

# ROTATIONAL MOTION

## \* Moment of Inertia:

→ Quantitative measure of the rotational Inertia of a body  $I = MR^2$

→ doesn't depends upon torque, Angular acc<sup>n</sup>, etc.

→  $I \propto M \propto R^2$

→ MOI for 2 body System:  $I = \left( \frac{m_1 m_2}{m_1 + m_2} \right) r^2$

MOI of Some Selected body:-

1) Rod:

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

$$I = \frac{MR^2}{12}$$

\* Radius of Gyration:

$$I = MK^2$$

2) Ring:

$$I = MR^2$$

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

$$I = 2MR^2$$

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

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

3) Disc:

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

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

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

$$I = \frac{5MR^2}{4}$$

$$I = \frac{5MR^2}{4}$$

4) Hollow Sphere:

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

$$I = \frac{5}{3} MR^2$$

5) Solid Sphere:

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

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

## TORQUE 'Moment of force'

• Cause of change in Rotational State of the body.

• Always  $\perp$  to the plane of  $\vec{r}$  &  $\vec{F}$ .

$$\vec{\tau} = I \vec{\alpha} \rightarrow \tau = r F \sin \theta \rightarrow \tau = \vec{r} \times \vec{F}$$

• Torque  $\propto R \propto F \propto \sin \theta$

• If force is passing through axis of rotation:  $\tau = 0$

• Hmacha jwari rhi hota hai ki force Lage to torque bhi create ho.

$$\tau = r F \sin \theta$$

If  $\theta = 0^\circ$  or  $\theta = 180^\circ$  then,  $\tau = 0$

If  $\theta = 90^\circ$   $(\tau)_{\max} = rF$

$$\vec{\tau}_{\text{net}} = 2 \times r \times F \text{ Couple}$$

## ROTATION

⇒ Pure Translational Motion: Every part of the particle is moving with same translational velocity.

⇒ Pure Rotational Motion: Every particle of the body is moving with same in a circle where centre of all the circle lies on the same straight line.

\* All equation of Motion ( $\alpha = \text{const}^n$ ) are applicable:-

• velocity -  $\vec{\omega} = \frac{d\theta}{dt}$

• Acc<sup>n</sup> -  $\vec{\alpha} = \frac{d\vec{\omega}}{dt}$

• Power -  $P = \vec{\tau} \cdot \vec{\omega}$

• Force -  $\tau = I \alpha$

• Momentum -  $\vec{L} = I \vec{\omega}$

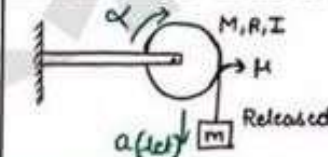
• Work -  $W = \vec{\tau} \cdot \vec{\theta}$

• K.E -  $\frac{1}{2} I \omega^2$

Relation b/w ( $\omega_1, \omega_2$ ) ( $a_1, a_2$ ):

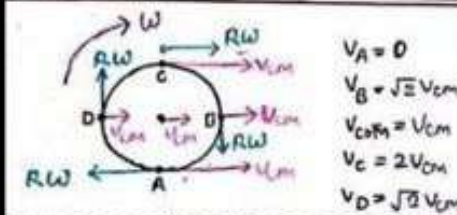
$$1) \omega_1 r_1 = \omega_2 r_2$$

$$2) \alpha_1 r_1 = \alpha_2 r_2$$



"THE MR"

$$\alpha = \frac{Mg}{M + I/R^2}$$



## Kinetic Energy in Pure Rolling:

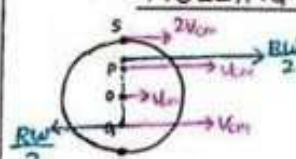
\*  $K.E_{\text{Total}} = K.E_{\text{Translational}} + K.E_{\text{Rotational}}$

$$\frac{K.E_{\text{Translational}}}{K.E_{\text{Total}}} = \frac{1}{1 + \frac{K}{R^2}} \rightarrow \text{Let it be } \beta$$

$$\frac{K.E_{\text{Rotational}}}{K.E_{\text{Total}}} = 1 - \beta$$

Jaha Rahega g waha Rahega  $\beta$

## ROLLING MOTION



$$V_R = 0$$

$$V_A = V_{CM}/2$$

$$V_O = V_{CM}$$

$$V_S = 2V_{CM}$$

$$V_P = 3V_{CM}/2$$

$$V_Q = 4V_{CM}/2$$

$$V_R = 0$$

$$V_S = 2V_{CM}$$

$$V_T = 3V_{CM}$$

$$V_U = 4V_{CM}$$

$$V_V = 5V_{CM}$$

$$V_W = 6V_{CM}$$

$$V_X = 7V_{CM}$$

$$V_Y = 8V_{CM}$$

$$V_Z = 9V_{CM}$$

$$V_{AA} = 10V_{CM}$$

$$V_{BB} = 11V_{CM}$$

$$V_{CC} = 12V_{CM}$$

$$V_{DD} = 13V_{CM}$$

$$V_{EE} = 14V_{CM}$$

$$V_{FF} = 15V_{CM}$$

$$V_{GG} = 16V_{CM}$$

$$V_{HH} = 17V_{CM}$$

$$V_{II} = 18V_{CM}$$

$$V_{JJ} = 19V_{CM}$$

$$V_{KK} = 20V_{CM}$$

$$V_{LL} = 21V_{CM}$$

$$V_{MM} = 22V_{CM}$$

$$V_{NN} = 23V_{CM}$$

$$V_{OO} = 24V_{CM}$$

$$V_{PP} = 25V_{CM}$$

$$V_{QQ} = 26V_{CM}$$

$$V_{RR} = 27V_{CM}$$

$$V_{SS} = 28V_{CM}$$

$$V_{TT} = 29V_{CM}$$

$$V_{UU} = 30V_{CM}$$

$$V_{VV} = 31V_{CM}$$

$$V_{WW} = 32V_{CM}$$

$$V_{XX} = 33V_{CM}$$

$$V_{YY} = 34V_{CM}$$

$$V_{ZZ} = 35V_{CM}$$

$$V_{AA} = 36V_{CM}$$

$$V_{BB} = 37V_{CM}$$

$$V_{CC} = 38V_{CM}$$

$$V_{DD} = 39V_{CM}$$

$$V_{EE} = 40V_{CM}$$

$$V_{FF} = 41V_{CM}$$

$$V_{GG} = 42V_{CM}$$

$$V_{HH} = 43V_{CM}$$

$$V_{II} = 44V_{CM}$$

$$V_{JJ} = 45V_{CM}$$

$$V_{KK} = 46V_{CM}$$

$$V_{LL} = 47V_{CM}$$

$$V_{MM} = 48V_{CM}$$

$$V_{NN} = 49V_{CM}$$

$$V_{OO} = 50V_{CM}$$

$$V_{PP} = 51V_{CM}$$

$$V_{QQ} = 52V_{CM}$$

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$$V_{PP} = 77V_{CM}$$

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$$V_{VV} = 83V_{CM}$$

$$V_{WW} = 84V_{CM}$$

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$$V_{YY} = 86V_{CM}$$

$$V_{ZZ} = 87V_{CM}$$

$$V_{AA} = 88V_{CM}$$

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$$V_{ZZ} = 113V_{CM}$$

$$V_{AA} = 114V_{CM}$$

$$V_{BB} = 115V_{CM}$$

$$V_{CC} = 116V_{CM}$$

$$V_{DD} = 117V_{CM}$$

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$$V_{FF} = 119V_{CM}$$

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