Revision Booster
WORKSHOP
for
NEET & JEE Main

MECHANICS

Work, Energy, Power, SOP & RBD

Notes of Revision Booster Workshop for JEE Main & NEET

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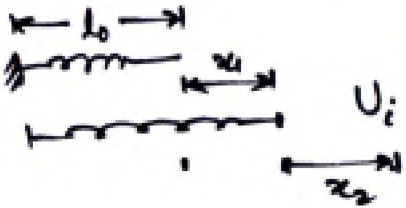
Questions Based on

Work Done in Extending Stretch in a Spring



$U_i = \frac{1}{2} k x_1^2$

$U_f = \frac{1}{2} k (x_1 + x_2)^2$

W/D in ext $= U_f - U_i =$ ____

QUESTIONS BASED ON

A BODY MOVING AT CONSTANT POWER

$F \longrightarrow \boxed{m} \xrightarrow{v}$ $\longrightarrow a = F/m$

$P = F \cdot v \rightarrow \text{Const}$

$a \cdot v = C$

$v\frac{dv}{dx} = \frac{dv}{dt} = a = \frac{C}{v} \longrightarrow \int v^2 dv = \int C\, dx$

$\frac{v^3}{3} = Cx$

$v = (3C)^{1/3} x^{1/3}$

$\int_0^v v\, dv = \int_0^t C\, dt$

$v^2 = Ct$

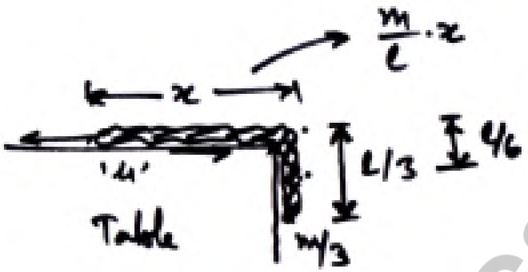
$\frac{dx}{dt} = v = k\sqrt{t}$

$\int dx = \sqrt{C} \cdot \int t^{1/2} dt$

$x = \sqrt{C}\,\frac{2}{3} t^{3/2} \longrightarrow x \propto t^{3/2}$

Questions Based on

Chain Sliding on a Table



If Table is Smooth $W = \left(\frac{m}{3}\right) g \cdot \left(\frac{l}{6}\right) = \frac{1}{18} mgl$

" " is rough. $W = \int_{2l/3}^{l} \mu \left(\frac{m}{l} x\right) g \cdot dx + \frac{1}{18} mgl$

Questions Based on

A Particle in a Potential Field

$U_{(x)} = \left(\frac{x^4}{4} - \frac{x^2}{2}\right) J$ ⟶ Conservative field

force $F_{(x)} = -\frac{dU_{(x)}}{dx} = x^3 - x = 0$

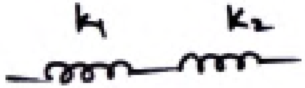
$(x^2 - 1) \cdot x = 0$

$x = 0$
or $x = \pm 1$] Type of eq^n

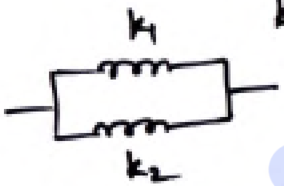
E_x at a particular value of x — $K_x = 5J$, $U_x = C_{(x)}$] $TE = 5 + C_{(x)} = \text{Constant}$

Questions Based on

Cases of Spring Combination

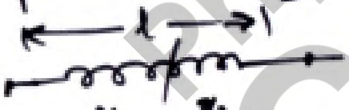


$$k_{eq} = \frac{k_1 k_2}{k_1 + k_2}$$



$$k_{eq} = k_1 + k_2$$

Cutting of Springs



n equal parts

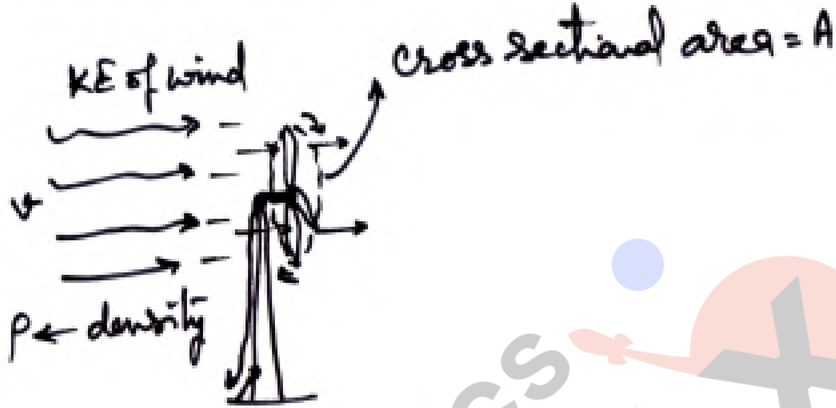
$k_{each} = n k_0$

k_1 k_2

$$k_1 = \frac{k_0 l}{x_1} \qquad k_2 = \frac{k_0 l}{x_2}$$

QUESTIONS BASED ON

POWER GENERATED BY A WIND MILL



volume flow rate of wind $= Av$

$$\text{mass/sec} = \rho A v$$

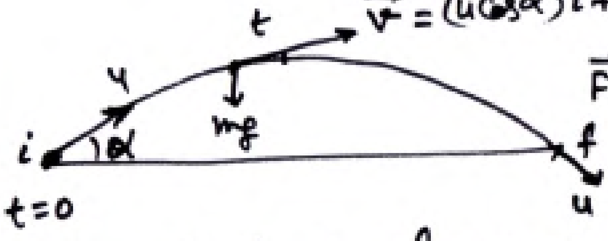
$$\text{KE/sec} = \frac{1}{2}(\rho A v)v^2$$

$$= \frac{1}{2}\rho A v^3$$

$$P_w \propto v^3$$

QUESTIONS BASED ON

AVERAGE POWER CALCULATION



$\vec{v} = (u\cos\alpha)\hat{i} + (u\sin\alpha - gt)\hat{j}$

$\vec{F} = -mg\hat{j}$

Power due to grav forces is $P_t = \vec{F}\cdot\vec{v}$

$P_t = -mg(u\sin\alpha - gt)$ Avg

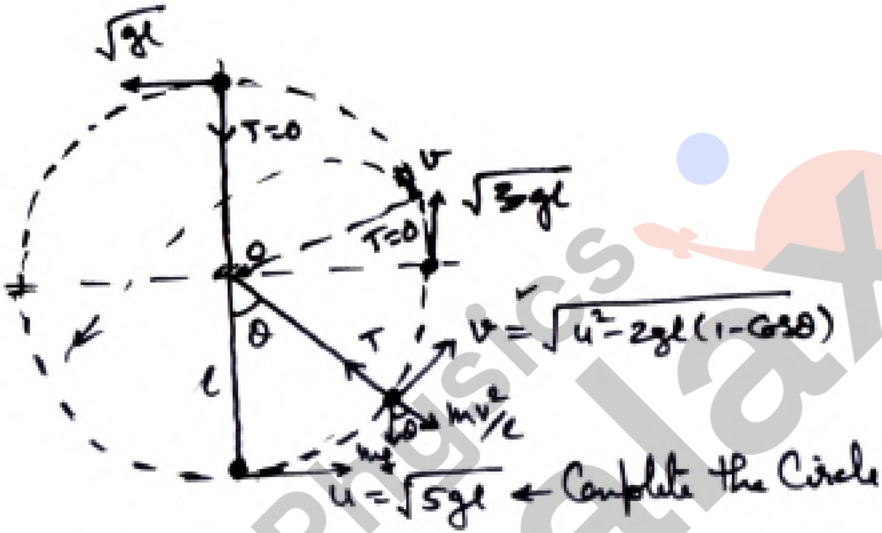
$\langle P_{avg} \rangle = \frac{\Delta K}{\Delta t} = \frac{\Delta W}{\Delta t}$

$\underset{\text{start to TOfp}}{\langle P_{avg} \rangle} = \frac{-(\frac{1}{2}mu^2 - \frac{1}{2}mu^2\cos^2\alpha)}{(u\sin\alpha/g)}$

$\underset{\text{whole TOF}}{P_{avg}} = \frac{0}{T_f} = 0$

Questions Based on

Cases Of Vertical Circular Motion



$$T = mg\cos\theta + \frac{mv^2}{l}$$

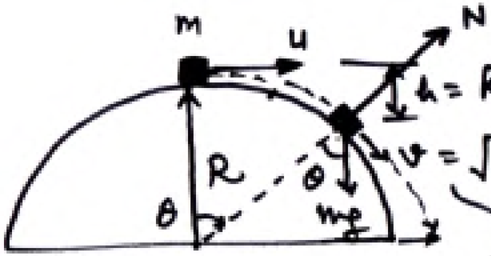
if $u \le \sqrt{2gl}$ ← Oscillate in lower half

$u \ge \sqrt{2gl}$ ← in upper half it may start projectile motion

QUESTIONS BASED ON

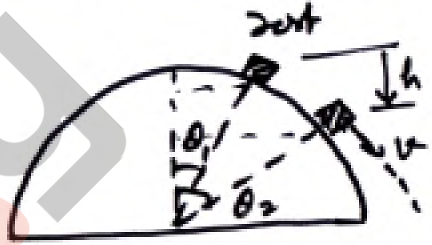
VERTICAL CIRCULAR MOTION OUTSIDE A CIRCULAR TRACK

$h = R[\cos\theta_1 - \cos\theta_2]$



$h = R(1-\cos\theta)$

$v = \sqrt{u^2 + 2gR(1-\cos\theta)}$ ✓



At angle θ $\quad N = mg\cos\theta - \frac{mv^2}{R}$

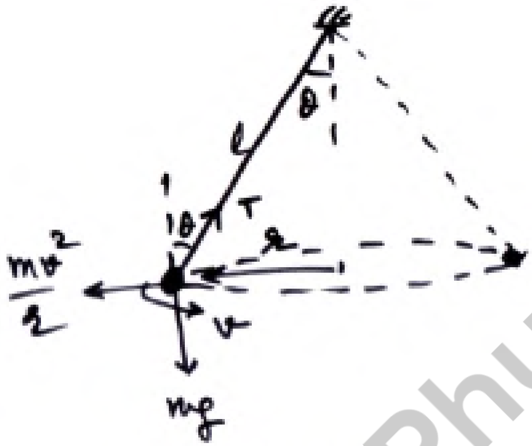
$v = \sqrt{2gh}$

$\theta_2 =$ — Ans

Body will loose contact from surface where $N = 0$

QUESTIONS BASED ON

ANALYSIS OF CONICAL PENDULUM



$r = l\sin\theta$

for stable UCM

$T\sin\theta = \frac{mv^2}{r}$

$T\cos\theta = mg$

$\left[\tan\theta = \frac{v^2}{rg}\right]$

$T = m\sqrt{g^2 + \frac{v^4}{r^2}}$

QUESTIONS BASED ON

POWER IN CIRCULAR MOTION

UCM

$a_t = 0$

$a_N = \frac{v^2}{r}$

$P = \vec{F}\cdot\vec{v} = (m\vec{a}_N)\cdot\vec{v} = 0$

NUCM

$P = \vec{F}\cdot\vec{v} = m(\vec{a}_t + \vec{a}_N)\cdot\vec{v}$

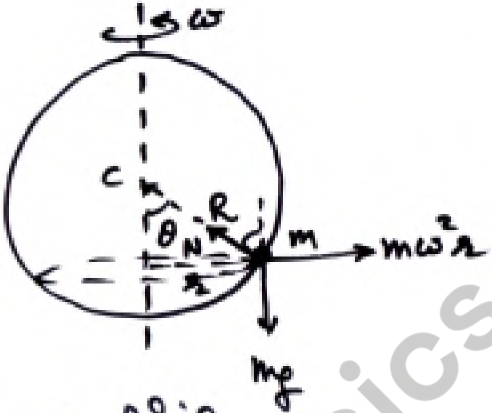
$P_t = m a_t v$ → +ve if accelerating, −ve if retarding

if $a_t = f(t)$

$v = \int_0^v dv = \int_0^t f(t)\,dt$

QUESTIONS BASED ON

MOTION OF A BEAD ON A ROTATING CIRCULAR WIRE



$r = R\sin\theta$

for eq^n of bead

$N\cos\theta = mg$

$N\sin\theta = m\omega^2 R\sin\theta$

QUESTIONS BASED ON

EXPLOSION OF A MOVING BODY

⇓

$K_f > K_i$

only by internal

no external is present $\Rightarrow P_i = P_f$

by Cons. of linear momentum

$$\begin{bmatrix} 2mv_0 = mv_1\cos\theta_1 + mv_2\cos\theta_2 \\ mv_1\sin\theta_1 = mv_2\sin\theta_2 \end{bmatrix}$$

QUESTIONS BASED ON

ELASTIC/PARTICAL ELASTIC HEAD ON COLLISION OF BODIES

$e = 1 \leftarrow$ elastic

$0 < e < 1$

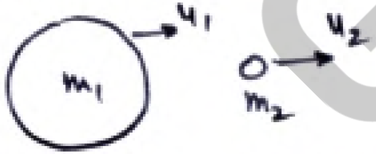
$\uparrow$ partial elastic

$u_1 > u_2$

$$\vec{v}_1 = \frac{m_1 - e m_2}{m_1 + m_2}\vec{u}_1 + \frac{m_2}{m_1 + m_2}(1+e)\vec{u}_2$$

$$\vec{v}_2 = \frac{m_2 - e m_1}{m_1 + m_2}\vec{u}_2 + \frac{m_1}{m_1 + m_2}(1+e)\vec{u}_1$$

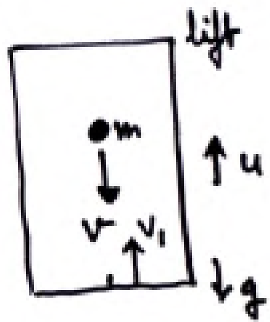
for $e = 1$ & $m_1 >> m_2$



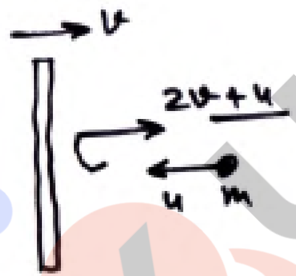
$\rightarrow$ $\boxed{v_1 = u_1}$ $\quad$ $\boxed{\vec{v}_2 = 2u_1 - u_2}$

Questions Based on

Collision of a Falling Particle in a Lift



$M_{lift} >> m$



$$\vec{v}_1 = 2\vec{u} - \vec{v}$$

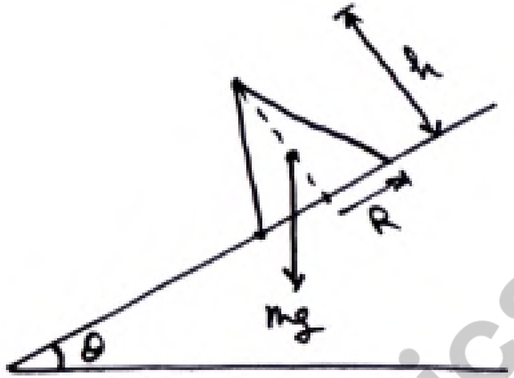
$$v_1 = 2u + v$$

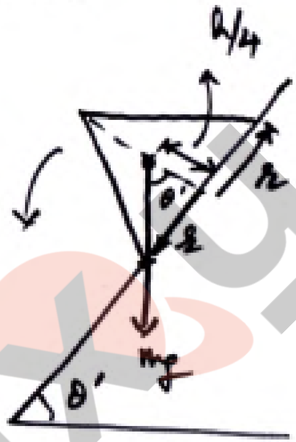
after rebound, max height attained

$$H_{max} = \frac{v_1^2}{2g} = \frac{(2u+v)^2}{2g} = \text{—— Ans}$$

Questions Based on

Cases of Toppling on Inclined Plane





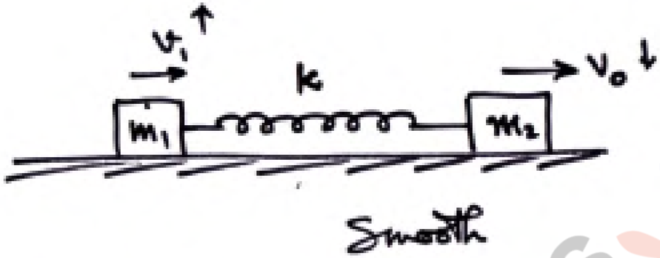
$$\tan\theta' = \frac{4R}{h}$$

$$\theta' = \tan^{-1}\left(\frac{4R}{h}\right)$$

if $\theta' < \theta_R$ then body will topple before sliding

Questions Based on

Spring Block Systems



spring elongation will be max when $v_1 = v_2 = \frac{m_2 v_0}{m_1 + m_2}$

$$m_2 v_0 = (m_1 + m_2) v_f$$

By Cons. of energy

$$\frac{1}{2} m_2 v_0^2 = \frac{1}{2} k x_m^2 + \frac{1}{2}(m_1 + m_2)\left(\frac{m_2 v_0}{m_1 + m_2}\right)^2$$

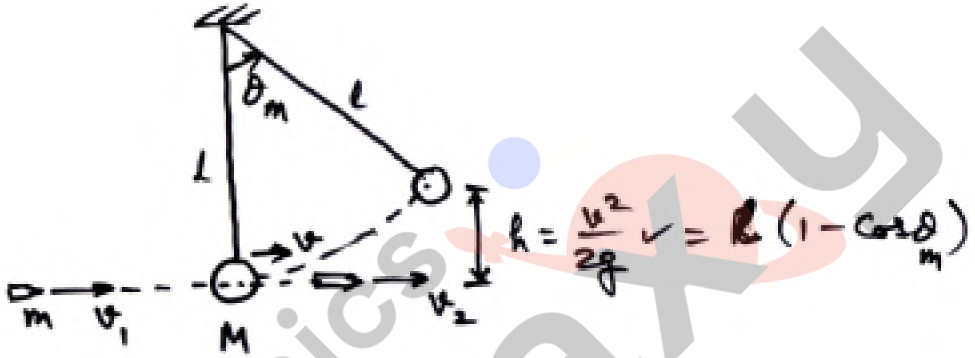
$x_m =$ ——— Ans

if initial vel are v_1 and v_2

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_2$$

QUESTIONS BASED ON

CASES A BULLET HITTING A PENDULUM BOB



By Cons of momentum

$$mv_1 = Mv + mv_2 \quad \text{—— (1)}$$

QUESTIONS BASED ON

SAND FALLING ON A CONVEYOR BELT

per unit time momentum gained by sand $F = \lambda v$

force required by rollers to keep belt moving at uniform speed

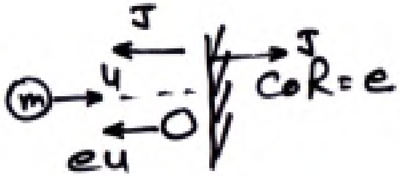
Power reqd = energy/sec gained by sand $= \frac{1}{2}\lambda v^2$

[+ energy loss due to inelastic collision] → $\frac{1}{2}\lambda v^2$

$\Big\} = \lambda v^2$

Questions Based on

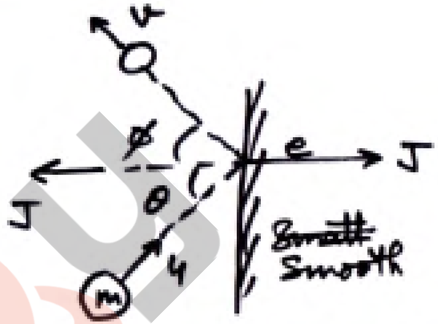
Impulse in a Collision



Impulse eqⁿ for ball

$$mu - J = -m(eu)$$

$$mu(1+e) = J$$



$$u\sin\theta = v\sin\phi$$

$$v\cos\phi = eu\cos\theta$$

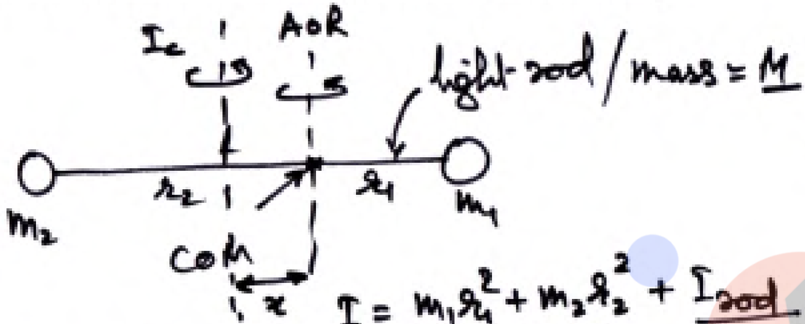
Impulse-momentum eqⁿ

$$mu\cos\theta - J = -mv\cos\phi$$

$$J = m[u\cos\theta + v\cos\phi]$$

Questions Based on

Moment of Inertia Calculation



$$I_c = \frac{Ml^2}{12}$$

$$I = m_1 r_1^2 + m_2 r_2^2 + I_{rod}$$

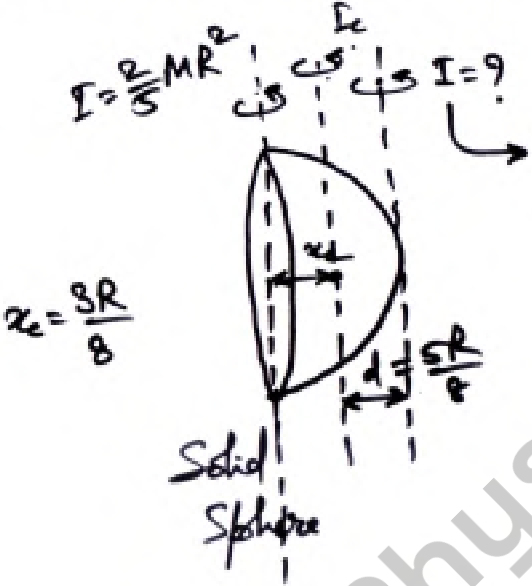
$$I_{rod} = I_c + M\left(\frac{l}{2} - r_1\right)^2$$

$$r_1 = \frac{m_2 l}{m_1 + m_2}$$

$$r_2 = \frac{m_1 l}{m_1 + m_2}$$

Questions Based on

Reverse Parallel Axes Theorem



$$I = I_c + M\left(\frac{5R}{8}\right)^2$$

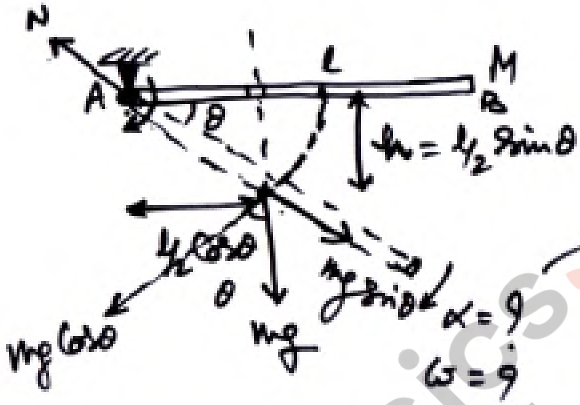
$$= \text{———} \checkmark$$

$$\frac{2}{5}MR^2 = I_c + M\left(\frac{3R}{8}\right)^2$$

$$I_c = \text{———}$$

Questions Based on

Falling Rod Pivoted at a Point



$\alpha = ?$

$\omega = ?$

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

$\tau = I\alpha$

$mg \cdot \frac{l}{2}\cos\theta = \frac{Ml^2}{3} \cdot \alpha$

$\alpha = \frac{3g}{2l}\cos\theta$ ✓

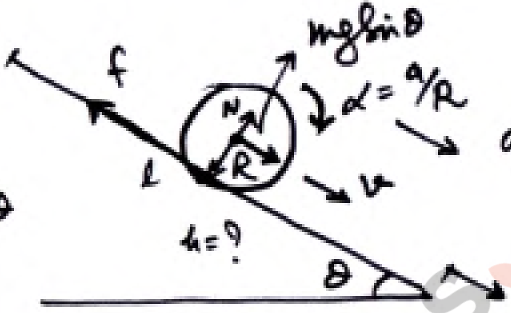
By WE theorem.

$mg\left(\frac{l}{2}\sin\theta\right) = \frac{1}{2}\left(\frac{Ml^2}{3}\right)\omega^2$

$\omega = \ldots$ ✓

QUESTIONS BASED ON

ACCELERATION OF ROLLING BODIES ON INCLINED PLANE



$N = mg\cos\theta$

$$a = \frac{g\sin\theta}{1 + \frac{k^2}{R^2}}$$

$v = \sqrt{2al}$

$t = \sqrt{\frac{2l}{a}}$

Ring $k = R$

Disc $k = \frac{R}{\sqrt{2}}$

Cyl $k = R/\sqrt{2}$

H. Sph. $k = \sqrt{\frac{2}{3}}R$

S. Sph $k = \sqrt{2/5}R$

Calculation of Static friction on Rolling body on incline

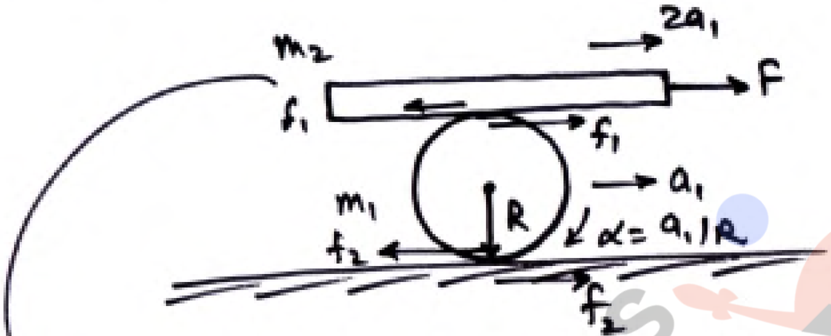
eqⁿ of motion $mg\sin\theta - f = ma$

$f = \text{——} \leq \mu mg\cos\theta$ for pure rolling to continue

or $f.R = I.(a/R)$

QUESTIONS BASED ON

MOTION OF A PLANK OVER A ROLLER



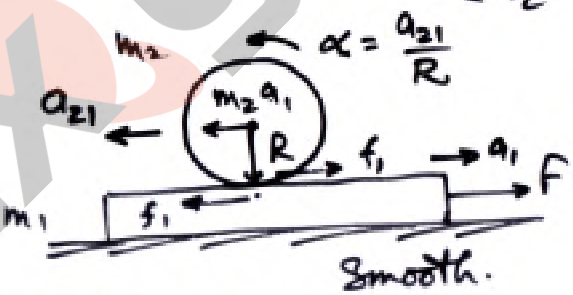
$$F - f_1 = m_2(2a_1)$$

$$f_1 - f_2 = m_1 a_1$$

$$f_1 R + f_2 R = \frac{1}{2} m_1 R^2 \left(\frac{a_1}{R}\right)$$

in pure rolling

$f_1, f_2 \rightarrow$ Static friction $\leq f_L$

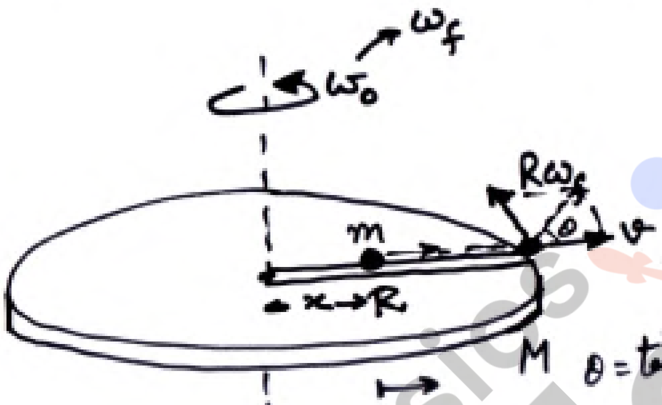


$$\left[\begin{aligned} F - f_1 &= m_1 a_1 \\ m_2 a_1 - f_1 &= m_2 a_{21} \\ f_1 R &= \frac{1}{2} m_2 R^2 \left(\frac{a_{21}}{R}\right) \end{aligned}\right] \rightarrow \begin{aligned} a_1 &= \text{—} \\ a_{21} &= \text{—} \\ f_1 &= \text{—} \leq \mu m_2 g \end{aligned}$$

$$a_{2\,ground} = a_{21} - a_1 = \text{—} \text{ (leftward)}$$

Questions Based on

Ball Sliding in a Groove on Disc



by conservation of angular momentum

$$I_1\omega_0 = I_2\omega_f$$

$$\left(\frac{1}{2}MR^2\right)\omega_0 = \left(\frac{1}{2}MR^2 + mR^2\right)\omega_f$$

$$\omega_f = \text{—}$$

$$\theta = \tan^{-1}\frac{R\omega_f}{R\omega}$$

$$\theta = \tan^{-1}\left(\frac{\omega_f}{R}\right)$$

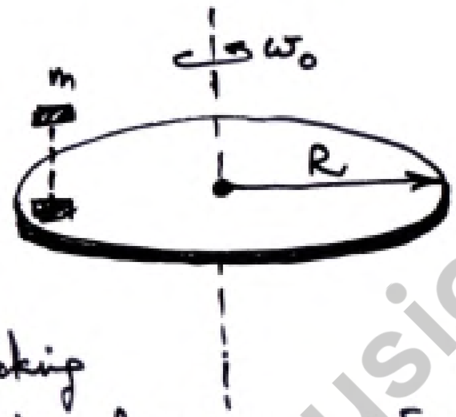
$$v\frac{dv}{dx} = a = \omega^2 x$$

$$\int_0^v v\,dv = \int_0^R \omega^2 x\,dx$$

$$\frac{v^2}{2} = \frac{\omega^2R^2}{2} \Rightarrow v = \omega R$$

QUESTIONS BASED ON

ADDING A BODY ON ANOTHER ROTATING BODY



By ang momentum conservation

$$\left(\frac{1}{2}MR^2\right)\omega_0 = \left[\frac{1}{2}MR^2 + mR^2\right]\omega_f$$

$$\omega_f = \_\_\_\_$$

Sticking

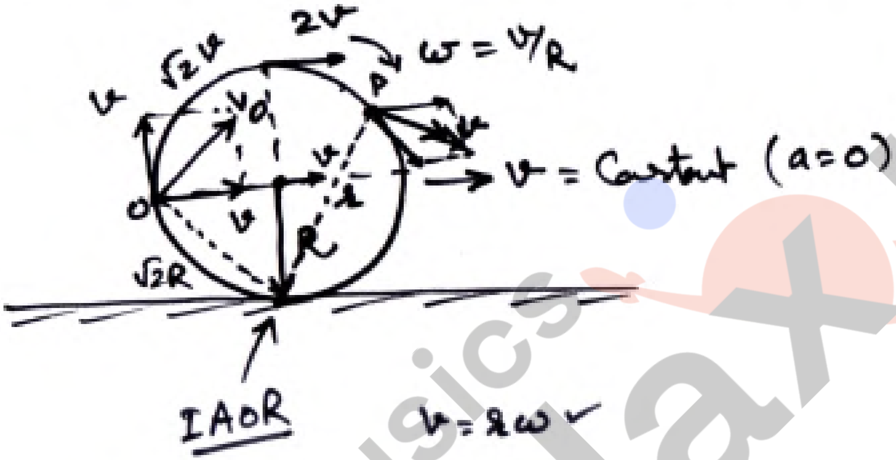
$\Rightarrow$ loss of energy $\Delta E = E_i - E_f$

$$E_i = \frac{1}{2}I\omega_0^2 \qquad E_f = \frac{1}{2}I'\omega_f^2$$

$$= \_\_\_\_\_\_$$

QUESTIONS BASED ON

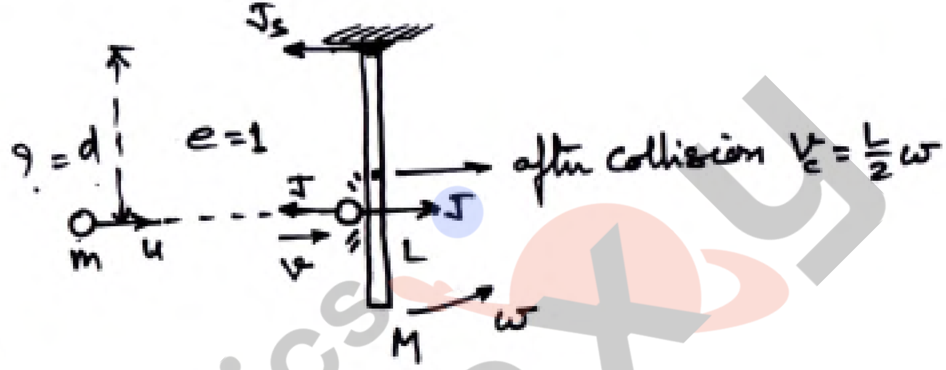
VELOCITIES AND ACCELERATIONS OF PARTICLES IN A ROLLING BODY



$V_0 = \sqrt{2}R.\omega = \sqrt{2}v$

Questions Based on

A Ball Hitting a Vertical Hanging Rod



Impulse eqn

$$mu - J = mv$$

$$Jd = \frac{ML^2}{3}\cdot\omega$$ — (1)

as $e = 1$ ⇒

$$eu = (d\omega - v)$$ — (2)

$v = $ —

$\omega = $ —

for rod we use

$$J - J_s = M\cdot\frac{L}{2}\omega \rightarrow J_s = J - \frac{ML\omega}{2} = \text{—}$$