Name: _____ ( ) Class: 22 / _____

ANDERSON SERANGOON JUNIOR COLLEGE

2022 JC2 Preliminary Examination

PHYSICS Higher 2 9749/01

Paper 1 Multiple Choice **Tuesday 20 September 2022**

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 class on the Multiple Choice Answer Sheet.
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 Multiple Choice Answer Sheet.

Read the instructions on the Multiple Choice 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 question paper.
The use of an approved scientific calculator is expected, where appropriate.

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	$\phi = -\frac{Gm}{r}$
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.	$v = v_0 \cos \omega t$ $= \pm\omega\sqrt{x_o^2 - x^2}$
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 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	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 The SI unit of specific heat capacity is J kg^{-1} K^{-1}.

What is the unit of specific heat capacity expressed in SI base units?

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

2 Quantity X has a fractional uncertainty of x. Quantity Y has a fractional uncertainty of y.

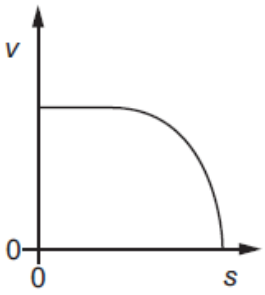
What is the fractional uncertainty in $\frac{3X}{Y^2}$?

A $3x + 2y$ **B** $3x - 2y$ **C** $x + 2y$ **D** $x - 2y$

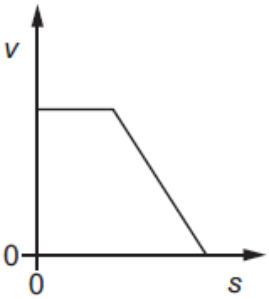
3 A car is travelling at constant velocity. Its brakes are then applied, causing uniform deceleration.

Which graph shows the variation with distance s of the velocity v of the car?

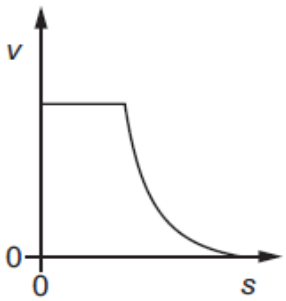
A



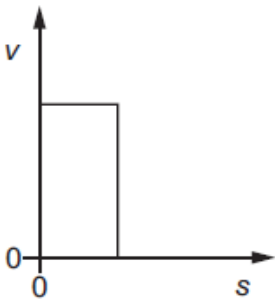
B



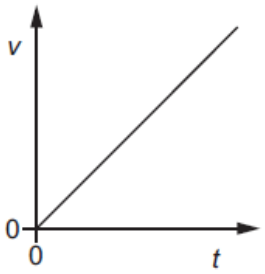
C



D

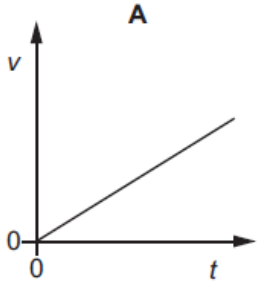


4 An object falls freely from rest in a vacuum. The graph shows the variation with time t of the velocity v of the object.

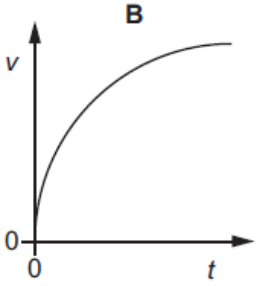


Which graph, using the same scales, represents the object falling in air?

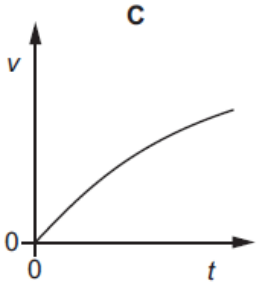
A



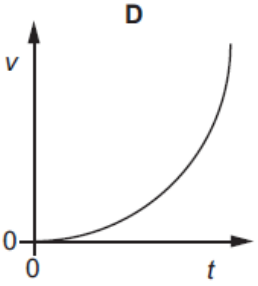
B



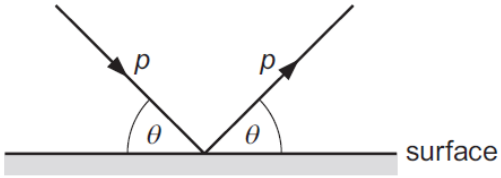
C



D



5 A ball strikes a horizontal surface with momentum p at an angle θ to the surface, as shown.



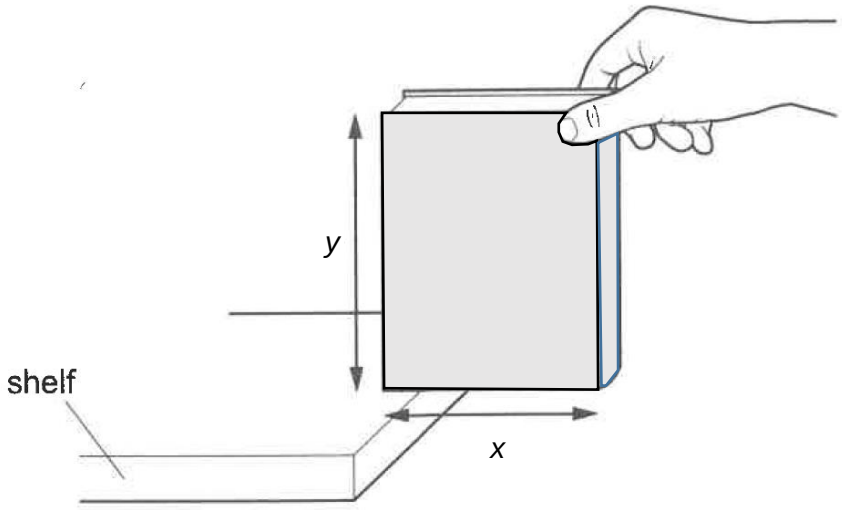
The ball rebounds with the same magnitude of momentum at an angle θ to the surface.

The ball is in contact with the surface for time t.

What is the magnitude of the average resultant force acting on the ball during the collision?

A zero **B** $\frac{2p}{t}$ **C** $\frac{2p\cos\theta}{t}$ **D** $\frac{2p\sin\theta}{t}$

6 A student pulls a book from a shelf by its top corner, holding it between his forefinger and thumb. The book is uniform and has weight W and dimensions x and y as shown.



What moment must the student provide at the corner of the book to stop it from rotating just before it leaves the shelf?

A $\frac{Wy}{2}$ anticlockwise

B $\frac{Wx}{2}$ anticlockwise

C $\frac{W(y-x)}{2}$ clockwise

D Wx clockwise

7 A train of mass 250 000 kg is accelerating at 0.90 m s^{-2}. At one instant, the speed of the train is 5.0 m s^{-1} and the resistive force to its motion is 15 kN.

At this instant, what is the rate of increase of kinetic energy of the train?

A 75 kW **B** 1.1 MW **C** 1.2 MW **D** 3.1 MW

8 Titan, the largest moon of Saturn, orbits in a circle around Saturn with a radius of 1.22×10^6 km. It has an orbital period of 15.9 days.

What is the centripetal acceleration of Titan?

A 4.06×10^{-3} m s^{-2}

B 2.55×10^{-2} m s^{-2}

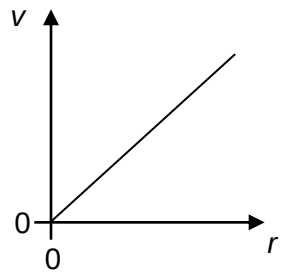
C 9.19×10^{-2} m s^{-2}

D 1.55×10^{3} m s^{-2}

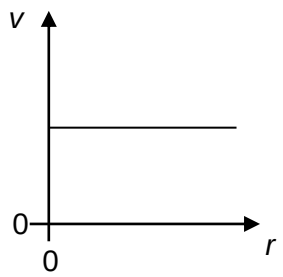
9 A record on a turntable rotates at a constant number of revolutions per second.

Which graph best represents the relationship between the linear speed *v* of a point on the record and its distance *r* from the centre of the rotation?

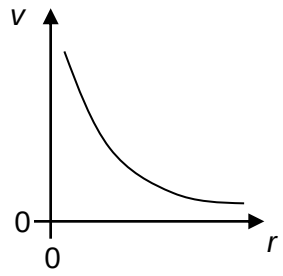
A



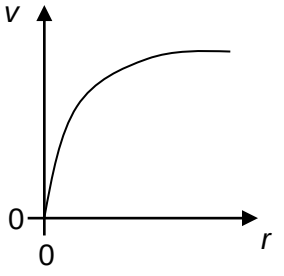
B



C



D



10 The escape speed of a nitrogen molecule at the Earth's surface is 1.1×10^4 m s^{-1}.

What is the escape speed at a height of 2 R_E above the Earth's surface, where R_E is the radius of the Earth?

A 6.4×10^3 m s^{-1} **B** 7.8×10^3 m s^{-1} **C** 1.6×10^4 m s^{-1} **D** 1.9×10^4 m s^{-1}

11 Which of the following statement about a geostationary satellite is true?

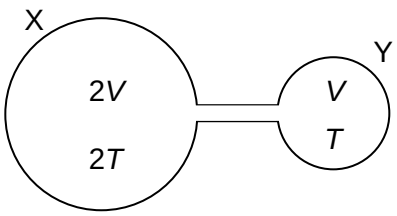
A It can remain vertically above any chosen fixed point on the Earth.

B Its linear speed is equal to the speed of a point on the Earth's equator.

C It has the same angular velocity as the Earth's rotation on its own axis.

D It is always travelling from east to west.

12 An ideal gas is contained in two spherical containers X and Y of volume 2V and V respectively, connected by a hollow tube of negligible volume. The containers X and Y are maintained at temperatures 2T and T respectively. The setup is shown in the diagram below.



What is the ratio $\frac{\text{number of moles of gas in container X}}{\text{number of moles of gas in container Y}}$?

A 0.25 **B** 1 **C** 2 **D** 4

13 Water has a higher specific heat capacity than iron. 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 statements is true?

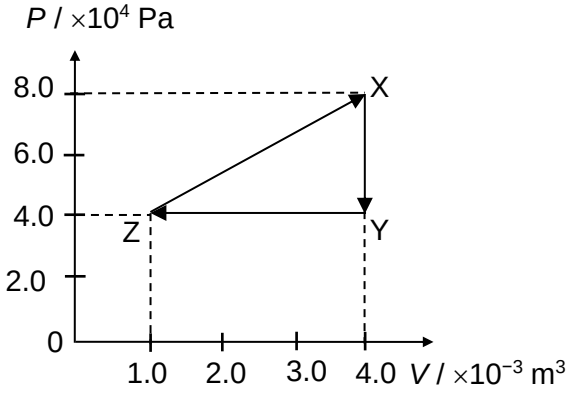
A The temperature of the iron rises faster than the water but both reach the same final temperature.

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

C The iron is now warmer than the water.

D The water is now warmer than the iron.

14 A gas undergoes one cycle of pressure and volume changes X→Y→Z→X as shown.

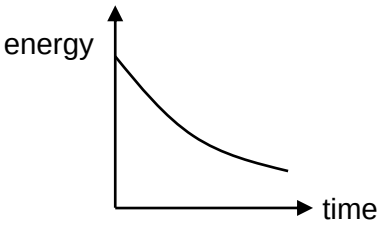


What is the net work done on the gas?

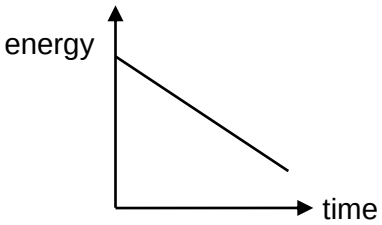
A − 180 J **B** − 60 J **C** 60 J **D** 120 J

15 Which of the following graphs show the variation in the total energy of an object under light damping as time passes?

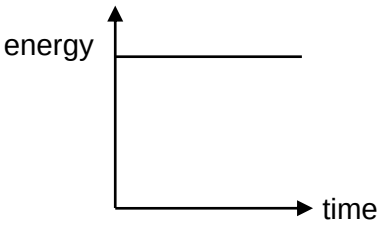
A



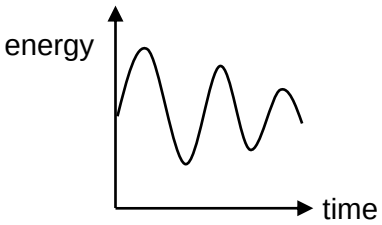
B



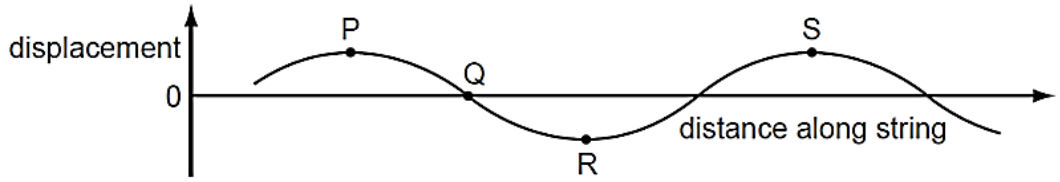
C



D



16 The graph shows the shape at a particular instant of part of a transverse wave travelling along a string.



Which statement about the motion of points in the string is correct?

A The speed at point P is a maximum.

B The displacement at point Q is always zero.

C The energy at point R is entirely kinetic.

D The acceleration at point S is a maximum.

17 In a double-slit interference experiment, one slit transmits waves of twice the amplitude compared to the other slit. The intensity at one of the bright fringes on the screen is I_o.

What is the intensity at the dark fringe closest to this bright fringe?

A zero **B** $\frac{I_o}{2}$ **C** $\frac{I_o}{4}$ **D** $\frac{I_o}{9}$

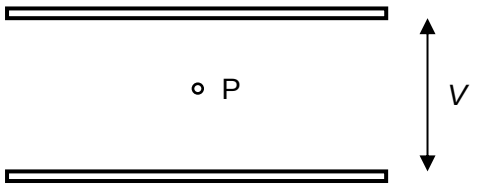
18 A space station orbits at a height of 335 km above the surface of the Earth. It carries two panels separated by a distance of 25 m. The panels reflect light of wavelength 500 nm towards an observer on the Earth's surface.

The observer views the panels with a telescope that has an aperture diameter of 200 mm. Assume that the panels act as point sources of light for the observer.

Which of the following is correct?

	Will the two images seen by the observer be resolved?	Angular separation of two panels as measured from aperture / rad
A	Yes	2.5×10^{-6}
B	Yes	7.5×10^{-5}
C	No	2.5×10^{-6}
D	No	7.5×10^{-5}

19 A small positively-charged particle P is balanced halfway between two horizontal plates when a potential difference *V* is applied between the plates.



When *V* is increased, P rises towards the upper plate.

When *V* is decreased, P falls towards the lower plate.

Which statement is correct?

A Decreasing *V* decreases both the electric and the gravitational potential energy of the particle.

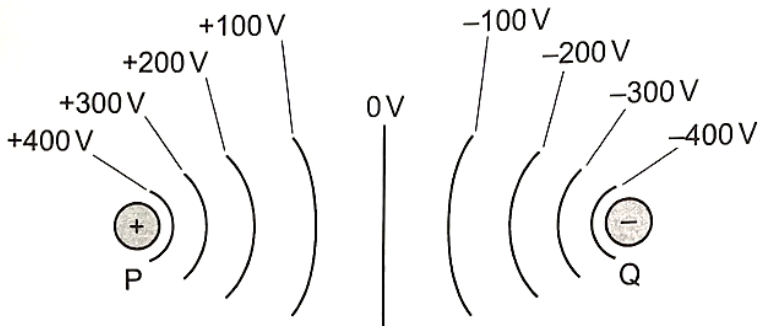
B Decreasing *V* increases the electric potential energy and decreases the gravitational potential energy of the particle.

C Increasing *V* increases both the electric and the gravitational potential energy of the particle.

D The change of electric potential energy of the particle must equal the change of gravitational potential energy of the particle.

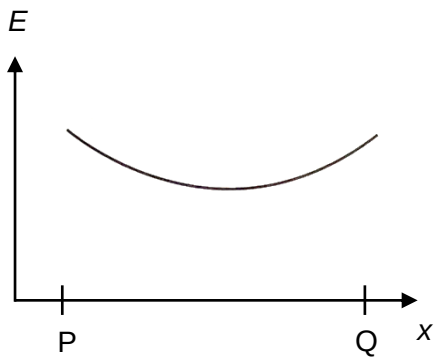
20 An object with a positive charge is placed at P and a similar object with a negative charge placed at Q.

The diagram shows a number of lines along which the potential has a constant value.

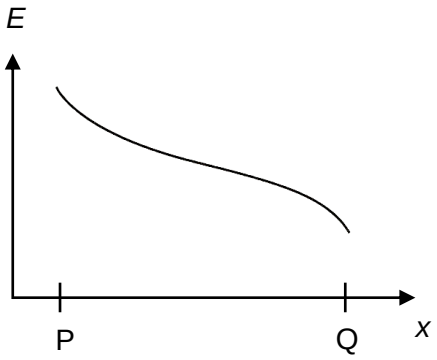


Which graph shows the variation with distance *x* along line PQ of the electric field strength *E*?

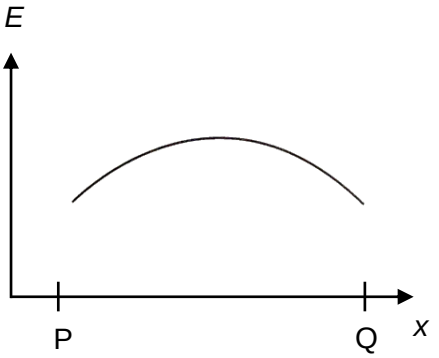
A



B



C



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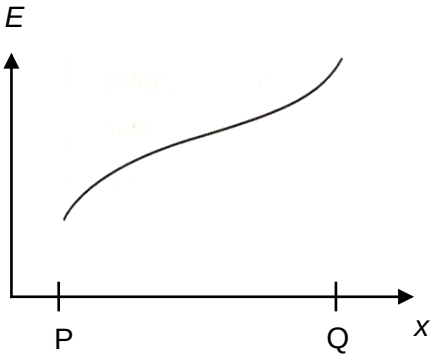
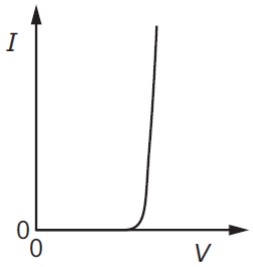
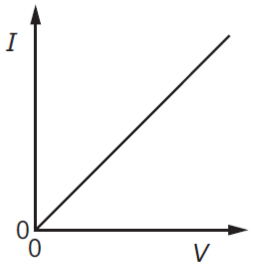


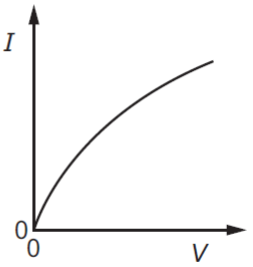
21 The graphs show the variation with potential difference V of the current I for three circuit components.



graph X



graph Y



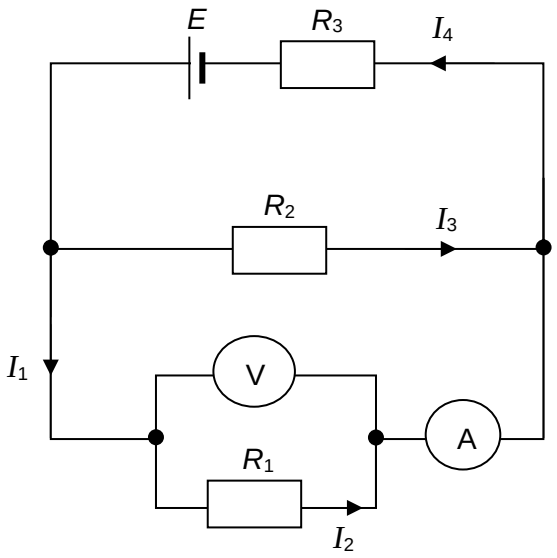
graph Z

The components are a metal wire at constant temperature, a semiconductor diode and a filament lamp.

Which row correctly identifies these graphs?

	metal wire at constant temperature	semiconductor diode	filament lamp
A	X	Z	Y
B	Y	X	Z
C	Y	Z	X
D	Z	X	Y

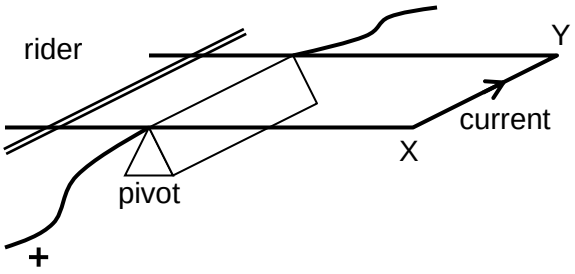
22 The figure below shows a circuit that comprises of a battery, 3 resistors, an ideal voltmeter and an ideal ammeter. The electromotive force (e.m.f.) of the battery is E.



Which of the following shows the correct expression for the ammeter reading and voltmeter reading?

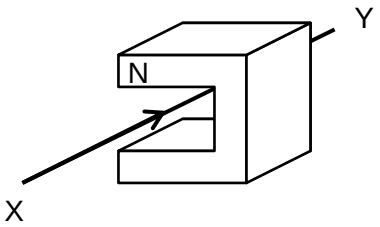
	ammeter reading / A	voltmeter reading / V
A	I_1	$I_4R_3 + I_3R_2$
B	$I_3 + I_4$	E
C	I_2	$E - I_4R_3$
D	$I_1 + I_3$	I_2R_1

23 The diagram below shows a current balance used to determine the strength of a magnet. When the light frame is pivoted and the rider placed as seen in the diagram, the frame remains horizontal.

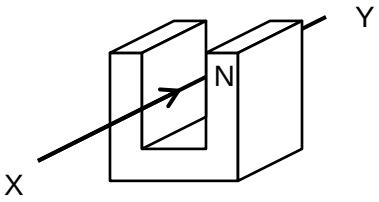


Which of the following shows the correct placement of the magnet relative to XY?

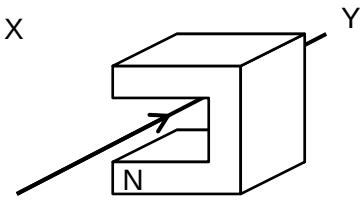
A



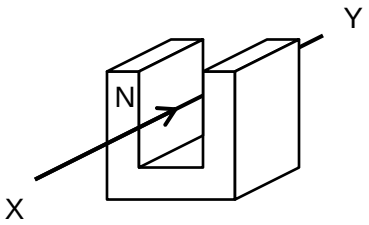
B



C

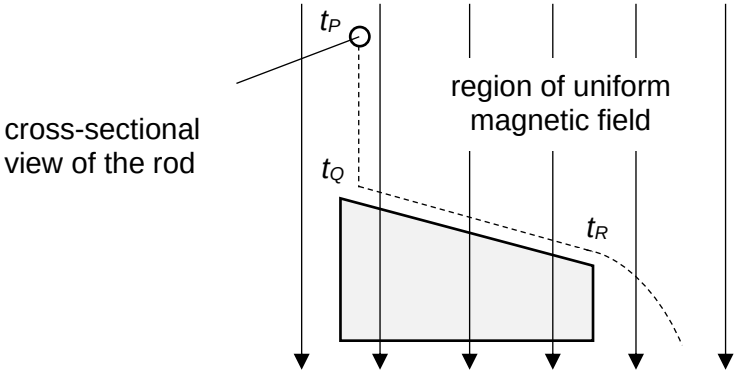


D



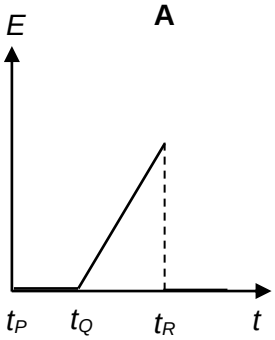
24 In a region of uniform magnetic field, a metal rod falls vertically from rest and lands on a slope. It continues to roll down the slope and launches off the slope as shown in the diagram.

The diagram shows the positions of the rod at times t_P, t_Q and t_R respectively.

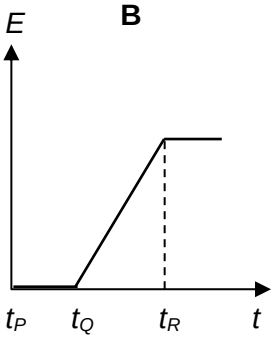


Which graph best shows the variation with time t of the e.m.f. induced in the rod, from the time it is released?

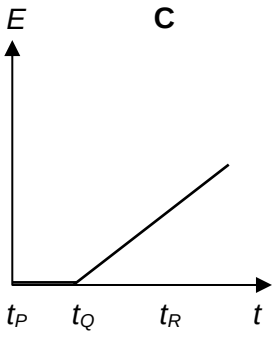
A



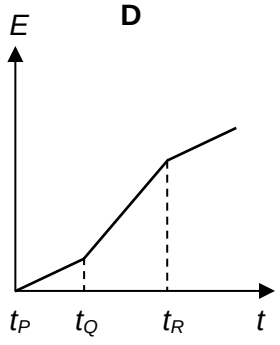
B



C



D

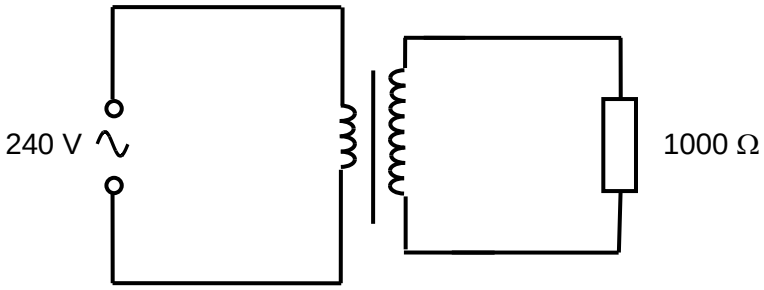


25 When a fixed resistor is connected across an a.c. source of peak voltage 150 V, the power dissipated is 13 W. Two such fixed resistors are now connected in series to the electrical mains of 240 V r.m.s.

What is the total power dissipated in the resistors?

A 17 W **B** 33 W **C** 47 W **D** 67 W

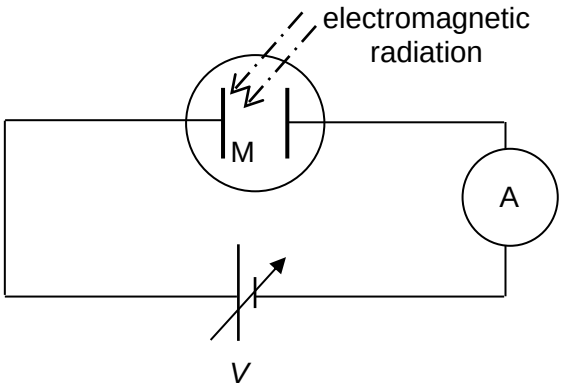
26 An ideal transformer is used to step-up a 240 V a.c. power supply. The output is used to heat a 1000 Ω resistive load. The ratio of the primary turns to secondary turns is 1:5.



What is the current in the primary coil?

A 0.24 A **B** 1.2 A **C** 6.0 A **D** 36.0 A

27 A 3.1 mW beam of electromagnetic radiation comprising photons each with energy 3.11 eV is incident on a clean metal plate M. The potential difference *V* is varied until the ammeter gives a maximum reading of 2.0 μA.



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

A 3.2×10^{-22} **B** 2.0×10^{-3} **C** 1.0 **D** 1.3×10^{16}

28 In the lungs, there are tiny sacs of air known as alveoli. 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?

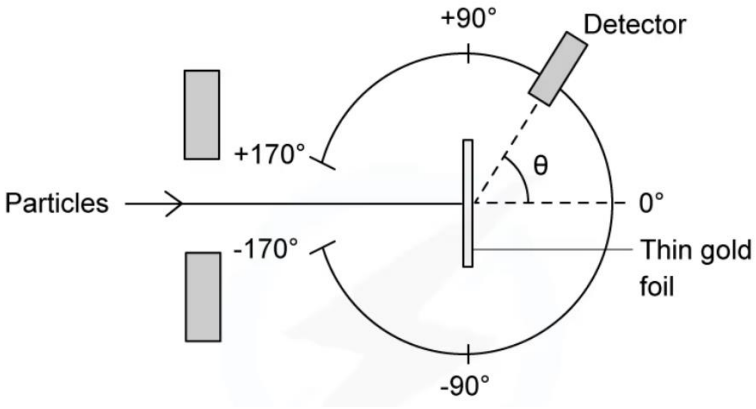
A 10^{-5} m s^{-1}

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

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

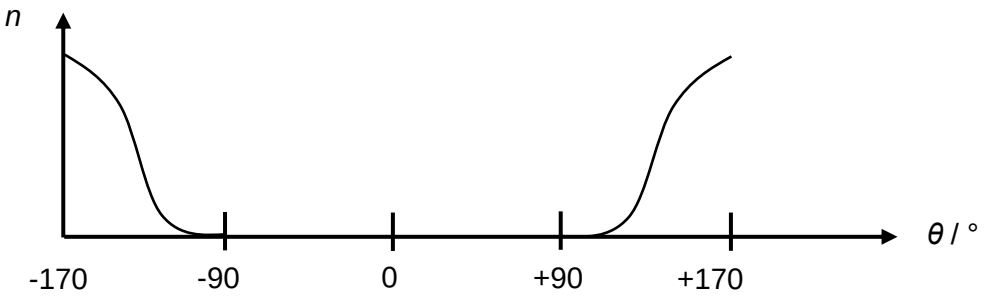
D 10^{-12} m s^{-1}

29 In repeating Rutherford's alpha particle scattering experiment, a student used the apparatus shown, in a vacuum, to determine *n* the number of alpha particles incident per unit time on a detector held at various angular positions *θ*.

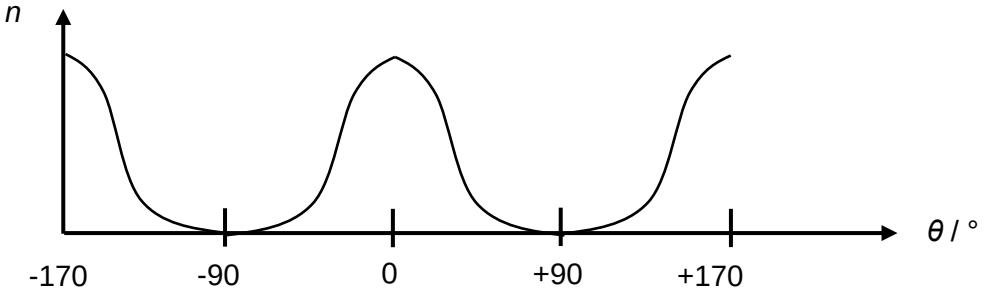


Which graph best represents the variation of *n* with *θ*?

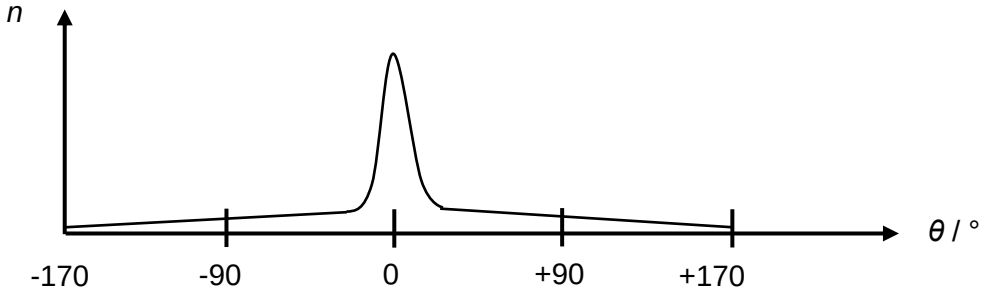
A



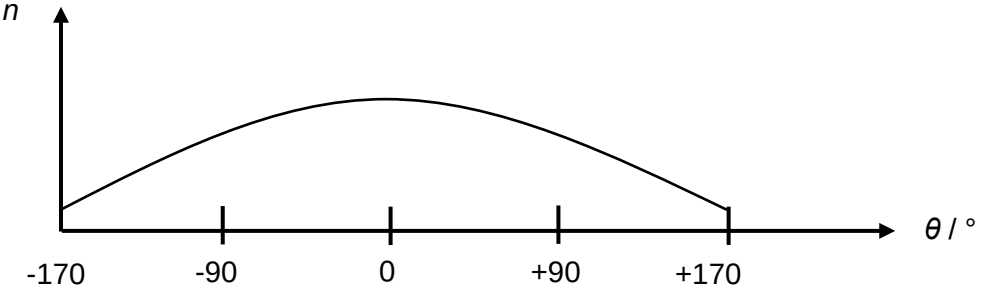
B



C



D



30 Today, the activity of a sample of caesium−137 is 4.0×10^5 Bq. The half-life of caesium−137 is 33 years.

What is the best estimate of the number of caesium−137 nuclei that will decay in the next two days?

A 5.0×10^8 **B** 1.2×10^9 **C** 6.9×10^{10} **D** 9.5×10^{12}

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