JEE(ADVANCED)–2026 (EXAMINATION)

(Held On Sunday 17th MAY, 2026)

PHYSICS	TEST PAPER WITH ANSWER AND SOLUTION

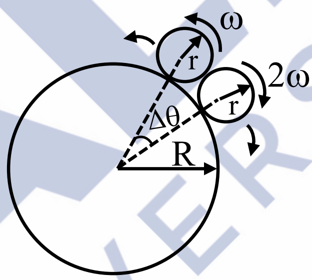
SECTION-1 (Maximum Marks : 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +3 If **ONLY** the correct option is chosen;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : −1 In all other cases.

1. Consider a large disk of radius R and two smaller disks, each of radius r = R/50, lying on its circumference, as shown in the figure. The smaller disks are initially in contact with each other, with an angular separation $\Delta\theta$ between their centers. They are made to roll without slipping in opposite directions, with constant angular velocities ω and 2ω while the large disk is held stationary. The time τ at which the smaller disks are again in contact is :

[Use $\sin(\Delta\theta) = \Delta\theta$ and ignore gravity.]



(A) $\tau = 51\times\left(2\pi - \frac{4}{51}\right)/\omega$

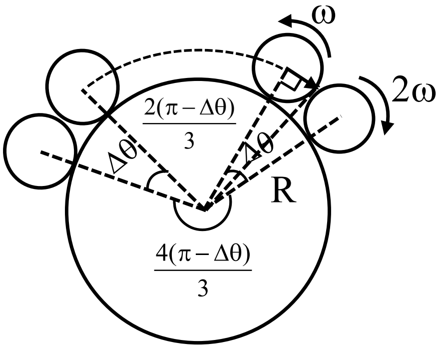
(B) $\tau = 51\times\left(2\pi - \frac{2}{51}\right)/3\omega$

(C) $\tau = 51\times\left(2\pi - \frac{4}{51}\right)/3\omega$

(D) $\tau = 51\times\left(2\pi - \frac{2}{51}\right)/\omega$

Ans. (C)

Sol.



$$\frac{2}{3}(\pi-\Delta\theta)\left(R+\frac{R}{50}\right) = \omega t.\frac{R}{50}$$

$$\frac{\Delta\theta}{2}=\frac{R/50}{R+\frac{R}{50}}=\frac{1}{51}$$

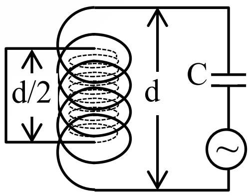
$$\Delta\theta=\frac{2}{51}\text{rad}$$

$$t=\frac{102}{3\omega}(\pi-\Delta\theta)$$

$$t=\frac{102}{3\omega}\left[\pi-\frac{2}{51}\right]$$

$$t=\frac{51}{3\omega}\left(2\pi-\frac{4}{51}\right)\text{sec}$$

2. Consider a circuit consisting of a capacitor of capacitance C and a coil with N turns per unit length, cross sectional area S and length d, where $d^2 \gg S$. There is another coil of length $d/2$, cross sectional area $S/2$ and $2N$ turns per unit length completely inside the larger coil, as shown in the figure. The ends of this smaller coil are connected with each other by an insulated conducting wire. The self-inductance of the larger coil is L. Neglecting edge effects and all the Ohmic resistances, the resonant frequency of the circuit is:

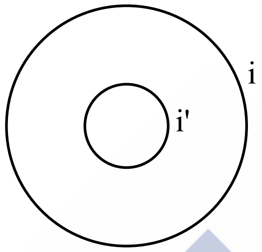


(A) $\frac{4}{\sqrt{15LC}}$ (B) $\frac{6}{\sqrt{5LC}}$ (C) $\frac{2}{\sqrt{3LC}}$ (D) $\sqrt{\frac{2}{3LC}}$

Ans. **(C)**

Sol. Larger coil, $L = \mu_0 \pi R^2 N^2 \ell = \mu_0 S N^2 d$

Smaller coil, $L' = \mu_0 \frac{S}{2}(2N)^2 \frac{d}{2} = L$



For mutual inductance $(\mu_0 N i) \times \frac{S}{2}(2N)\frac{d}{2} = Mi$

$$M = \frac{\mu_0 S N^2 d}{2} = \frac{L}{2}$$

Induced emf in bigger coil $e = -L\frac{di}{dt}$

In smaller coil $e' = -M\frac{di}{dt} - \frac{L}{2}\frac{di}{dt} = -L\frac{di'}{dt}$

$$\frac{di'}{dt} = \frac{1}{2}\frac{di}{dt}$$

$$i' = \frac{i}{2}$$

Net emf in bigger coil

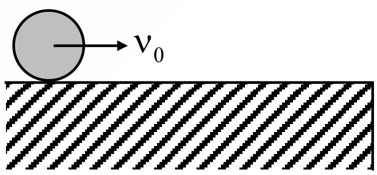
$$e = e_1 - e_2 = -L\frac{di}{dt} + M\frac{di'}{dt} = -L\frac{di}{dt} - \frac{L}{2}.\frac{1}{2}\frac{di}{dt}$$

$$= -\frac{3}{4}L\frac{di}{dt}$$

$$\therefore \quad L_{eq} = \frac{3L}{4}$$

$$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{\frac{3L}{4}.C}} = \frac{2}{\sqrt{3LC}}$$

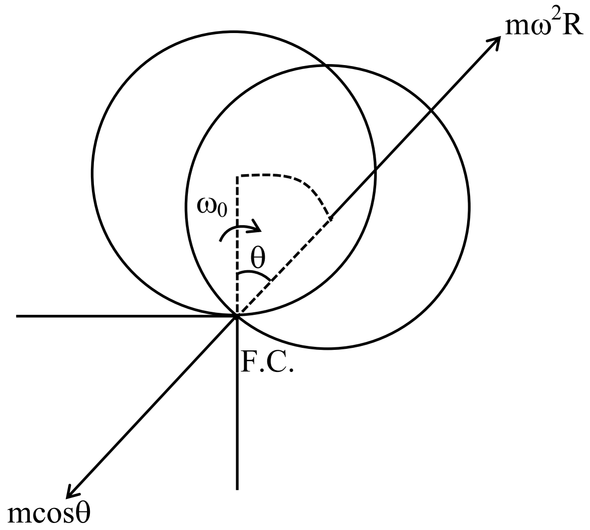
3. A solid cylinder of radius *R* rolls without slipping with a center of mass speed $v_0 = \sqrt{\frac{gR}{3}}$ on a horizontal surface with a vertical edge, as shown in the figure. Here, *g* is the acceleration due to the gravity. At the moment when the cylinder loses contact with the surface due to rotation around the corner, the speed of its center of mass is:



(A) 0 (B) $\sqrt{\frac{5gR}{7}}$ (C) $\sqrt{\frac{gR}{15}}$ (D) $\sqrt{\frac{3gR}{7}}$

Ans. **(B)**

Sol.



$\omega_0 = \sqrt{g/3R}$

to loose contact

$m\omega^2 R = mg\cos\theta$

$\omega^2 R = g\cos\theta$

W.E.T

$mgR\,(1-\cos\theta) = \frac{1}{2}\cdot\frac{3}{2} mR^2\,(\omega^2 - \omega_0^2)$

$g - g\cos\theta = \frac{3}{4}R(\omega^2 - \frac{g}{3R})$

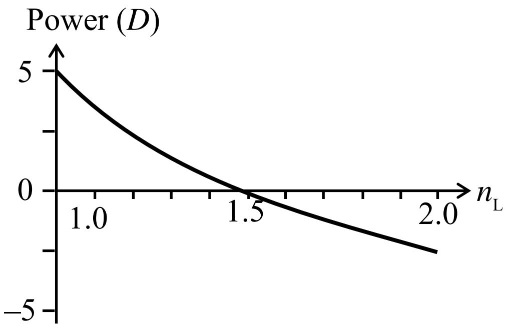
$g - \omega^2 R = \frac{3}{4}R\omega^2 - \frac{g}{4}$

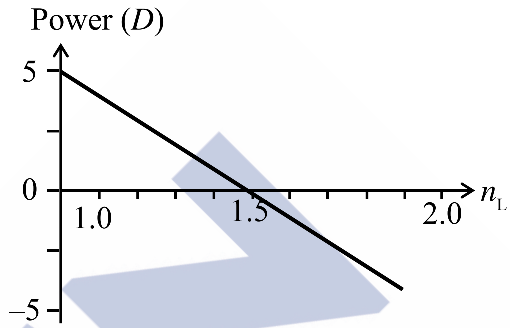
$\frac{5g}{4} = \frac{7}{4}R\omega^2$

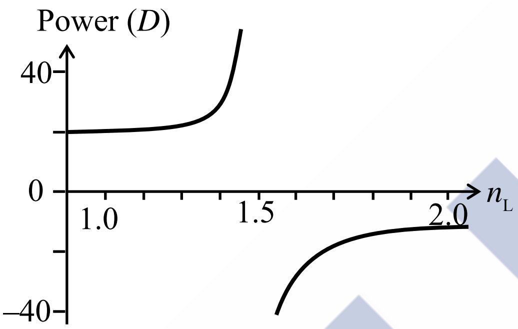
$\omega = \sqrt{\frac{5}{7}g/R}$

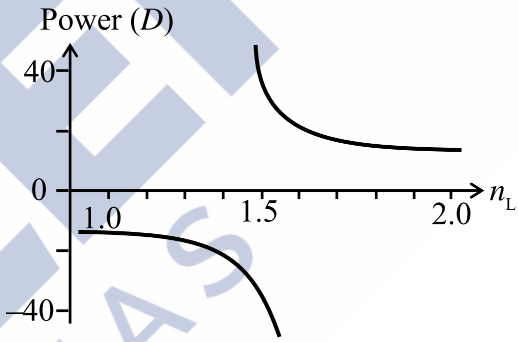
$v = R\omega = \sqrt{5g\frac{R}{7}}$

4. A double convex lens made of glass of refractive index 1.5 and radii of curvature of the curved surfaces 20 cm each is immersed in a liquid of refractive index n_L. The correct plot showing the variation of the power, in the units of diopter (D), as a function of n_L is :

(A)


(B)


(C)


(D)


Ans. (A or B)

Sol. $\frac{1}{f} = \left(\frac{1.5}{n} - 1\right)\left(\frac{1}{0.2} - \frac{1}{-0.2}\right) = \left(\frac{1.5}{n} - 1\right) \cdot 10$

According to NCERT, $P = \frac{1}{f}$

If $P = \frac{1}{f}$ (By NCERT)

$P = \frac{15}{n} - 10$

Then, correct **(Ans. A)**

OR

If $P = \frac{n}{f}$

Then $P = (1.5 - n) \cdot 10$

Then, correct **(Ans. B)**

SECTION-2 : (Maximum Marks : 16)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (A), (B), (C) and (D). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks	: +4	**ONLY** if (all) the correct option(s) is(are) chosen;
Partial Marks	: +3	If all the four options are correct but **ONLY** three options are chosen;
Partial Marks	: +2	If three or more options are correct but **ONLY** two options are chosen, both of which are correct;
Partial Marks	: +1	If two or more options are correct but **ONLY** one option is chosen and it is a correct option;
Zero Marks	: 0	If none of the options is chosen (i.e. the question is unanswered);
Negative Marks	: −1	In all other cases.

- For example, in a question, if (A), (B) and (D) are the ONLY three options corresponding to correct answers, then
  choosing ONLY (A), (B) and (D) will get +4 marks;
  choosing ONLY (A) and (B) will get +2 marks;
  choosing ONLY (A) and (D) will get +2 marks;
  choosing ONLY (B) and (D) will get +2 marks;
  choosing ONLY (A) will get +1 marks;
  choosing ONLY (B) will get +1 marks;
  choosing ONLY (D) will get +1 marks;
  choosing no option (i.e. the question is unanswered) will get 0 marks; and
  choosing any other combination of options will get –1 marks.

5. Consider a hydrogen atom with v_k, r_k and K_k denoting the velocity, orbital radius and kinetic energy of the electron in the k^{th} orbit, respectively. The electron undergoes a transition from the n^{th} orbit, emitting radiation corresponding to the Lyman series. Considering h to be the Planck's constant and $\in_0$ the permittivity of the free space, the correct statement(s) is/are:

(A) Magnitude of change in kinetic energy of electron can be expressed as $\frac{h}{4\pi}\left|\frac{nv_n}{r_n}-\frac{v_1}{r_1}\right|$.

(B) Magnitude of change in de Broglie wavelength of the electron can be expressed as $\frac{e^2}{4\in_0}\left|\frac{1}{K_n}-\frac{1}{K_1}\right|$.

(C) Frequency of the radiation emitted can be expressed as $\frac{e^2}{8\pi\in_0 h}\left(\frac{1}{r_1}-\frac{1}{r_n}\right)$.

(D) Magnitude of change in total energy of the electron can be expressed as $\frac{h}{2\pi}\left|\frac{v_1}{r_1}-\frac{nv_n}{r_n}\right|$.

Ans. **(A, C)**

Sol. $\frac{mv_k^2}{r_k} = \frac{1}{4\pi\varepsilon_0}.\frac{e^2}{r_k^2}$

or, $mv_k^2 r_k = \frac{e^2}{4\pi\varepsilon_0}$ .....(1)

$mv_k r_k = \frac{kh}{2\pi}$ .....(2)

$(1)/(2) \Rightarrow v_k = \frac{e^2}{2kh\varepsilon_0}$

$r_k = \frac{\varepsilon_0 k^2 h^2}{\pi e^2 m}$

$k_k = \frac{1}{2}mv_k^2 = \frac{1}{2}m\frac{e^4}{4k^2h^2\varepsilon_0^2} = \frac{me^4}{8k^2h^2\varepsilon_0^2} = \frac{e^2}{8\pi\varepsilon_0 r_k}$

K = n to 1 for Lymen series

$\frac{h}{4\pi}\left|\frac{nv_n}{r_n} - \frac{v_1}{r_1}\right| = \left|\frac{nh}{2\pi}.\frac{v_n}{2r_n} - \frac{h}{2\pi}\frac{v_1}{2r_1}\right|$

$= \left|mv_n r_n \frac{v_n}{2r_n} - mv_1 r_1 \frac{v_1}{2r_1}\right|$

$= \left|\frac{1}{2}mv_n^2 - \frac{1}{2}mv_1^2\right| = \Delta KE \Rightarrow$ (A) is correct

$\frac{e^2}{4\varepsilon_0}\left|\frac{1}{k_n} - \frac{1}{k_1}\right| = \frac{e^2}{4\varepsilon_0}\left|\frac{2}{mv_n^2} - \frac{2}{mv_1^2}\right|$

$= \frac{me^2}{2\varepsilon_0}\left|\frac{1}{\lambda_n^2} - \frac{1}{\lambda_1^2}\right| \neq |\lambda_n - \lambda_1|$ (Here λ_n indicates de-Broglie wave – length)

$\Rightarrow$ (B) is wrong

Frequency f of radiation emitted is given by

$h_f = K_1 - K_n$

$f = \frac{K_1}{h} - \frac{K_n}{h} = \frac{e^2}{8\pi\varepsilon_0 hr_1} - \frac{e^2}{8\pi\varepsilon_0 hr_n}$

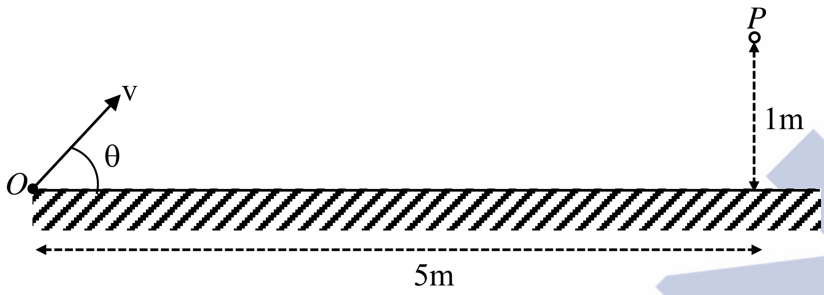
$= \frac{e^2}{8\pi\varepsilon_0 h}\left(\frac{1}{r_1} - \frac{1}{r_n}\right) \Rightarrow$ (C) correct

Change in total energy $= K_1 - K_n = \frac{e^2}{8\pi\varepsilon_0}\left(\frac{1}{r_1} - \frac{1}{r_2}\right)$

also, $\frac{h}{2\pi}\left|\frac{v_1}{r_1} - \frac{nv_n}{r_4}\right| = \frac{h}{2\pi}\left|v_1\frac{mv_1}{h}2\pi - nv_n\frac{mv_n}{nh}2\pi\right|$

$= |mv_1^2 - mv_2^2| = \frac{K_1 - K_n}{2} \Rightarrow$ (D) is wrong.

6. A particle is thrown with a speed v from a point O at an angle θ with the horizontal plane such that it passes through the point P at a height of 1 m and horizontal distance of 5 m from O, as shown in the figure. If acceleration due to gravity is g ms^{-2}, then the correct statement (s) is/are :



(A) If $\theta = 45°$, then $v = \frac{5\sqrt{g}}{2}$ ms^{-1}

(B) If $\theta = 45°$, the particle reaches its maximum height before it reaches P.

(C) If $\theta = 30°$, the particle reaches its maximum height after reaching P.

(D) If $\theta = \tan^{-1}\left(\frac{1}{5}\right)$, then $v = 125\sqrt{g}$ ms^{-1}

Ans. **(A, B)**

Sol. $y = x\tan\theta - \frac{1}{2}\frac{gx^2}{v^2\cos^2\theta}$

Passes through (5, 1)

$\Rightarrow \quad 1 = 5 \times 1 - \frac{25g}{2v^2\cos^2\theta}$

(A) If $\theta = 45°$, then

$$1 = 5 \times 1 - \frac{25g}{2v^2\left(\frac{1}{\sqrt{2}}\right)^2} \Rightarrow \frac{25g}{v^2} = 4$$

$$v^2 = \frac{25g}{4}$$

$v = \frac{5\sqrt{g}}{2}$ m/s $\Rightarrow$ (A) is correct.

(B) If $\theta = 45°$

$$R = \frac{v^2\sin 90°}{g} = \frac{25g}{4g} = 6.25 \text{ m}$$

$$\frac{R}{2} = 3.125 \text{ m} < 5\text{m}$$

Hence, particle reaches maximum height before reaching P

$\Rightarrow$ (B) is correct

(C) If $\theta = 30°$,

$$y = x\tan\theta\left(1-\frac{x}{R}\right)$$

$$1 = \frac{5}{\sqrt{3}}\left(1-\frac{5}{R}\right) \Rightarrow \frac{5}{R} = 1-\frac{\sqrt{3}}{5}$$

$$\Rightarrow R = \frac{25}{5-\sqrt{3}} \Rightarrow \frac{R}{2} = \frac{12.5}{5-\sqrt{3}} = 3.83 < 5$$

$\Rightarrow$ Particle reaches maximum height before reaching P.

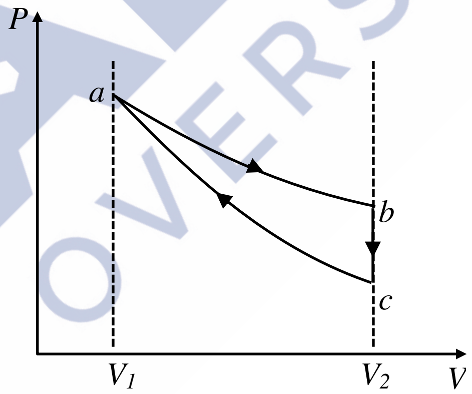
$\Rightarrow$ (C) is wrong.

(D) If $\theta = \tan^{-1}\left(\frac{1}{5}\right) \Rightarrow \tan\theta = \frac{1}{5}, \cos\theta = \frac{5}{\sqrt{26}}$

$$\therefore 1 = 5\times\frac{1}{5} - \frac{g\times 5^2}{2v^2\times\left(\frac{5}{\sqrt{26}}\right)^2} \Rightarrow v \to \infty \Rightarrow \text{(D) incorrect.}$$

7. A quasi-static cycle of a monoatomic ideal gas contains an isothermal process (***ab***), followed by an isochoric process (***bc***) and an adiabatic process (***ca***) as shown in the figure. The volumes of the gas are V_1 and V_2 at ***a*** and ***b***, respectively. If the cycle has heat input Q_{in} and output Q_{out}, then the efficiency of the cycle is defined as $\eta = \frac{Q_{in} - Q_{out}}{Q_{in}}$. The correct statement(s) is/are:

[Given : $\ln 2 \approx 0.7$]



(A) If V_2/V_1=8, the heat released in the process ***bc*** is smaller than the heat absorbed in the process ***ab***.

(B) For a given value of V_2/V_1, η does not depend on the temperature of the isothermal process

(C) If $V_2/V_1 = 8$, then the temperature of the gas at ***a*** is 4 times the temperature of the gas at ***c***.

(D) If $V_2/V_1 = 8$, then the pressure of the gas at ***a*** is 4 times the pressure of the gas at ***b***.

Ans. (A, B, C)

Sol. $C_v = \frac{3R}{2}$, $C_p = \frac{5R}{2}$, $\gamma = \frac{5}{3}$

$$Q_{in} = Q_{ab} = nRT_a \ \ell n\left(\frac{V_2}{V_1}\right)$$

$$Q_{out} = -Q_{bc} = -nC_v\,(T_c - T_b) = nC_v\,(T_a - T_c)$$

also, $TV^{\gamma-1}$ = constant for ca

$\Rightarrow T_aV_1^{2/3} = T_cV_2^{2/3}$

(A) $Q_{ab} + Q_{bc} + Q_{ca} > 0$ (Clockwise P-V cycle)

$Q_{ab} + Q_{bc} + 0 > 0$

$Q_{ab} > -Q_{bc}$ $\Rightarrow$ (A) is correct

(B) $\eta = \frac{Q_{in} - Q_{out}}{Q_{in}} = 1 - \frac{Q_{out}}{Q_{in}}$

$$= 1 - \frac{nC_v(T_a - T_c)}{nRT_a\ell n\left(\frac{V_2}{V_1}\right)}$$

$$= 1 - \frac{C_v}{R}\cdot\left(\frac{(1 - T_c/T_a)}{\ell n(V_2/V_1)}\right)$$

$$= 1 - \frac{C_v}{R}\left(\frac{1-(V_1/V_2)^{2/3}}{\ell n\left(\frac{V_2}{V_1}\right)}\right)$$

$\Rightarrow$ Independent of $T_a \Rightarrow$ (B) is correct

(C) $\frac{V_2}{V_1} = 8 \Rightarrow \frac{T_a}{T_c} = 8^{2/3} = 4$

$\Rightarrow$ (C) is correct

(D) $P_aV_a = P_bV_b$

$\Rightarrow$ $\frac{P_a}{P_b} = \frac{V_b}{V_a} = \frac{V_2}{V_1} = 8 \neq 4$

$\Rightarrow$ (D) is wrong

8. The electric field associated with an electromagnetic wave travelling in vacuum is given by $E_0 \sin(3y+4z+\omega t)\hat{i}$, where ω is the angular frequency. All quantities are in SI units. The correct statement(s) about this wave is/are:

[Given: speed of light in vacuum $c = 3 \times 10^8$ ms^{-1}.]

(A) The wave is travelling in $-\frac{1}{5}(3\hat{j}+4\hat{k})$ direction.

(B) The magnitude of the wave vector is 0.5 m^{-1}.

(C) The value of ω is 1.5×10^9 rad s^{-1}.

(D) The magnetic field associated with this wave is given by $\frac{E_0}{c}\sin(3y+4z+\omega t)\,(4\hat{j}-3\hat{k})$

Ans. **(A, C)**

Sol. $\vec{E} = E_0 \sin\left(\omega t + (x\hat{i}+y\hat{j}+z\hat{k}).5\left(\frac{3\hat{j}}{5}+\frac{4\hat{k}}{5}\right)\right)\hat{i}$

$\Rightarrow$ Wave propagating along $\hat{v} = -\left(\frac{3\hat{j}}{5}+\frac{4\hat{k}}{5}\right)$

$\Rightarrow$ (A) is correct

(B) Wave vector is $-5\left(\frac{3\hat{j}}{5}+\frac{4\hat{k}}{5}\right) \Rightarrow$ its magnitude is 5m^{-1}

$\Rightarrow$ (B) is wrong

(C) $C = \dfrac{\omega}{k} \Rightarrow \omega = ck = 15 \times 10^8$ rad/s

$\Rightarrow$ (C) is correct

(D) $\hat{B} = \hat{v} \times \hat{E} = -\left(\dfrac{3\hat{j}}{5} + \dfrac{4\hat{k}}{5}\right) \times \hat{i} = -\dfrac{1}{5}\left(-3\hat{k} + 4\hat{j}\right) = \dfrac{3\hat{k}}{5} - \dfrac{4\hat{j}}{5}$

$\therefore \quad \vec{B} = \dfrac{E_0}{5C} \sin(3y + 4z + \omega t)\left(3\hat{k} - 4\hat{j}\right)$

$\Rightarrow$ (D) is wrong

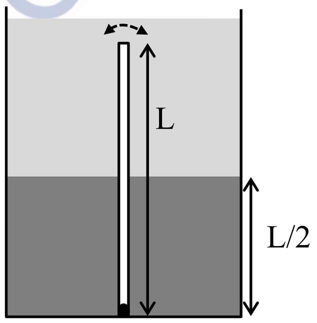
SECTION-3 : (Maximum Marks : 16)

- This section contains **FOUR (04)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value corresponding to the answer using in the designated place using the mouse and the on-screen virtual numeric keypad.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated **according to the following marking scheme:**

  Full Marks : +4 If **ONLY** the correct numerical value is entered in the designated place;

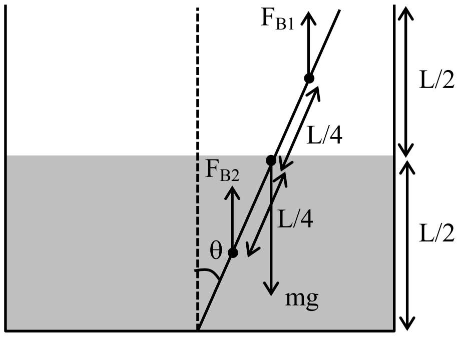
  Zero Marks : 0 In all other cases.

9. A tank contains two immiscible liquids of densities 6ρ and 2ρ. The higher density liquid is filled up to a height $L/2$ from the bottom. A thin rod of density ρ and length L is fully immersed and hinged at the bottom so that it can oscillate freely, as shown in the figure. If the rod is slightly disturbed from its equilibrium, the time period of small oscillations is $\dfrac{2\pi}{n}\sqrt{\dfrac{L}{g}}$, where g is the acceleration due to gravity. The value of n is:



Ans. (1.73)

Sol.



$$\tau_{\text{about hinge}} = F_{B1}\frac{3L}{4}\sin\theta + F_{B2}\frac{L}{4}\sin\theta - mg\frac{L}{2}\sin\theta$$

$$F_{B1} \approx 2\rho\frac{L}{2}Ag$$

$$F_{B2} \approx 6\rho\frac{L}{2}Ag \text{ [if } \theta \text{ is small]}$$

$$m = \rho LA$$

$$\therefore \tau = \left[\rho\ell Ag\frac{3L}{4} + 3\rho LAg\frac{L}{4} - \rho LAg\frac{L}{2}\right]\theta$$

$$= \rho AgL^2\left[\frac{3}{4} + \frac{3}{4} - \frac{1}{2}\right]\theta = \rho AgL^2\theta$$

$$I = \frac{mL^2}{3} = \frac{\rho LAL^2}{3}$$

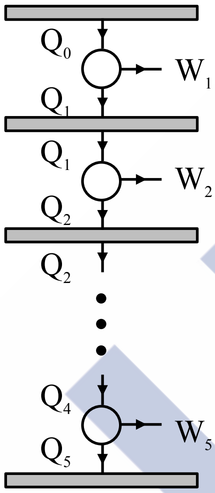
Since τ is restoring

$$\therefore \alpha = -\frac{3\rho AgL^2}{\rho AL^3}\theta = \frac{-3g}{L}\theta$$

$$\therefore T = 2\pi\sqrt{\frac{L}{3g}}$$

$$\therefore n = \sqrt{3} = 1.732 \text{ Ans.}$$

10. As shown in the figure, five Carnot engines, each with efficiency η and same number of cycles per unit time, are operating between six heat reservoirs. The amount of heat released per cycle by one engine is completely absorbed by the next engine. Consider Q_0 to be the amount of heat absorbed per cycle by the first engine and *W* as the amount of total work done by all the engines per cycle, then the net efficiency of the system is found to be $\eta_{net} = \frac{W}{Q_0} = \frac{211}{243}$. The value of η is:



Ans. **(0.33)**

Sol. From the given information

$W_n = \eta\, Q_{n-1}$

$Q_n = Q_{n-1} - W_n = Q_{n-1}(1-\eta)$

$\therefore\ Q_1 = Q_0(1-\eta)$

$Q_2 = Q_1(1-\eta) = Q_0(1-\eta)^2$

.

.

.

$Q_5 = Q_0(1-\eta)^5$

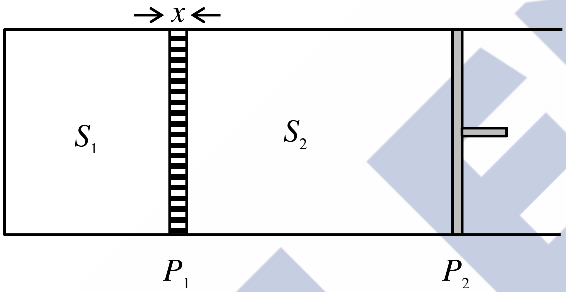
$\therefore$ Total work $= Q_0 - Q_5 = Q_0[1-(1-\eta)^5]$

$$\therefore \eta_{net} = \frac{Q_0 - Q_5}{Q_0} = 1-(1-\eta)^5 = \frac{211}{243}$$

$$\therefore (1-\eta)^5 = 1 - \frac{211}{243} = \frac{32}{243}$$

$$\therefore 1-\eta = \frac{2}{3} \Rightarrow \eta = \frac{1}{3} = 0.33$$

11. As shown in the figure, an insulated container is fitted with a thermally conducting but immovable partition (P_1) and a freely movable but thermally insulated piston (P_2). The partition P_1 with thermal conductivity K, cross sectional area A and width x divides the container into two sections, S_1 and S_2, each containing one mole of a monoatomic gas. The piston P_2 moves freely such that the gas in S_2 is always at the atmospheric pressure. Initially, the difference between the temperatures of S_1 and S_2 is ΔT_0. The time it takes for the temperature difference to become $\frac{\Delta T_0}{2}$ is nxR/KA, where R is the universal gas constant. The value of n is: [Given: $\ln 2 \approx 0.7$]



Ans. **(0.66)**

Sol. Let at any instant temperature difference be $(T_{S1} - T_{S2})$

$$\therefore \frac{dQ}{dt} = \frac{KA(T_{s1} - T_{s2})}{x}$$

Since V_{S1} = constant $\Rightarrow dQ = nC_V dT_1 = \frac{3}{2} R dT_1$

Since P_{S2} = constant $\Rightarrow dQ = nC_P dT_2 = \frac{5}{2} R dT_2$

$$\therefore \frac{d(\Delta T)}{dt} = \frac{dT_1}{dt} - \frac{dT_2}{dt} = -\frac{dQ/dt}{\frac{3}{2}R} - \frac{dQ/dt}{\frac{5}{2}R}$$

$$\therefore -\frac{kA\Delta T}{xR}\left(\frac{2}{3} + \frac{2}{5}\right) = \frac{d(\Delta T)}{dt}$$

$$\Rightarrow \frac{d(\Delta T)}{dt} = -\frac{kA\Delta T}{xR} \times \frac{16}{15}$$

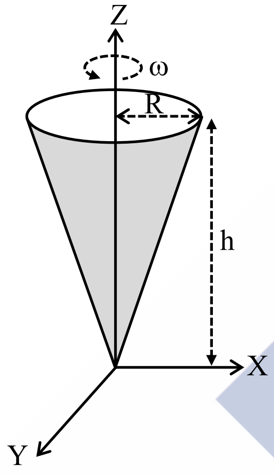
$$\Rightarrow -\int_{\Delta T_0}^{\Delta T_0/2} \frac{d(\Delta T)}{\Delta T} = \int_0^t \frac{16}{15}\frac{KA}{xR} dt$$

$$\Rightarrow \ell n 2 = \frac{16}{15}\frac{KA}{xR} t$$

$$\therefore t = \frac{0.7 \times 15 xR}{16 KA}$$

$$\therefore n = 0.65625 \approx 0.66$$

12. A hollow, right circular cone of base radius *R* and height *h*, with its tip at the origin is rotating about the Z-axis with an angular velocity ω, as shown in the figure. The cone carries a total charge Q uniformly distributed on its curved surface. The magnitude of magnetic field at a point (0, 0, *z*), where z >> R and z >> h, is $\frac{n\mu_0}{4\pi}\frac{QR^2\omega}{z^3}$. The value of *n* is:



Ans. **(0.50)**

Sol. The system can be treated as a magnetic dipole.

$$\therefore \frac{M}{L} = \frac{q}{2m}$$

$$\therefore M = \frac{q}{2m}L = \frac{Q}{2m}\cdot\frac{1}{2}mR^2\omega = \frac{Q\omega R^2}{4}$$

$$\therefore B = 2\frac{\mu_0}{4\pi}\frac{M}{r^3} = \frac{\mu_0}{2\pi}\cdot\frac{Q\omega R^2}{4\cdot z^3} = \frac{\mu_0}{8\pi}\frac{QR^2\omega}{z^3}$$

$$\therefore n = 0.5$$

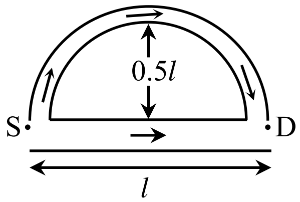
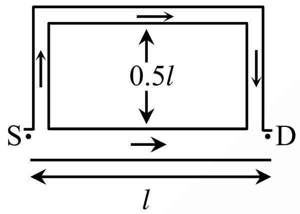
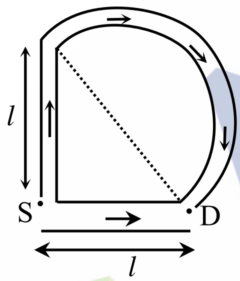
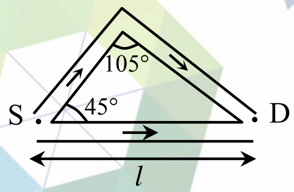
SECTION-4 : (Maximum Marks : 16)

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists : **List-I** and **List-II**.
- **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +4 **ONLY** if the option corresponding to the correct combination is chosen;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : –1 In all other cases.

13. **List-I** shows four configurations made of straight and semi-circular narrow tubes containing air. A sound wave of wavelength $\lambda = 0.29$ m enters these structures at the point S and a sound detector is placed at D. Between the points S and D, the sound travels only through the tubes. **List-II** contains the possible smallest values of l (refer to the figures) for which the detector D records maximum amplitude. Ignore effects of sharp corners. [Given cos(15°) = 0.97]

Choose the option that best describes the match between the entries in **List-I** to those in **List-II**.

List-I		**List-II**	
(P)		(1)	1.32 m
(Q)		(2)	1.19 m
(R)		(3)	0.51 m
(S)		(4)	0.29 m
		(5)	0.13 m

(A) P→4, Q→3, R→5, S→1 (B) P→4, Q→3, R→1, S→5

(C) P→3, Q→4, R→1, S→2 (D) P→3, Q→4, R→5, S→2

Ans. **(D)**

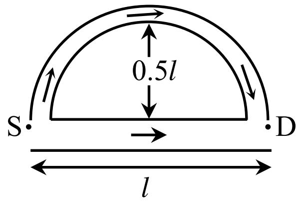
Sol. (P) Path difference :

$\Delta x = \pi R - 2R$

$= (\pi - 2)\frac{\ell}{2}$

For maxima $(\pi - 2)\frac{\ell}{2} = n\lambda$

$\ell_{min} = \frac{2\lambda}{\pi - 2} = 0.51\text{m}$



(Q) Path difference

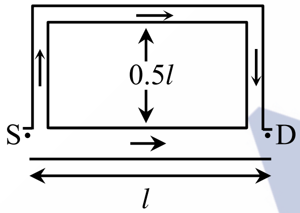
$\Delta X = 2\ell - \ell = \ell$

For maxima

$\ell = n\lambda$

$\ell_{min} = \lambda$

$= 0.29$ m



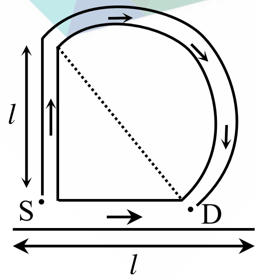
(R) Path difference :

$\Delta X = \ell + \pi R - \ell$

$\pi R = \frac{\pi \ell}{\sqrt{2}}$

For maxima $\frac{\pi \ell}{\sqrt{2}} = n\lambda$

$\Rightarrow \ell_{min} = \frac{\sqrt{2}\lambda}{\pi} = 0.13\text{m}$



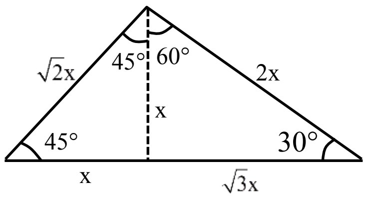
(S) $\Delta X = \left[\left(\sqrt{2}+2\right) = \left(\sqrt{3}+1\right)\right]x = 0.682x$

And $x + \sqrt{3}x = \ell \Rightarrow x = 0.366\ell$

$\Delta x = 0.249\ell$

For maxima $0.249\ell = n\lambda$

$\Rightarrow \ell_{min} = \lambda/0.249 \approx 1.19$



14. In the **List-I**, four optical effects are mentioned. The physical phenomena of light which are essential to describe these optical effects are given in **List-II**. Choose the option which describes the correct match between the entries in **List-I** to those in **List-II**.

List-I		**List-II**	
(P)	Colorful sky in north polar region (Aurora Borealis)	(1)	Dispersion and reflection
(Q)	Partially polarized sun light	(2)	Total internal reflection
(R)	Rainbow	(3)	Diffraction
(S)	Dark and bright fringes	(4)	Scattering of light by molecules in the atmosphere
		(5)	Emission of radiation from oxygen and nitrogen atoms excited by charged particles

(A) P→5, Q→4, R→1, S→3
(B) P→4, Q→2, R→1, S→3
(C) P→4, Q→1, R→2, S→3
(D) P→5, Q→4, R→1, S→2

Ans. **(A)**

Sol. (P) Aurora Borealis is a phenomenon in which a natural light is seen in Earth's upper atomosphere caused by the charged particles from Sun colliding with atoms in the atmospheric. These collisions excite oxygen and nitrogen, which then emits light of different colours such as green, red and purple.

$(P) \rightarrow (5)$

(Q) Partially Polarised Sun light occurs due to the scattering of light by dust molecules in the atmosphere.

$(Q) \rightarrow (4)$

(R) Rainbow formation occurs due to the dispersion and reflection of light inside the water molecules in air.

$(R) \rightarrow (1)$

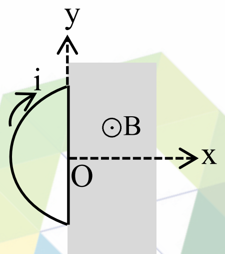
(S) Dark and bright fringes occur due to interference of light such as YDSE or diffraction.

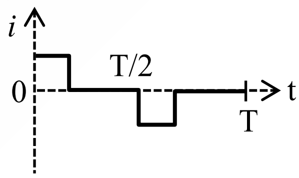
$(S) \rightarrow (3)$

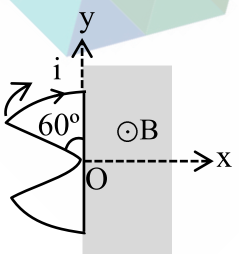
Ans. (A)

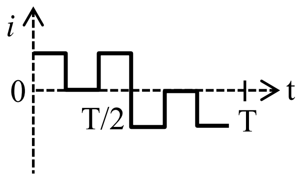
15. **List-I** contains four conducting loops lying in the XY plane, as shown in the figures. The loops are rotating about Z axis passing through the point 0 with time period T in clockwise direction. The region $x > 0$ contains a uniform magnetic field B in the +z direction. **List-II** contains the qualitative variation of the induced current $i(t)$ for each of these loops. Choose the option which describes the correct match between the entries in **List-I** to those in **List-II**.

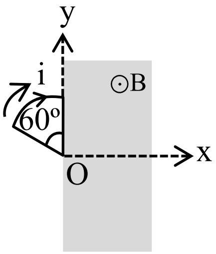
List-I | **List-II**

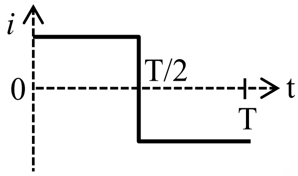
(P)


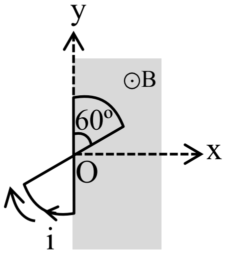
(1)


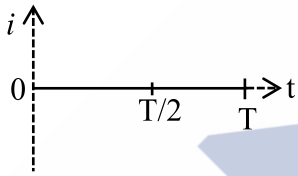
(Q)


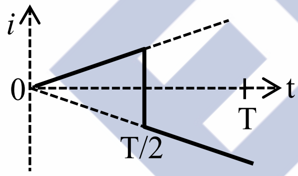
(2)


(R) 

(3) 

(S) 

(4) 

(5) 

(A) $P \rightarrow 5, Q \rightarrow 4, R \rightarrow 1, S \rightarrow 3$

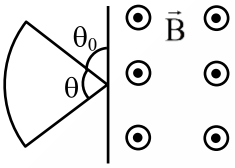
(B) $P \rightarrow 3, Q \rightarrow 2, R \rightarrow 5, S \rightarrow 4$

(C) $P \rightarrow 3, Q \rightarrow 2, R \rightarrow 1, S \rightarrow 4$

(D) $P \rightarrow 5, Q \rightarrow 1, R \rightarrow 2, S \rightarrow 3$

Ans. **(C)**

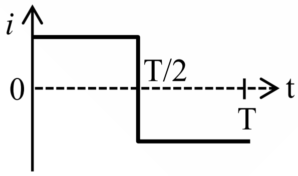
Sol. For a general loop of θ angle intilally making θ_0 angle with field.

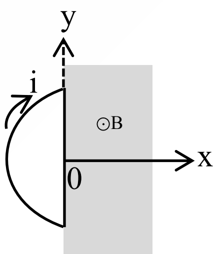


The graph starts at $t_{start} = \frac{\theta_0}{\omega} = \frac{\theta_0}{2\pi}T$

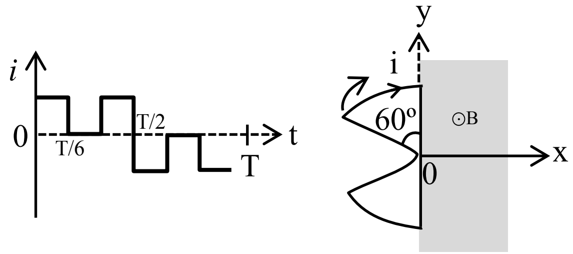
and remains constant for next $t_{constant} = \frac{\theta}{\omega} = \frac{\theta}{2\pi}T$

(P) $t_{start} = 0,\ t_{constant} = \frac{\pi}{2\pi}T = \frac{T}{2}$

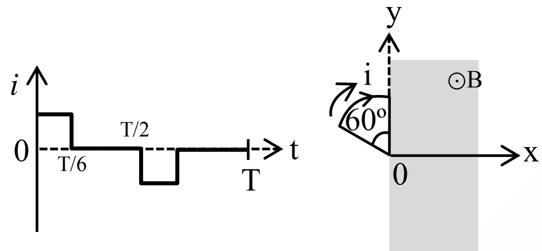




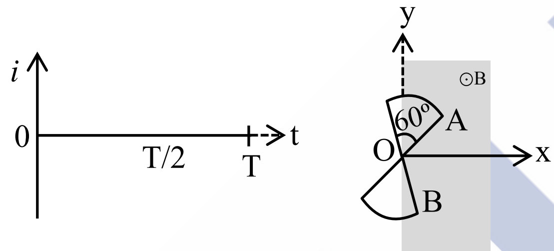
(Q) $t_{start} = 0, \frac{T}{3} \quad t_{constant} = \frac{\pi}{3.2\pi}T = \frac{T}{6}$



(R) $t_{start} = 0 \quad t_{constant} = \frac{\pi}{3.2\pi}T = \frac{T}{6}$

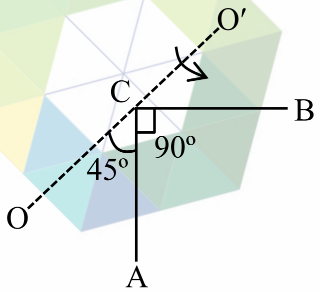
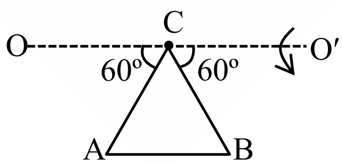


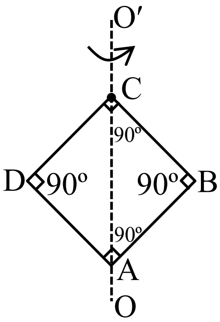
(S) Total emf of loop remains zero due to $V_{A0} = -V_{0B}$



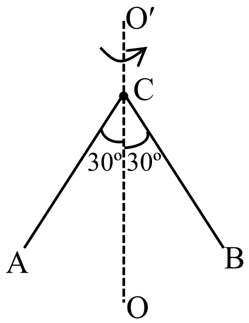
16. **List-I** shows four planar structures made of uniform solid rods each of mass m and length l. In the **List-II** the possible moment of inertia of these structures about an axis OCO′, which lies in the plane of the structures, are given.

Choose the option that describes the correct match between the entries in **List-I** to those in **List-II**.

List-I	**List-II**
(P) 	(1) $\frac{5}{4}m\ell^2$
(Q) 	(2) $\frac{1}{6}m\ell^2$

(R) 

(3) $\frac{1}{12}m\ell^2$

(S) 

(4) $\frac{2}{3}m\ell^2$

(5) $\frac{1}{3}m\ell^2$

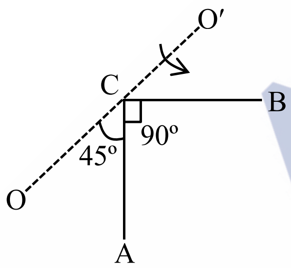
(A) P → 5, Q → 1, R → 4, S → 2

(B) P → 1, Q → 3, R → 4, S → 2

(C) P → 5, Q → 3, R → 2, S → 1

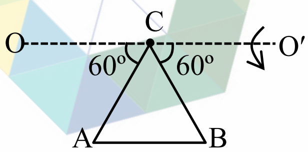
(D) P → 5, Q → 4, R → 2, S → 1

Ans. **(A)**

Sol. (P) 

$$I = \frac{M\ell^2}{3}\sin^2 45° + \frac{M\ell^2}{3}\sin^2 45°$$

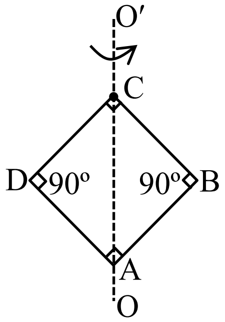
$$= \frac{M\ell^2}{3}$$

(Q) 

$$I = \frac{M\ell^2}{3}\sin^2 60° + \frac{M\ell^2}{3}\sin^2 60°$$

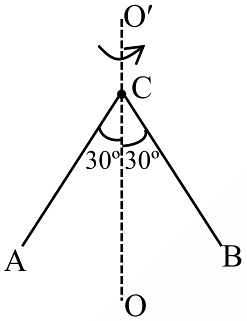
$$+\left(0 + M\left(\frac{\ell\sqrt{3}}{2}\right)^2\right)$$

$$I = \frac{M\ell^2}{2} + \frac{3}{4}M\ell^2 = \frac{5}{4}M\ell^2$$

(R) 

$$I = 4\left(\frac{M\ell^2}{3}\sin^2 45°\right)$$

$$= \frac{2}{3}M\ell^2$$

(S) 

$$I = 2\times\left(\frac{M\ell^2}{3}\sin^2 30°\right)$$

$$= \frac{M\ell^2}{6}$$