x_o \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_o \cos \omega t$
		=	$\pm \omega \sqrt{(x_o^2 - x^2)}$
electric current,	I	=	$A n v q$
resistors in series,	R	=	$R_1 + R_2 + \ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage,	x	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil,	B	=	$\frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_o n I$
radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

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Section A

Answer **all** questions in the spaces provided.

1 A ball of mass 0.059 kg is thrown vertically downwards to the ground, as illustrated in Fig. 1.1.

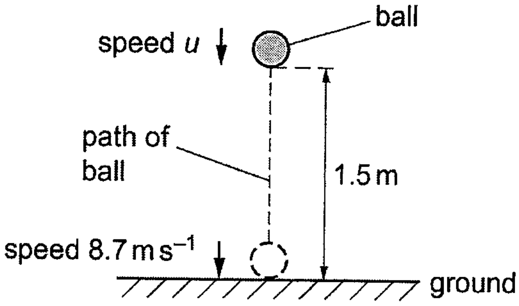


Fig. 1.1

The ball is thrown with speed u from a height of 1.5 m. The ball then hits the ground with speed 8.7 m s^{-1}. Assume that air resistance is negligible.

(a) Calculate speed u.

u = ... m s^{-1} [2]

(b) The ball was thrown downwards at time $t = 0$ and hits the ground at time $t = T$.

On Fig. 1.2, sketch a graph to show the variation of the speed of the ball with time t, from time $t = 0$ to when it hits the ground at time $t = T$. Numerical values are not required.

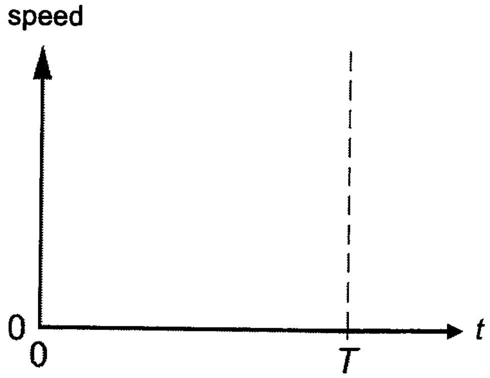


Fig. 1.2

[1]

(c) State how Newton's third law applies to the forces between the ball and the ground during the collision.

....

....

.... [2]

(d) The ball is in contact with the ground for a time of 0.091 s. The ball rebounds vertically and leaves the ground with speed 5.4 m s^{-1}.

(i) Calculate the change in momentum of the ball during the collision.

change in momentum = ... N s [2]

(ii) Calculate the magnitude of the average force exerted by the ground on the ball during collision.

average force = ... N [3]

(e) In practice, air resistance is not negligible.

State and explain the variation, if any, with time *t* of the gradient of the graph in **(b)**.

....

....

.... [2]

[Total: 12]

2 (a) Explain why, for an object moving in a horizontal circular motion at a constant speed, its resultant force must be perpendicular to its velocity.

....

....

.... [2]

(b) A theme-park ride consists of two cages. They are moving in a circular path at constant speed v about a horizontal axis. Fig. 2.1 shows the ride at one instant when cage A is vertically above cage B.

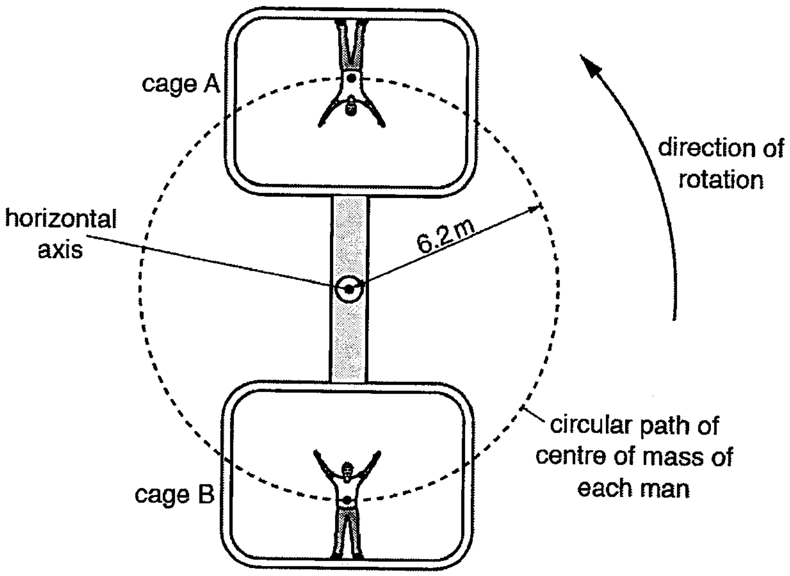


Fig. 2.1 (not to scale)

A man is riding in each cage. The mass of each man is 75 kg. The centre of mass of each man is 6.2 m from the horizontal axis. The period of one rotation is 4.1 s.

(i) Determine the speed v of the centre of mass of each man.

v = ... m s^{-1} [2]

(ii) Calculate the magnitude of the acceleration of the centre of mass of each man.

acceleration = ... m s^{-2} [2]

(iii) Calculate the magnitude of the normal contact force R_B on the man in cage B at this instant.

R_B = ... N [2]

(c) Explain why a minimum value for the speed is needed for the man in cage A to maintain contact with the floor of his cage.

....

....

.... [2]

(d) Determine the minimum speed required for the man in cage A to maintain contact with the floor of his cage.

minimum speed = ... m s^{-1} [2]

[Total: 12]

3 A battery is connected with resistors *R*, X and Y, as shown in Fig. 3.1.

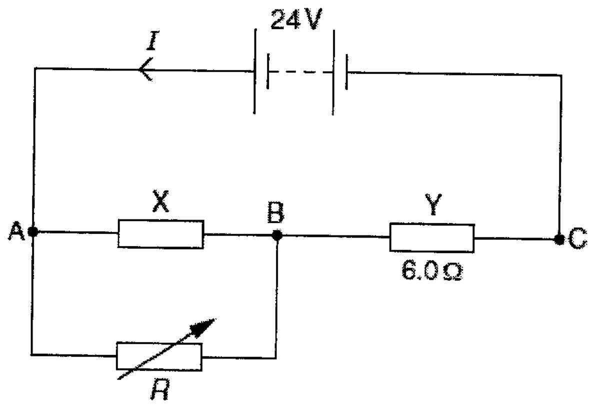


Fig. 3.1

The resistance of X is constant. The resistance of Y is 6.0 Ω. The battery has electromotive force (e.m.f.) 24 V and zero internal resistance. A variable resistor of resistance *R* is connected in parallel with X.

The current *I* from the battery is changed by varying *R* from 5.0 Ω to 20 Ω. The variation with *R* of *I* is shown in Fig. 3.2.

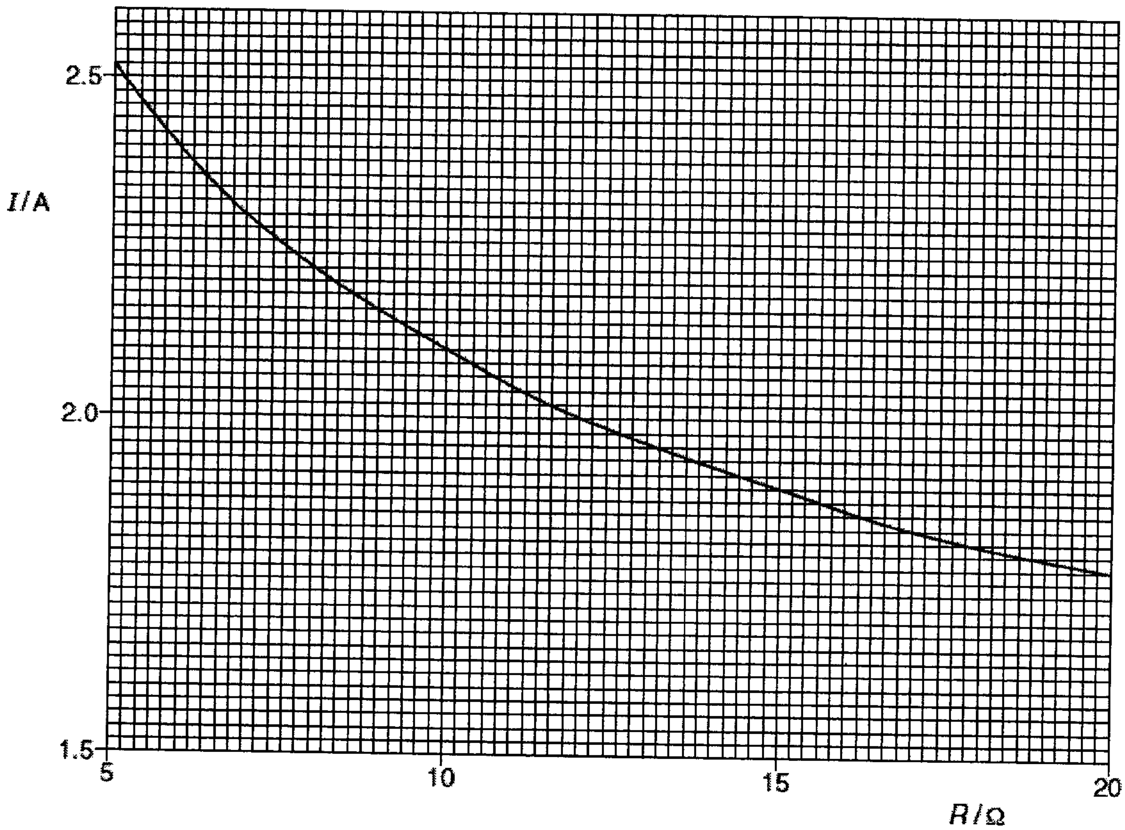


Fig. 3.2

(a) Explain why the potential difference (p.d.) between points A and C is 24 V for all values of *R*.

....

.... [1]

[Turn over

(b) Use Fig. 3.2 to state and explain the variation of p.d. across resistor Y as R is increased. Numerical values are not required.

....

....

.... [2]

(c) For $R = 6.0\ \Omega$,

(i) show that the p.d. between A and B is 9.6 V,

[2]

(ii) calculate the resistance of X,

resistance = ... Ω [3]

(iii) calculate the power provided by the battery.

power = ... W [1]

(d) State and explain qualitatively how the power provided by the battery changes as the resistance R is increased.

....

.... [1]

[Total: 10]

4 Two long straight vertical wires X and Y pass through a horizontal card, as shown in Fig. 4.1.

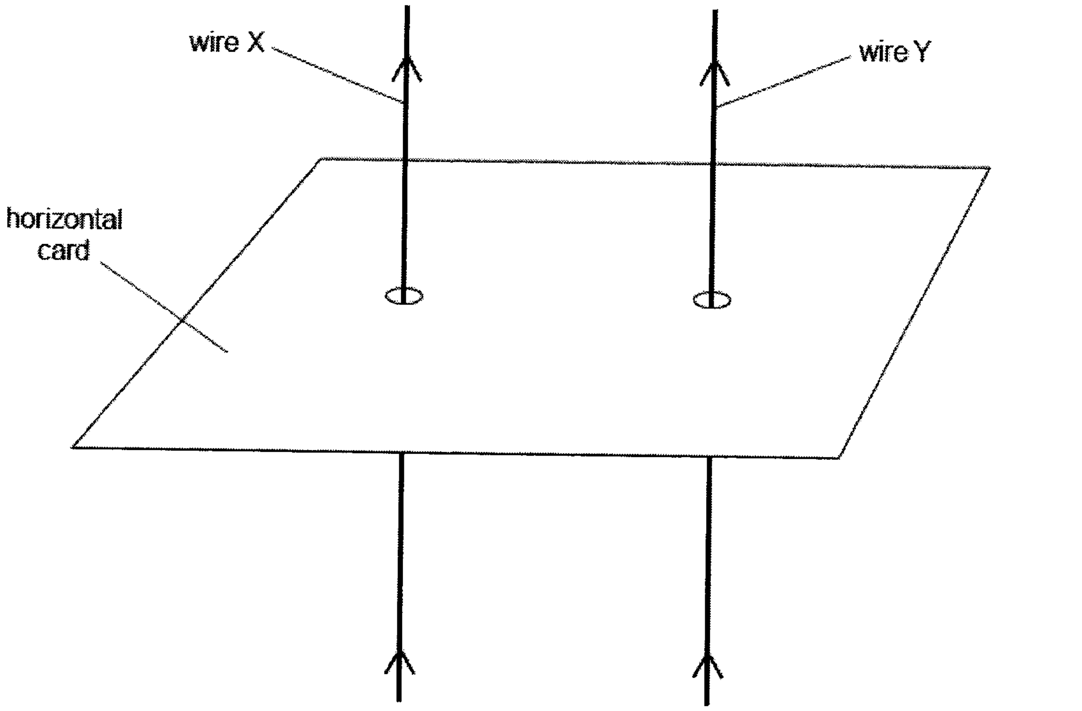


Fig. 4.1

The current in each wire is in the upward direction.

The top view of the card, seen by looking downwards at the card, is shown in Fig. 4.2.

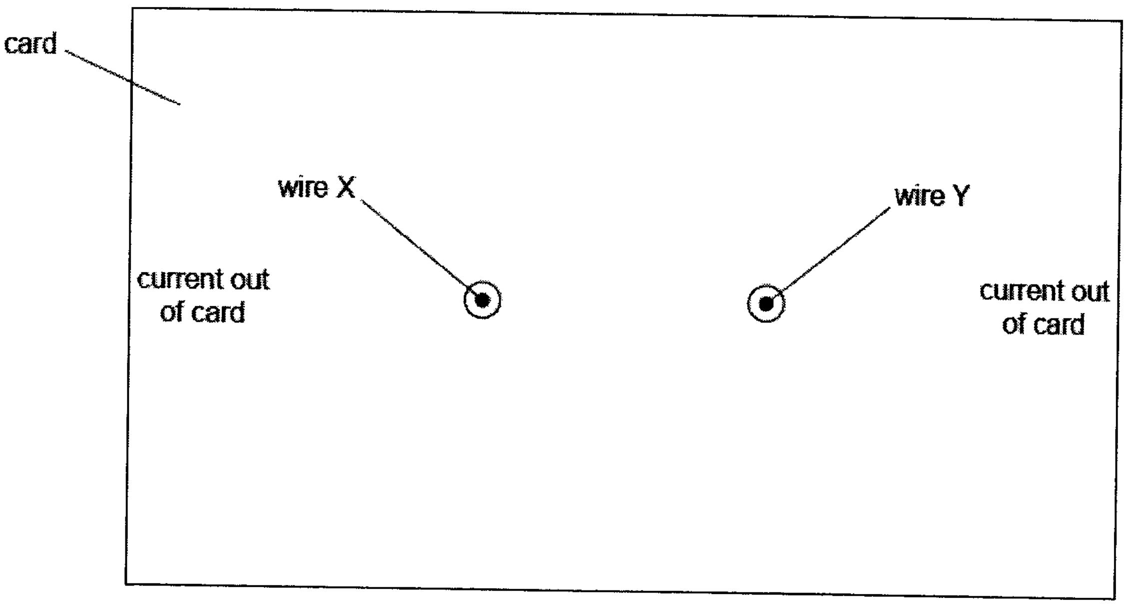


Fig. 4.2 (not to scale)

(a) On Fig. 4.2,

(i) draw four field lines to represent the pattern of the magnetic field around wire X due solely to the current in wire X, [2]

(ii) draw an arrow to show the direction of the force on wire Y due to magnetic field of wire X. [1]

(b) The current in the wire X is 5.0 A and that in wire Y is 7.0 A. The separation of the wires is 2.5 cm.

(i) Calculate the force per unit length on the wire Y due to the current in wire X.

force per unit length = ... N m^{-1} [3]

(ii) The currents in the wires are not equal.

State and explain whether the forces on the wires are equal in magnitude.

....

....

....

....[2]

(c) The direct currents in wires X and Y are now replaced by sinusoidal alternating currents of equal peak values. The currents are in phase.

Describe the variation, if any, of the force experienced by wire Y.

....

....

....

....

.... [2]

[Total: 10]

5 (a) Explain what is meant by r.m.s. value of an alternating voltage in terms of energy dissipation.

....

....

.... [2]

(b) A voltage supply V_s has the voltage output waveform as shown in Fig. 5.1. The curved portion of the voltage follows a sinusoidal shape.

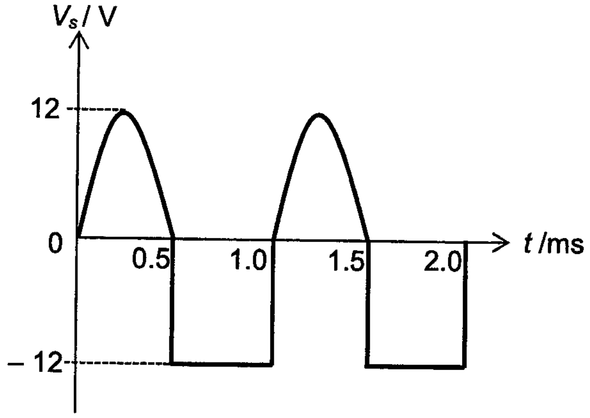


Fig. 5.1

(i) Calculate the root-mean-square voltage of this supply.

root-mean-square voltage = ...V [3]

(ii) The voltage supply is then connected to a circuit as shown in Fig. 5.2. Each of the three resistors has a resistance of 10 Ω. The two diodes can be taken to be ideal. The value of the voltage shown in Fig. 5.1 is taken to be positive when terminal X is at higher potential.

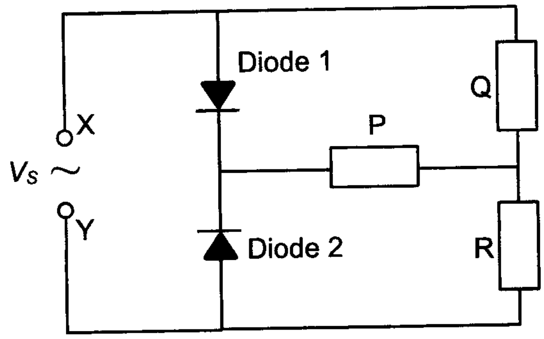


Fig. 5.2

In Fig. 5.3, state whether each diode is forward-biased or reversed-biased when terminal X of the voltage supply is at a higher potential.

Diode 1	
Diode 2	

Fig. 5.3

[1]

(iii) Calculate the maximum potential difference across resistor P when terminal X of the supply is at higher potential.

potential difference = ... V [2]

(iv) Hence, sketch on Fig. 5.4 below, how the potential difference, V_P, across resistor P varies with time from $t = 0$ until $t = 2.0$ ms. Exact numerical values are not required.

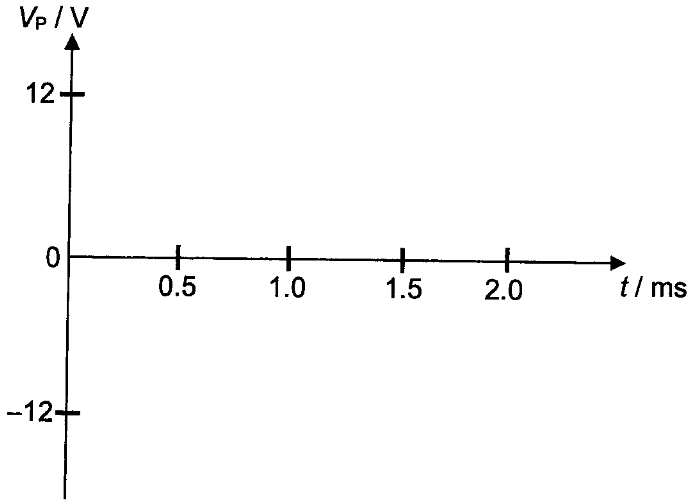


Fig. 5.4 [2]

[Total : 10]

6 (a) Data for the wavelength λ of the radiation incident on a metal surface and the maximum kinetic energy E_k of the emitted electrons are shown in Fig. 6.1.

λ /nm	E_k/10^{-19} J
670	–
240	4.44

Fig. 6.1

(i) Without any calculation, suggest why no value is given for E_k for radiation of wavelength 670 nm.

....

....[1]

(ii) Use data from Fig. 6.1 to determine the threshold frequency of the surface.

threshold frequency = ...Hz [2]

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

State and explain the effect of this change on

1. E_k

....

....

.... [1]

2. I

....

....

.... [2]

[Total : 6]

Section B

Answer **one** question from this Section in the spaces provided.

7 **(a)** Distinguish between *longitudinal* and *transverse* progressive waves.

....

....

....

.... [2]

(b) The intensity of sound from a loudspeaker as perceived by an observer is the same at a distance D from it in all directions. The amplitude of the sound heard at this distance is A.

The power of the loudspeaker is now halved.

(i) Deduce the value of the new amplitude in terms of A when the observer remains at the same distance D from the source.

amplitude = ... [2]

(ii) Determine, in terms of D, the new distance from the loudspeaker that the observer should be at if he wishes the sound to seem as loud as before.

distance = ... [2]

(c) Fig. 7.1 shows two loudspeakers S and T separated by a distance of 0.50 m. They are connected to separate signal generators. The line OY is at a distance d from the loudspeakers and point O is equidistant from loudspeakers S and T.

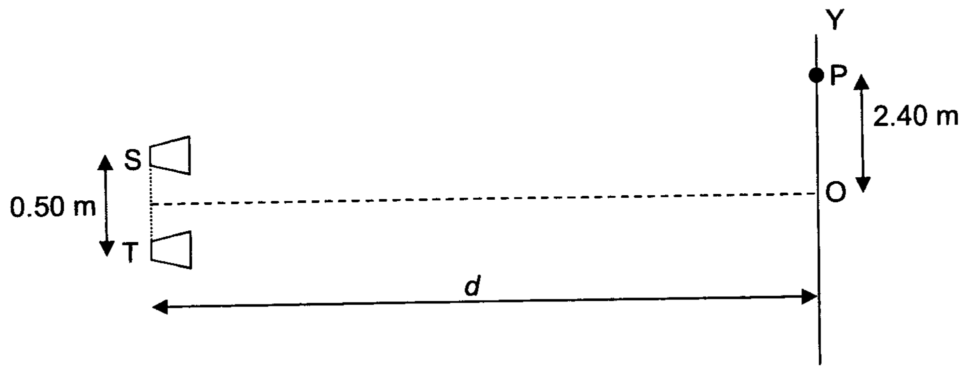
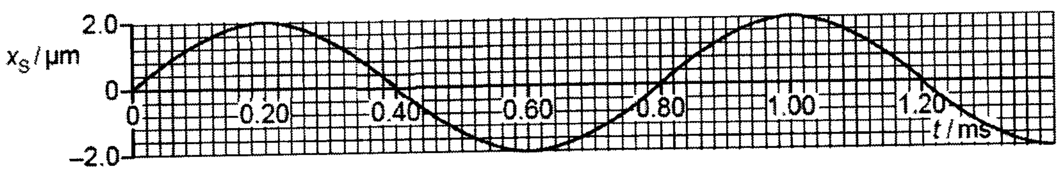


Fig. 7.1 (not to scale)

Fig. 7.2 shows the sound waves emitted by S and T having displacements x_S and x_T respectively at point P. Point P is the position of the first minimum at distance 2.40 m from point O. The graphs show the variation with time t of each of these displacements.

Wave arriving at P from loudspeaker S only.



Wave arriving at P from loudspeaker T only.

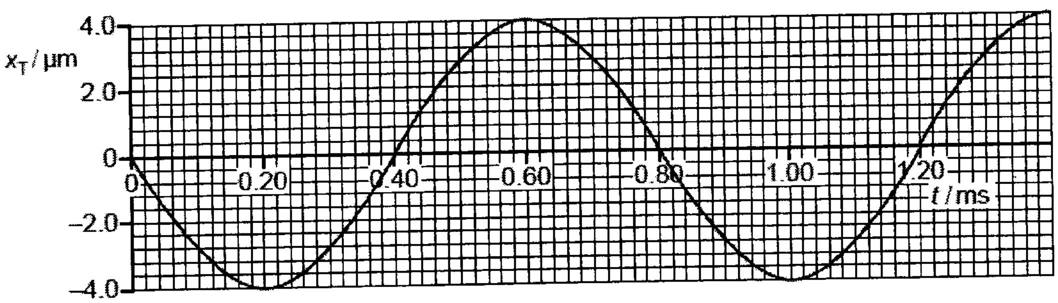


Fig.7.2

(i) With reference to Fig. 7.2, explain whether the two sound waves are coherent.

....

.... [1]

(ii) Explain why the sound heard at P is of non-zero intensity.

....

....

.... [2]

(iii) The intensity of the waves arriving at P from source S only has the intensity I. State, in terms of I, the intensity of the combined sound when waves from both sources S and T arrive at P.

intensity = ... [1]

(iv) Use data from Fig. 7.2 to determine the wavelength of the sound waves emitted from the loudspeakers. The speed of sound is 330 m s^{-1}.

wavelength = ... m [2]

(d) Based on the layout in Fig. 7.1, a student drew a more detailed version with angle θ shown in Fig. 7.3. The length TQ represents the path difference between the two loudspeakers to P. This is to help him with the steps towards determining the value of *d*.

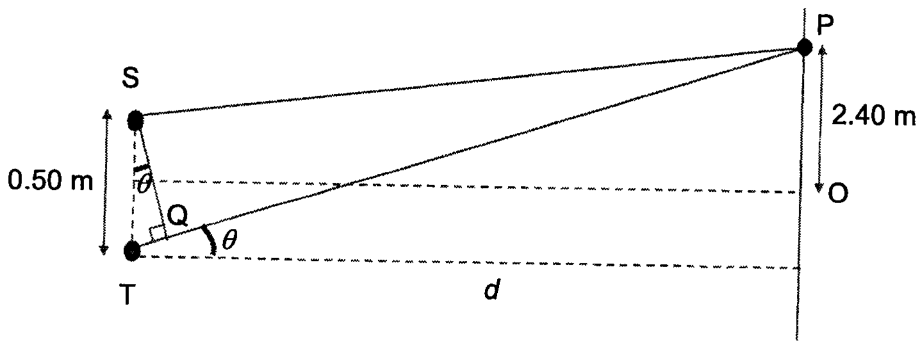


Fig. 7.3 (not to scale)

Note that point O is also a position of minimum intensity.

(i) State the value of the path difference between TP and SP.

path difference = ... m [1]

(ii) Hence, determine

1. the angle θ.

angle θ = ... ° [2]

2. the value of d.

d = ... m [2]

(iii) To find the distance d in Fig. 7.3, another student suggested using the Young's double-slit interference formula,

$$\text{wavelength } \lambda = \frac{ax}{d}$$

where a = slit separation
x = fringe separation
d = perpendicular distance between the double slit and screen

Explain why it is wrong to do so for this case.

....

....

.... [2]

(e) Another student noted that the sound from the loudspeakers travelled through a metal grill fence like those shown in Fig. 7.4. This fence is situated between the loudspeakers and the line OY.

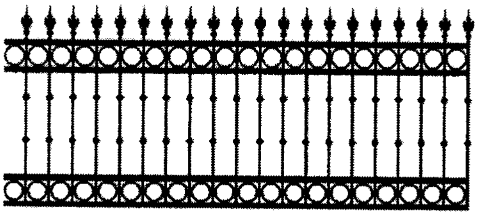


Fig. 7.4

He then suggested that the variation in the sound intensity across the line OY can be attributed to the effects of polarisation.

Suggest how polarisation could not be the contributing factor.

....

.... [1]

[Total: 20]

8 (a) In the early 1900s, Geiger and Marsden (1909) fired a beam of alpha particles at a thin foil of gold. The experiment was conducted in a dark room.

A setup of this experiment is as shown in Fig. 8.1 below.

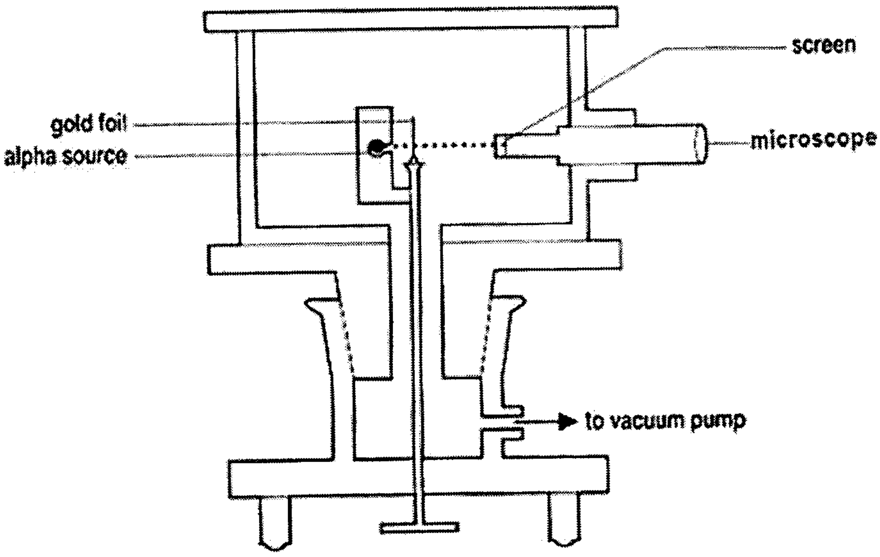


Fig. 8.1

(i) Explain the significance of the vacuum pump.

....

....

.... [2]

(ii) Suggest why the room is darkened.

....

....

.... [2]

(iii) State one of the experimental observations and corresponding implications on the understanding of the structure of the gold atom.

Observation:

....

....

....

Implication:

....

....

.... [2]

(iv) Fig. 8.2 below shows two alpha particles approaching a gold nucleus inside the foil. Both will be deflected by the nucleus.

The arrows indicate the direction of the velocities at line A. Sketch their respective paths from line A to line B.

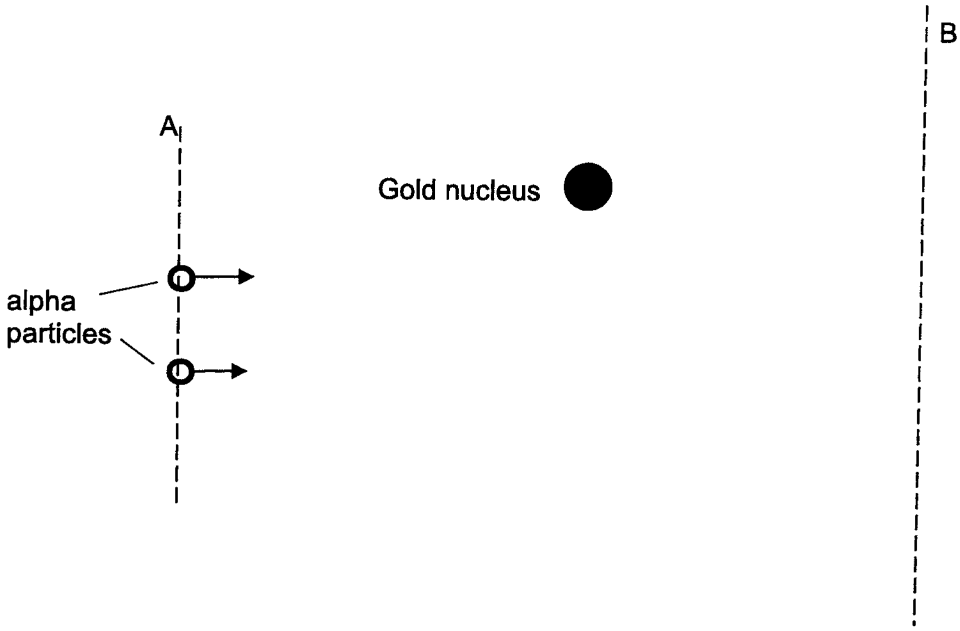


Fig. 8.2

[2]

(b) Data for the masses of some particles and nuclei are given in Fig. 8.3.

	mass / u
proton	1.0073
neutron	1.0087
deuterium ($^{2}_{1}H$)	2.0141
zirconium ($^{97}_{40}Zr$)	97.0980

Fig. 8.3

(i) Show that the energy equivalence of 1.0 u is 934 MeV.

[2]

(ii) State what is meant by the binding energy of a nucleus.

....

....

.... [2]

(iii) Determine the binding energy per nucleon of zirconium.

binding energy per nucleon = ... MeV [3]

(c) The spontaneous and random decay of a radioactive substance involves the emission of one or more types of radiation.

(i) Explain what is meant by spontaneous decay.

....

....

.... [1]

(ii) Describe how the randomness of decay is manifested in a decay curve.

....

....

.... [1]

(iii) Fill up the table in Fig. 8.4 by stating the type of radiation emitted during decay, one in each case, that

1. is not affected by electric and magnetic fields,

2. produces the greatest number of ions per unit length along its path,

3. does not directly result in a change in the proton number of the nucleus,

4. has a range of energies, rather than discrete values.

	Type of radiation
1.	
2.	
3.	
4.	

Fig. 8.4 [2]

(iv) Explain why the radiation in **(c)(iii)4**. has a range of energies.

....

....

.... [1]

[Total : 20]

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YISHUN INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
Higher 2

CANDIDATE NAME			
CG		INDEX NO	

PHYSICS

9749/04

Paper 4 Practical

25 Aug 2022

2 hours 30 minutes

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

READ THESE INSTRUCTIONS FIRST

Write your name and class in the spaces at the top of this page.
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, highlighters, glue or correction fluid/tape.

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 marks if you do not show your working, where appropriate, in the boxes provided.

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	
1	/ 14
2	/ 6
3	/ 23
4	/12
Total	/ 55

This document consists of **17** printed pages and **3** blank pages.

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1 In this experiment, you will investigate an electrical circuit.

(a) Assemble the circuit as shown in Fig. 1.1.

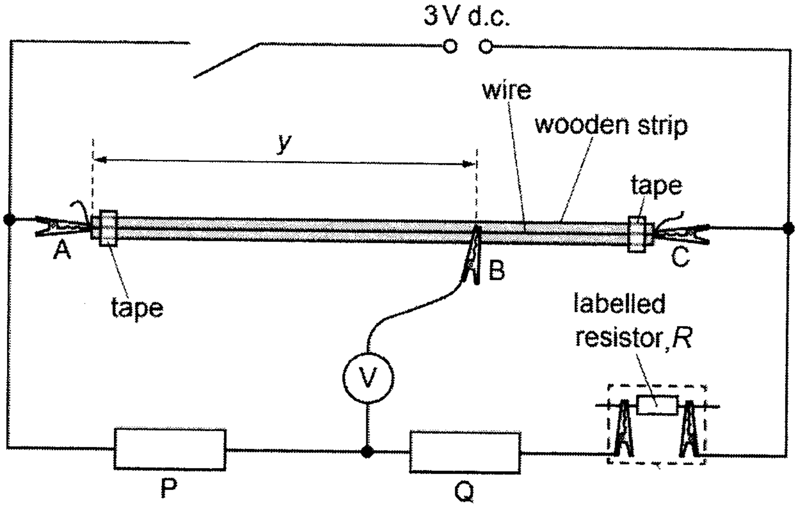


Fig. 1.1

Connect the resistor labelled 150 Ω and record it as resistance R.

R = ...

Close the switch. The voltmeter reading will be non-zero.

Adjust the position of B on the wire until the voltmeter reading is as close as possible to zero.

The distance between A and B is y, as shown in Fig. 1.1.

Measure and record y.

y = ... [1]

Open the switch.

(b) Change the labelled resistor R and repeat **(a)**.

Present your results clearly.

[3]

(c) It is suggested that the quantities y and R are related by the equation

$$\frac{1}{y} = a(R + b)$$

where a and b are constants.

Plot a suitable graph to determine a and b.

a = ...

b = ...

[6]

(d) Measure and record the length W of the wire between the crocodile clips A and C.

W = ... [1]

(e) The resistor P has resistance P.

Calculate the value of P using the relationship

$$a = \frac{1}{PW}$$

P = ... [1]

(f) The experiment is repeated with a larger value of P.

Sketch a line on your graph grid on page 5 to show the expected result.

Label this line Z.

[1]

(g) Explain, without calculation, why the value of y is approximately equal to 0 cm when resistor P is replaced with a wire of negligible resistance.

....

....

.... [1]

[Total: 14]

[Turn over

2 In this experiment, you will investigate the result of a collision between two cylinders.

(a) The thicker wooden cylinder has diameter D.

Measure and record D.

D = ... [1]

(b) The thinner wooden cylinder has diameter d.

Measure and record d.

d = ... [1]

(c) (i) You have been provided with a wooden ruler with a line drawn on the face without the scale.

Use the stand, boss and clamp to set up the ruler in the position shown in Fig. 2.1. The end near the line should touch the cork board and the other end should be approximately 7 cm above the bench.

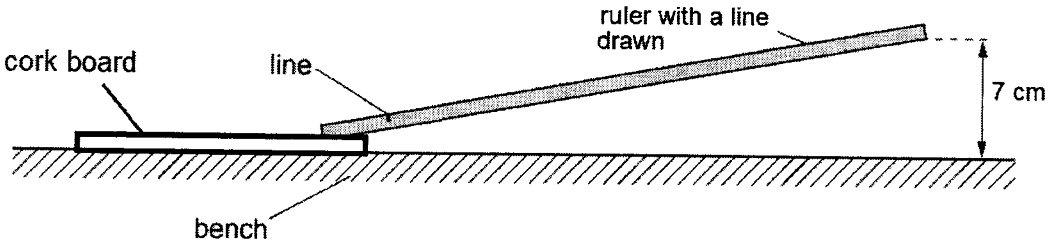


Fig 2.1

Place the cylinder with smaller diameter approximately 8 cm from the end of the wooden ruler.

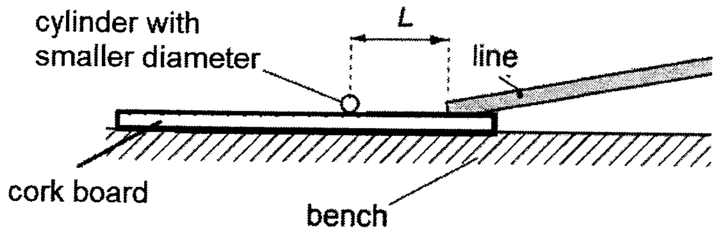


Fig 2.2

The distance between the end of the ruler and the cylinder is L, as shown in Fig. 2.2.

Measure and record L.

L = ...

(ii) Place the cylinder with bigger diameter on the line on the ruler as shown in Fig 2.3.

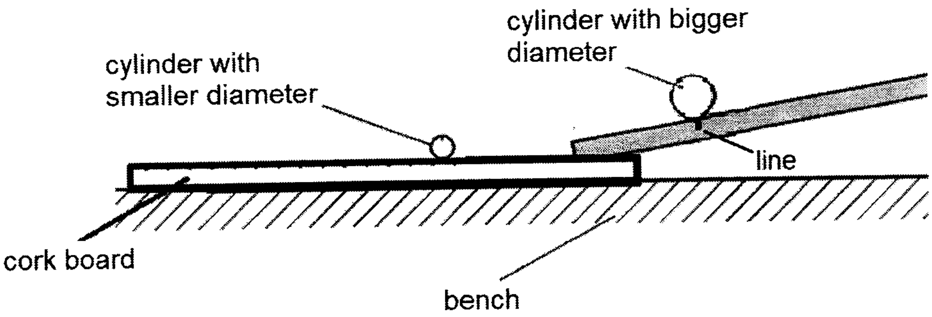


Fig 2.3

Release the cylinder of the bigger diameter.

It will roll down the ruler and on the cork board until it collides with the cylinder of the smaller diameter.

The cylinder of the smaller diameter will roll and then come to rest as shown in Fig. 2.4.

The distance between the cylinder of smaller diameter and the end of the ruler is l, as shown in Fig. 2.4.

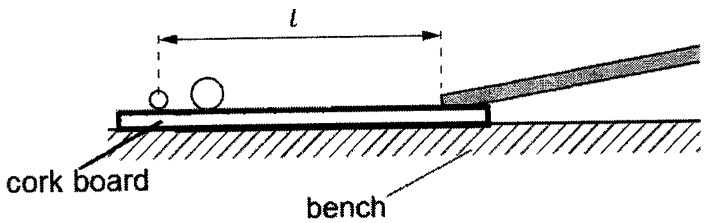


Fig 2.4

Measure and record l.

l = ... [1]

(d) It is suggested that the relationship between l, L, D and d is

$$(l-L)^2 = z(D-d)^3$$

where z is a constant.

(i) Using your data, calculate z.

z = ... [1]

(ii) If you were to repeat this experiment using a similar wooden ruler and cylinders but with different starting position of the cylinder with smaller diameter, describe the graph that you would plot and how *z* can be determined from the graph.

....

....

....

....

.... [2]

[Total: 6]

3 In this experiment, you will investigate the motion of a loaded plastic ruler.

(a) Assemble the apparatus as shown in Fig. 3.1.

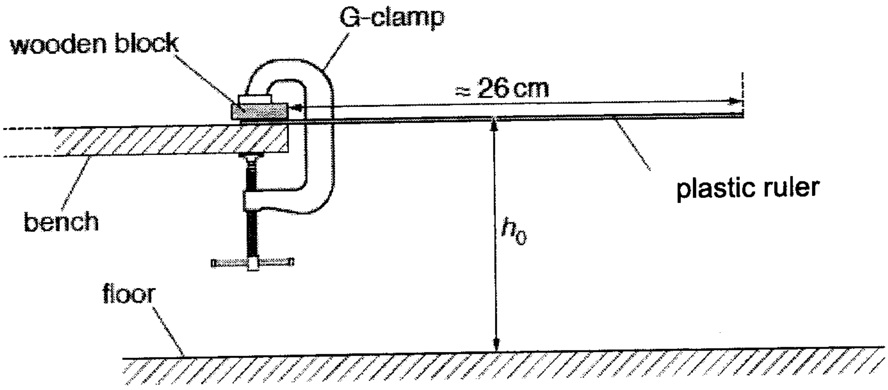


Fig. 3.1 (not to scale)

The vertical distance from the floor to the top surface of the plastic ruler is h_0, as shown in Fig. 3.1.

Measure and record h_0.

h_0 = ... [1]

(b) (i) Place the 50 g slotted mass on the plastic ruler with its centre approximately 19 cm from the bench and tape it in position.

When released, the plastic ruler will bend down, as shown in Fig. 3.2.

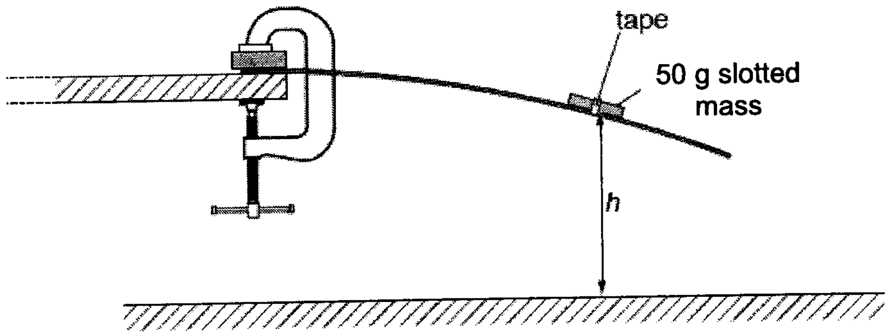


Fig. 3.2 (not to scale)

The vertical distance from the floor to the top surface of the plastic ruler at the centre of the mass is h.

Measure and record h.

h = ... [1]

(ii) Calculate y, where $y = h_0 - h$.

y = ... [1]

[Turn over

(c) (i) Estimate the percentage uncertainty in your value of *y*.

percentage uncertainty = ... [1]

(ii) Suggest one significant source of uncertainty in this experiment.

....

....

.... [1]

(iii) Suggest an improvement that could be made to the experiment to reduce the uncertainty identified in **(c)(ii)**.

You may suggest the use of other apparatus or a different procedure.

....

....

.... [1]

(d) Push the end of the plastic ruler down a small distance and then release it. The plastic ruler will oscillate.

Determine the period *T* of the oscillations.

T = ... [2]

(e) Move the slotted mass approximately 3 cm further from the bench and fix it with tape.

Measure and record *h*.

h = ...

Repeat **(b)(ii)** and **(d)**.

y = ...

T = ...

[3]

(f) It is suggested that the relationship between T and y is

$$T = c\sqrt{y}$$

where c is a constant.

(i) Using your data, calculate two values of c.

first value of c = ...

second value of c = ...

[1]

(ii) Justify the number of significant figures given for your values of c.

....

.... [1]

(iii) State whether the results of your experiment support the suggested relationship.

Justify your conclusion by referring to your answers in **(c)(i)**.

....

....

....

....

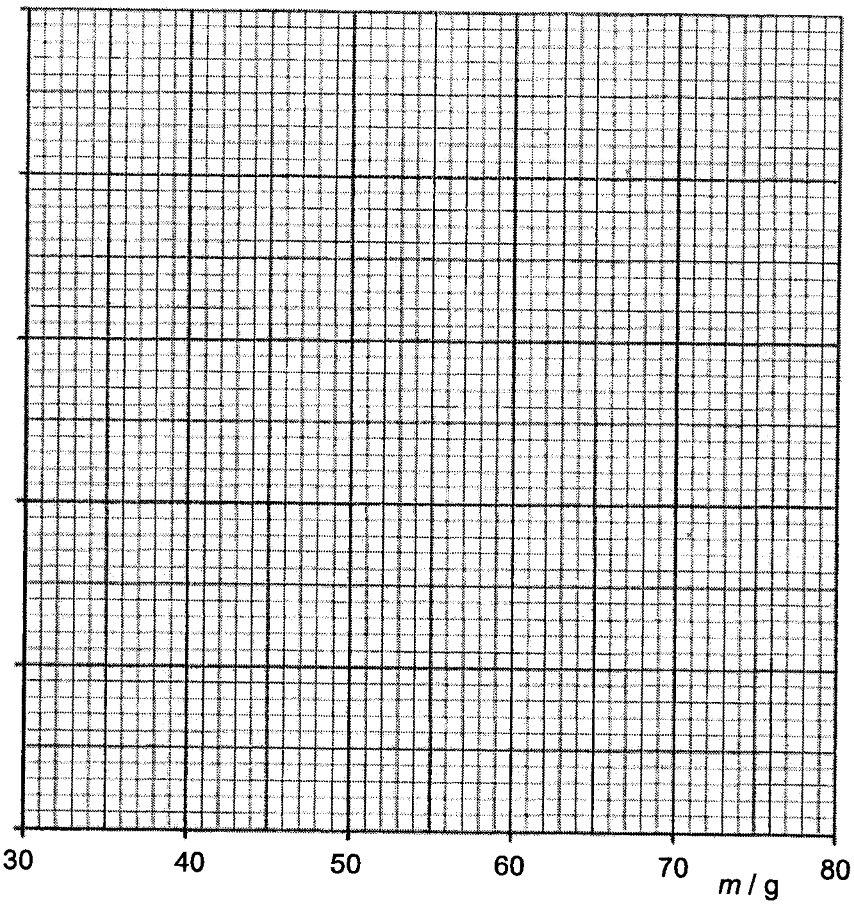
.... [1]

(g) In an investigation, the mass *m* of the slotted mass attached to the centre of the plastic rule was varied.

The following results for *m* and *T* were recorded. The value of T^2 is then calculated.

m / g	40	50	60	70	80
T / s	0.3250	0.3555	0.3794	0.4074	0.4243
T^2 / s^2	0.1056	0.1264	0.1439	0.1660	0.1800

(i) Plot T^2 against *m* on the grid and draw the straight line of best fit. [2]



(ii) Use your graph to determine the value of *T* when no mass is attached to the plastic rule.

T = ... s [3]

(h) The behaviour of the loaded plastic rule depends on the thickness of the plastic rule.

It is suggested that the square of the period T is inversely proportional to the cube of the thickness b of the plastic rule.

Explain how you would investigate this relationship.

Your account should include:

- your experimental procedure
- control of variables
- how you would use your results to show inverse proportionality
- why you might have difficulties using very thin plastic rules.

....

....

....

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....

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....

....

....

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.... [4]

[Total: 23]

4 An aluminium ring is placed on a coil with the rod of a metal retort stand passing through their centres, as shown in Fig. 4.1.

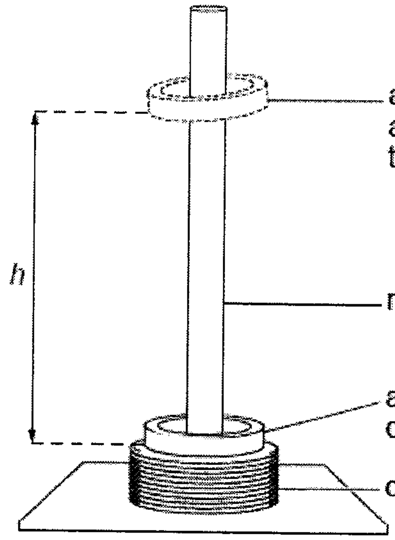

Fig. 4.1

The aluminium ring has a thickness b.

When an alternating current of frequency f is applied to the coil, the ring rises until it is in equilibrium at a height h above the coil.

The height h that the aluminium ring rises until it is in equilibrium is given by

$$h = k f^p b^q$$

where k, p and q are constants.

Design an experiment to determine the values of p and q.

You would be provided with several aluminium rings with different thicknesses.

Draw a diagram to show the arrangement of your apparatus. Pay particular attention to:

(a) the equipment you would use
(b) the procedure to be followed
(c) how the frequency of the alternating current, thickness of ring and height risen are measured
(d) the control of variables
(e) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

[Total: 12]

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