TEMASEK JUNIOR COLLEGE
2023 JC2 PRELIMINARY EXAMINATION
Higher 2

PHYSICS 9749/01

Paper 1 Multiple Choice **15 September 2023**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and Civics group on the Answer Sheet in the spaces provided.

There are **thirty** questions in 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 booklet.
The use of an approved scientific calculator is expected, where appropriate.

Do NOT open the booklets until you are told to do so.

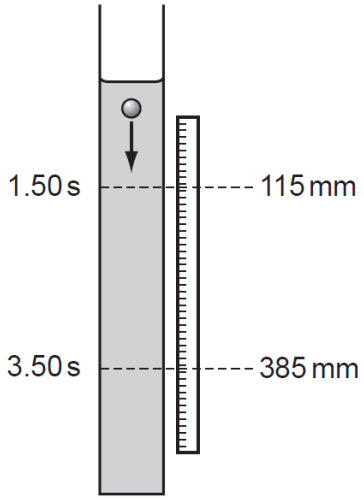
Data

speed of light in free space	$c = 3.00 \times 10^8$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$= (1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ 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	$\phi = -Gm/r$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
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.	$x = x_0 \sin \omega t$
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	$R = R_1 + R_2 + \ldots .$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots .$
electric potential	$V = Q/(4\pi\varepsilon_0 r)$
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	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 The diagram shows an experiment to measure the speed of a small ball falling at constant speed through a clear liquid in a glass tube.

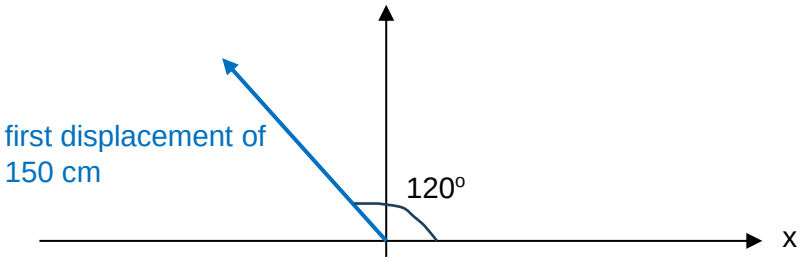


There are two marks on the tube. The top mark is positioned at 115 ± 1 mm on the adjacent rule and the lower mark at 385 ± 1 mm. The ball passes the top mark at 1.50 ± 0.02 s and passes the lower mark at 3.50 ± 0.02 s.

Which of the following gives the correct uncertainty in the value of this speed?

A 0.01 mm s^{-1} **B** 0.03 mm s^{-1} **C** 2 mm s^{-1} **D** 4 mm s^{-1}

2 A man pushing a mop across a floor causes it to undergo two displacements. The first displacement, as shown in the figure below, has a magnitude of 150 cm and makes an angle of 120° measured anticlockwise with respect to the positive *x*-axis.



The resultant displacement has a magnitude of 140 cm and is directed at an angle of 30° measured anticlockwise with respect to the positive *x*-axis.

What are the magnitude and direction of the second displacement?

	magnitude / cm	angle(measured anticlockwise) to the positive *x*-axis
A	290	90°
B	290	270°
C	205	17°
D	205	343°

3 An electric train consists of two carriages, each of mass 1.0 x 10^5 kg. The motor, which is in the front carriage, provides a constant traction force of 1.2 x 10^5 N. Assume that all resistive forces are negligible.

The train accelerates from rest. After 20 s, the coupling between the two carriages breaks.

How far apart are the carriages after another 20 s?

A 120 m **B** 240 m **C** 360 m **D** 480 m

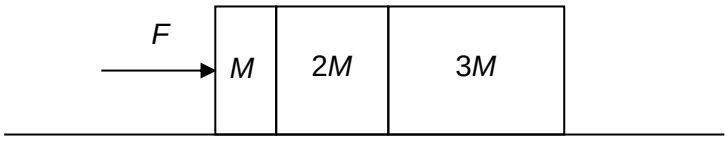
4 Ball A is projected horizontally with an initial velocity 2*v* from a height *h* above ground, while ball B is projected horizontally with an initial velocity *v* from a height 2*h* above ground.

Neglecting air resistance, what is the ratio

$$\frac{\text{horizontal displacement of ball A from the point of projection}}{\text{horizontal displacement of ball B from the point of projection}}?$$

A 2.83 **B** 1.41 **C** 1.00 **D** 0.353

5 Three blocks with masses *M, 2M* and 3*M* are pushed along a rough surface by a horizontal force *F* as shown.

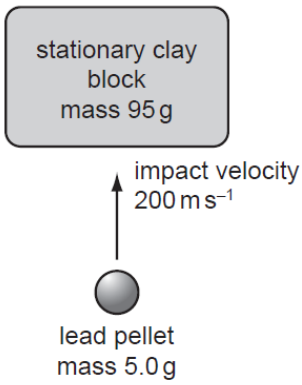


The friction between mass *M* and the rough surface is *f,* and *f* is proportional to *M*.

What is the magnitude of the force mass 3*M* exerts on mass 2*M*?

A $\frac{F}{2}$ **B** $\frac{F}{2}+3f$ **C** $\frac{F}{3}+f$ **D** $\frac{F}{3}+3f$

6 A lead pellet is shot vertically upwards into a clay block that is stationary initially but is able to rise freely after impact. The mass of pellet is 5.0 g and the mass of clay block is 95 g.

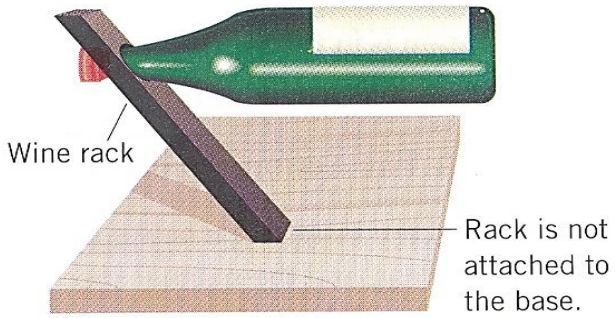


The pellet hits the block with an initial velocity of 200 m s^{-1}. It embeds itself in the block and does not emerge.

How high above its initial position will the block rise?

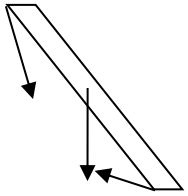
A 5.1 m **B** 10 m **C** 61 m **D** 102 m

7 The diagram shows a wine rack with a bottle of wine that is balanced on the table.

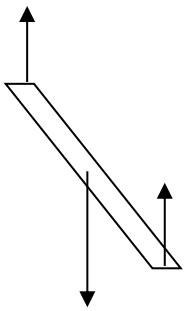


Which of the following diagrams correctly shows the directions of the forces acting on the wine rack?

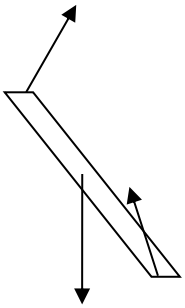
A



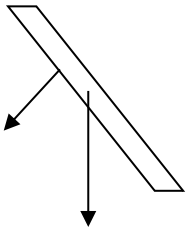
B



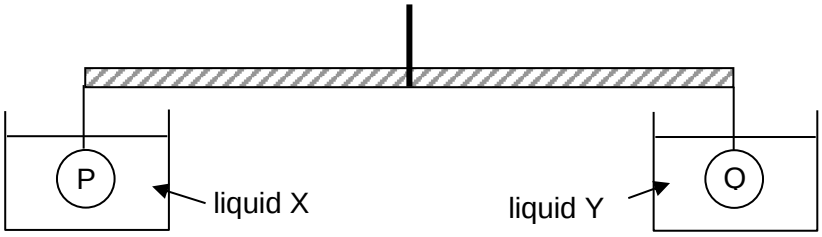
C



D



8 Two objects P and Q having the same volume are hung at either ends of a light uniform rod and subsequently submerged in two different liquids X and Y respectively. The density of liquid X is greater than that of liquid Y. The system is balanced when a string is hung right at the centre of the rod as shown in the figure below.



Which of the following statements is correct?

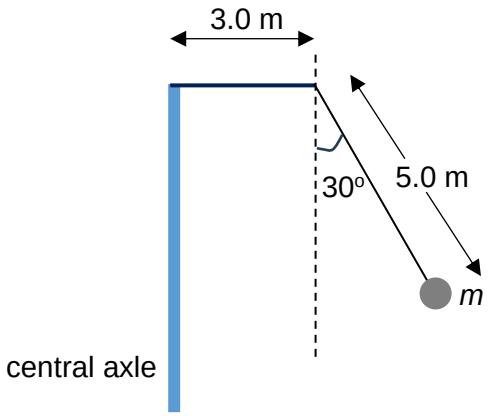
A P and Q experience the same magnitudes of upthrust.

B Upthrust acting on P is smaller than the upthrust acting on Q.

C Mass of P is smaller than mass of Q.

D Mass of P is greater than mass of Q.

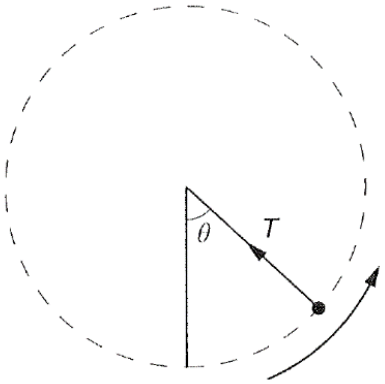
9 A mass *m*, attached to one end of an inextensible string of length 5.0 m, is made to move in a horizontal circle as the central axle is rotated. In a particular circular motion, the string makes an angle of 30^{o} with the vertical as shown in the figure below.



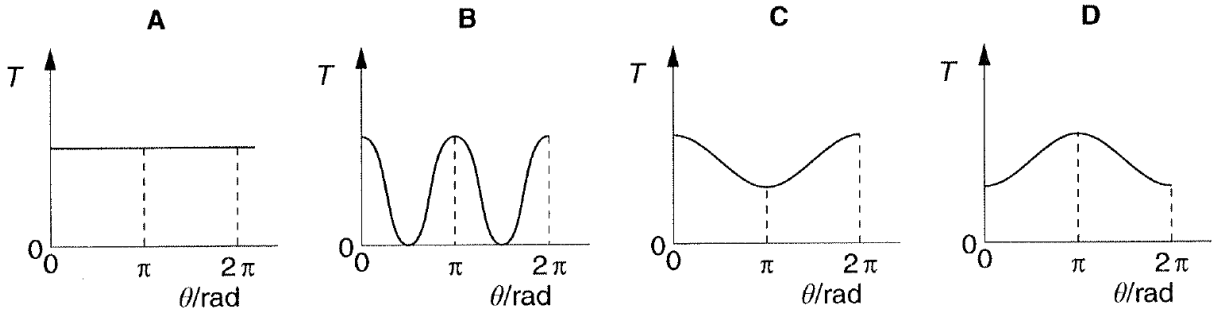
What is the period of the mass's motion about the central axle?

A 1.0 s **B** 3.5 s **C** 4.8 s **D** 6.2 s

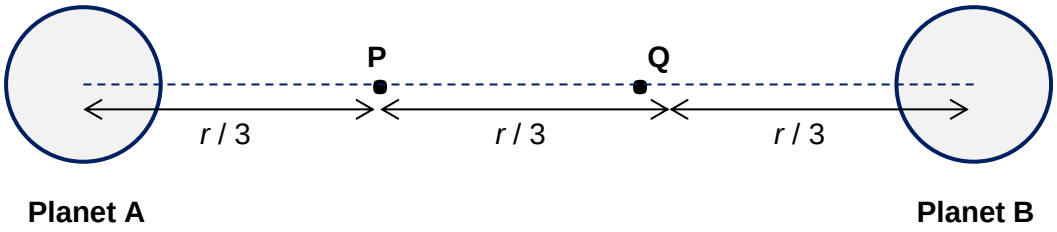
10 An object is fixed to one end of a light rod which rotates in a vertical circle with a constant speed.



Which graph could represent the variation with angle θ of the tension T in the rod?



11 Planet A, of mass M, and planet B, of unknown mass, are found to be at a fixed separation of r, measured from their respective centres of mass. When a spacecraft moves from point P to point Q, its gravitational potential energy changes from U to $1.25U$.



What is the mass of planet B in terms of M?

A $\frac{5M}{4}$ **B** $\frac{4M}{3}$ **C** $\frac{3M}{2}$ **D** $2M$

12 A satellite moves from one circular orbit around the Earth into another circular orbit with a smaller orbital radius.

Which of the following is correct?

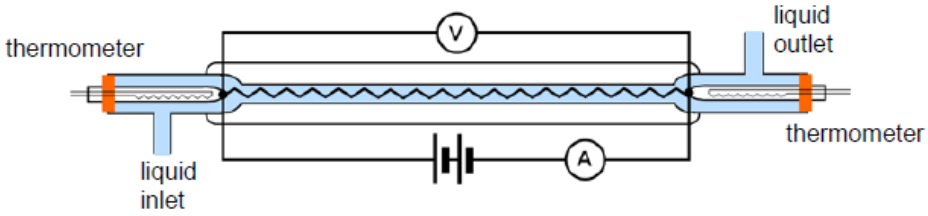
A Angular velocity of the satellite decreases.

B Gravitational force on the satellite by earth decreases.

C Kinetic energy of the satellite decreases.

D Potential energy of the satellite decreases.

13 The specific heat capacity of a liquid is to be found using a continuous flow calorimeter as shown. Initially, the experiment was carried out with an input power of 10 W. When the experiment was repeated with an input power of 18 W, it was found that the liquid flow rate must be tripled to give the same temperature rise.



What is the rate of heat loss to the surroundings?

A 2.7 W **B** 6.0 W **C** 7.5 W **D** 8.0 W

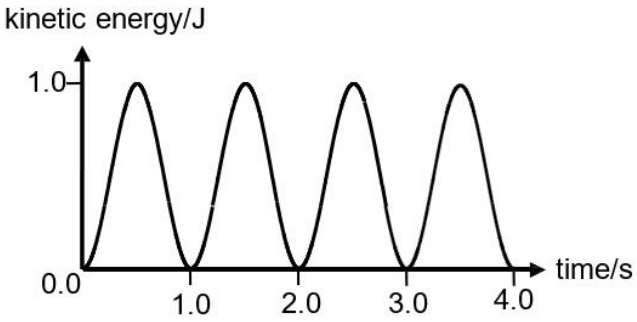
14 The first law of thermodynamics states that ΔU, the increase in internal energy of a system, is related to q, the heat supplied to it, and w, the work done on it, by the equation

$$\Delta U = q + w$$

What are the signs of ΔU, q and w for a constant mass of ideal gas which is cooled at constant pressure?

	ΔU	q	w
A	negative	positive	negative
B	negative	negative	positive
C	positive	negative	positive
D	positive	positive	positive

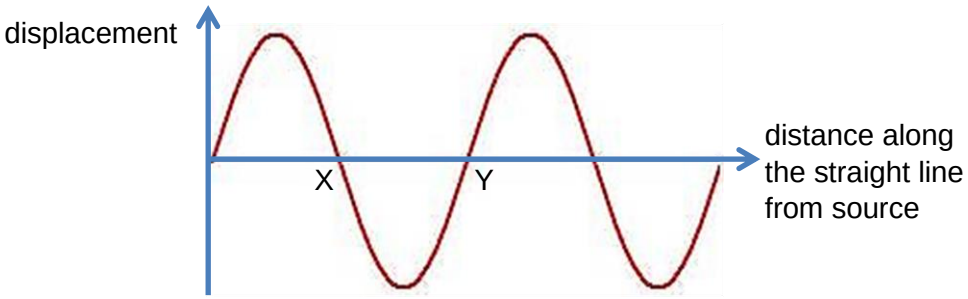
15 The variation with time of the kinetic energy of a particle undergoing simple harmonic motion with amplitude of 3.0 cm is shown in the figure below.



What is the maximum velocity of the particle?

A 0.59 m s^{-1} **B** 0.30 m s^{-1} **C** 0.19 m s^{-1} **D** 0.094 m s^{-1}

16 As a sound wave passes through a region of space, the displacement of the air molecules along a straight line is plotted as shown below.



Which of the following correctly describes the sound wave at locations X and Y?

	X	Y
A	compression	compression
B	compression	rarefaction
C	rarefaction	compression
D	rarefaction	rarefaction

17 A student observed two blue dots of 5 mm diameter on a screen. The distance between the two dots is 7.0 mm. The student who is facing the screen takes a few steps backwards and stops walking when the two dots are no longer resolved.

The student wishes to still resolve the two dots at this distance from the screen.

What should she do?

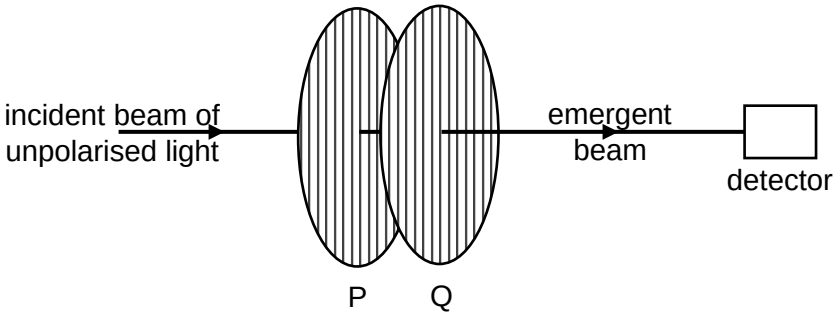
A darken the room to increase the size of the pupil of the eye.

B change the colour of the two dots from blue to red.

C make the blue dots slightly brighter.

D make the two dots closer.

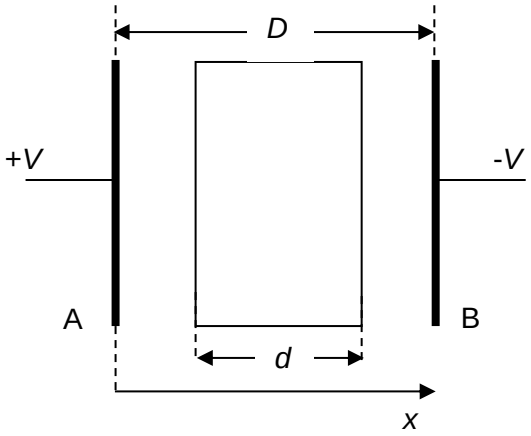
18 Two sheets of polaroid P and Q are placed such that their planes of polarisation are parallel as shown. A beam of unpolarised light passes through them and the intensity of the emergent beam is detected by the detector.



Which of the following is a possible angle through which Q can be rotated such that the intensity detected is reduced by 30%?

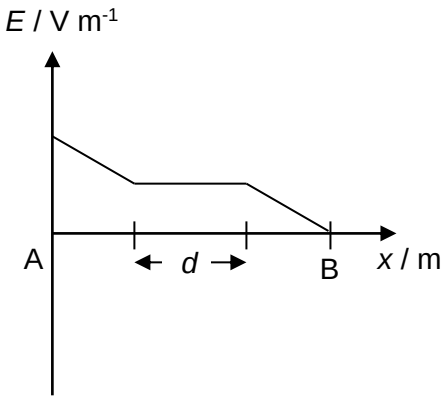
A 213° **B** 226° **C** 237° **D** 253°

19 Two large metal plates are oppositely charged and placed a distance *D* apart. A conductor of thickness *d* is placed centrally between the plates.

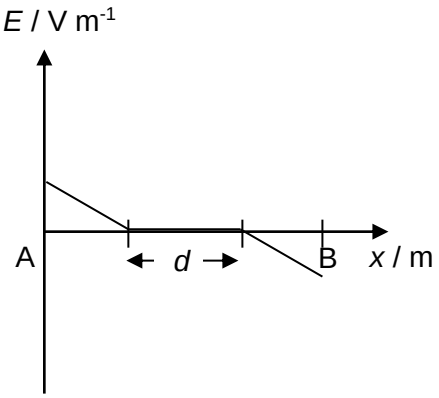


Which graph shows the possible variation with the distance *x* (measured from A to B) of the electric field strength *E*?

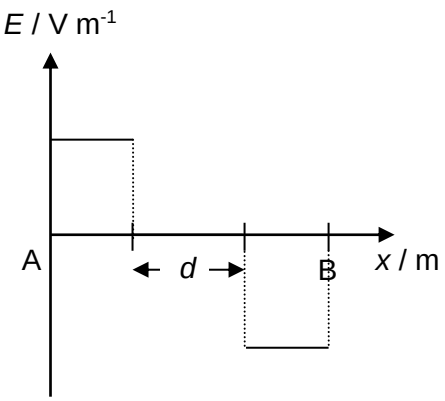
A



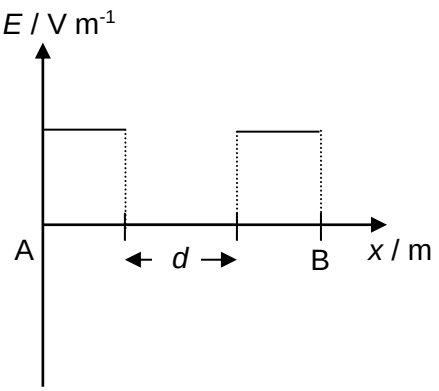
B



C



D



20 A 240 V electric heater uses a current of 2.0 A. It is to be rewound with resistance wire of diameter 6.0×10^{-4} m.

At working temperature, the resistance wire has resistivity of 1.4×10^{-6} Ω m.

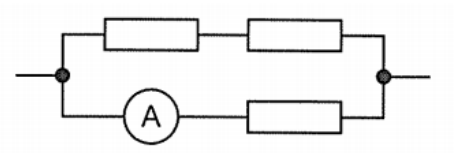
What length of wire is required?

A 6.0 m **B** 24 m **C** 51 m **D** 97 m

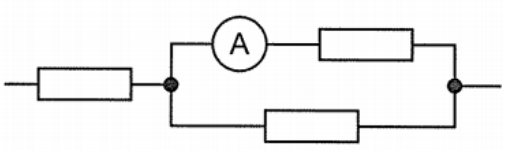
21 Four different arrangements of identical resistors are connected to the same constant voltage power supply. An ammeter of negligible resistance is connected as shown in each arrangement.

In which arrangement will the ammeter show the minimum reading?

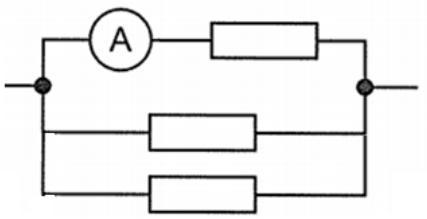
A



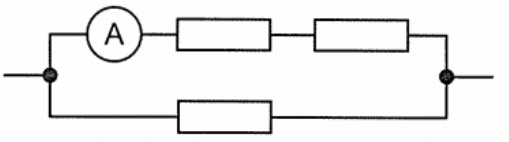
B



C



D



22 A cell of emf *E* and internal resistance *r* is connected to a variable resistor *R* as shown in Fig. 1. Fig. 2 shows the variation of the ammeter reading *I* with the voltmeter reading *V* as *R* is varied.

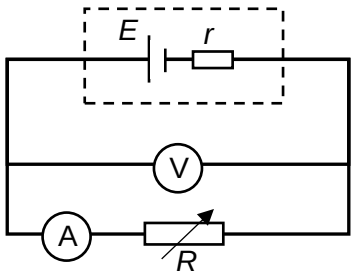


Fig. 1

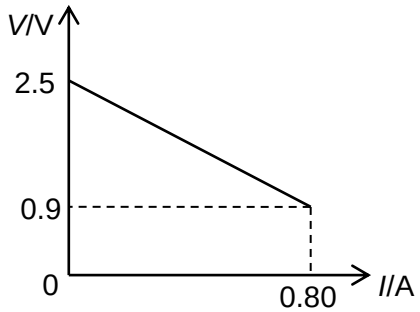


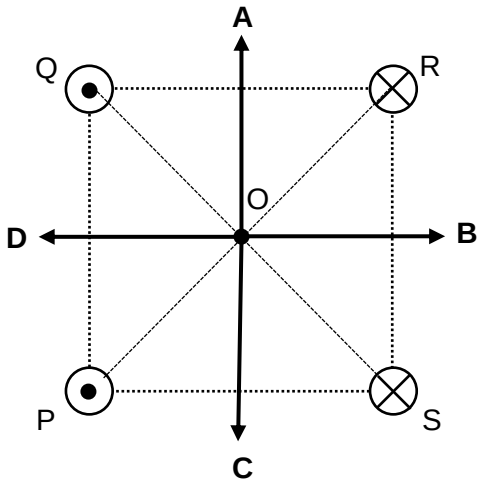
Fig. 2

Assuming that both the voltmeter and ammeter are ideal, what is the internal resistance *r* of the cell?

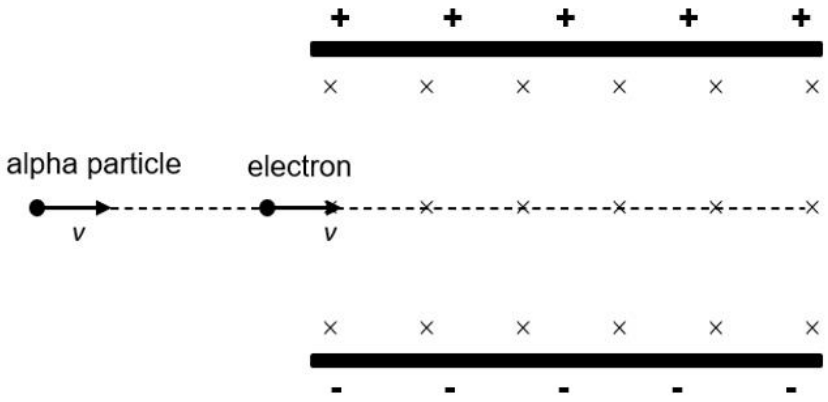
A 2.0 Ω **B** 1.7 Ω **C** 1.3 Ω **D** 1.1 Ω

23 Four parallel straight wires carrying equal currents pass through four corners of a square PQRS as shown below. The currents in wires P and Q are directed out of the page and the currents in wires R and S are directed into the page.

Which one of the options gives the direction of the resultant magnetic field at O?



24 An electron enters the vacuum between two oppositely charged plates with velocity *v*. The electron is followed by an alpha particle moving with the same initial velocity as the electron. A uniform magnetic field is directed into the plane of the paper.



The electron's path is undeflected.

The path of the alpha particle will be

A undeflected.

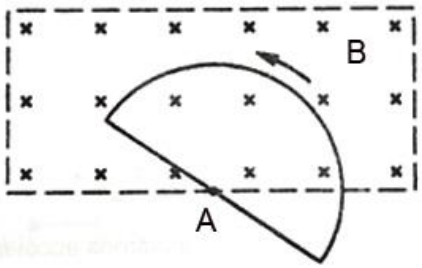
B deflected upward.

C deflected downward.

D deflected into the plane of the paper.

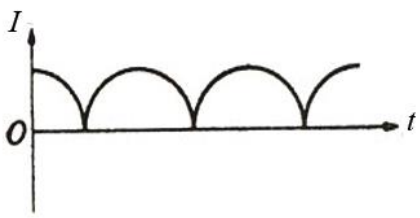
25 A uniform magnetic field of flux density B is directed perpendicularly into the plane everywhere within a rectangular region as shown.

A metal frame in the shape of a semi-circle is rotated anti-clockwise, at a constant angular speed, on the plane of the page about an axis A. The axis A is perpendicular to the page at the edge of the field and directed through the centre of the straight-line portion of the frame.

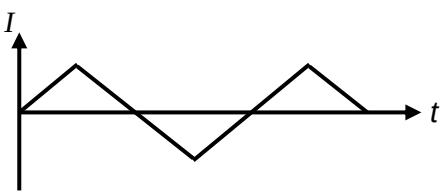


Which of the following graphs best represent the variation with time t of the induced current I in the metal frame?

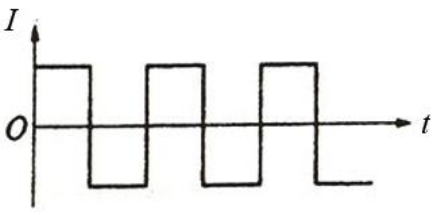
A



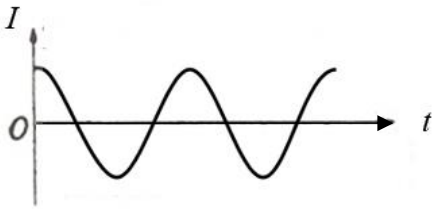
B



C



D



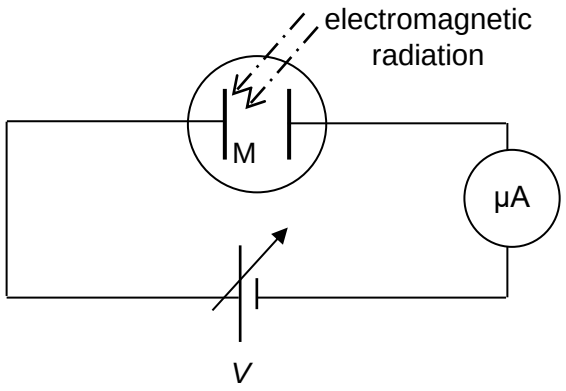
26 Electrons and protons in two beams are travelling at the same speed. The beams are diffracted by objects of the same size.

Which correctly compares the de Broglie wavelength λ_e of the electrons with the de Broglie wavelength λ_p of the protons and the width of the diffraction patterns that are produced by these beams?

	comparison of de Broglie wavelength	diffraction pattern
A	$\lambda_e < \lambda_p$	electron beam width > proton beam width
B	$\lambda_e < \lambda_p$	electron beam width < proton beam width
C	$\lambda_e > \lambda_p$	electron beam width > proton beam width
D	$\lambda_e > \lambda_p$	electron beam width < proton beam width

27 A 0.31 mW beam of electromagnetic radiation is incident on a clean metal plate M. Each photon of the electromagnetic radiation has energy 3.11 eV.

The potential difference *V* in the circuit is varied until the microammeter gives a maximum reading of 2.0 μA.



What is the ratio $\frac{\text{number of electrons emitted per unit time}}{\text{number of photons incident per unit time}}$?

A 3.2×10^{-21} **B** 2.0×10^{-2} **C** 1.0 **D** 1.3×10^{17}

28 An electron moves with a constant velocity of 1.5×10^{6} m s^{-1}. If its momentum is measured to a precision of 0.2%, what is the uncertainty associated with its position?

A 1.2 x 10^{-9} m **B** 2.4 x 10^{-9} m

C 2.4 x 10^{-7} m **D** 1.2 x 10^{-6} m

29 A nuclear fission reaction may be represented by the equation

$$^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{98}_{40}\text{Zr} + {}^{136}_{52}\text{Te} + 2\,{}^{1}_{0}\text{n}$$

The binding energy per nucleon *E* for the nuclides involved in the reaction are as shown:

Nuclide	*E* / MeV
$^{235}_{92}$U	7.60
$^{98}_{40}$Zr	8.58
$^{136}_{52}$Te	8.32

What is the energy released in the reaction?

A 186 MeV **B** 196 MeV **C** 1970 MeV **D** 3760 MeV

30 A radioactive source contains a radioisotope which has a half-life of 24 hours. In the absence of this source, a constant average count-rate of 10 min^{-1} is recorded. Immediately after the source is placed in a fixed position near the counter, the average count-rate rises to 90 min^{-1}.

What average count-rate is expected with the source still in place 12 hours later?

A 45 min^{-1} **B** 50 min^{-1} **C** 57 min^{-1} **D** 67 min^{-1}

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