$u = 0$.

1. An object moves from rest with a uniform acceleration a over a distance d in a time t.

What is a?

A. $\frac{d}{t^2}$

B. $\frac{d^2}{t}$

C. $\frac{2d}{t^2}$

D. $\frac{d^2}{2t}$

$s = ut + \frac{1}{2}at^2$

$d = \frac{1}{2}at^2$.

$2d = at^2$

$a = \frac{2d}{t^2}$.

379

2. A ball is launched with an initial velocity of $10\,m\,s^{-1}$ and an angle of 30° to the horizontal. Air resistance is ignored.

What is the instantaneous speed of the ball at the top of its path?

A. $10\,m\,s^{-1}$

B. $8.7\,m\,s^{-1}$

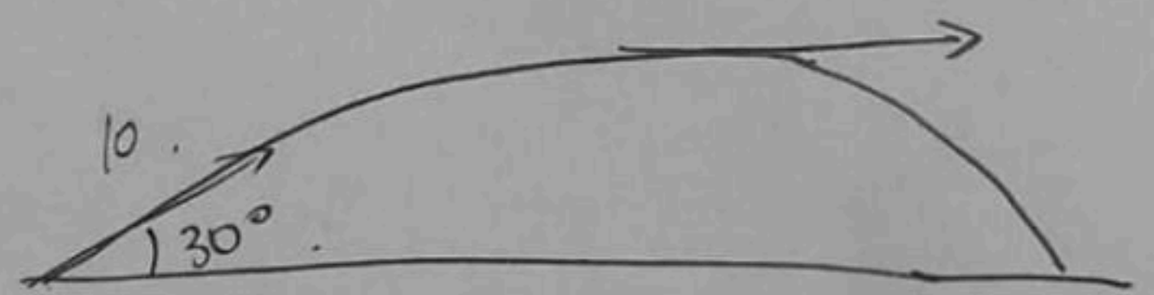
C. $5.0\,m\,s^{-1}$

D. zero $m\,s^{-1}$

$u = 10$. $\theta = 30°$.

$g = 9.8\,ms^{-1}$.

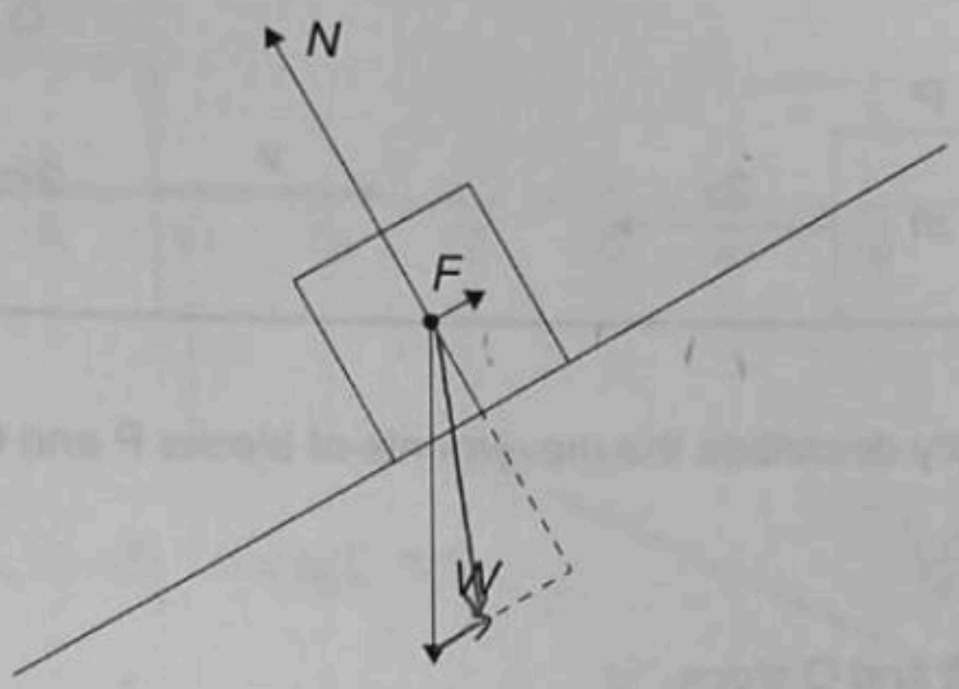
$10 \cdot \cos 30$



A005

$s = ut - \frac{1}{2}at^2$.

3. The free-body diagram shows a box on a frictionless inclined plane. The diagram and forces are drawn to scale. Weight W and normal force N are shown. The force F is acting up the plane.



What is correct about the motion of the box?

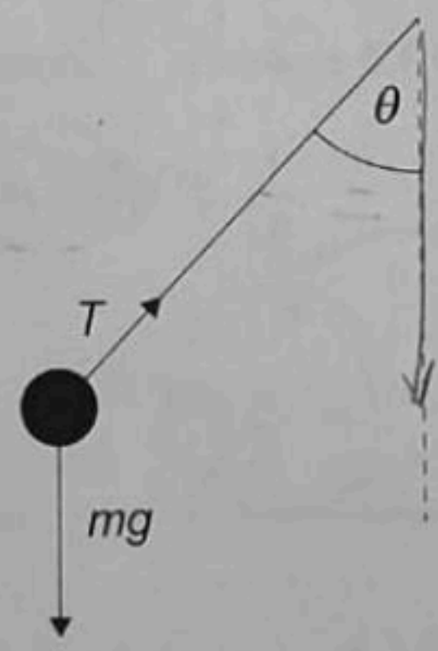
A. The box is sliding down the plane with a constant speed.

B. The box is sliding down the plane with an increasing speed.

C. The box is sliding up the plane with a constant speed.

D. The box is sliding up the plane with an increasing speed.

4. A sphere of mass m is attached to a string and acts as a pendulum. The diagram shows the moment when the sphere is released with an initial angle to the vertical of θ.



$T\cos\theta = mg$.

$\cos\theta = \frac{mg}{T}$.

What is the magnitude of the tension T in the string when it is released?

A. $mg\tan(\theta)$

B. $mg\sin(\theta)$

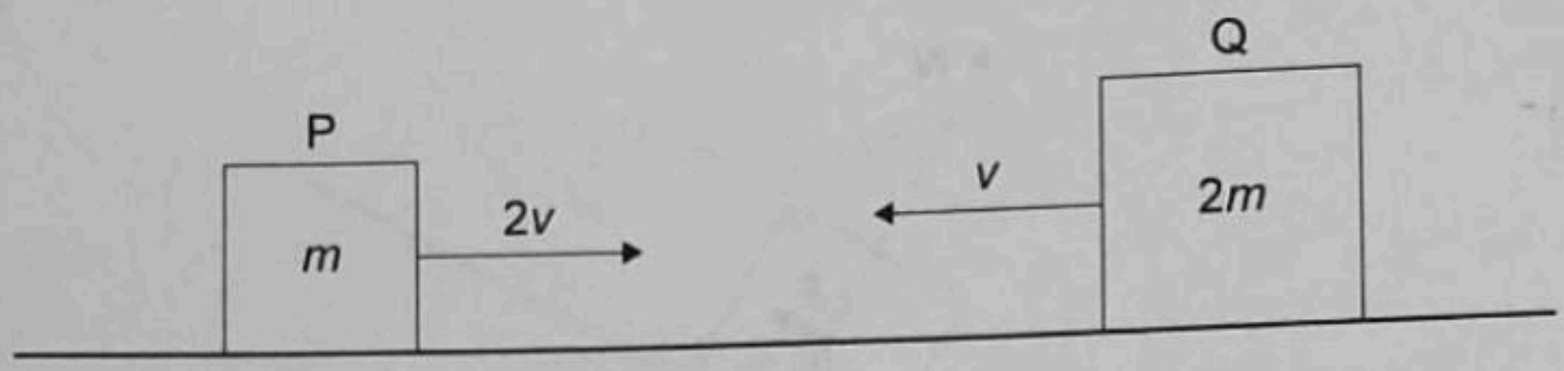
C. $mg\cos(90° - \theta)$

D. $mg\sin(90° - \theta)$ ✓

379

A005

5. Two blocks, P and Q, have mass m and $2m$ and speed $2v$ and v respectively. They move in opposite directions on a frictionless surface as shown. They collide elastically.



Which statement correctly describes the movements of blocks P and Q after the collision?

A. P and Q stop. ✗

B. P moves to the left and Q stops. ✗

C. P moves to the left and Q moves to the right. ✓

D. P and Q move to the left with different speeds. ✗

$P_1 = 2mv \quad P_2 = 2mv.$

$P_1 + P_2 = 4mv \neq 0.$

$4mv = 3m \cdot V_2$

$V_2 = \frac{4mv}{3m} = \frac{4}{3}v$

6. A car moves with speed v on a circular horizontal road of radius R. The coefficient of static friction between the road and the car tyres is μ.

What is the largest v at which the car can move without sliding?

A. $\frac{gR}{\mu}$

B. μgR

C. $\sqrt{\frac{gR}{\mu}}$

D. $\sqrt{\mu gR}$

$\frac{1}{2}MV^2$

$\frac{1}{2}(2V)^2 \cdot m + \frac{1}{2} \cdot 2m(V^2)$

$= \frac{1}{2} \times 4V^2 m + mV^2$

$= 3mV^2$

$F = ma = \frac{mv^2}{r}.$

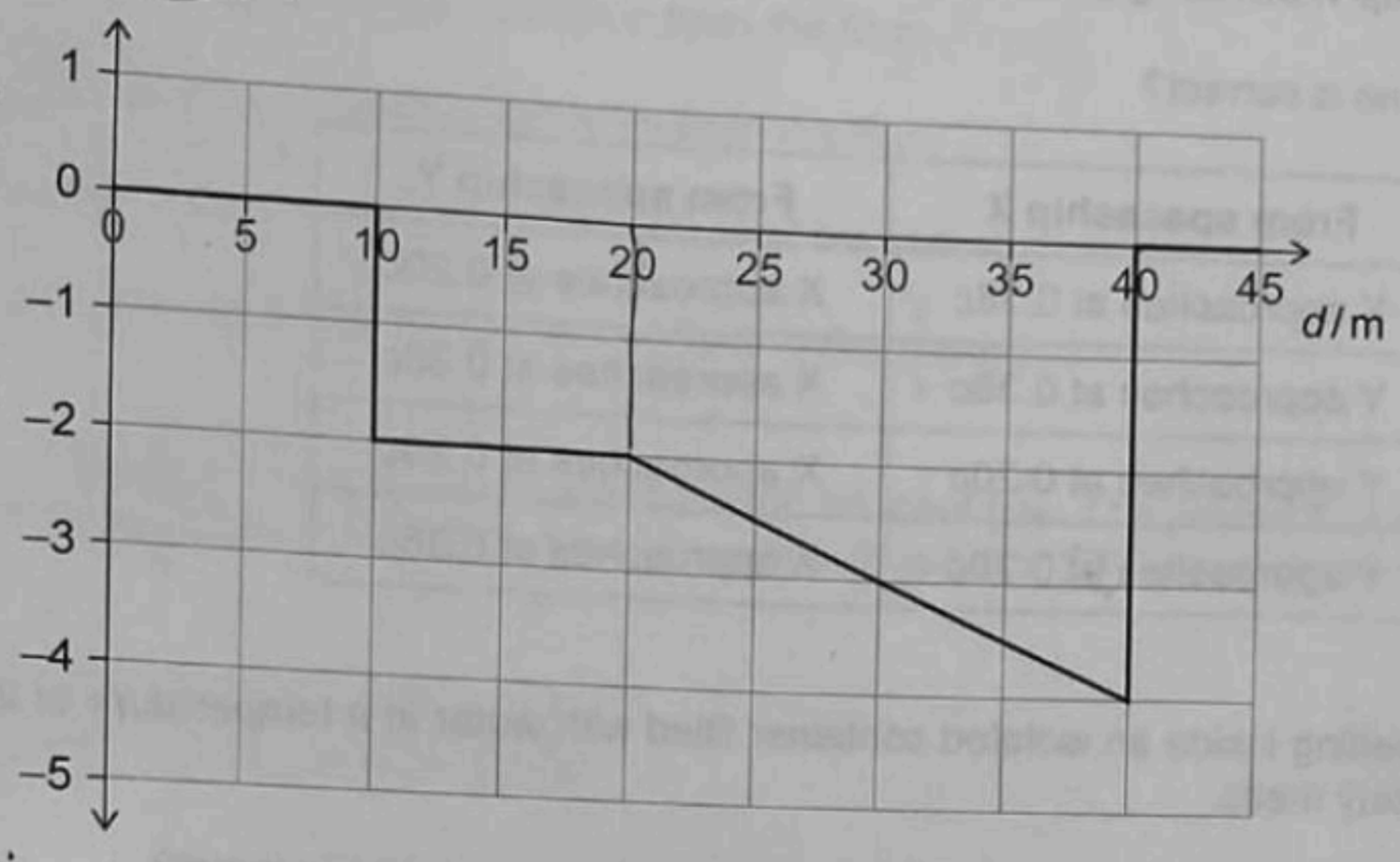
$\frac{mv^2}{r} = \mu \cdot N.$

$\frac{mv^2}{r} = \mu \cdot mg$

$v^2 = \mu g r$

$v = \sqrt{\mu g r}.$

7. The graph shows the variation of the acceleration with distance of a car of mass 1500 kg slowing down to a stop at $d = 40$ m.



What energy is dissipated during the process?

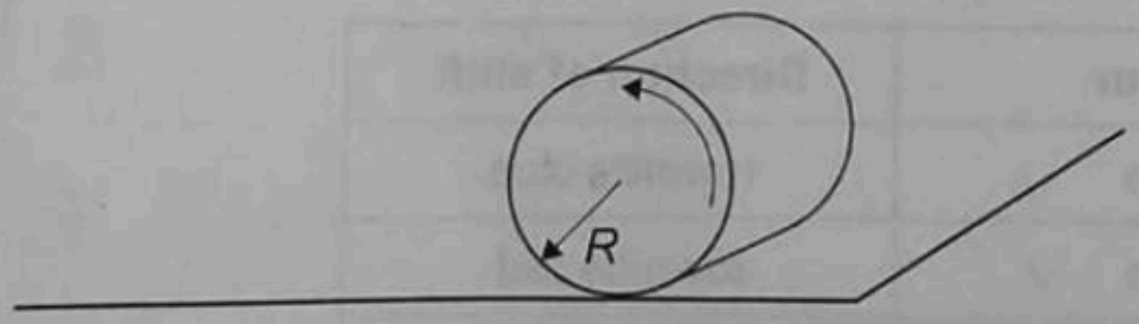
A. 80 J

B. 100 J

C. 120 kJ

D. 150 kJ

8. A cylinder of radius R rolls without slipping. It travels 5.0 metres in 2.5 seconds at a constant speed, completing five full turns.



What is R?

A. 0.08 m

B. 0.16 m

C. 0.80 m

D. 1.60 m

$u' = \frac{0.60c - 0.80c}{1 - \frac{0.60 \cdot 0.80c^2}{c^2}} = \frac{-0.20c}{-6 - 0.52} = 0.38c$

$u' = \frac{0.80 - 0.60}{1 - \frac{0.80 \times 0.6}{c^2}}$

9. An external observer sees spaceship X, travelling at 0.80*c*, approach and overtake another spaceship Y, travelling at 0.60*c*.

Which line is correct?

	From spaceship X	From spaceship Y
A.	Y approaches at 0.38*c* ✓	X approaches at 0.20*c* ✓
B.	Y approaches at 0.38*c* ✓	X approaches at 0.38*c* ✓
C.	Y approaches at 0.20*c*	X approaches at 0.20*c*
D.	Y approaches at 0.20*c*	X approaches at 0.38*c*

10. Ice is melting inside an isolated container filled with water at a temperature of 20 °C. The ice completely melts.

Which statement about the system during the phase change is correct?

379

A. The internal energy of the ice molecules increases.

B. The potential energy of the ice molecules decreases.

C. The kinetic energy of the ice molecules increases.

D. The kinetic energy of the water molecules increases.

11. The surface temperature of a star that is moving away from the Earth is 6500 K.

What colour is the peak of the star's emission spectrum and in which direction is it shifted to an observer on Earth due to the motion of the star?

R ↑ ⇒ λ.

B ↓ λ

	Colour	Direction of shift
A.	blue ✓	towards blue
B.	blue ✓	towards red
C.	red	towards blue
D.	red	towards red

A005

$\lambda_{max} T = 2.9 \times 10^{-3} \times 10^{-3}$.

6500

12. Which is correct about greenhouse gases in the atmosphere of a planet?

A. They reflect incoming ultraviolet radiation from the Sun.

B. They absorb incoming ultraviolet radiation from the Sun.

C. They reflect infrared radiation from the surface of the planet.

D. They absorb infrared radiation from the surface of the planet.

13. Two containers of equal volume, A and B, are filled with an ideal gas. The pressure in A is 8.1×10^6 Pa and its temperature is 18 °C. The pressure in B is 5.3×10^6 Pa and its temperature is 36 °C.

What is the ratio $\frac{\text{number of gas atoms in A}}{\text{number of gas atoms in B}}$?

A. 3.1

B. 1.6

C. 0.6

D. 0.3

$\frac{P}{T} = \frac{P}{T}$.

$PV = nRT$.

~~$PT = nRT$~~

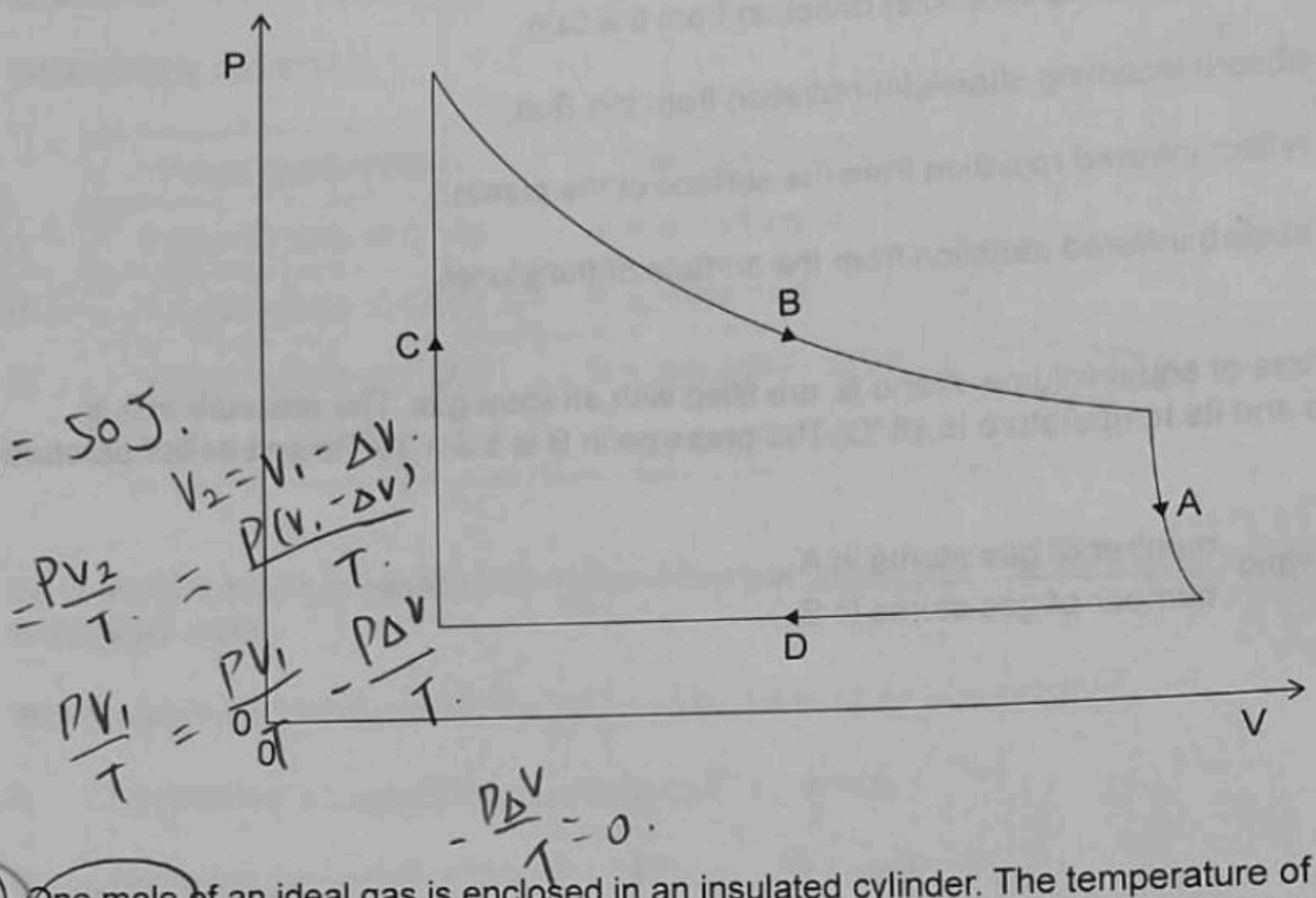
$\frac{n_1}{n_2} = \frac{\frac{PV}{RT}}{\frac{PV}{RT}}$.

$= \frac{\frac{P_1}{T_1}}{\frac{P_2}{T_2}}$

$= \frac{\frac{8.1 \times 10^6}{18+273}}{\frac{5.3 \times 10^6}{36+273}}$

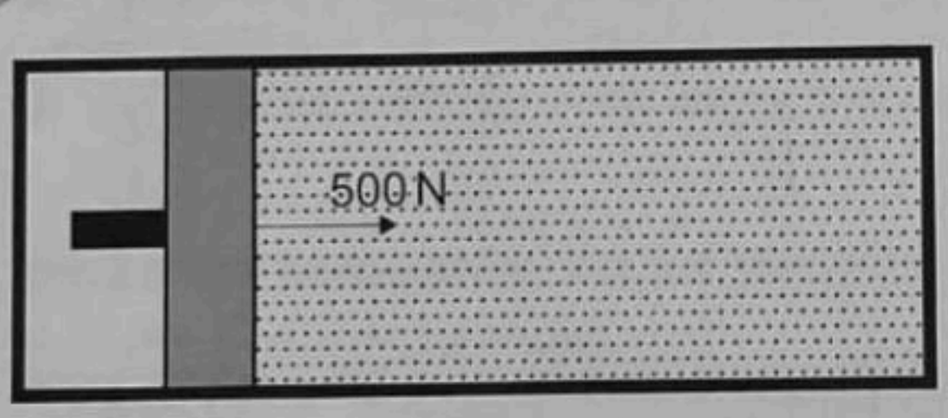
$= 1.6$.

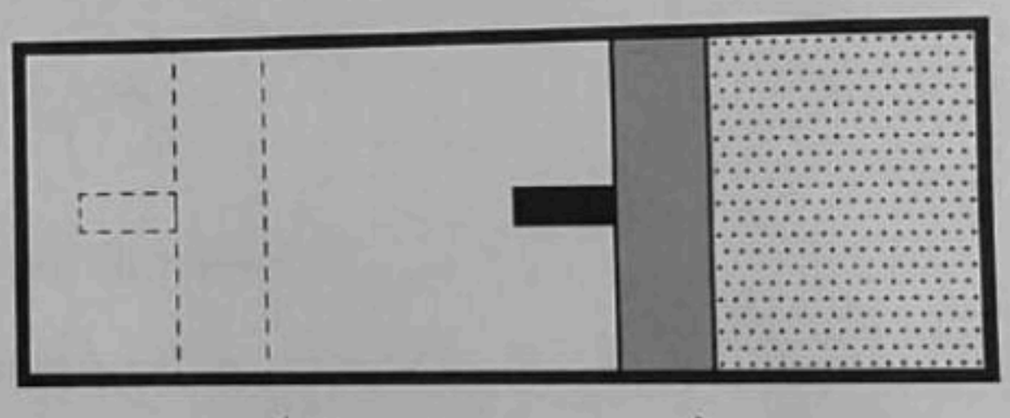
14. Which part of the graph represents an adiabatic process?



379

15. One mole of an ideal gas is enclosed in an insulated cylinder. The temperature of the gas is 80 °C. A piston is then pushed with a force of 500 N over a distance of 10 cm to compress the gas.





What is the final temperature?

A. 480 °C

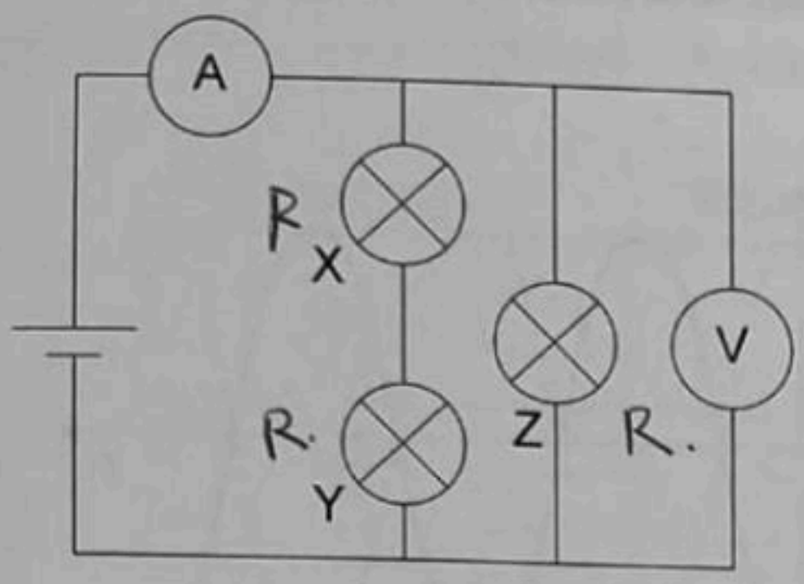
B. 400 °C

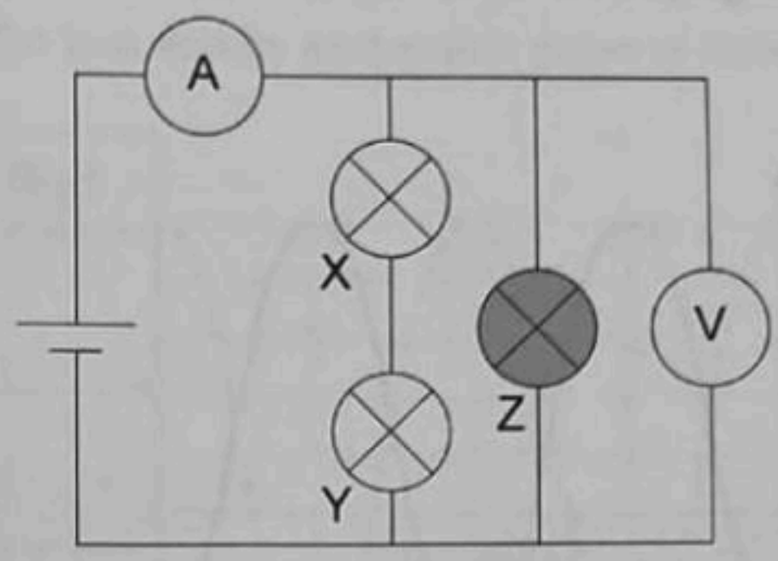
C. 84 °C

D. 4 °C

A005

16. Three identical lightbulbs are connected to a cell as shown. The cell has a negligible internal resistance. The ammeter and voltmeter read I_0 and V_0 respectively. Lightbulb Z (shown in grey) burns out and can no longer conduct electricity.





What are the new readings of the ammeter and the voltmeter?

	Ammeter reading	Voltmeter reading
A.	$\frac{1}{3}I_0$ √	less than V_0 √
B.	$\frac{2}{3}I_0$	less than V_0
C.	$\frac{1}{3}I_0$ √	V_0
D.	$\frac{2}{3}I_0$	V_0

379

$V_0 = IR$ $\quad V = IR$

$I = \frac{V}{R}$ $\quad \frac{1}{R_T} = \frac{1}{R} + \frac{1}{2R}$

$\frac{1}{R_T} = \frac{3}{2R}$

$I_0 = \frac{V}{\frac{2R}{3}} = \frac{3V}{2R}$. $\quad R_T = \boxed{\frac{2R}{3}}$.

$I = \frac{V}{2R} = \frac{1}{2}\frac{V}{R}$. $\quad \frac{1}{3}I_0 = \frac{1}{3} \times \frac{3V}{2R} = \frac{1}{2}\frac{V}{R}$.

$V_0 = I_0 \times R$. $\quad \frac{3V}{2} = 1.5V$

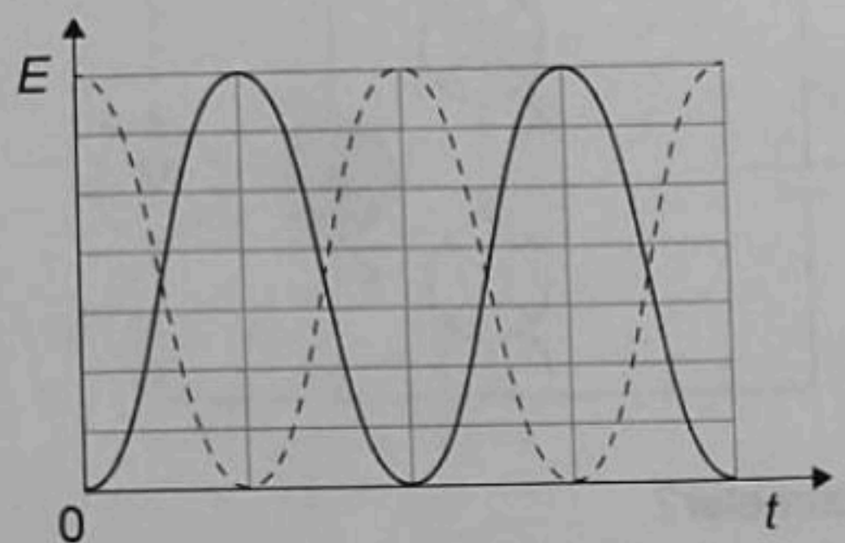
A005

mgh o $E_p = 0$ $E_{k\,max}$

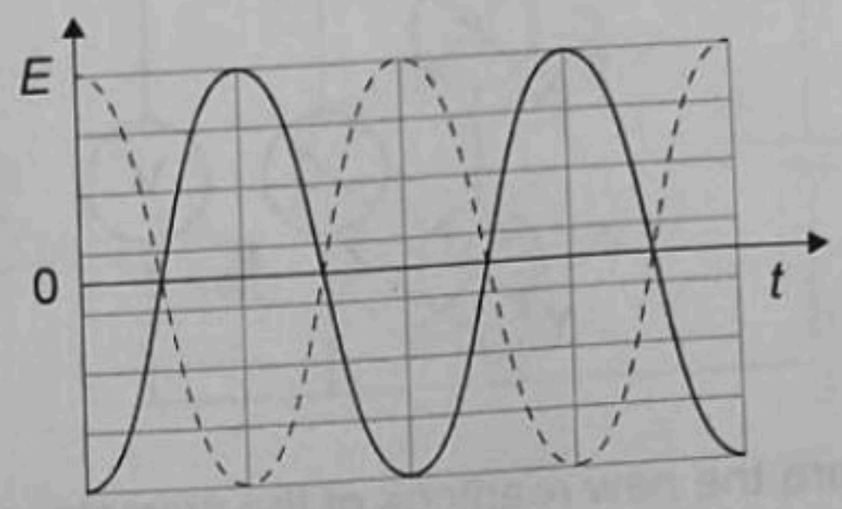
17. An object is undergoing simple harmonic motion. At $t = 0$ s the object goes through the equilibrium position. Kinetic energy is shown with a dashed line and potential energy with a solid line.

Which graph correctly represents the variation of kinetic and potential energy with time?

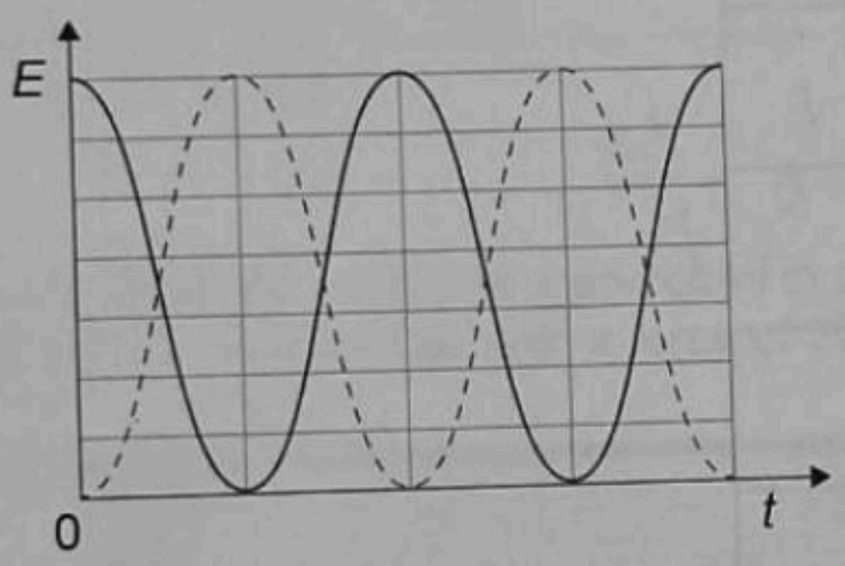
A.



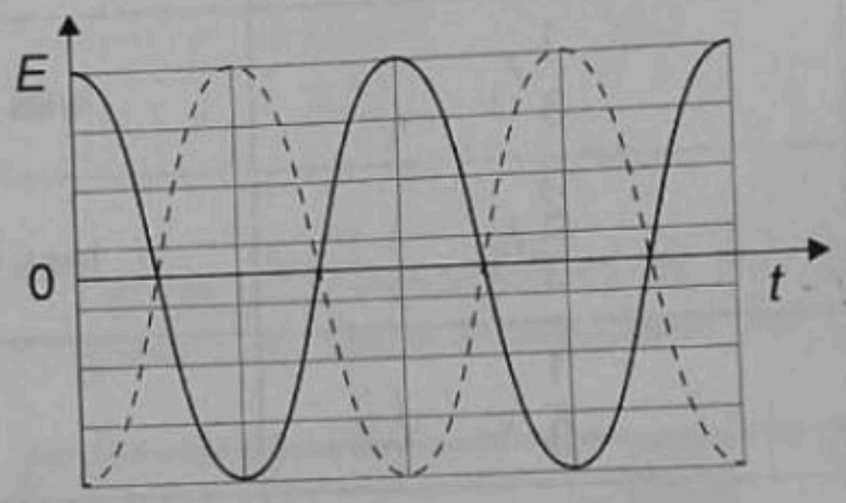
B.



C.



D.



379

18. A 1.0 kg mass undergoes undamped simple harmonic motion with a period of 2.0 s. The total energy is 72 J.

What is the amplitude?

A. 15 m

B. 12 m

C. 7.6 m

D. 3.8 m

A005

$\omega = \frac{2\pi}{T}$.

$E_T = \frac{1}{2} m \omega^2 x_0^2$

$= \frac{1}{2} \times 1 \times \left(\frac{2\pi}{2}\right)^2 x_0^2$

$= \frac{1}{2} \pi^2 x_0^2 = 72.$

$x_0^2 = \frac{2 \times 72}{\pi^2}$

19. Two waves, X and Y, are sent simultaneously through the Earth with a frequency of 5 Hz. They travel through different materials in the Earth's crust. Wave X has a wavelength of 1100 m and wave Y has a wavelength of 660 m. The waves are detected 300 km from their source.

What is the time interval between the detection of the two waves and which wave is detected first?

	Time interval / s	Wave detected first
A.	55	X
B.	36 ✓	X ✓ .
C.	55	Y
D.	36 ✓	Y

$s = vt$

$2s = v \cdot 2t$.

$s = 300000$.

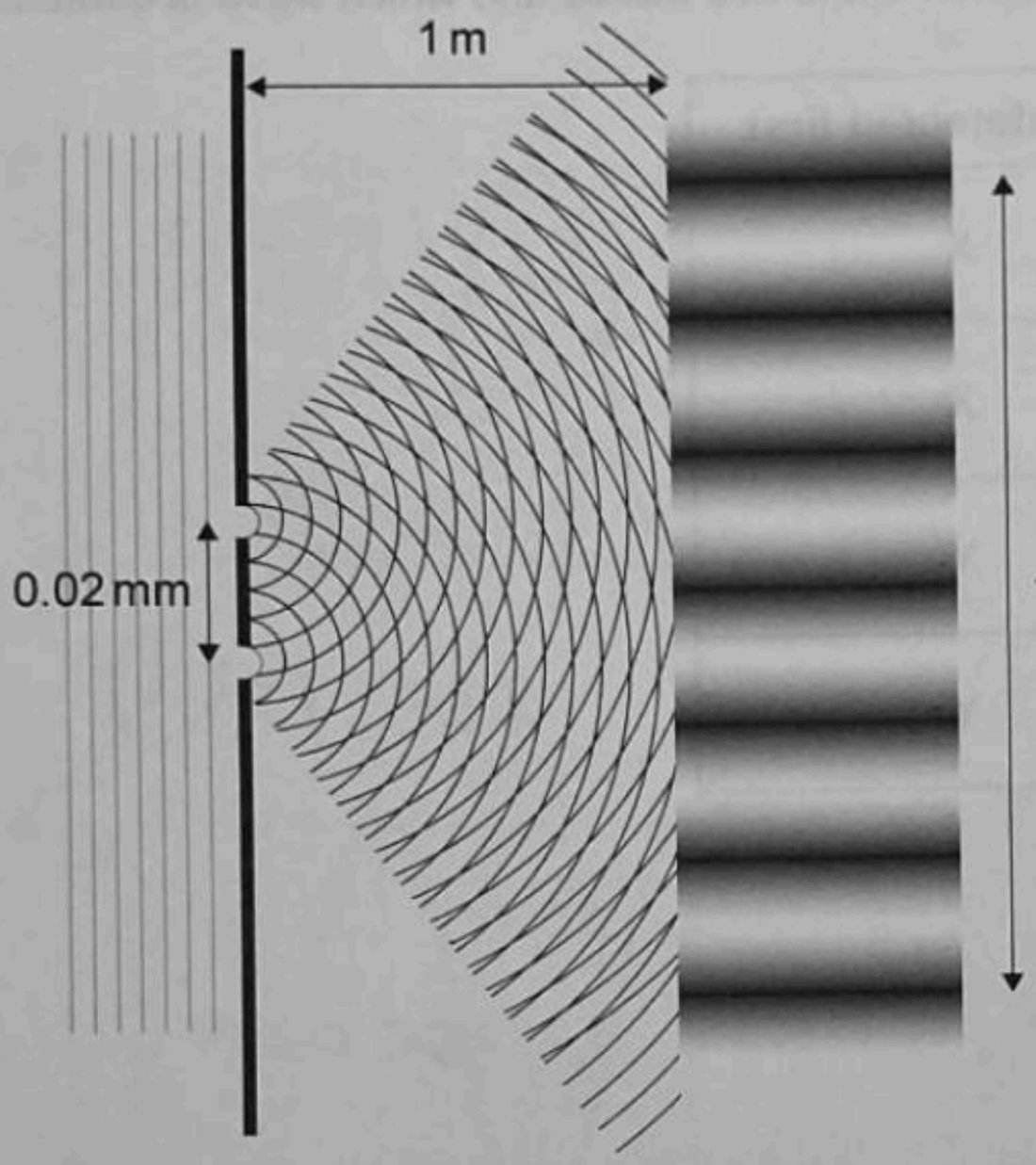
$v = f\lambda$.

$v_X = 1100 \times 5 = 5500\ m\,s^{-1}$

$v_Y = 660 \times 5 = 3300\ m\,s^{-1}$.

$t = \frac{s}{v} = \frac{600000}{}$

20. Light is sent through two slits separated by 0.020 mm. An interference pattern is observed on a screen 1.0 m from the double slit. The pattern in the diagram shows fringes along a distance of 12 cm.



$S = 0.020\ mm. \times 10^{-3}$

$D = 1.0\ m$

$d = \frac{12}{7} = 1.7\ cm. \times 10^{-2}$

$\lambda = \frac{Sd}{D}$

$= \frac{0.02 \times 10^{-3} \times 1.7 \times 10^{-2}}{1}$

$=$

What is the wavelength of the light?

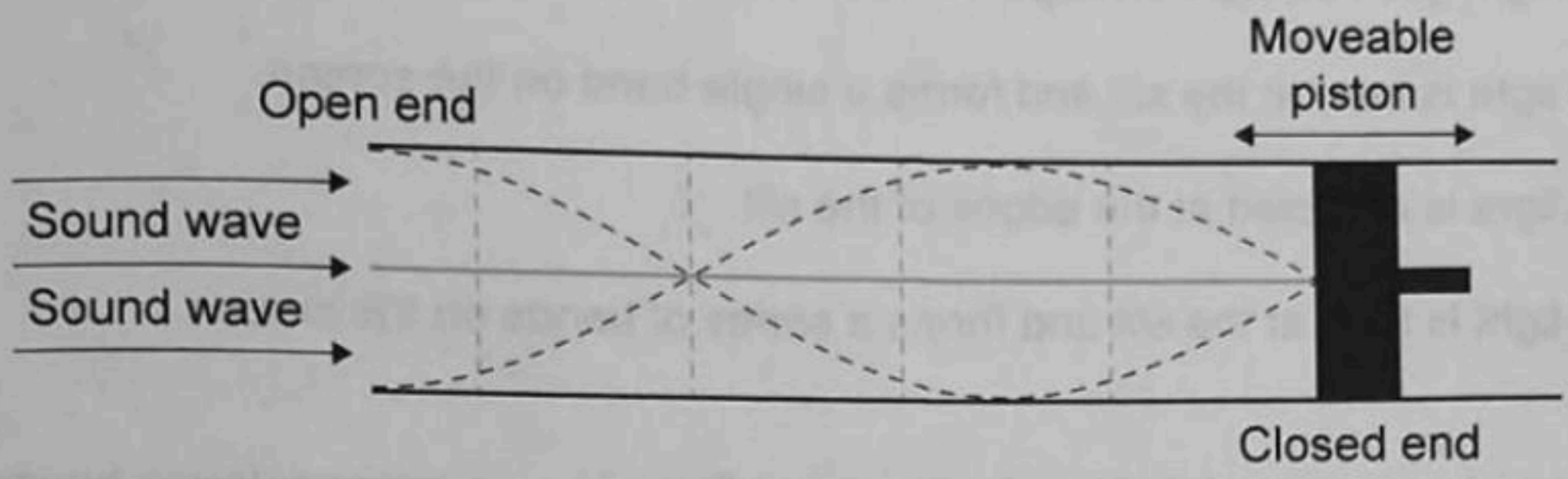
A. $4.0 \times 10^{-7}\ m$

B. $2.4 \times 10^{-6}\ m$

C. $4.0 \times 10^{-5}\ m$

D. $1.0 \times 10^{-3}\ m$

21. A loudspeaker is directed into a tube that is closed at one end by a movable piston. A standing wave is formed. In this configuration, the tube generates a loud sound with a constant frequency. The tube is shortened by moving the piston to the left until another loud sound is heard.



What was the initial harmonic and what is the final harmonic?

	Initial harmonic	Final harmonic
A.	first	first
B.	first	second
C.	third	first
D.	third	second

22. Which observation made during the single-slit experiment is consistent with the wave nature of light?

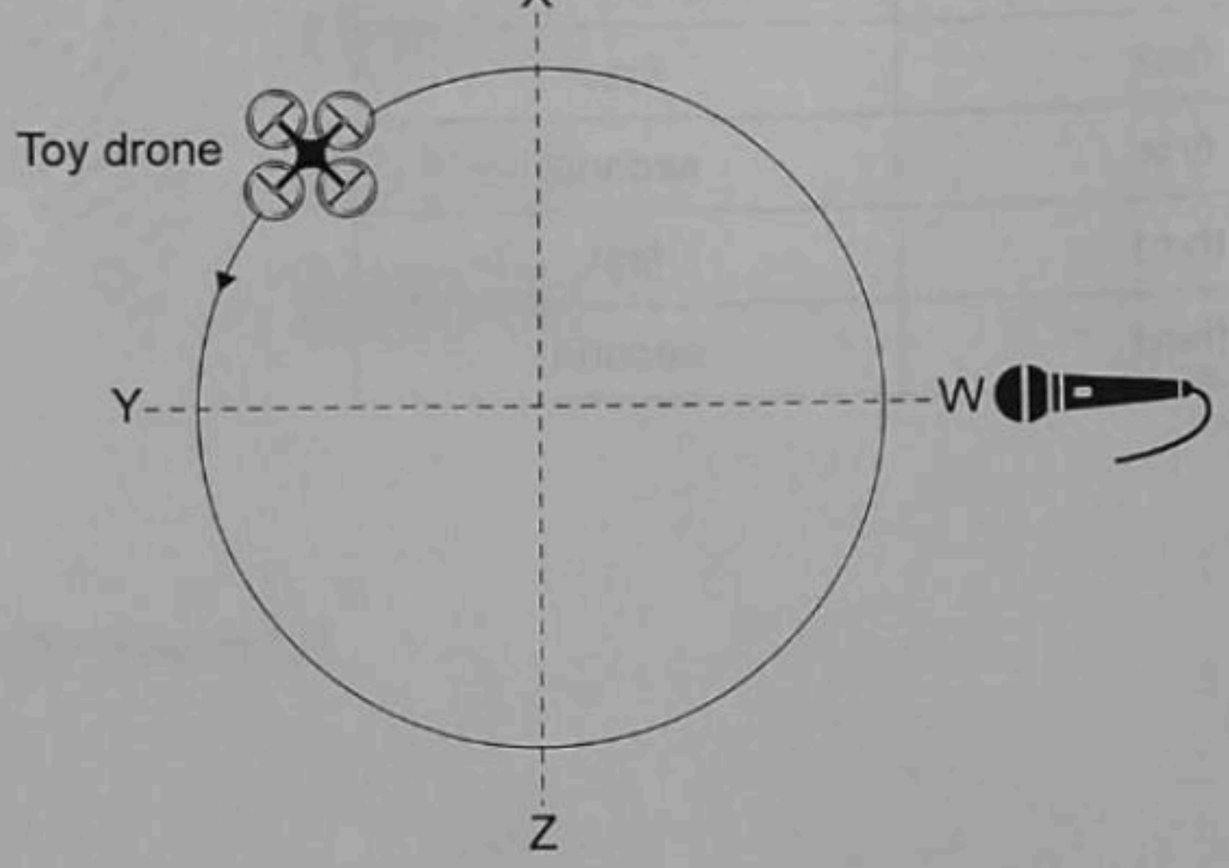
A. The light goes straight through the slit and forms a single dot on the screen. X

B. The light is bent at the slit and forms a single band on the screen. X

C. The light is reflected at the edges of the slit. X

D. The light is bent at the slit and forms a series of bands on the screen. ✓

23. The diagram shows an aerial view of a toy drone flying in a counterclockwise horizontal circle at a height of 1 meter. A microphone is mounted at the same height on a stand. The toy drone emits sound of constant frequency.



Where is the toy drone positioned when the microphone registers the highest frequency?

A. At point Z

B. At point X

C. At a point between Y and Z

D. At a point between Z and W

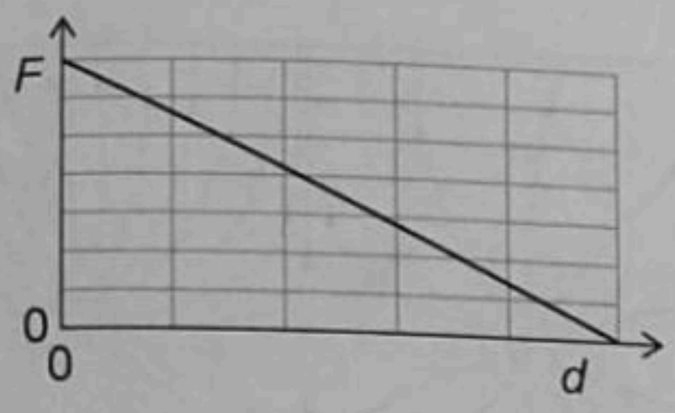
379

A005

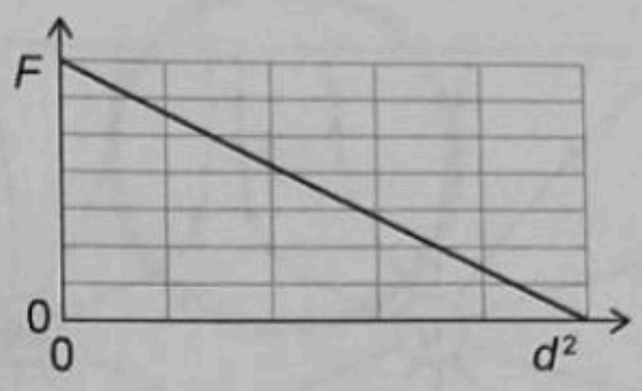
24. A spaceship is approaching a planet.

Which graph correctly represents the variation of the attractive force F with distance d as measured to the centre of the planet?

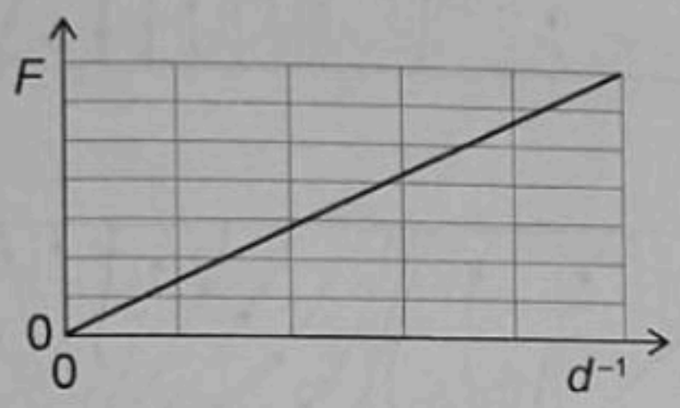
A.



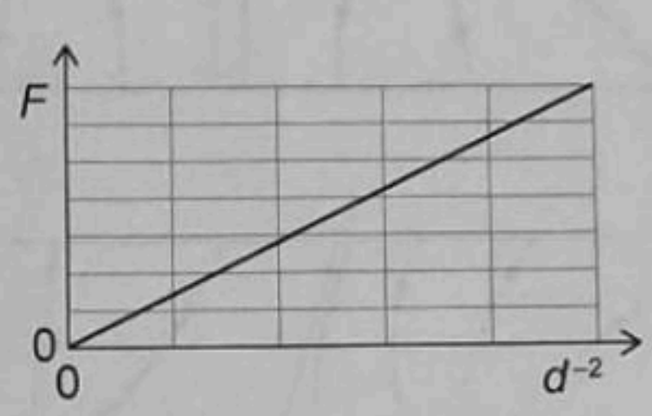
B.



C.



D.



25. A satellite orbiting Earth is moved from a higher orbit to a lower orbit.

How do the speed and orbital period of the satellite change?

	Speed	Orbital period
A.	increase	shorter
B.	increase	longer
C.	decrease	shorter
D.	decrease	longer

26. The escape speed from the surface of Earth is v_{Earth}.

What is the escape speed from the surface of a planet that has a mass 6 times that of Earth and a volume 27 times that of Earth?

A. 0.2 v_{Earth}

B. 0.5 v_{Earth}

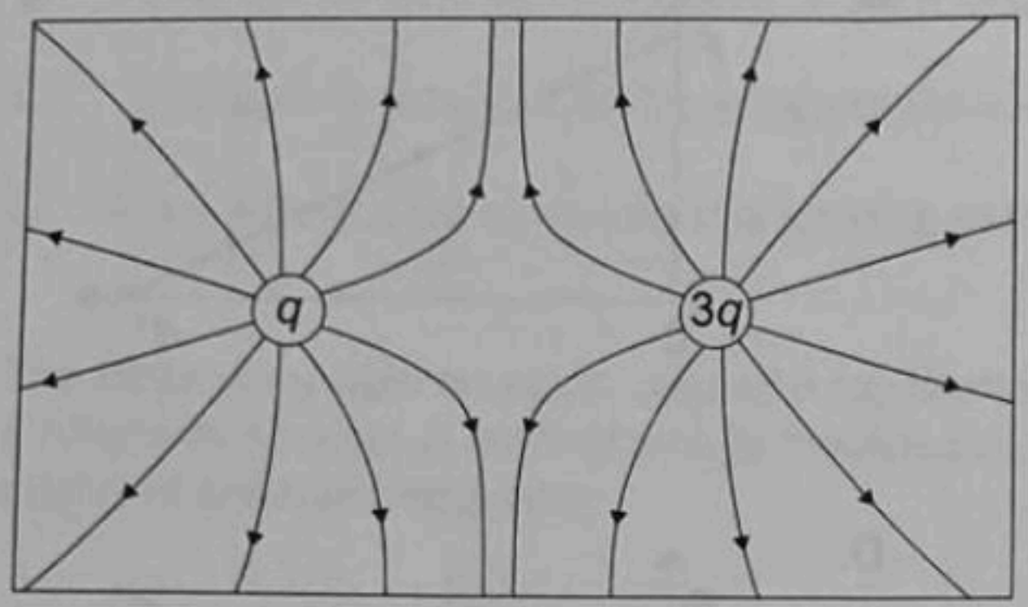
C. 1.4 v_{Earth}

D. 2.0 v_{Earth}

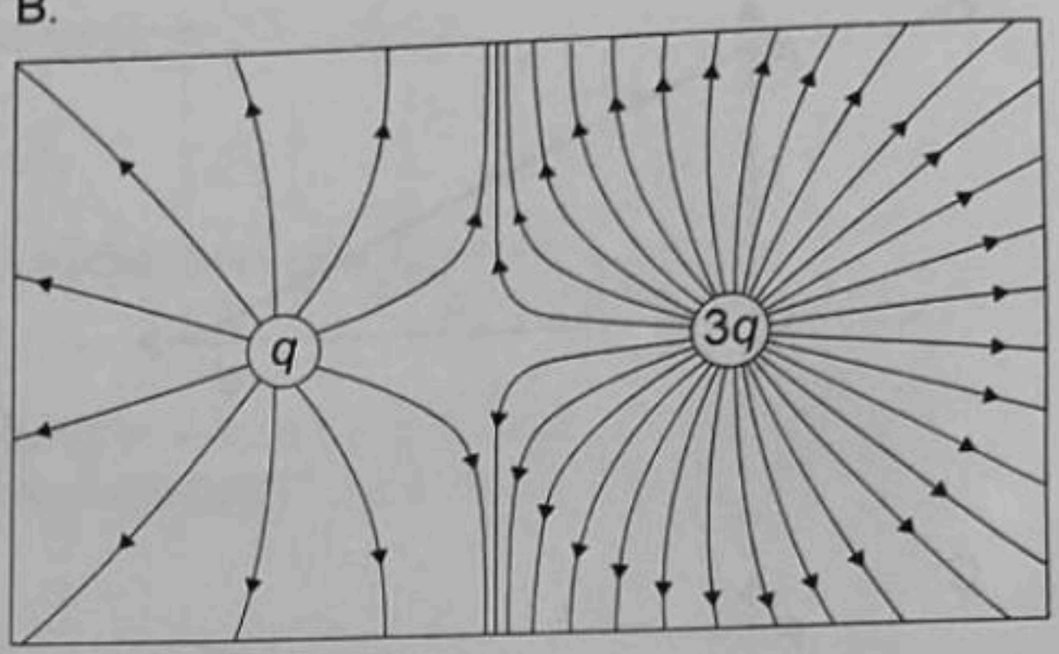
27. Two positive charges, q and $3q$, are brought together.

Which diagram best represents the electric field lines for this situation?

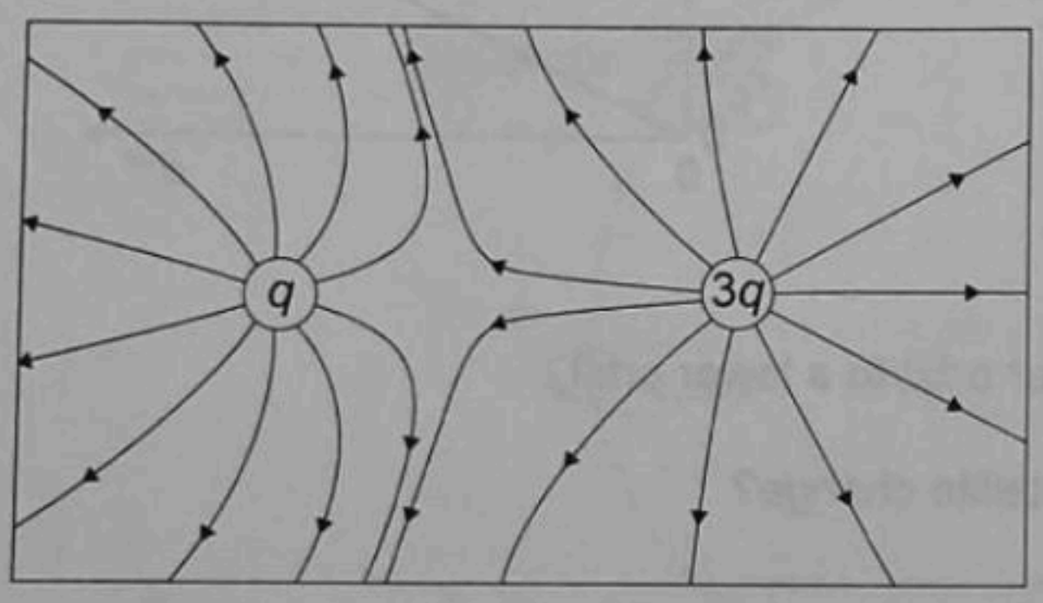
A.



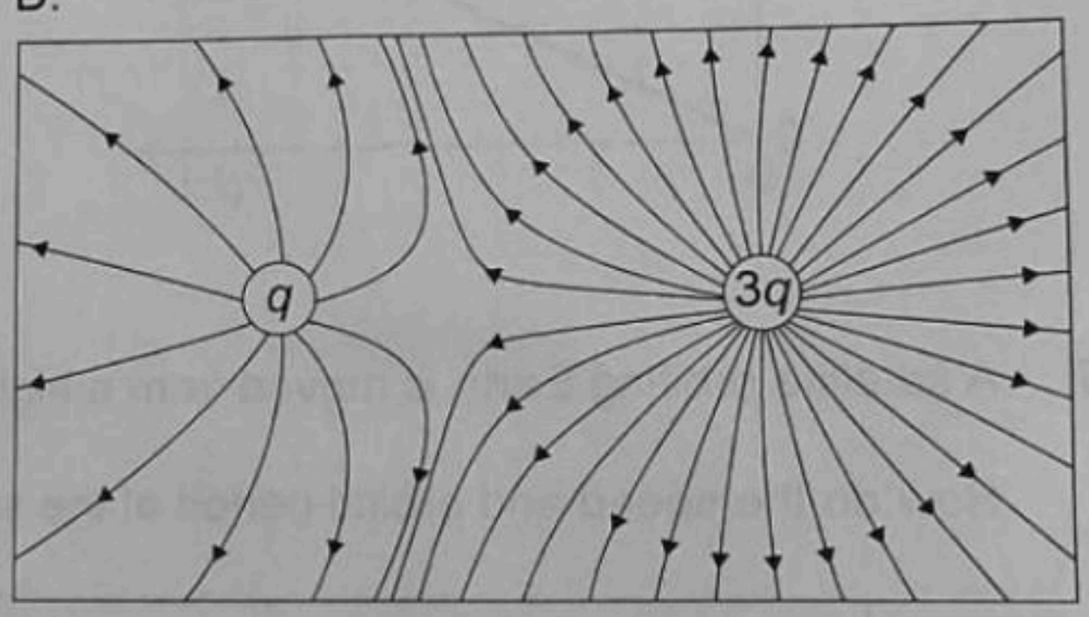
B.



C.

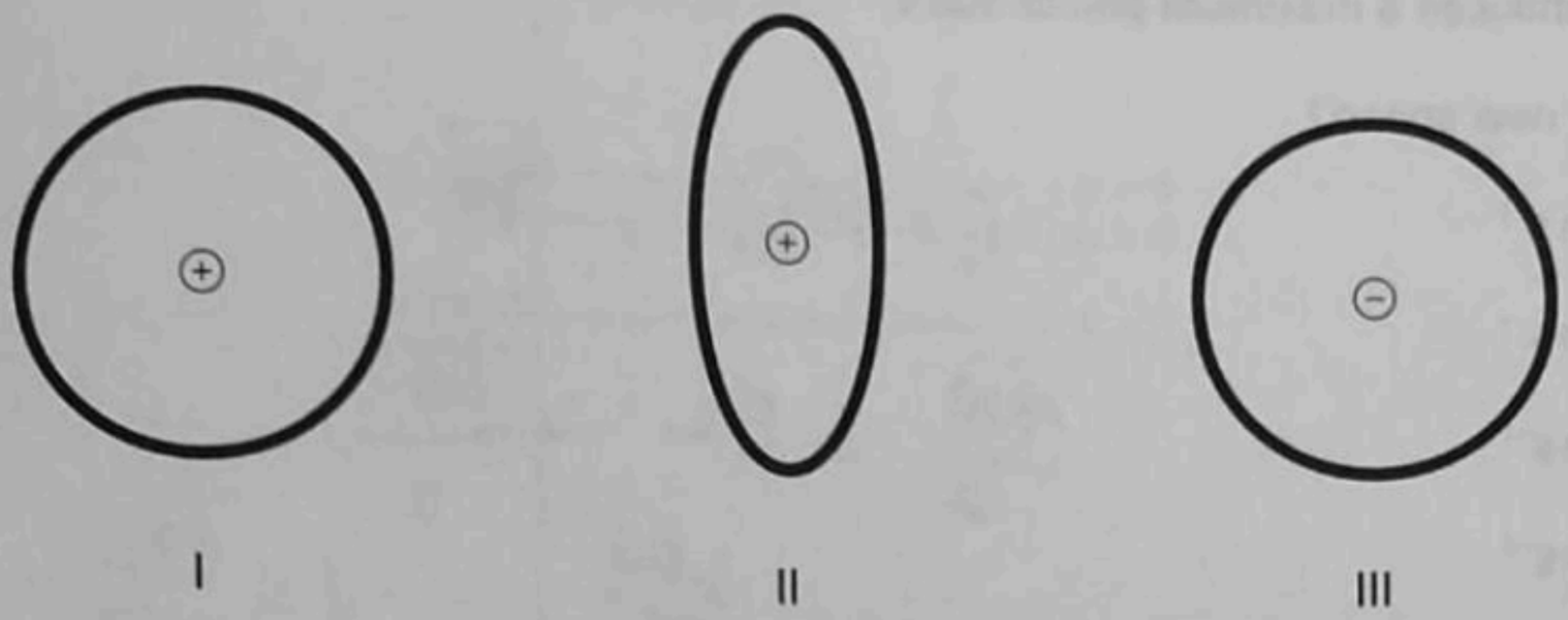


D.



379

28. The diagrams show three regions around isolated point charges. In diagram I and II the charge is positive. In diagram III the charge is negative.



I II III

In which diagrams does the region show an equipotential line?

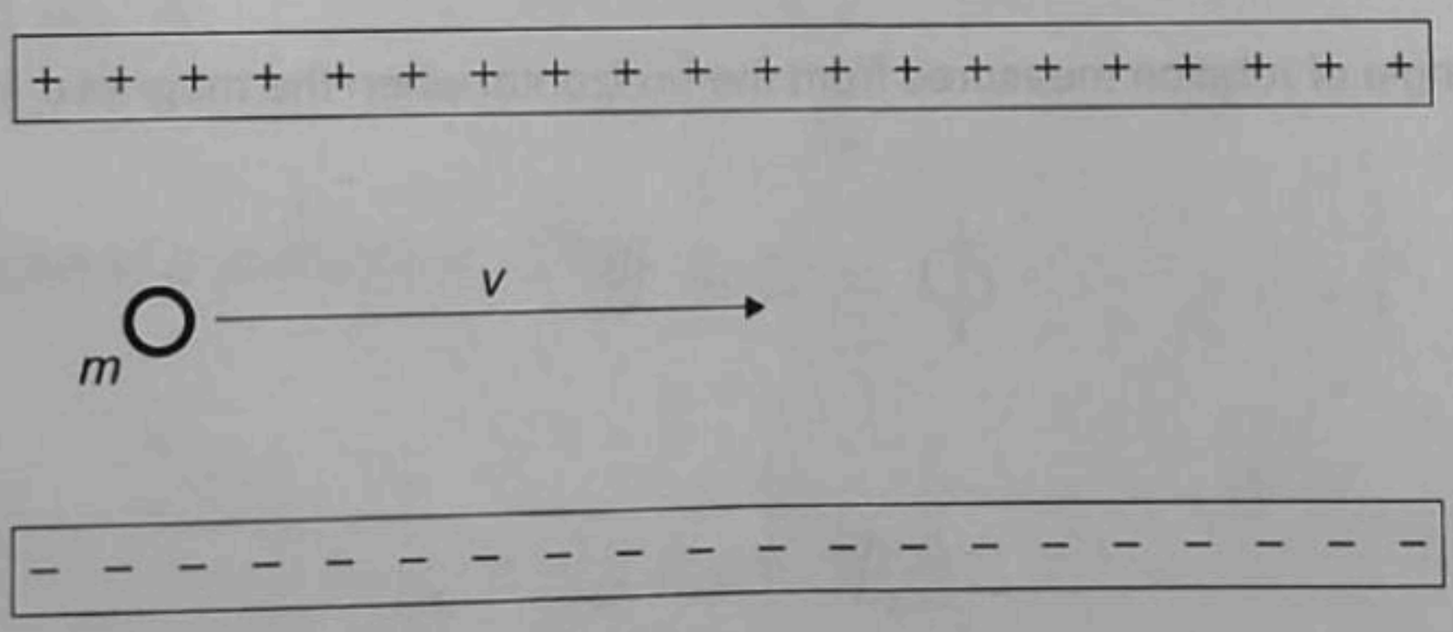
A. I and II only

B. I and III only

C. II and III only

D. I, II, and III

29. A particle with mass m and negative charge q is moving with speed v between two charged plates. The plates form an electric field E.



What is the resultant force on the particle?

A. mg

B. $qE - mg$

C. $qE + mg$

D. qE

30. A magnet is inserted into a coil of 100 turns with speed 2.0 ms^{-1} and induces a maximum emf of 400 V. The magnet is then inserted into a coil of the same length and cross-sectional area with 300 turns and induces a maximum emf of 300 V.

What is its new speed?

A. 6.0 ms^{-1}

B. 2.3 ms^{-1}

C. 1.5 ms^{-1}

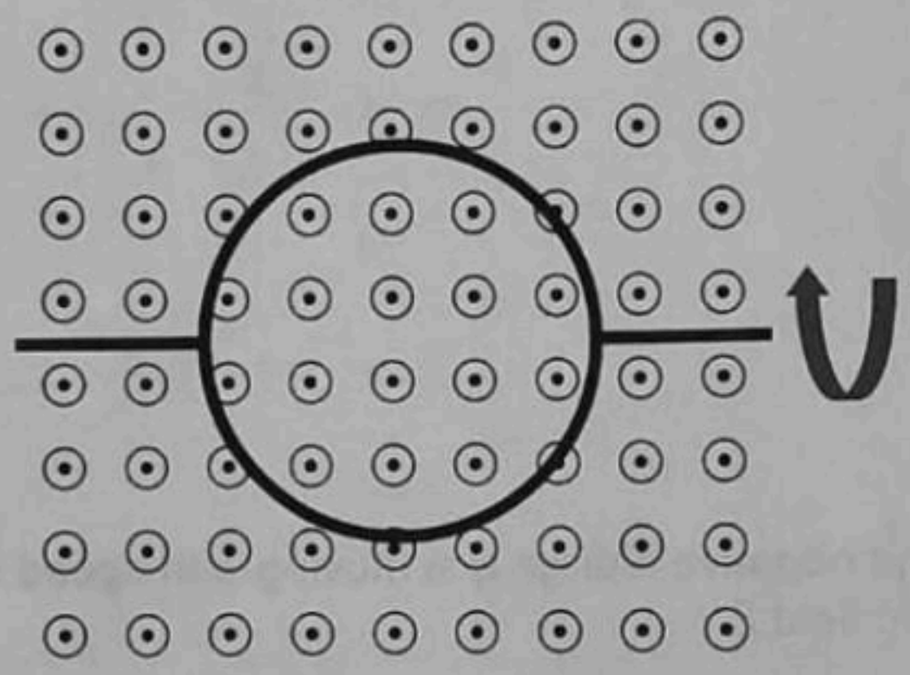
D. 0.5 ms^{-1}

$\mathcal{E} = BvL$.

$\frac{400}{2} = BL = \frac{300}{v}$

$200 = \frac{300}{v}$ $\quad v = \frac{300}{200} = 1.5$

31. A ring with a radius of 5 cm rotates about a horizontal axis in a uniform magnetic field of 0.5 T.



What is the angle of rotation measured from the horizontal when the magnetic flux through the ring is 2.0 mWb?

A. 60°

B. 75°

C. 85°

D. 89°

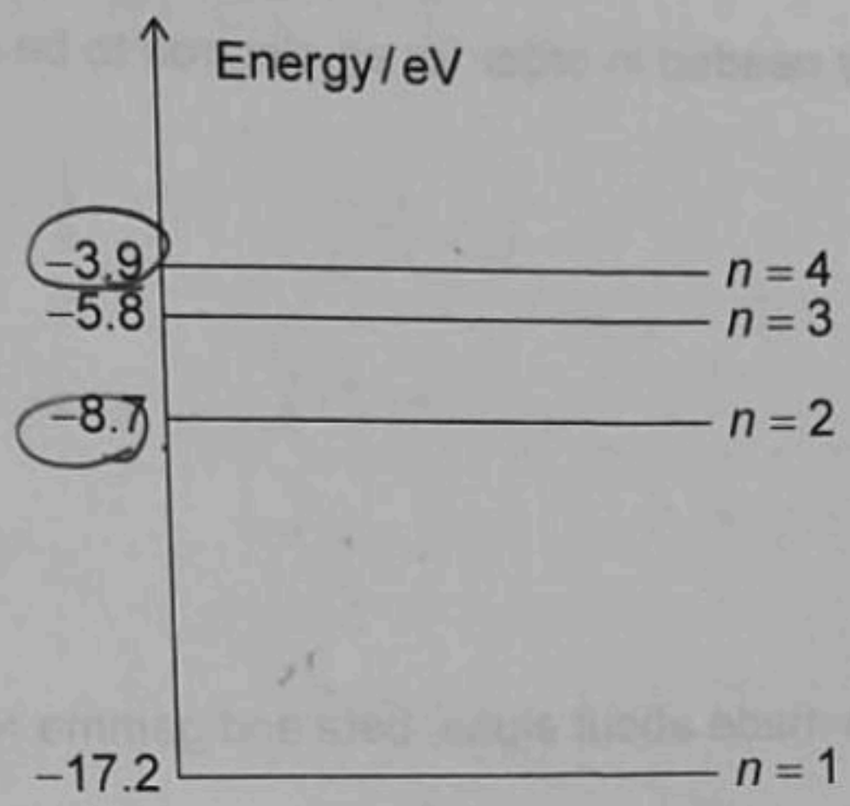
$\Phi = 2.0$

$BA\cos\theta = 2.$

$0.5 \times \pi \times (5 \times 10^{-2})^2 \cos\theta = 2$

$A = \pi r^2$

32. The diagram shows the first four energy levels in an atom.



Which statement gives the correct wavelength for a transition from $n = 4$ to $n = 2$ in this atom?

A. $\dfrac{c \times h}{(-8.7 + 3.9)e}$

B. $\dfrac{c \times (-8.7 + 3.9)e}{h}$

C. $\dfrac{c \times h}{(-3.9 + 8.7)e}$

D. $\dfrac{c \times (-3.9 + 8.7)e}{h}$

33. What is the radius of a gold nucleus $^{197}_{79}Au$?

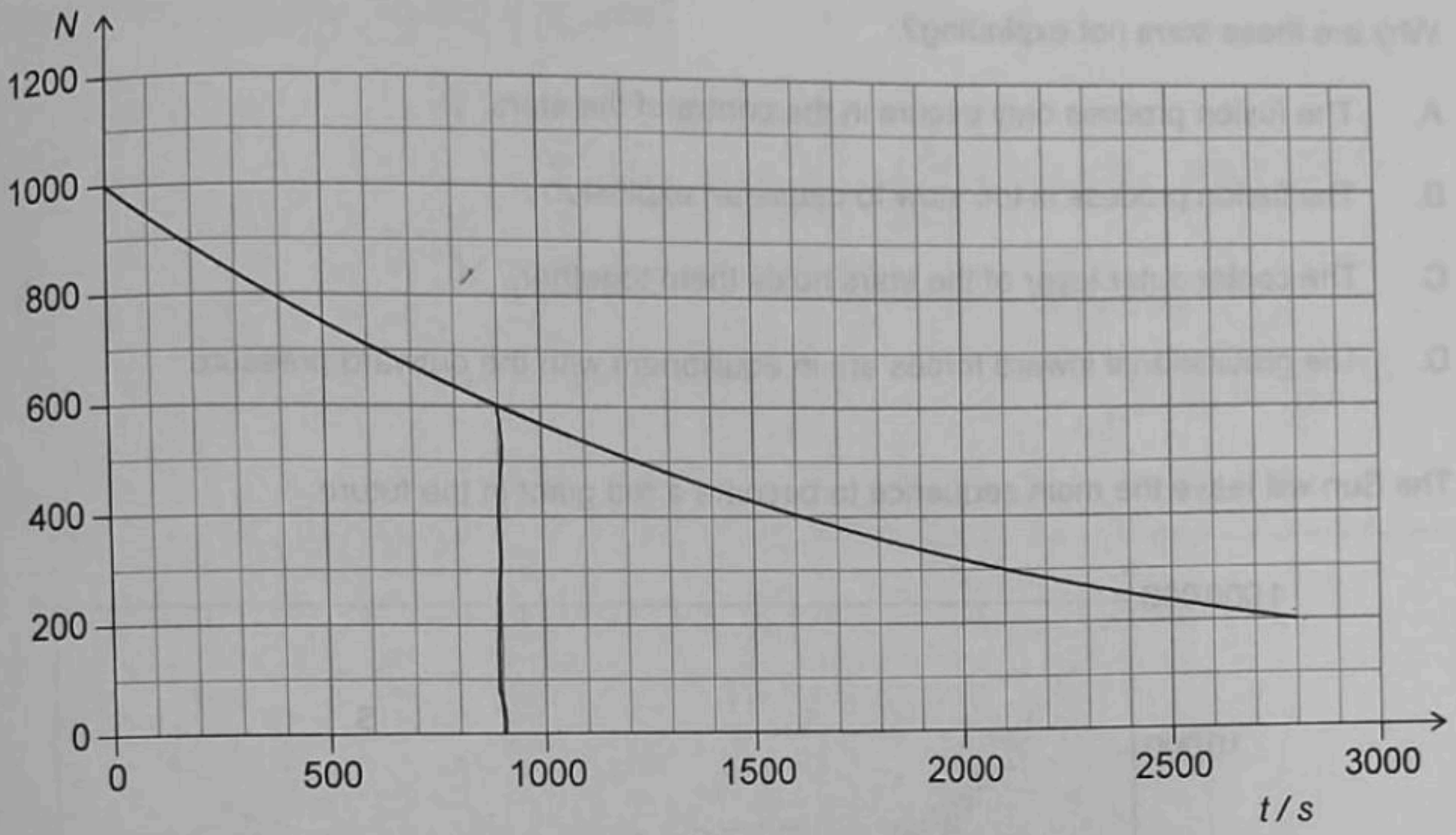
A. $R_0\sqrt[3]{79}$

B. $R_0\sqrt[3]{118}$

C. $R_0\sqrt[3]{197}$

D. $R_0\sqrt[3]{276}$

36. The graph shows the radioactive decay curve for an isotope.



What is its half-life? 900s.

A. 20 minutes

B. 15 minutes

C. 12 minutes

D. 10 minutes

37. Which statement about nuclear power plants is correct?

A. The fission process generates radioactive waste that is difficult to dispose of.

B. Nuclear power plants use water from nearby rivers to control chain reactions. X.

C. Nuclear power plants use control rods to cool down reactors. X

D. Chain reactions in fission reactors are unstoppable once they have started. ✓.

38. Nuclear fusion in stable stars produces very high temperatures and pressures.

Why are these stars not exploding?

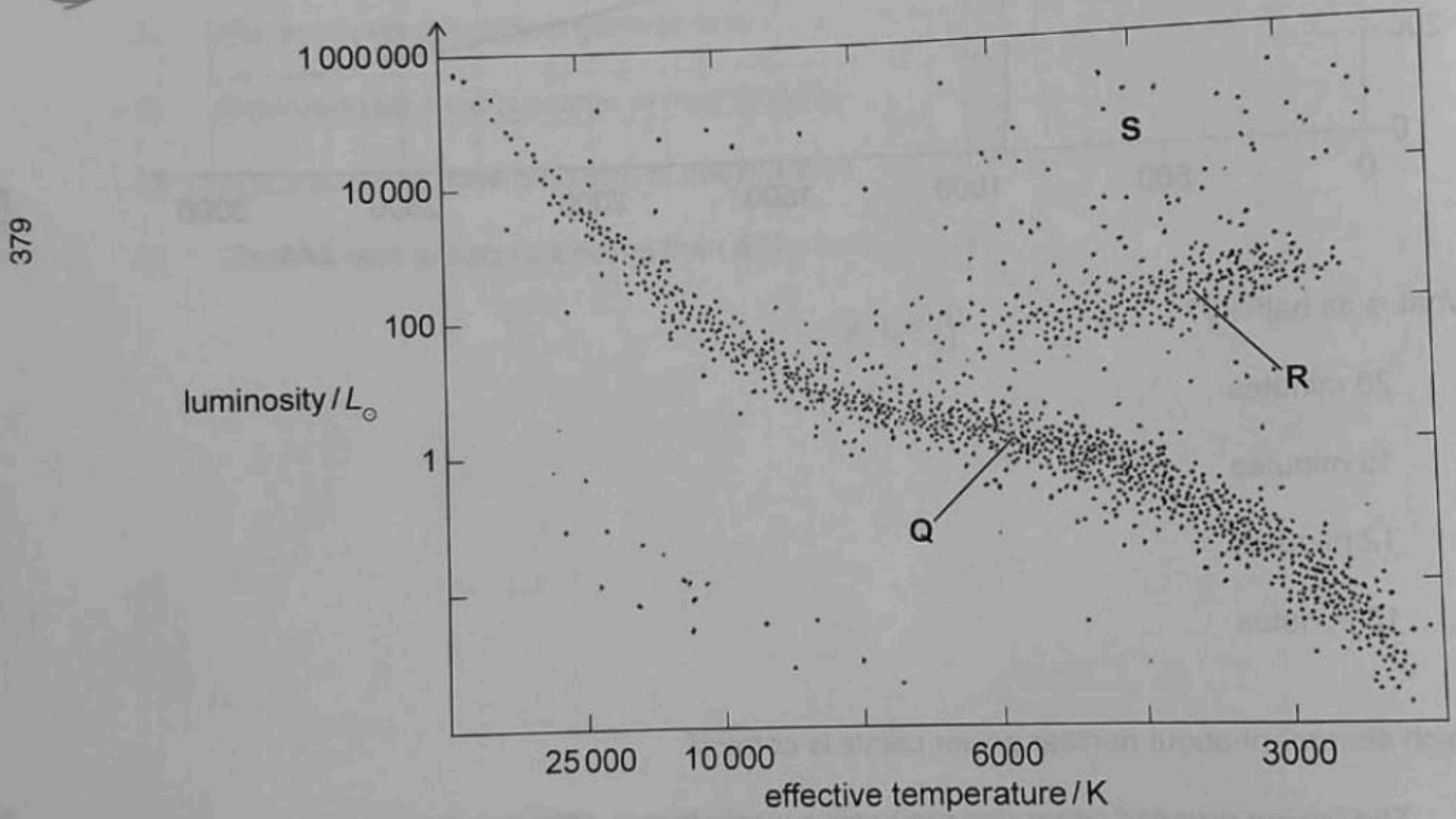
A. The fusion process only occurs in the centre of the stars. X

B. The fusion process is too slow to cause an explosion.

C. The cooler outer layer of the stars holds them together. X

D. The gravitational inward forces are in equilibrium with the outward pressure.

39. The Sun will leave the main sequence to become a red giant in the future.



379

A005

In which of the areas shown in the Hertzsprung–Russell diagram will the Sun begin and end this process?

	Begins	Ends
A.	R	R
B.	R	S
C.	Q √	R
D.	Q √	S

40. A very distant star is measured to have a parallax angle of 0.10 arcsec.

What is the distance to the star in SI units?

A. 10 pc

B. 32.6 ly

C. 3.1×10^{17} m ✓

D. 6.2×10^{17} m

$\frac{1}{0.1} = 10$ parsec.

$= 32.6$ ly.

$= 32.6 \times 10^{15}$

$=$