Mechanics II (JEE Main)

Work Power & Energy

Q 1.

Ans.

$$F = cx$$

$$W = \int_0^{x_1} F\,dx$$

$$= \int_0^{x_1} cx\,dx$$

$$= \left[\frac{1}{2} c x^2\right]_0^{x_1}$$

$$= \frac{1}{2} c x_1^2$$

Q 2.

Ans.

$$W = \int \vec{F} \cdot d\vec{s}$$

$$= \int_0^{10} F \cos\theta\,dx$$

$$25 = F \cos\theta \times 10$$

$$\cos\theta = 1/2 \quad \Rightarrow \quad \theta = 60^\circ$$

Q 3.

Ans.

$$W = \Delta KE = F.S = \frac{1}{2} m u^2$$

$$F_2 . S = \frac{1}{2} (2m)(2u)^2$$

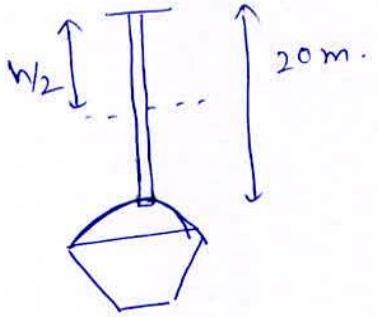
$$= 8 \times \frac{1}{2} m u^2$$

$$F_2 \cdot \not{S} = 8 \times F \cdot \not{S}$$

$$F_2 = 8F$$

Q. 4.

Ans.



$$W = \Delta P.E.$$

$$= m_w g h + m_r g h/2$$

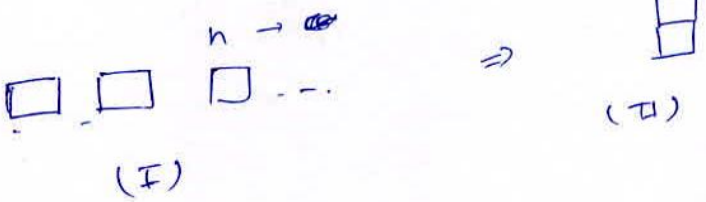
$$= 20 \times 10 \times 20 + 0.2 \times 20 \times 10 \times 10$$

$$= 4000 + 400$$

$$= 4400 \text{ J}$$

Q 5.

Ans.



$$W = \Delta P.E.$$

$$= P.E_{II} - P.E_{I}$$

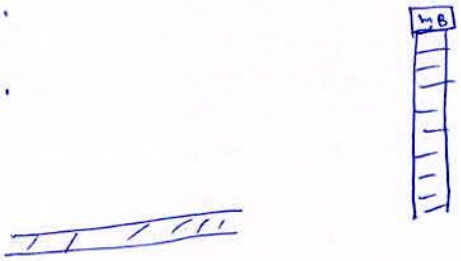
$$= nmg\frac{nl}{2} - nmg\frac{l}{2}$$

$$= nmg\frac{l}{2}(n-1)$$

$$= \frac{mgl}{2} n(n-1)$$

Q 6.

Ans.



$$\Rightarrow \quad W = \Delta P.E.$$

$$= m_B g h + m_l g \frac{h}{2}$$

$$= 80 \times 5 + 300 \times \frac{5}{2}$$

$$= 400 + 750$$

$$= 1150 \text{ J}$$

Q 7.

Ans. $W = \int F \cdot dx = 0$

$F S \cos\theta = 0$

$\theta = 90°$

$F \cdot S = 0$

$(2\hat{i} + 3\hat{j}) \cdot \left(\hat{i} + \frac{-K}{3}\hat{j}\right) = 0$

$2 - K = 0$

$K = 2$

Q 8.

Ans. $W = \int_2^3 F \cdot dx$

$= \int_2^3 (4x^2 + 3x)\, dx$

$= \left[\frac{4x^3}{3} + \frac{3x^2}{2}\right]_2^3$

$= 4 \times 3^2 + \frac{3}{2} \times 9 - \frac{4}{3} \times 8 - 3 \times 2$

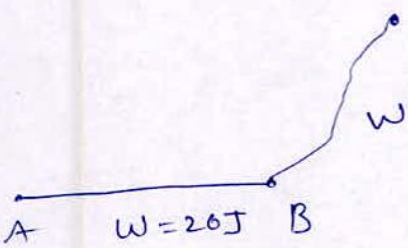
$= 36 + 3 \times (4.5 - 2) - \frac{32}{3}$

$= 36 + 7.5 - 10.66$

$= 32.8\ J$

Q 9.

Ans.



$W_{AC} = 35\ J$

Q 10.

Ans. $K.E. = \frac{p^2}{2m}$

Q 11.

Ans. $W = \Delta KE. = 40\ J$

$\Rightarrow F.S.\cos\theta = 40$

$20 \times 4 \cdot \cos\theta = 40$

$\cos\theta = 1/2$

$\theta = 60°$

Q 12.

Ans. $W = F.S.$

$\text{energy} = [F]^1\ [S]^1$

$= [4F]^1\ [4S]^1$

$= 16\ F.S$

Q 13.

Ans. $\frac{K.E._l}{K.E_c} = \frac{3}{2} = \frac{m_l V_l^2}{m_c V_c^2}$

$\frac{V_l^2}{V_c^2} = \frac{3}{8}$

$a_l = \frac{F_l}{m_l}$, $a_c = \frac{F_c}{m_c}$

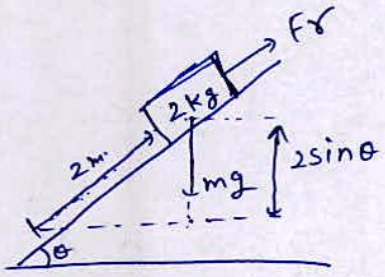
$\frac{a_l}{a_c} = \frac{F_l}{F_c} \times \frac{m_c}{m_l} = \frac{1}{2} \times \frac{1}{4} = \frac{1}{8}$

$0 = V_l - a_l t_l$, $0 = V_c - a_c t_c$

$\frac{t_l}{t_c} = \frac{V_l}{V_c} \times \frac{a_c}{a_l} = \frac{\sqrt{3}}{2\sqrt{2}} \times 8 = 2\sqrt{6}/1$

Q 14.

Ans.



$$W_g = mg\sin\theta \times 2$$

$$= 20 \times \frac{\sqrt{3}}{2} \times 2$$

$$= 34.6 \text{ J}$$

$$W_f = -\mu mg\cos\theta \times 2$$

$$= -\frac{1}{2} \times 20 \times \frac{1}{2} \times 2$$

$$= -10 \text{ J}$$

Q 15.

Ans.

$$E_A = \frac{1}{2} K_A r_A^2 \qquad K_A r_A = F$$

$$E_B = \frac{1}{2} K_B r_B^2 \qquad K_B r_B = F$$

$$\frac{E_A}{E_B} = \frac{K_A}{K_B}\left(\frac{r_A}{r_B}\right)^2 = \frac{K_A}{K_B} \times \left(\frac{K_B}{K_A}\right)^2 = \frac{K_B}{K_A}$$

$$\frac{E}{E_B} = \frac{K_B}{2K_B} \Rightarrow E_B = 2E$$

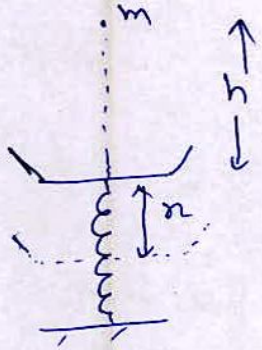
Q 16.

Ans.

Work done upon the system = ΔE

Q 17.

Ans.

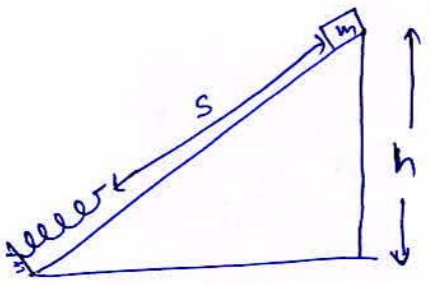


$$mg(h+x) = \frac{1}{2} k x^2$$

$$k = \frac{2mg(h+x)}{x^2}$$

Q 18.

Ans.



$$mgh = \frac{1}{2} k x^2$$

$$x = \left(\frac{2mgh}{k} \right)^{1/2}$$

Q 19.

Ans.

$$W = E_{st.\ II} - E_{st.\ I}$$

$$= \frac{1}{2} k (2 \times 5) \times 10^{-2})^2 - \frac{1}{2} k (5 \times 10^{-2})^2$$

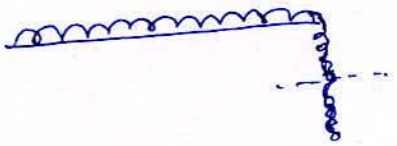
$$= \frac{1}{2} \times 5 \times 10^3 \times 10^{-4} \times 75$$

$$= 5 \times \frac{7.5}{2}$$

$$= \frac{37.5}{2} = 18.75 \text{ N-m.}$$

Q 20.

Ans.



$$\Rightarrow W = \Delta P.E.$$

$$= \frac{69}{200} \times A^2 \times g \times 30 \times 10^{-2}$$

$$= 3.6 \text{ J}$$

Q 21.

Ans.

$$V(x) = \left(\frac{x^4}{4} - \frac{x^2}{2} \right) J$$

$$P.E + K.E. = 2 J$$

for max. K.E. P.E. should be minimum.

$$\frac{dV}{dx} = 0 \Rightarrow x^3 - x = 0 \Rightarrow x(x-1) = 0$$

$x(x-1) = 0$

$x = 0 \quad , \quad x = 1$

at $x = 0$ $\quad P.E. = 0$

at $x = 1$ $\quad P.E. = -\frac{1}{4}$ ✓

$$-\frac{1}{4} + K.E_{max} = 2$$

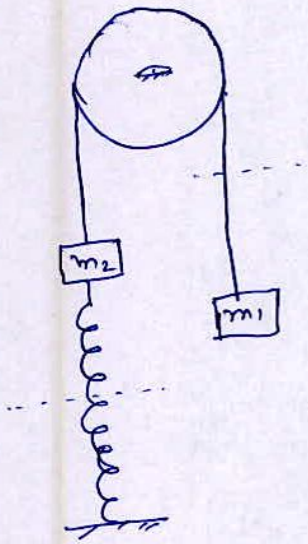
$$K.E_{max} = \frac{1}{2} \times 1 \, V_{max}^2 = 2 + \frac{1}{4}$$

$$V_{max}^2 = \frac{9}{2}$$

$$V_{max} = \frac{3}{\sqrt{2}}$$

Q 22.

Ans.



$$\Delta P.E. = \frac{1}{2} k x^2$$

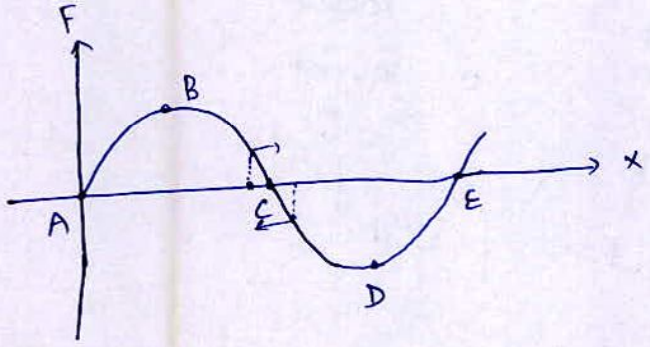
$$m_2 g x - m_1 g x = \frac{1}{2} k x^2$$

$$(m_2 - m_1) g \, x = \frac{1}{2} k x^2$$

$$x = \frac{2(m_2 - m_1) g}{k}$$

Q 23.

Ans.



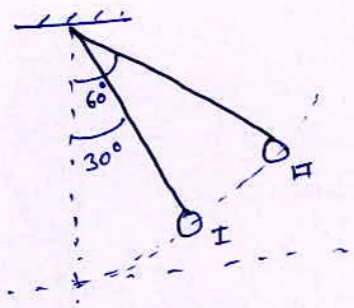
for stable equilibrium

$F = 0$ & $\frac{dF}{dx} < 0$

Ans. (C)

Q 24.

Ans.



$$\frac{P.E._I}{P.E._{II}} = \frac{mgl(1-\cos 30^\circ)}{mgl(1-\cos 60^\circ)}$$

$$= \frac{2-\sqrt{3}}{1}$$

Q 25.

Ans.

$$P = \frac{dW}{dt} = \frac{W}{t} = \frac{\Delta K.E.}{t}$$

$$P = \frac{\frac{1}{2} \times m(v^2 - 0^2)}{40}$$

$$= \frac{\frac{1}{2} \times 12 \times (16)}{40}$$

$$= 2.4 \text{ W}$$

Q 26.

Ans.

$$\text{Power} = F.v = m.a\,v$$

$$= m.\frac{v_1}{t_1}.v$$

$$= \frac{mv_1}{t_1}.\frac{v_1}{t_1}t$$

$$= \frac{mv_1^2}{t_1^2}t$$

Q 27.

Ans.

$$\text{Power} = \text{constant} = \frac{dW}{dt} = \frac{d}{dt}\left(\frac{1}{2}mv^2\right)$$

$$K = \frac{1}{2}m \times 2v\frac{dv}{dt}$$

$$\int_0^t \frac{K}{m}\,dt = \int_0^v v\,dv$$

$$\frac{v^2}{2} = \frac{K}{m}t$$

$$v = \sqrt{\frac{2K}{m}}\, t^{1/2}$$

$$\int_0^s ds = \int_0^t \sqrt{\frac{2K}{m}}\, t^{1/2}\, dt$$

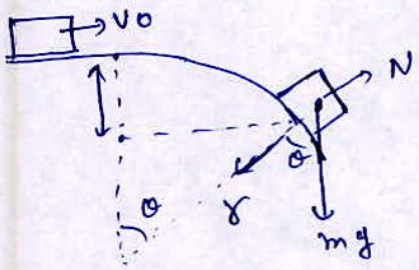
$$s = \sqrt{\frac{2K}{m}}\, t^{3/2} \Rightarrow s \propto t^{3/2}$$

Q. 28.

Ans. Q. 26.

Q. 29.

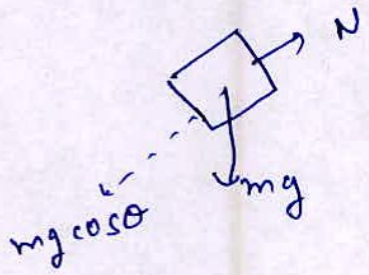
Ans.



$$v_0 = 0.5\sqrt{gr}$$

$$mgr(1-\cos\theta) = \frac{1}{2}m(v^2 - v_0^2)$$

$$\frac{1}{2}mv^2 = mgr(1-\cos\theta) + \frac{mgr}{8}$$



$$mg\cos\theta - N = \frac{mv^2}{r}$$

$$mg\cos\theta = 2mg(1-\cos\theta) + \frac{mg}{4}$$

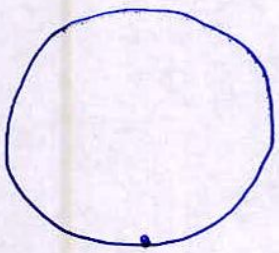
$$3mg\cos\theta = \frac{9}{4}mg$$

$$\cos\theta = 3/4$$

$$\theta = \cos^{-1} 3/4$$

Q. 30.

Ans.



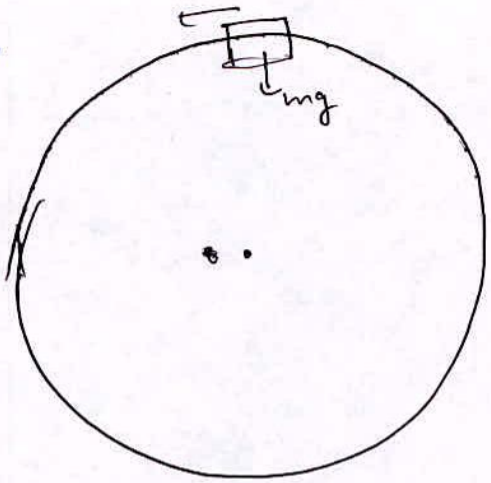
P.E. + K.E. = Constant

at lowest point P.E. is minimum

K.E. will be maximum.

Q 31.

Ans.



$mg = m \cdot r\omega^2$

$\omega = \sqrt{g/r}$

$T = \frac{2\pi}{\omega} = \frac{2\pi}{\sqrt{g/4}}$

$T = \frac{2\pi}{\sqrt{g}} \times 2 = 4 \text{ sec.}$

(Assuming ω constant)

Q 1.

Ans. $W = \Delta P.E$

$= \frac{1}{2} K \left[(15\times10^{-2})^2 - (5\times10^{-2})^2 \right]$

$= \frac{1}{2} \times 800 \times 200 \times 10^{-4}$

$= 8\ J$

Q 2.

Ans. $W = \vec{F} . \vec{s}$

$= (5\hat{i} + 3\hat{j} + 2\hat{k}) . (2\hat{i} - \hat{j})$

$= 10 - 3$

$= 7\ J$

Q 3.

Ans. $W_g = \Delta K.E.$

$= -\left(\frac{1}{2} m v^2 - 0\right)$

$= -\frac{1}{2} \times 100 \times 10^{-3} \times 25$

$= -1.25\ J$

Q 4.

Ans. $W_{Force} = \cancel{\Delta K.E.}^{\,0} + \Delta P.E.$

$= \Delta P.E.$

$= mg(2 + 0.2)$

$F \times 0.2 = 0.2 \times 10 (2.2)$

$F = 22\ N$

Q 5.

Ans. $W_{Friction} + W_{spring} = \Delta K.E.$

$$-F.x - \frac{1}{2}Kx^2 = 0 - \frac{1}{2}mv^2$$

$$30x + 10^4 x^2 - 32 = 0$$

$$x^2 + 3 \times 10^{-3} x - 32 \times 10^{-4} = 0$$

$x =$ -

Q 6.

Ans. $v = \frac{100}{10} = 10 m/s$

$$K.E. = \frac{1}{2} m v^2$$

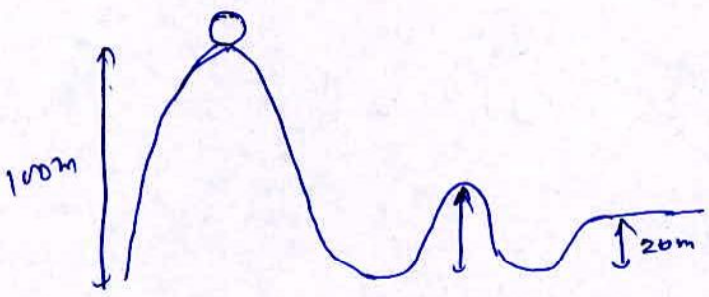
$$= 50 \times m$$

assuming m to be btw. 40 to 100

$$2000 J < K.E. < 5000 J$$

Q 7.

Ans.



$$\frac{1}{2}mv^2 = mg(100-20)$$

$$v = \sqrt{2g \times 80}$$

$$= 40 m/s$$

Q 8.

Ans. $F.V = \frac{d}{dt}\left(\frac{1}{2}mv^2\right) = K$

$= 2mv\frac{dv}{dt} = K$

$F = \frac{K}{V}$

$\frac{1}{2}mv^2 = Kt$

$v = t^{1/2}$

$F = \frac{K}{t^{1/2}}$

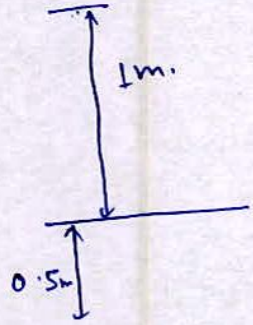
Q 9.

Ans. $\varepsilon_1 = \frac{1}{2}K_1x_1^2 = \frac{F^2}{2K_1}$

$\varepsilon_2 = \frac{1}{2}K_2x_2^2 = \frac{F^2}{2K_2}$

Q 10.

Ans. max power will be at take off



$P_{max} = F.V_{max}$

$F \times 0.5 = mg(1+0.5)$

$F \times 0.5 = 700 \times 1.5$

$F = 2100\ N$

$V = \sqrt{2gh} = \sqrt{20}$

$P_{max} = 2100 \times \sqrt{20} = 9.45 \times 10^3\ W$ at take off

Circular Motion

Q 1.

Ans.

$$\omega = \omega_0 + \alpha t$$

$$\omega = 0 + \alpha t$$

$$20 = \alpha 5 \quad \Rightarrow \quad \alpha = 4 \text{ rad/sec}^2$$

$$\theta = \theta_0 + \frac{1}{2}\alpha t^2$$

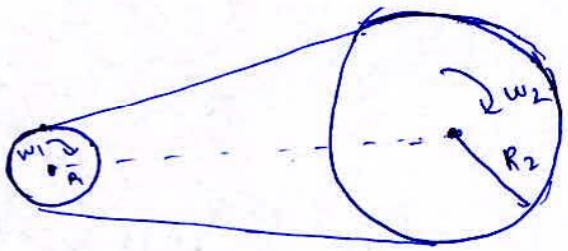
$$= 0 + \frac{1}{2} \times 4 \times 5^2$$

$$= 50 \text{ rad}$$

$$\text{Number of revolution} = \frac{50}{2\pi} = \frac{25}{\pi}$$

Q 2.

Ans.



$$r_1 \omega_1 = r_2 \omega_2$$

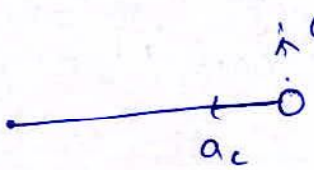
$$\omega_1 = \omega_2 \frac{r_2}{r_1}$$

$$= 200 \times \frac{0.5}{0.1}$$

$$= 1000 \text{ rpm}$$

Q 3.

Ans.



$$a = \sqrt{a_t^2 + a_c^2}$$

$$= \sqrt{(r\alpha)^2 + (\omega^2 r)^2}$$

$$= r\sqrt{\alpha^2 + \omega^4}$$

$$= 1\sqrt{36 + 64}$$

$$= 10 \text{ m/sec}^2$$

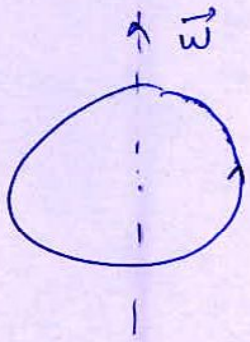
Q 4:

Ans. $f = 50\ Hz$

$\omega = 2\pi f = 100\pi\ rad/sec$

Q 5.

Ans.



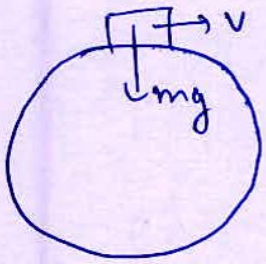
Q 6.

Ans. $36000 = \dfrac{2\pi}{\omega_h} \Rightarrow \dfrac{\omega_h}{\omega_s} = \dfrac{60}{36000} = \dfrac{1}{60}$

$60 = \dfrac{2\pi}{\omega_s}$

Q 7.

Ans.

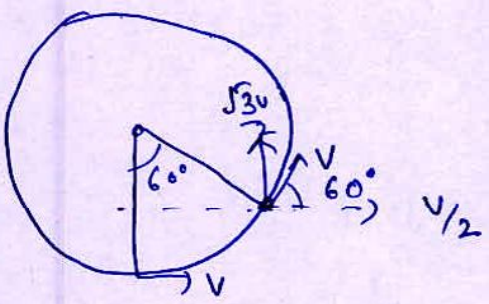


$mg = \dfrac{mv^2}{r}$

$v = \sqrt{gr}$

Q 8.

Ans.



$|\Delta\vec{v}| = \left|\frac{v}{2}\hat{i} + \frac{\sqrt{3}v}{2}\hat{j} - v\hat{i}\right|$

$= \left|\frac{\sqrt{3}}{2}v\hat{j} - \frac{v}{2}\hat{i}\right|$

$= v$

Q 9.

Ans.

$V_1 = r\omega$

$V_2 = 2V = R_2 \frac{\omega}{2}$

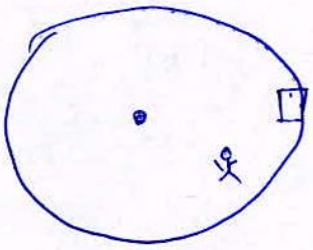
$R_2 =$

$$a_c = \frac{v^2}{R} = \frac{v^2}{v/\omega} = v\omega$$

$$a_{c_{new}} = 2v \times \frac{\omega}{2} = v\omega$$

Q 10.

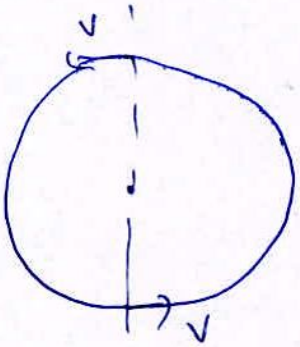
Ans.



Centrifugal force is considered as pseudo force when the frame of observer is same as object.

Q 11.

Ans.



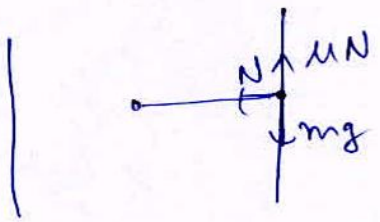
$$a_{avg} = \frac{\vec{v}_f - \vec{v}_i}{t}$$

$$= \frac{2v}{t} = \frac{2 \times 8}{\pi \times 6^3 / 8}$$

$$= \frac{64}{3\pi} \text{ m/s}^2$$

Q 12.

Ans.



$\mu N = mg$

$\mu m r \omega^2 = mg$

$$\omega_{min} = \sqrt{\frac{g}{\mu R}}$$

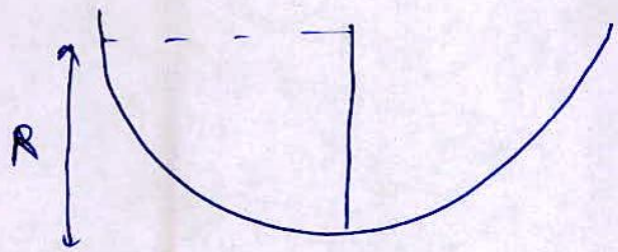
Q 13.

Ans.

$$T = \frac{mv^2}{R} = \frac{1}{2} \times \frac{16}{1} = 8\ N$$

Q 14.

Ans.



$$mgR = \frac{1}{2}mv^2$$

$$v = \sqrt{2gR}$$

Q 15.

Ans.

$$a_c = \frac{v^2}{R}$$

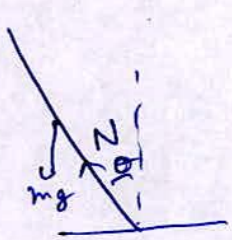
$$a_t = a$$

$$a = \sqrt{a_c^2 + a_t^2}$$

$$= \sqrt{\left(\frac{v^2}{R}\right)^2 + a^2}$$

Q 16.

Ans.



$$N\cos\theta = mg$$

$$N\sin\theta = \frac{mv^2}{R}$$

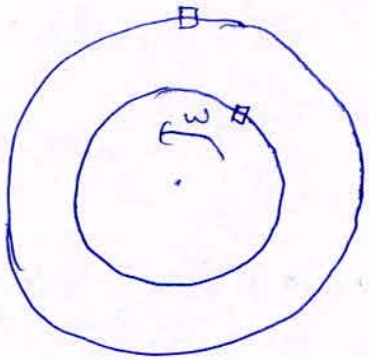
$$\tan\theta = \frac{v^2}{Rg}$$

$$\tan\theta = \frac{1}{2}$$

$$\theta = \tan^{-1}(1/2)$$

Q1.

Ans.



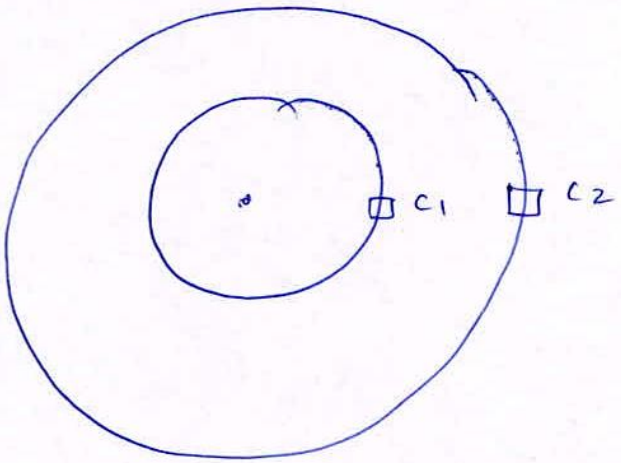
$$F_1 = m R_1 \omega^2$$

$$F_2 = m R_2 \omega^2$$

$$\frac{F_1}{F_2} = \frac{R_1}{R_2}$$

Q2.

Ans.



ω is same

$$a_{c_1} = \frac{v_1^2}{R_1} = \omega_1^2 R_1$$

$$a_{c_2} = \frac{v_2^2}{R_2} = \omega_2^2 R_2$$

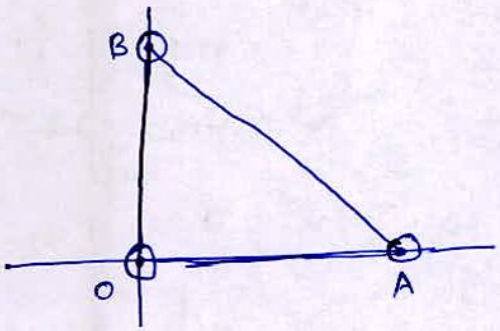
$$\omega_1 = \omega_2$$

$$\frac{a_{c1}}{a_{c2}} = \frac{R_1}{R_2}$$

Centre of Mass & Collision

Q 1.

Ans.



$$x_{cm} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3}$$

$$= \frac{1.0 + 1.0 + 1.1}{3}$$

$$= \frac{1}{3}$$

$$y_{cm} = \frac{m_1 y_1 + m_2 y_2 + m_3 y_3}{m_1 + m_2 + m_3} = \frac{1}{3}$$

$$\text{position vector} = \frac{\hat{i} + \hat{j}}{3}$$

Q 2.

Ans.

$$x_{cm\,new} = \frac{40x + (10+20+30)1}{100}$$

$$0 = 40x + 60$$

$$x = -3/2$$

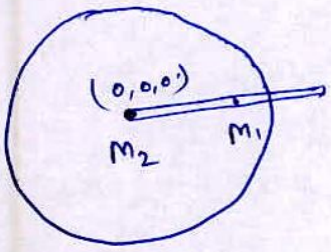
$$y_{cm,new} = \frac{40y + 60 \cdot 1}{100} = 0$$

$$y = -3/2$$

$$z_{cm,new} = -3/2$$

Q 3.

Ans.

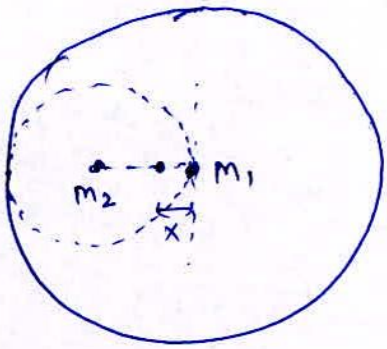


$$x_{cm} = \frac{m_1 L/2 + m_2 \cdot 0}{m_1 + m_2}$$

$$= \left(\frac{L}{2}\,\frac{m_1}{m_1 + m_2}\right)$$

Q 4.

Ans.



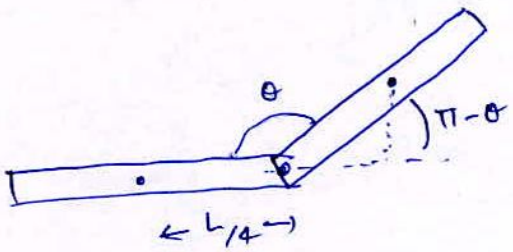
$$x_{cm} = \frac{m_1 \cdot 0 + m_2 R}{m_1 + m_2}$$

$$= \frac{\pi R^2 \rho R}{\pi R^2 \rho + 4\pi R^2 \rho}$$

$$= \frac{R}{5}$$

Q 5.

Ans.



$$x_{cm} = \frac{\frac{M}{2}\left(-\frac{L}{4}\right) + \frac{M}{2}\left(\frac{L}{4}\right)(-\cos\theta)}{M}$$

$$y_{cm} = \frac{\frac{M}{2}(0) + \frac{M}{2}\frac{L}{4}\sin\theta}{M}$$

$$x_{cm} = -\frac{L}{8}(1 + \cos\theta)$$

$$y_{cm} = \frac{L}{8}\sin\theta$$

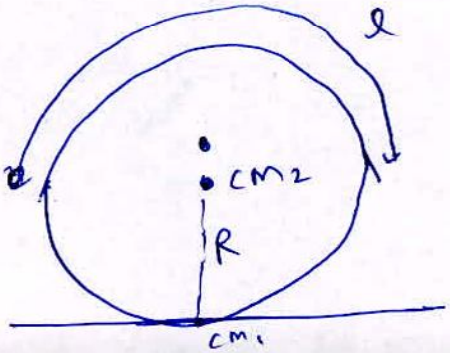
$$\text{distance} = \sqrt{x^2 + y^2} = \frac{L}{8}\sqrt{1 + \cos^2\theta + 2\cos\theta + \sin^2\theta}$$

$$\frac{L}{8}\sqrt{2(1+\cos\theta)} = \frac{L}{8} \times 2\cos\frac{\theta}{2}$$

$$= \frac{L}{4}\cos\frac{\theta}{2}$$

Q 6.

Ans.

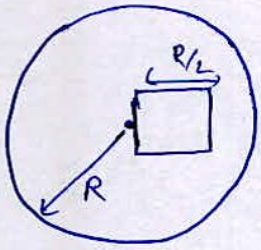


$$2\pi R = l$$

$$R = \frac{l}{2\pi}$$

Q 7.

Ans.

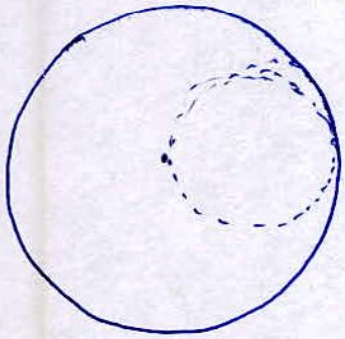


$$x_{cm} = \frac{\rho \times \pi R^2 \cdot 0 - \rho\left[\frac{R}{2}\right]^2 \times \frac{R}{4}}{\rho \times \pi R^2 - \rho\left(\frac{R}{2}\right)^2}$$

$$= \frac{R}{4(4\pi - 1)}$$

Q 8.

Ans.



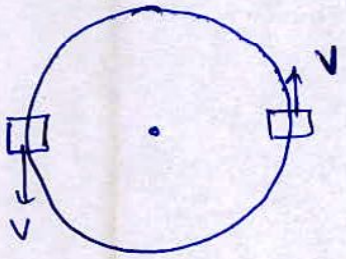
$$x_{cm} = \frac{4\sigma\pi R^2 \cdot 0 - \sigma\pi R^2 R}{\sigma 4\pi R^2 - \sigma\pi R^2}$$

$$= -\frac{R}{3}$$

$$\alpha = 1/3$$

Q 9.

Ans.



$$\Delta\vec{p} = 2mV$$

Q 10.

Ans.

$$K.E. = \frac{p^2}{2m}$$

for equal p $\quad K.E \propto \frac{1}{m}$

Q 11.

Ans.

$F_{ext} = 0$

$\vec{p}_{initial} = \vec{p}_{final}$

$0 = m_1 v_1 - m_2 v_2$

$m_1 v_1 = m_2 v_2$

Q 12.

Ans. $\vec{P}_{initial} = \vec{P}_{final}$

$$mv = m \cdot 0 + (M - m) v'$$

$$v' = \frac{mv}{M - m}$$

Q 13.

Ans. $\vec{F}_{ext} = 0$ Momentum conserved

Q 14.

Ans. $a \cdot b = (a + c) v$

$$v = \frac{ab}{a+c}$$

Q 15.

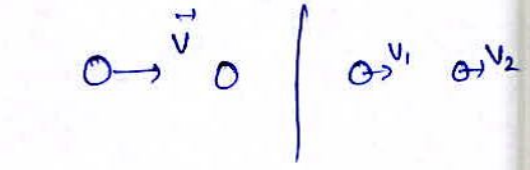
Ans. $2m \times 3\vec{v} = (3m)\vec{v}_2$

$$v_2 = \frac{6m\vec{v}}{3m} = 2v$$

Q 16.

Ans. perfectly elastic collision

$$1 = \frac{\vec{v}_2 - \vec{v}_1}{\vec{v}}$$



$$\vec{v} = \vec{v}_2 - \vec{v}_1 \quad -(1)$$

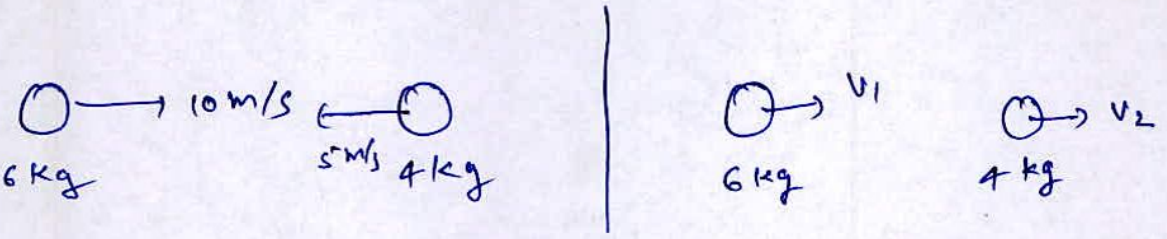
$$m\vec{v} = m\vec{v}_1 + m\vec{v}_2 \Rightarrow \vec{v} = \vec{v}_2 + \vec{v}_1 \quad -(2)$$

from (1) & (2) $\vec{v}_1 = 0$

$$\vec{v}_2 = \vec{v}$$

Q 17.

Ans.



$$1 = \frac{v_2 - v_1}{10 + 5} \Rightarrow v_2 - v_1 = 15 \quad -(1)$$

$$6 \times 10 - 5 \times 4 = 6v_1 + 4v_2$$

$$6v_1 + 4v_2 = 40$$

$$6v_2 - 6v_1 = 15 \times 6$$

$$10 v_2 = 130$$

$$v_2 = 13 \text{ m/s}$$

$$v_1 = -2 \text{ m/s}$$

Q 18.

Ans.

$$e = \frac{\sqrt{2g \times 0.64}}{\sqrt{2g \times 1}} = 0.8$$

Q 19.

Ans.

$$mv_1 = m_2 v_2 \Rightarrow m_2 = \frac{mv_1}{v_2}$$

$$\frac{1}{2}\left(\frac{1}{2} m v_1^2\right) = \frac{1}{2} m_2 v_2^2$$

$$\frac{1}{2} m v_1^2 = \frac{m v_1}{v_2} v_2^2 \qquad v_2 = \frac{v_1}{2}$$

$$e = \frac{v_2}{v_1} = \frac{v_1/2}{v_1} = \frac{1}{2}$$

Q 20.

Ans.

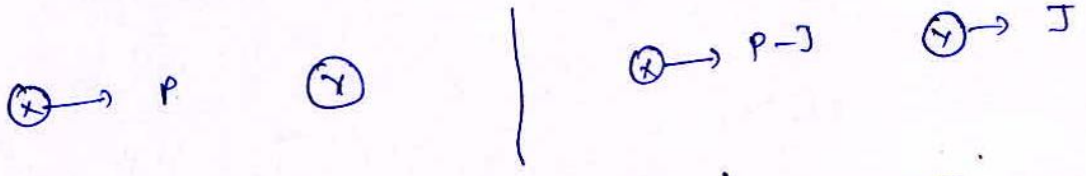
$$F_{ext} = 0 \quad \Sigma(m_i v_i) = m_f v_f$$

$$v_f = \frac{\Sigma m_i v_i}{\Sigma m} = \frac{5 + 8 + 9 + 8 + 5}{15}$$

$$v_f = 7/3 \text{ m/s}$$

Q 21.

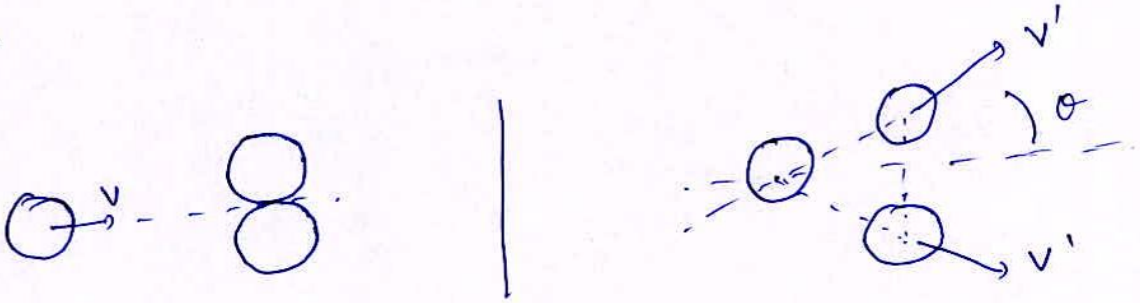
Ans.



$$e = \frac{J/m - (P - J/m)}{P/m} = \frac{2J}{P} - 1$$

Q 22.

Ans.



$\theta = 30^\circ$

$$mv = 2mv' \cos\theta$$

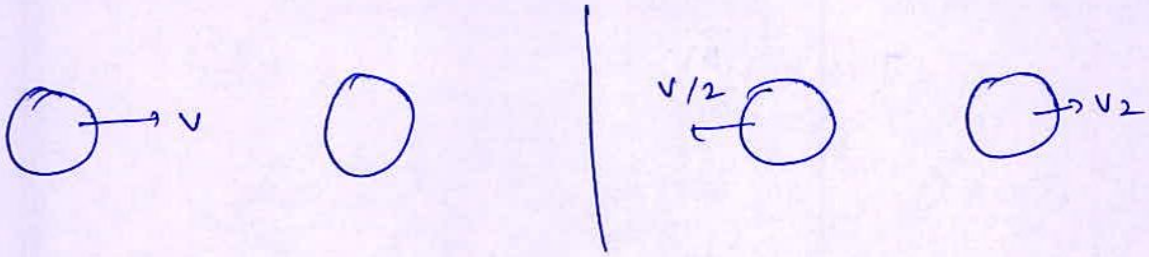
$$v' = \frac{v}{2\cos\theta}$$

$$e = \frac{v' - 0}{v\cos\theta} = \frac{\frac{v}{2\cos\theta}}{v\cos\theta} = \frac{1}{2\cos^2\theta}$$

$$e = \frac{4}{2 \times 3} = \frac{2}{3}$$

Q 23.

Ans.



$$mv = m_2 v_2' - m\,v/2$$

$$m_2 v_2' = 3vm/2 \Rightarrow m_2 = \frac{3}{2}\frac{vm}{v_2'}$$

$$e = \frac{v/2}{v}$$

$$\frac{1}{2}\left(\frac{1}{2} m v^2\right) = \frac{1}{2} m\left(\frac{v}{2}\right)^2 + \frac{1}{2} m (v')^2$$

$$\frac{1}{8} m v^2 = \frac{1}{2} m_2 (v')^2$$

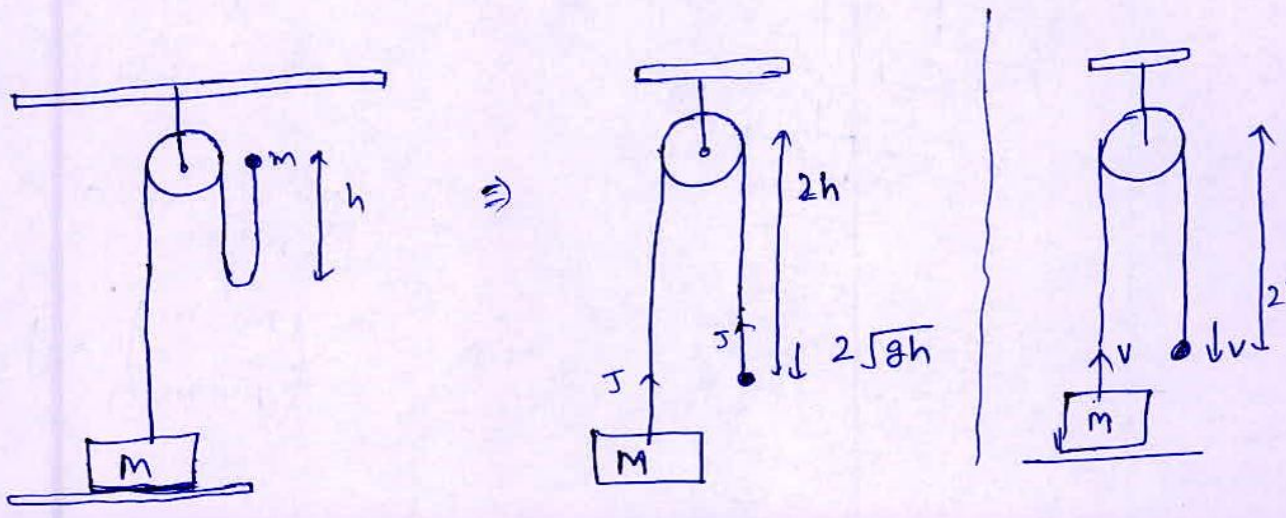
$$\frac{1}{4} m v^2 = \frac{3}{2}\frac{m}{m} v'^2$$

$$v' = \frac{1}{6} v$$

$$e = \frac{v' + v/2}{v} = \frac{\frac{v}{6} + \frac{v}{2}}{v} = \frac{2}{3}$$

Q 24.

Ans.



$$m\left(2\sqrt{gh}\right) - J = mv \quad -①$$

$$J = Mv \quad -②$$

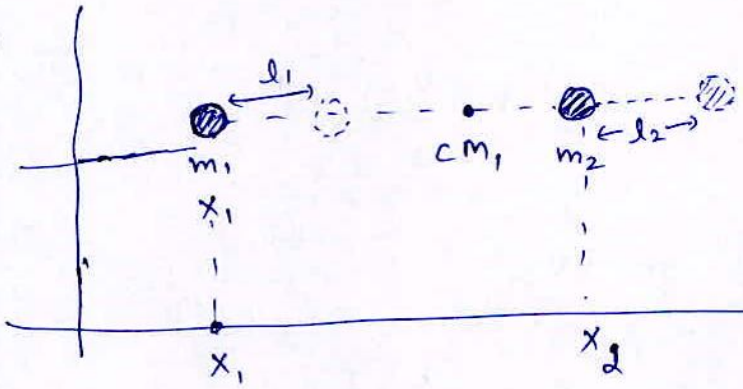
① + ②

$$2m\sqrt{gh} = (m+M)\,v$$

$$v = \frac{2m\sqrt{gh}}{(m+M)}$$

Q 25.

Ans.



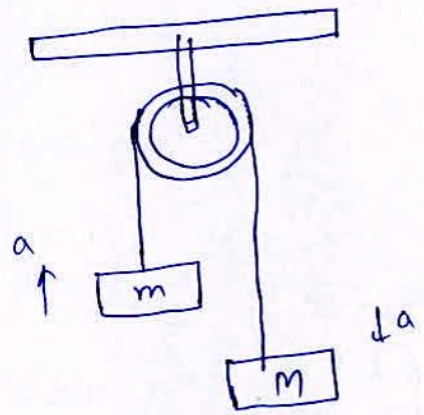
$$cm_1 = \frac{m_2x_2 + m_1x_1}{m_1+m_2}$$

$$cm_2 = \frac{m_2(x_2+l_2) + m_1(x_1+l_1)}{m_1+m_2}$$

$$cm_2 - cm_1 = \frac{m_2l_2 + m_1l_1}{m_1+m_2}$$

Q 26.

Ans.



$$a = \frac{(M-m)g}{M+m}$$

$$a_{cm} = \frac{Ma - ma}{M+m}$$

$$= \left(\frac{M-m}{M+m}\right)a$$

$$a_{cm} = \left(\frac{M-m}{M+m}\right)^2 g$$

Q 27.

Ans.

$$\frac{1}{2} K L^2 = \frac{p^2}{2m}$$

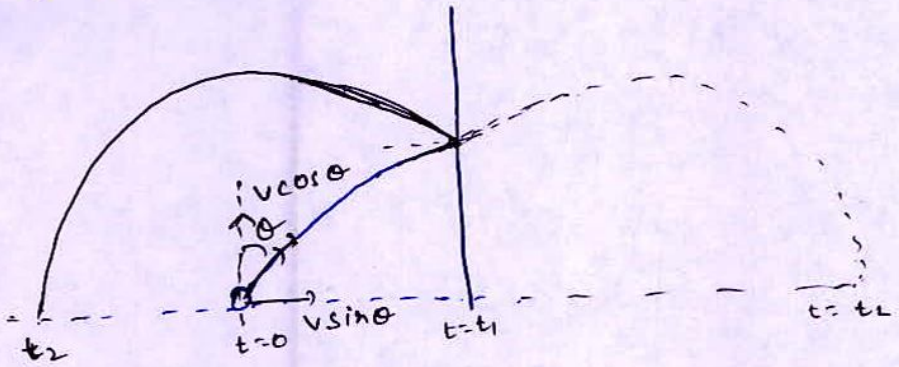
$$p = L\sqrt{mK}$$

Q 28.

Ans.

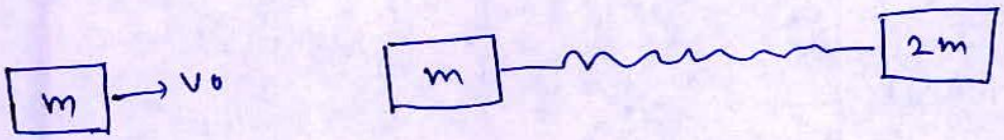
Time of flight = t_2

$$= \frac{2V\cos\theta}{g}$$



Q 29.

Ans.



$$mV_0 = 3mV$$

$$V = \frac{V_0}{3}$$

$$\frac{1}{2} mV_0^2 = \frac{1}{2} kx^2 + \frac{1}{2} 3m \times \frac{V_0^2}{9}$$

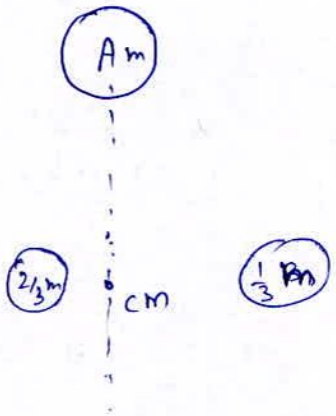
$$\frac{2}{3} V_0^2 = \frac{k}{m} x^2$$

$$x = \sqrt{\frac{2}{3}\frac{m}{k}}\, V_0$$

Q 1.

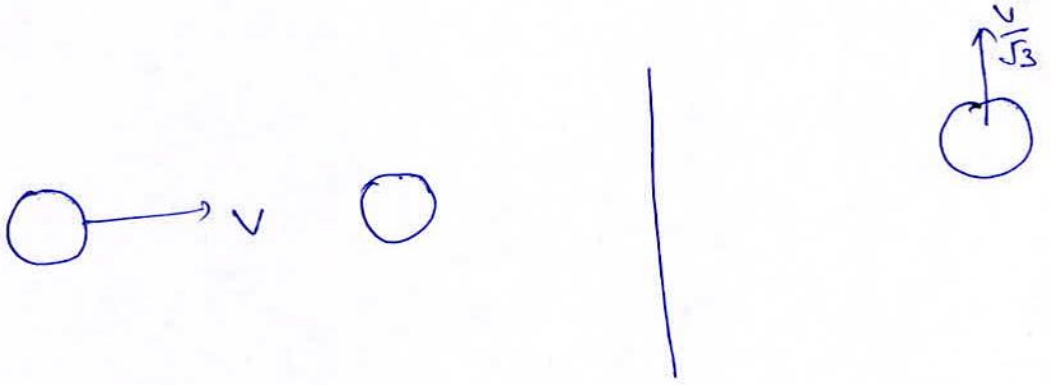
Ans.

does not shift



Q 2.

Ans.



$$P_{initial} = P_{final}$$

$$mV\hat{i} = m\frac{V}{\sqrt{3}}\hat{j} + m v'$$

$$|v'| = \left|V\hat{i} - \frac{V}{\sqrt{3}}\hat{j}\right| = V\sqrt{1+\frac{1}{3}} = \frac{2}{\sqrt{3}}V$$

Q3.

Ans.

$$P_{initial} = P_{final}$$

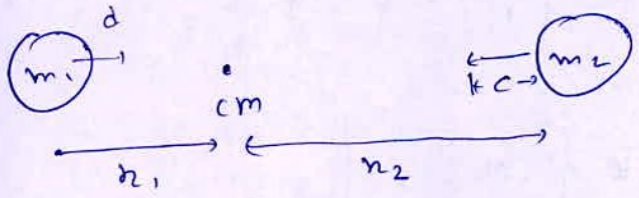
$$0 = 12 \times 4 + 4(v)$$

$$v = -12 \text{ m/s}$$

$$K.E. = \frac{1}{2} \times 4 \times (12)^2 = 288 \text{ J}$$

Q 4.

Ans.



$$m_1 x_1 = m_2 x_2$$

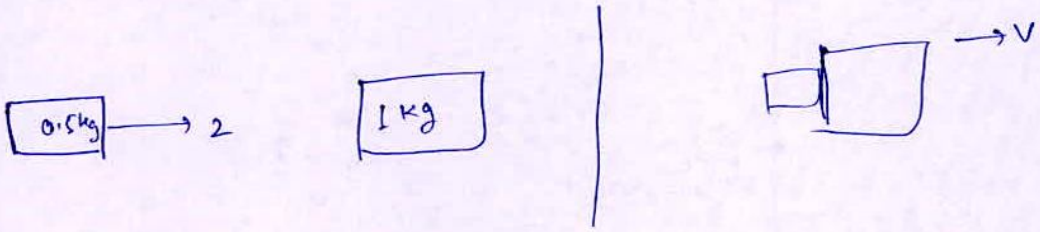
$$m_1(x_1 - d) = m_2(x_2 - c)$$

$$\frac{-m_1 d}{1} = \frac{-m_2 c}{1}$$

$$c = \frac{m_1 d}{m_2}$$

Q 5.

Ans.



$$0.5 \times 2 = 1.5 \times V$$

$$V = \frac{2}{3}$$

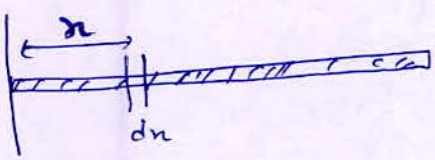
$$\Delta KE. = \frac{1}{2} \times \frac{1}{2} \times 2^2 - \frac{1}{2} \times \frac{3}{2} \times \left(\frac{2}{3}\right)^2$$

$$= \frac{1}{4}\left(4 - \frac{4}{3}\right)$$

$$= \frac{1}{4} \times {}^{8}/_{3} = \frac{2}{3} \text{ J}$$

Q C.

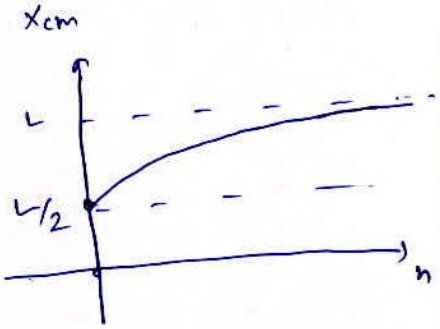
Ans.



$$x_{cm} = \frac{\int dm\, x}{\int dm}$$

$$x_{cm} = \frac{\int_0^L K\left(\frac{x}{L}\right)^n x\, dx}{\int_0^L K\left(\frac{x}{L}\right)^n dx}$$

$$= \frac{\left[\frac{x^{n+2}}{n+2}\right]_0^L}{\left[\frac{x^{n+1}}{n+1}\right]_0^L}$$



$$x_{cm.} = \left(\frac{n+1}{n+2}\right) L$$

at $n=0$ $x_{cm} = L/2$

as $n \to \infty$ $x_{cm} \to L$

Q 8.

Ans.

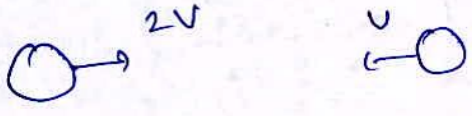
$$K.E. = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2 - - - -$$

$$K.E = 0 \Rightarrow v_1 = v_2 = v_3 = \cdots v_n = 0$$

$$\Rightarrow \vec{p}. = m_1 \vec{v_1} + m_2 \vec{v_2} + \cdots m_n \vec{v_n} = 0$$

Q 7.

Ans.



$$v_{cm} = \frac{2mv - mv}{2m} = \frac{v}{2}$$

Q 9.

Ans.

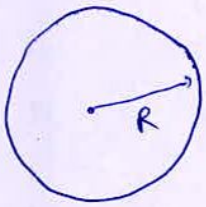
$$\frac{1}{2} K L^2 = \frac{p^2}{2m}$$

$$p = L\sqrt{mK}$$

Rotational Motion

Q 1.

Ans.



$\equiv$

8

$$\frac{2}{5} M R^2 = 64$$

$$\rho \frac{4}{3} \pi R^3 = 8\rho \frac{4}{3} \pi r^3$$

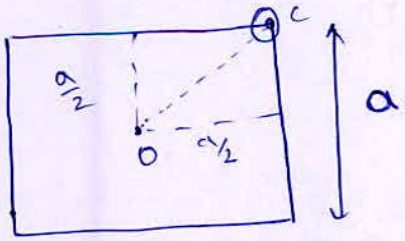
$$r = \frac{R}{2}$$

$$I = \frac{2}{5} \frac{m}{8} \times \left(\frac{R}{2}\right)^2 = \left(\frac{2}{5} mR^2\right) \times \frac{1}{32}$$

$$= \frac{64}{32} = 2 \text{ kg m}^2$$

Q 2.

Ans.



$$I_{cm} = \frac{ma^2}{6}$$

$$I_C = I_{cm} + m d^2$$

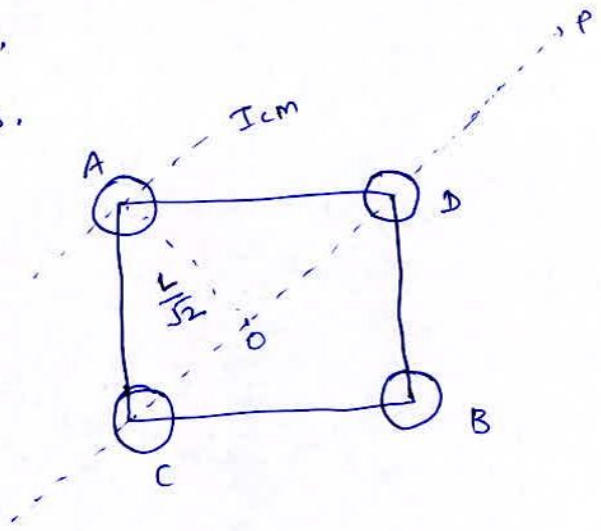
$$= \frac{ma^2}{6} + M\left(\frac{a}{\sqrt{2}}\right)^2$$

$$= \left(\frac{1}{2} + \frac{1}{6}\right) ma^2$$

$$= \frac{2}{3} ma^2$$

Q 3.

Ans.



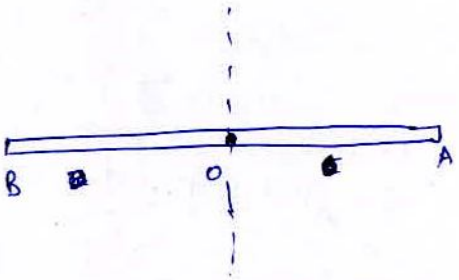
M. I about axis O.P.

$= 2\left(\frac{2}{5}MR^2 + \frac{ML^2}{2}\right) + 2\left(\frac{2}{5}MR^2\right)$

$= \frac{8}{5}MR^2 + ML^2$

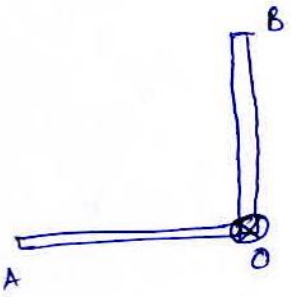
Q 4.

Ans.



$I = I_{OA} + I_{OB}$

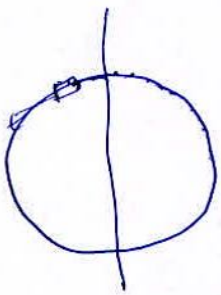
$I_2 = I$



$I_2 = I_{OA} + I_{OB}$

Q 5.

Ans.

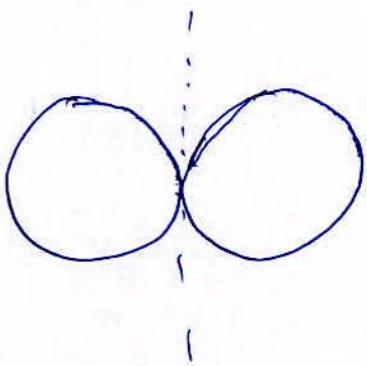


I increases

(distance of mass increases)

Q 6.

Ans.



$I' = 2(I + MR^2)$

$I = \frac{2}{5}MR^2$

$I' = 2\left(\frac{2}{5} + 1\right)MR^2$

$= 2 \times \frac{7}{5}MR^2$

$= \cancel{2} \times \frac{7}{\cancel{5}} \times \frac{\cancel{5}I}{\cancel{2}} = 7I$

Q 7.

Ans.

$I_{Disc} = MR^2$

$I_{sphere} = \frac{2}{5} MR_2^2$

I_{sphere} is less than I_{Disc}

Q 8.

Ans. M. I.

Q 9.

Ans.

$$\frac{I_S}{I_H} = 1 = \frac{\frac{2}{5} m R_s^2}{\frac{2}{3} m R_n^2} \Rightarrow \frac{R_s}{R_n} = \left(\frac{5}{3}\right)^{1/2}$$

$$\pi r^2 t = \pi (4R)$$

Q 10.

Ans.

$$\frac{I_A}{I_B} = \frac{\frac{1}{2} m r^2}{\frac{1}{2} 4M (4R)^2} = \frac{1}{64}$$

Q 11.

Ans.

$MK^2 = I \rightarrow$ depends on shape of body

$$\left(\frac{I}{M}\right)$$

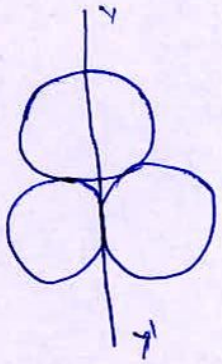
Q 12.

Ans.

$$\frac{I_x}{I_y} = \frac{\frac{1}{2} m R^2}{\frac{1}{2} 4M (4R)^2} = \frac{1}{64}$$

Q 13.

Ans.



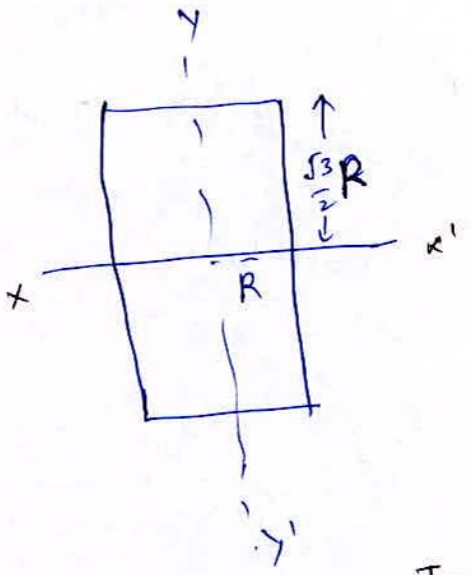
$$I_{YY'} = \frac{MR^2}{4} + 2\left(\frac{MR^2}{4} + MR^2\right)$$

$$= \frac{14}{4} MR^2$$

$$= \frac{7}{2} MR^2$$

Q 14.

Ans.



$$I_{YY'} = \frac{MR^2}{2}$$

$$I_{XX'} = \frac{MR^2}{4} + \frac{ML^2}{12}$$

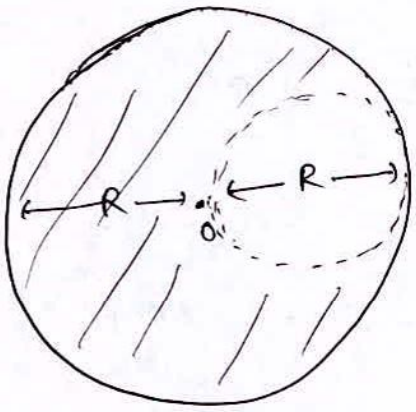
$$= \frac{MR^2}{4} + \frac{M\,3R^2}{12}$$

$$= \frac{MR^2}{2}$$

$$\frac{I_{YY'}}{I_{XX'}} = 1$$

Q 15.

Ans.



$$\sigma \pi R^2 = M$$

$$I_O = \frac{MR^2}{2} - \left(\frac{\frac{M}{4}\left(\frac{R}{2}\right)^2}{2} + \frac{M}{4}\left(\frac{R}{2}\right)^2 \right)$$

$$\boxed{\sigma \pi \left(\frac{R}{2}\right)^2 = \frac{M}{4}}$$

$$I_O = \frac{MR^2}{2} - \left(\frac{M}{16} R^2 \times \frac{3}{2} \right)$$

$$= \frac{13}{32} MR^2$$

Q 16.

Ans.

$$I = \frac{2}{5} MR^2$$

$$I = \left(\frac{M r^2}{2} + Mr^2 \right) = \frac{3}{2} Mr^2$$

$$\frac{\frac{3}{2}}{\frac{2}{5}} \left(\frac{r}{R}\right)^2 = 1 \Rightarrow \frac{r}{R} = \frac{2}{\sqrt{15}}$$

Q 17.

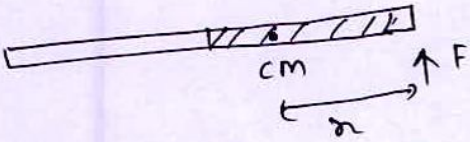
Ans. $\tau \frac{d\theta}{dt} =$ Power

$\tau \cdot \frac{2\pi \times 300}{60} = 3.14 \times 10^3$ W

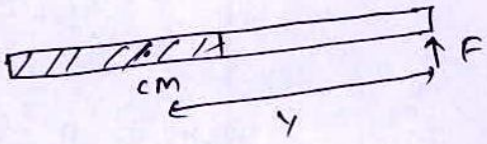
$\tau = \frac{60}{6} = 10$ N.m.

Q 18.

Ans.



(I)



(II)

$\tau_I = xF = I_{cm}\alpha_I$

$\tau_{II} = yF = I_{cm}\alpha_{II}$

$y > x \Rightarrow \tau_{II} > \tau_I \Rightarrow \alpha_{II} > \alpha_I$

Q 19.

Ans. $\tau = I\alpha$

Q 20.

Ans. $\omega^2 = \omega_0^2 - 2\alpha\theta$

$0 = (20 \times 2\pi)^2 - 2 \cdot \frac{\tau}{I} \times 10 \times 2\pi$

$\tau = \frac{4 \times 10^2 \times \pi^2}{4 \times 10 \times \pi} \times I$

$= 10 \times \pi \times 5 \times 10^{-3}$

$=$

Q 20.

Ans. $\omega = \omega_0 - \alpha t$

$0 = 20 \times 2\pi - \frac{\tau}{I} \times 10$

$\tau = \frac{20 \times 2\pi \times 5 \times 10^{-3}}{10} = 2\pi \times 10^{-2}$ N-m

Q 21.

Ans. $\tau = I\alpha$

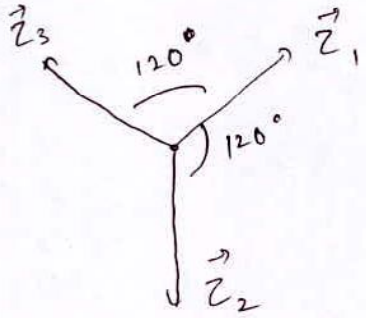
$\tau = Mk^2 \alpha$

$2 = M(2)^2 \times 2$

$M = \frac{1}{4}$ kg.

Q 22.

Ans. $|\vec{\tau}_1| = |\vec{\tau}_2| = |\vec{\tau}_3|$.

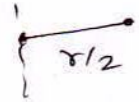


Resultant ≡ Zero

Q 23.

Ans. $\tau = I\alpha = Mr^2\alpha$

$\tau_2 = \frac{2M}{4} r^2 \alpha = \frac{\tau}{2}$



Q 24.

Ans. $\tau = I\alpha$

Q 25.

Ans.

$$\vec{\tau} = \vec{r} \times \vec{F}$$

$$= (3\hat{i} + 2\hat{j} - 4\hat{k}) \times (2\hat{i} - 4\hat{j} + 2\hat{k})$$

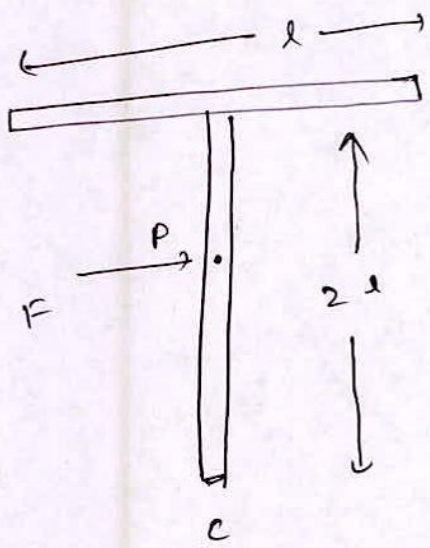
$$= -12\hat{k} - 6\hat{j} - 4\hat{k} + 4\hat{i} - 8\hat{j} - 16\hat{i}$$

$$= -12\hat{i} - 14\hat{j} - 16\hat{k}$$

$$|\vec{\tau}| = \sqrt{12^2 + 14^2 + 16^2} = 24.4 \text{ N-m.}$$

Q 26.

Ans.



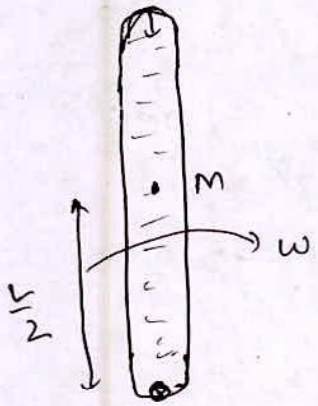
for only translation P should be center of mass

$$y_{cm} = \frac{2ml + m2l}{2m + m}$$

$$= \frac{4}{3}l$$

Q 27.

Ans.



$$F = \frac{m\omega^2 L}{2}$$

Q 28.

Ans.

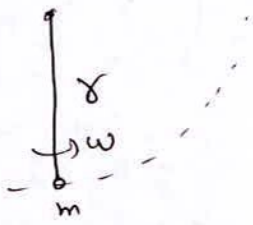
$$I_1 \omega_1 = I_2 \omega_2$$

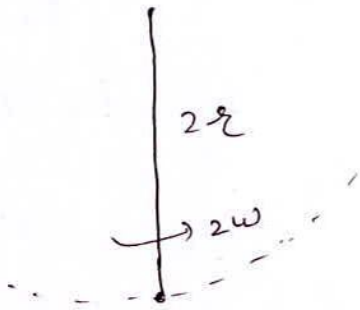
$$\frac{2}{5}MR^2 \times \frac{2\pi}{24\text{ hr}} = \frac{2}{3}MR^2 \cdot \frac{2\pi}{T_2} \Rightarrow T_2 = \frac{5}{3} \times 24$$

$$= 40\text{ hr}$$

Q 29.

Ans.





$L_1 = mR^2\omega$

$L_2 = m(2r)^2(2\omega)$

$L_2 = 8L_1$

Q 30.

Ans.

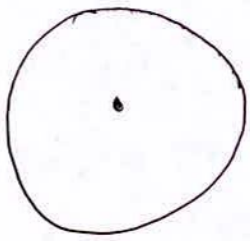
$L_1 + L_2 = L$

$-3 \times 600 + 5 \times 800 = (3+5)\omega$

$\omega = \frac{4000 - 1800}{8} = \frac{2200}{8} = 275$ rpm.

Q 31.

Ans.



$L = I\omega$

$= 1 \cdot (0.2)^2 \times 10 \times 2\pi$

$= \frac{1}{25} \times 100 \times 2\pi$

$= \frac{4}{5}\pi = 2.5$

Q 32.

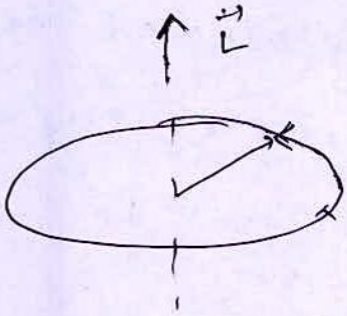
Ans.

$J = mvR$

$F = \frac{mv^2}{R} = \frac{J^2}{mR^2R} = \frac{J^2}{mR^3}$

Q 33.

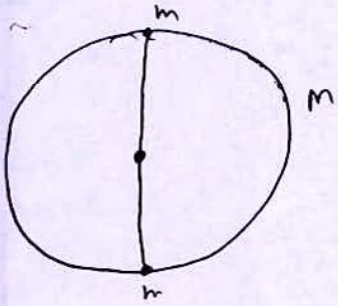
Ans.



$$\vec{L} = \vec{r} \times (m\vec{v})$$

Q 34.

Ans.

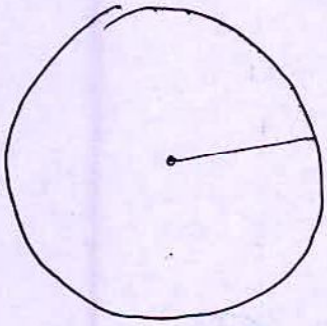


$$mR^2\omega = (M + 2m)R^2\omega_2$$

$$\omega_2 = \left(\frac{M}{M+2m}\right)\omega$$

Q 35.

Ans.



$$L = mvR = mR^2\omega$$

$$K.E. = \frac{1}{2}mR^2\omega^2$$

$$K.E._2 = \frac{1}{2}\left(\frac{1}{2}mR^2\omega^2\right) = \frac{1}{2}mR_2^2 4\omega^2$$

$$R_2 = \left(\frac{R}{2\sqrt{2}}\right)$$

$$L_{new} = m\left(\frac{R}{2\sqrt{2}}\right)^2 2\omega = \frac{mR^2\omega}{4} = \frac{L}{4}$$

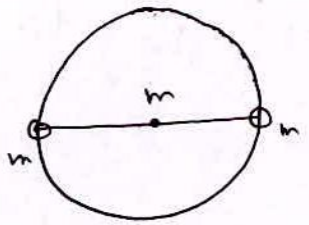
Q 36.

Ans.

$$\tau_{ext.} = 0 \qquad \vec{L} = \text{constant}$$

Q 37.

Ans.



gently removed

$\tau_{ext} = 0$ $\vec{L}$ intial of disc will be equal to $\vec{L}$ final of disc.

$$mR^2\omega = mR^2\omega_{new}$$

$$\omega_{new} = \omega$$

Q 38.

Ans.

$$\frac{d\vec{L}}{dt} = \vec{\tau} = 0$$

$\vec{L}$ conserved

Q 39.

Ans.

$$\frac{\Delta\omega}{\omega} = \frac{\Delta I}{I} = 2\,\frac{\Delta R}{R}$$

$$V = \frac{4}{3}\pi R^3$$

$$100 \times \frac{\Delta V}{V} = 3\,\frac{\Delta R}{R} \times 100 = \frac{1}{2}$$

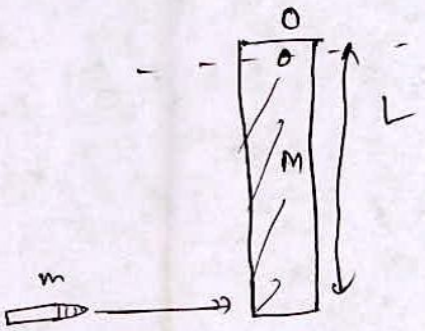
$$\frac{\Delta R}{R} = \frac{1}{6} \times 100$$

$$\frac{\Delta\omega}{\omega} \times 100 = \frac{1}{3} \times \frac{1}{6} \times 100$$

$$\frac{\Delta\omega}{\omega} = \frac{1}{3}\ \%$$

Q 40.

Ans.



Angular momentum conservation about point O

$$mvL = I_{new}\omega$$

$$mvL = \left(\frac{ML^2}{3} + mL^2\right)\omega$$

$$\omega = \frac{3mv}{(M+3m)L}$$

Q 41.

Ans.

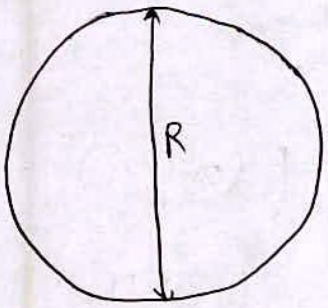
$$L_{initial} = L_{final}$$

$$\frac{MR^2}{2}\omega = \left(\frac{MR^2}{2} + \frac{mR^2}{4}\right)\omega_{new}$$

$$\omega_{new} = \frac{2\omega M}{(2M+m)}$$

Q 42.

Ans.



$$K.E. = \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}\frac{MR^2}{2}\omega^2$$

$$\frac{\Delta K.E.}{K.E} \times 100 = 2\frac{\Delta R}{R} \times 100$$

$$= 2 \times \frac{R\alpha\Delta t}{R} \times 100$$

$$= 2\alpha\Delta t \times 100$$

Q 43.

Ans.

$$K.E. = \frac{1}{2} I \omega^2 = 1500$$

$$\omega^2 = \frac{1500 \times 2}{1.2} = 2500$$

$$\omega = 50 \text{ rad/s}$$

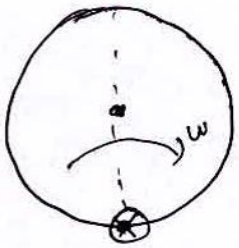
$$\omega = \omega_0 + \alpha t$$

$$50 = 0 + 25 \times t$$

$$t = 2 \text{ sec.}$$

Q 44.

Ans.



$$K.E. = \frac{1}{2} I \omega^2$$

$$= \frac{1}{2} (2MR^2) (2\pi n)^2$$

$$= 4\pi^2 MR^2 n^2$$

$$I = I_{cm} + MR^2$$

Q 45.

Ans.

$$K.E. = \frac{1}{2} I \omega^2 = \frac{1}{2} I (2\pi)^2 T^{-2}$$

Q 46.

Ans.

$$\omega = \Delta K.E. = \frac{1}{2} I \left((4\pi n)^2 - (2\pi n)^2 \right)$$

$$= \frac{1}{2} I \left(12\pi^2 n^2 \right)$$

$$= 6\pi^2 I n^2$$

Q 47.

Ans.

$$V = r\omega$$

$$\frac{K.E.R}{K.E_T} = \frac{\frac{1}{2} \frac{MR^2}{2} \omega^2}{\frac{1}{2} m v^2} = \frac{1}{2}$$

Q 48.

Ans. Total Energy = K.E.R + K.E.T

$$= \frac{1}{2}\frac{MR^2}{2}\omega^2 + \frac{1}{2}mv^2$$

$$= \frac{1}{2}\frac{MR^2}{2}\frac{v^2}{R^2} + \frac{1}{2}mv^2$$

$$= \left(\frac{1}{2} + \frac{1}{4}\right) mv^2$$

$$= 3/4\ mv^2$$

Q. 49.

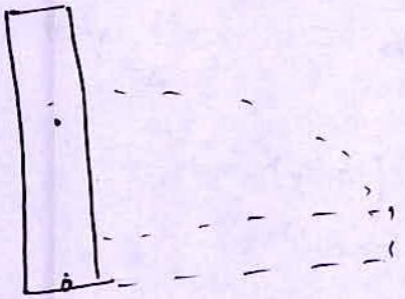
Ans.

$$\frac{K.E.R}{K.E\ Total} = \frac{\frac{1}{2}\frac{MR^2}{2}\frac{v^2}{R^2}}{\frac{1}{2}\frac{MR^2}{2}\frac{v^2}{R^2} + \frac{1}{2}mv^2}$$

$$= \frac{1/2}{3/4} = \frac{2}{3}$$

Q 50.

Ans.



$$mg\frac{h}{2} = \frac{1}{2}\frac{mh^2}{3}\times\omega^2$$

$$\omega = \sqrt{\frac{3g}{h}}$$

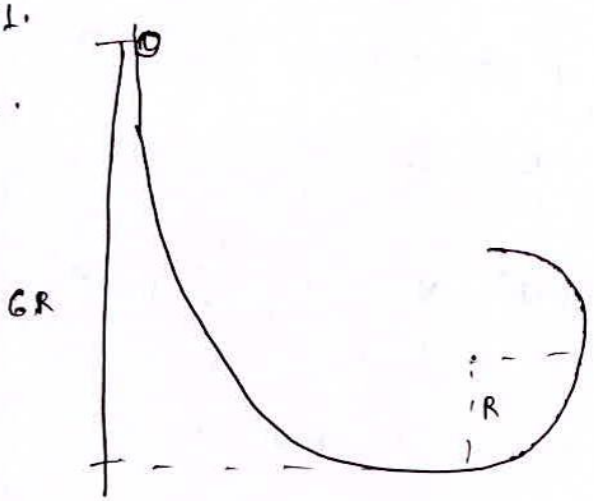
$$v = h\omega = \sqrt{\frac{3g}{h}}\times h$$

$$= \sqrt{3gh}$$

$$= \sqrt{30}$$

Q 51.

Ans.



$mg6R = mg5R + \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$

$\omega = \frac{v}{R}$

Rolling

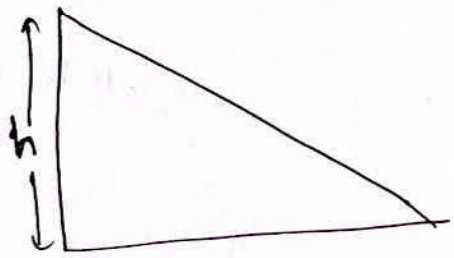
$5mgR = \frac{1}{2} \times \frac{2}{5} m R^2 \times \frac{v^2}{R^2} + \frac{1}{2}mv^2$

$5mgR = \left(\frac{1}{2} + \frac{1}{5}\right) mv^2$

$v = \sqrt{\frac{50}{7} gR}$ Ans.

Q 52.

Ans.

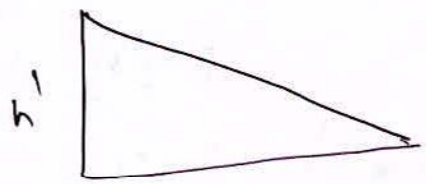


$mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$

$mgh = \frac{1}{2} \cdot \frac{mR^2}{2} \frac{v^2}{R^2} + \frac{1}{2}mv^2$

$mgh = \frac{3}{4}mv^2$

$v = \sqrt{\frac{4gh}{3}}$



$mgh' = \frac{1}{2}mv^2$

$mgh' = \frac{1}{2}m \frac{4gh}{3}$

$h' = \frac{2h}{3}$ Ans.

Q 53.

Ans. $I = mR^2$

Q 54.

Ans. ~~$mgh = \frac{1}{2} I\omega^2 + \frac{1}{2} MV^2$~~

for Rolling $a = R\alpha$

$$a = R \frac{Fr \cdot R}{MK^2}$$

$$mg\sin\theta - Fr = ma$$

$$Fr = \frac{MK^2 a}{R^2}$$

$$mg\sin\theta - \frac{MK^2 a}{R^2} = ma$$

$$a = \frac{mg\sin\theta}{\left(M + \frac{MK^2}{R^2}\right)}$$

for a to be max. K should be min.

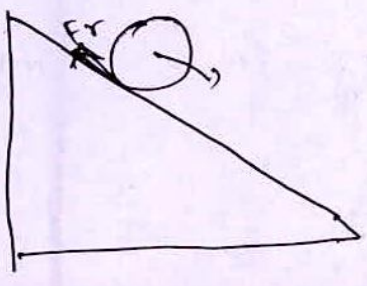
Q 55.

Ans. frictionless

$$a_s = a_h = a_R = g\sin\theta$$

Q 56.

Ans.



$$mg\sin\theta - Fr = ma$$

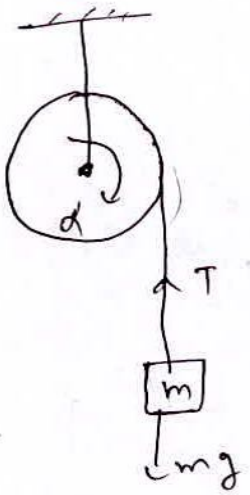
$$Fr \cdot 1 = \frac{I}{R} \cdot \frac{a}{R}$$

$$mg\sin\theta - \frac{Ia}{R^2} = ma$$

$$a = \frac{g\sin\theta}{1 + I/mR^2}$$ Ans.

Q 57.

Ans.



$$mg - T = ma$$

$$TR = I\alpha$$

$$T = \frac{mR^2}{2R}\frac{a}{R}$$

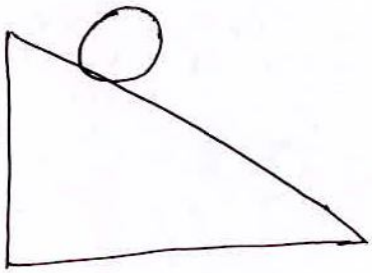
$$= \frac{ma}{2}$$

$$mg - \frac{ma}{2} = ma$$

$$a = \frac{2}{3}g$$

Q 58.

Ans.



Sol Ans. 56.

$$a = \frac{g\sin\theta}{1 + I/MR^2}$$

$I_{\text{hollow sphere}} > I_{\text{solid sphere}}$

$a_{\text{hollow}} < a_{\text{solid}}$

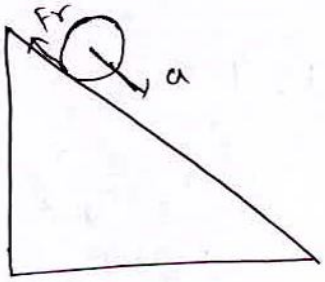
Hence, solid sphere will reach the bottom first.

Q 59.

Ans. $a = g\sin\theta$ for both

Q 60.

Ans.



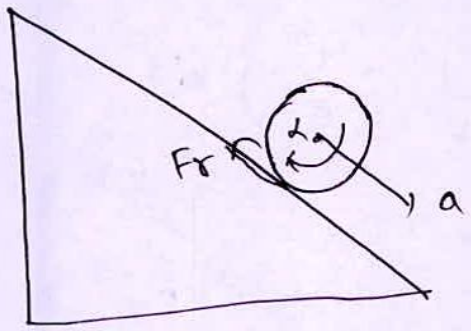
$$F_r R = \frac{2}{5}MR^2\frac{a}{R}$$

$$\mu mg\cos\theta = \frac{2}{5}mR^2\frac{g\sin\theta}{1 + \frac{2/5\,MR^2}{MR^2}}$$

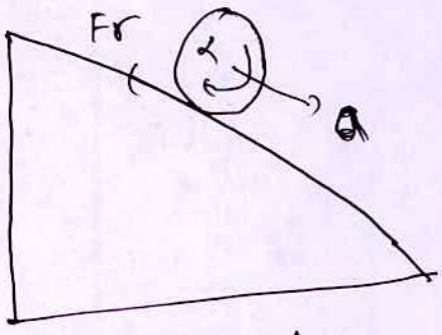
$$\mu = \frac{2}{7}\tan\theta$$

Q 61.

Ans.



going up

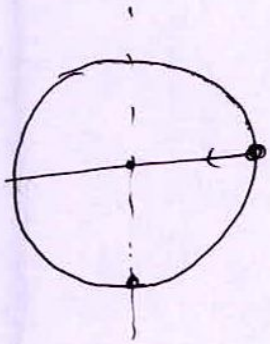


going down

Window to JEE Main

Q 1.

Ans.



$\vec{L}$ will be constant

$L = I\omega$ = constant

I decreas intially and then increases

$\Rightarrow$ ω first increases then decreases.

Q 2.

Ans.

$$I\frac{d\omega}{dt} = R(20t - 5t^2)\,dt$$

$$\int_0^{\omega} d\omega = R\int_0^{t}\left(\frac{20t - 5t^2}{I}\right)dt$$

$$\omega = R\left(\frac{10t^2}{I} - \frac{5}{3I}t^3\right) = 0$$

for $\omega = 0$

$$\frac{5t^2}{I}\left(2 - \frac{t}{3}\right) = 0 \Rightarrow t = 6 \text{ sec.}$$

$$\frac{d\theta}{dt} = \omega = 2\left(t^2 - \frac{t^3}{6}\right) = 2t^2 - \frac{t^3}{3}$$

$$\int_0^{\theta} d\theta = \int_0^6 \left(2t^2 - \frac{t^3}{3}\right) dt$$

$$= \left[\frac{2t^3}{3} - \frac{t^4}{12}\right]_0^6$$

$$= 6^3\left[\frac{2}{3} - \frac{1}{2}\right] = 36$$

$$2\pi n = 36$$

$$n = \frac{36}{2\pi} = \frac{18}{\pi}$$

Q 3.

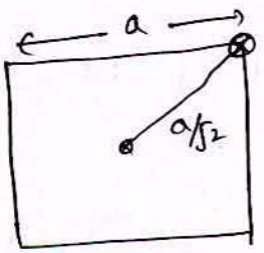
Ans.

$$mgh = \frac{1}{2}\frac{mL^2}{3}\omega^2$$

$$h = \frac{1}{6}\frac{l^2\omega^2}{g}$$

Q 4.

Ans.



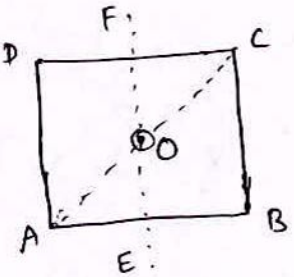
$$I = I_{cm} + \frac{ma^2}{2}$$

$$= \frac{ma^2}{6} + \frac{ma^2}{2}$$

$$= \frac{2}{3}ma^2$$

Q 5.

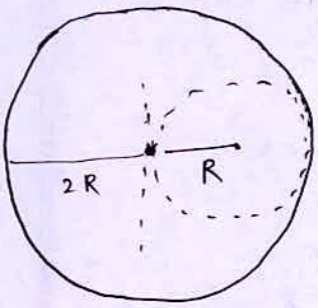
Ans.



$$I_{AC} = I_{EF} = \frac{1}{2}I_O$$

Q 6.

Ans.



$$X_{cm} = \frac{\sigma\pi(2R)^2 0 - \sigma\pi R^2 R}{\sigma\pi(2R)^2 - \sigma\pi R^2}$$

$$= \frac{-1}{3R}$$

$$\alpha = 1/3$$

Q 7.

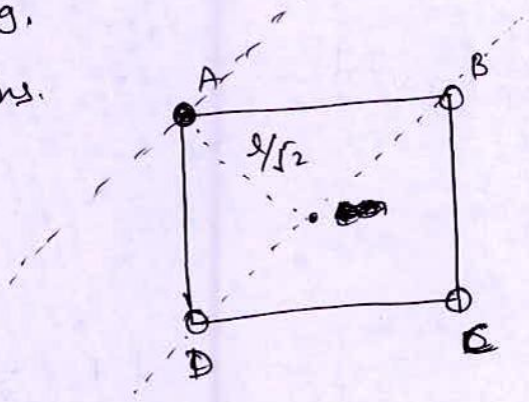
Ans. see ans. of Q. no. 56 (Exercise Rotational motion)

Q 8.

Ans. $$\tau = \frac{d\vec{L}}{dt} = 0$$

Q 9.

Ans.



$$I = \text{  }$$

$$= m\left(\frac{l}{\sqrt{2}}\right)^2 + m\left(\frac{l}{\sqrt{2}}\right)^2 + m(\sqrt{2}l)^2$$

$$= \frac{ml^2}{2} + \frac{ml^2}{2} + 2ml^2$$

$$= 3ml^2$$

Q 10.

Ans. Torque $= \vec{r} \times \vec{F}$

$$= (-1\hat{i} + 1\hat{j}) \times F(-\hat{k})$$

$$= F(-\hat{j} - \hat{i})$$

$$= -F(\hat{i} + \hat{j})$$

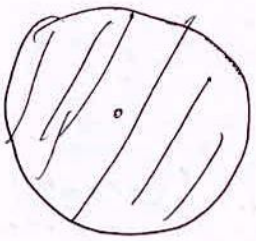
Q 11.

Ans. $mR^2 \omega = (mR^2 + 2MR^2)\omega'$

$$\omega' = \left(\frac{\omega m}{m + 2M}\right)$$

Q 12.

Ans.



$$I = \frac{MR^2}{2}$$

Q 13.

Ans. $I_A = \frac{2}{5} MR^2$ $\qquad I_B > I_A$

$I_B = \frac{2}{3} MR^2$

Q 14.

Ans. $\vec{\tau}_{ext} = 0$ $\qquad \vec{L}$ conserved

Q 15.

Ans. $M_Y = 4M_X$

$I_X = \frac{MR^2}{2}$ $\qquad I_Y = 64 I_X$

$I_Y = \frac{4 M_X (4R)^2}{2}$

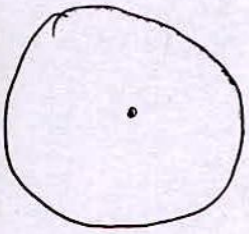
Q 16.

Ans. $\vec{\tau} = \vec{r} \times \vec{F}$

$\vec{r} \cdot \vec{\tau} = 0$ & $\vec{F} \cdot \vec{\tau} = 0$

Q 17.

Ans.

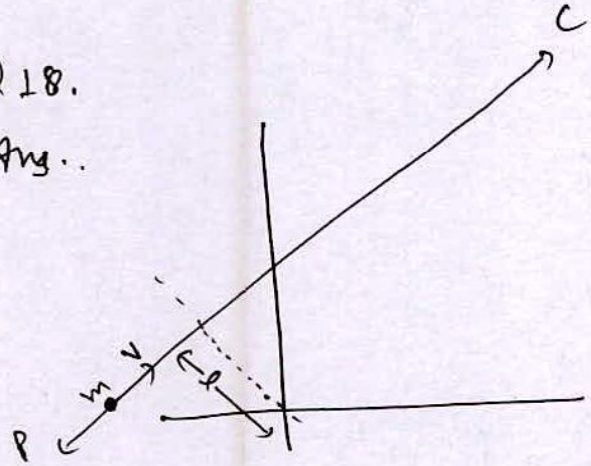


$$\frac{MR^2}{2}\omega = \left(\frac{MR^2}{2} + 2mR^2\right)\omega'$$

$$\omega' = \frac{M\omega}{4m+M}$$

Q 18.

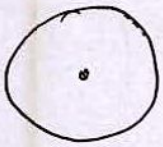
Ans..



$$\vec{L} = mvl$$

Q 19.

Ans.



$$I = \frac{MR^2}{2}$$

Q 20.

Ans.

$$a = g\sin\theta \quad \text{(for all)}$$

Q 21.

Ans.

$$I_1\omega_1 = I_2\omega_2$$

$$K.E_1 = \frac{1}{2}I_1\omega_1^2$$

$$K.E_2 = \frac{1}{2}I_2\omega_2^2$$

$$K.E_2 = \frac{L^2}{2I_2}$$

$$K.E_1 = \frac{L^2}{2I_1}$$

$$K.E_1 - K.E_2 = \frac{L^2}{2}\left(\frac{1}{I_1} - \frac{1}{I_2}\right)$$

$$= \frac{(MR^2\omega)^2}{2}\left(\frac{1}{MR^2} - \frac{1}{(M+2m)R^2}\right)$$

$$= \frac{M^2 R^4 \omega^2}{2} \left(\frac{(M+2m)R^2 - MR^2}{(M+2m)MR^4} \right)$$

$$= \frac{2mR^2\omega^2 M}{2(M+2m)}$$

$$= \frac{Mm R^2\omega^2}{M+2m}$$

Q. 22.

Ans. $\vec{r}(t) = 5\hat{i} - 2t^2\hat{j}$

$$\frac{d\vec{r}}{dt} = -4t\hat{j}$$

at $t = 2$ $\quad v = -8\hat{j}$ m/s

$$\vec{L} = \vec{r} \times (m\vec{v})$$

$$= 2 \times (5\hat{i} - 8\hat{j}) \times (-8\hat{j})$$

$$= -80\hat{k}.$$

Q. 23.

$$v = R\omega'$$

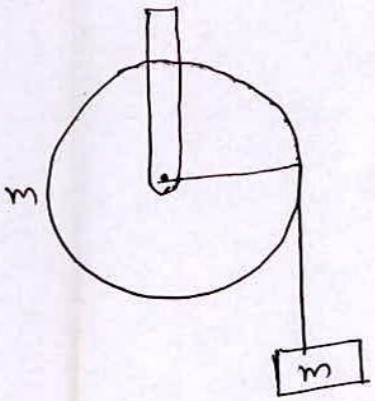
$$L_{xx'} = MR^2\omega_0 = MvR + MR^2\omega'$$

$$MR^2\omega_0 = MvR + MR^2\frac{v}{R}$$

$$v = \frac{MR^2\omega_0}{2MR} = \frac{R\omega_0}{2}$$

Q. 24.

Ans.



$$mg - T = ma$$

$$TR = \frac{mR^2}{R}\frac{a}{R}$$

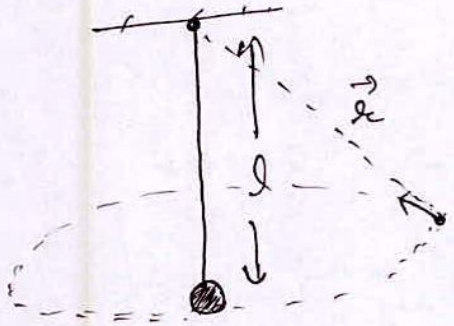
$$T = ma$$

$$mg - ma = ma$$

$$a = g/2$$

Q 25.

Ans.

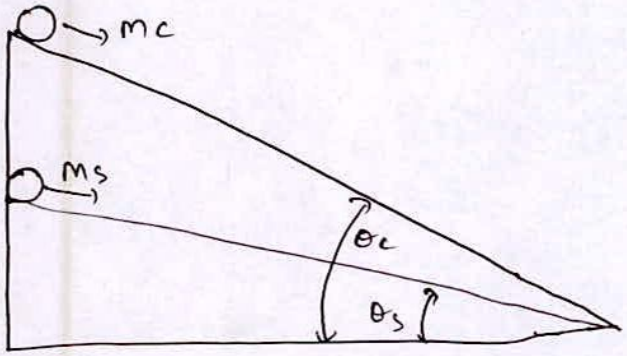


$$\vec{L} = \vec{r} \times m\vec{v}$$

$$|\vec{L}| = mvr$$

Q 26.

Ans.



$$a_c = \frac{g\sin\theta_c}{1 + \frac{\frac{1}{2}M_cR^2}{M_cR^2}} = \frac{g\sin\theta_c}{1 + 1/2}$$

$$a_s = \frac{g\sin\theta_s}{1 + \frac{\frac{2}{5}M_sR^2}{M_sR^2}} = \frac{g\sin\theta_s}{1 + 2/5}$$

$$\frac{a_c}{a_s} = 1 = \frac{\sin\theta_c}{\sin\theta_s} \times \frac{7/5}{3/2}$$

$$\frac{\sin\theta_c}{\sin\theta_s} = \frac{15}{14}$$