IMPULSE AND MOMENTUM

IMPULSE

Impulse of a force 'F' acting on a body for a time interval $t = t_1$ to $t = t_2$ is defined as

$$\vec{I} = \int_{t_1}^{t_2} \vec{F}\,dt \qquad \vec{I}_{Re} = \int_{t_1}^{t_2} \vec{F}_{Res}\,dt = \Delta\vec{P}$$

(Impulse - Momentum Theorem)

COEFFICIENT OF RESTITUTION (e)

The coefficient of restitution is defined as the ratio of the impulses of reformation and deformation of either body.

$$e = \frac{\text{Impulse of reformation}}{\text{Impulse of deformation}} = \frac{\int F_r\,dt}{\int F_d\,dt} \qquad e = \frac{\text{Velocity of separation of point of contact}}{\text{Velocity of approach of point of contact}}$$

LINEAR MOMENTUM

Linear momentum is a vector quantity defined as the product of an object's mass m, and its velocity v. Linear momentum is denoted by the letter p and is called "momentum" in short:

$$p = mv$$

Note that a body's momentum is always in the same direction as its velocity vector. The units of momentum are kg.m/s.

CONSERVATION OF LINEAR MOMENTUM

For a single mass or single body, If net force acting on the body is zero. Then,

$$\vec{p} = \text{constant} \quad \text{or} \quad \vec{v} = \text{constant}$$

(if mass = constant)

If net external force acting on a system of particles or system of rigid bodies is zero. Then,

$$\vec{P}_{CM} = \text{constant} \quad \text{or} \quad \vec{V}_{CM} = \text{constant}$$

COLLISION

Note :- In every type of collision, only linear momentum remains constant.

HEAD ON ELASTIC COLLISION

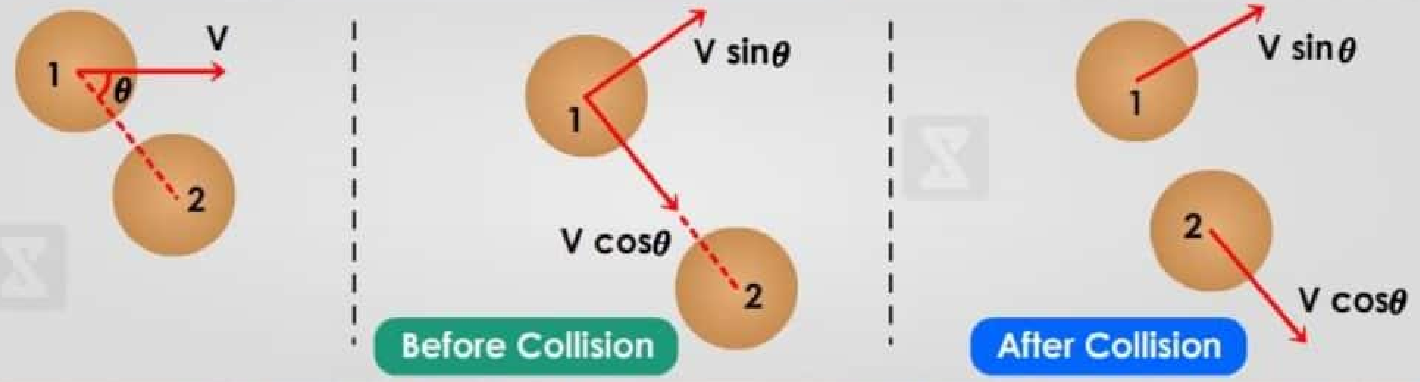
In this case, linear momentum and kinetic energy both are conserved. After solving two conservation equations. We get,

$$V'_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)V_1 + \left(\frac{2m_2}{m_1 + m_2}\right)V_2$$ and $$V'_2 = \left(\frac{m_2 - m_1}{m_1 + m_2}\right)V_2 + \left(\frac{2m_2}{m_1 + m_2}\right)V_1$$

HEAD ON INELASTIC COLLISION

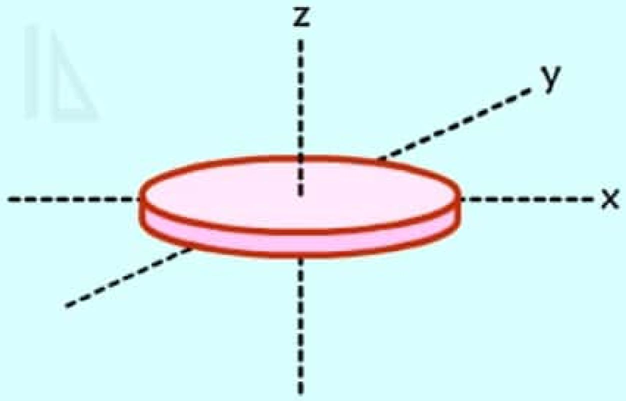
- In an inelastic collision, the colliding particles do not regain their shape and size completely after the collision.
- Some fraction of mechanical energy is retained by the colliding particles in the form of deformation potential energy. Thus, the kinetic energy of the particles no longer remains conserved.
- $(\text{Energy loss})_{\text{Perfectly Inelastic}} > (\text{Energy loss})_{\text{Partial Inelastic}}$
- $0 < e < 1$: e = coefficient of restitution

OBLIQUE COLLISION (BOTH ELASTIC IN ELASTIC)



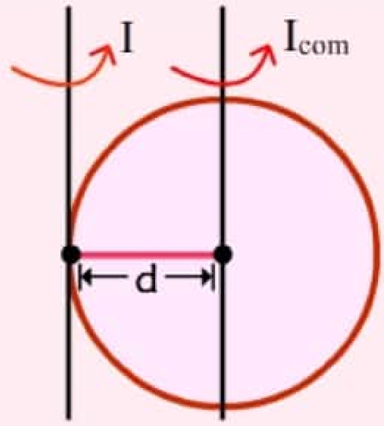
BALL	COMPONENT ALONG COMMON TANGENT DIRECTION		COMPONENT ALONG COMMON NORMAL DIRECTION	
	Before Collision	After Collision	Before Collision	After Collision
1	V sinθ	V sinθ	V cosθ	0
2	0	0	0	V cosθ

Perpendicular Axis Theorm



$$I_z = I_x + I_y$$

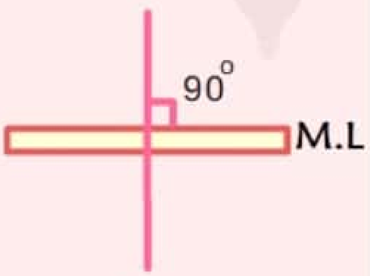
Parellel Axis Theorm



$$I = I_{com} + Md^2$$

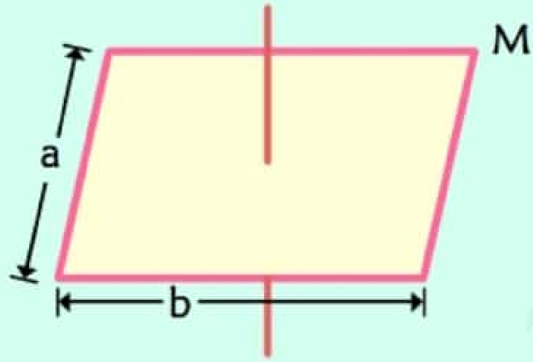
Rod

$\frac{ML^2}{3}$ (Uniform)



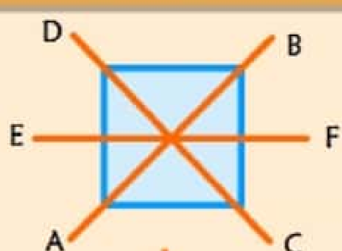
$\frac{ML^2}{12}$ (Uniform)

Rectangular Plate



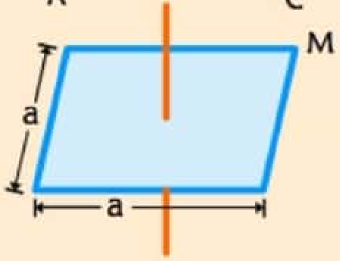
$I = \frac{M(a^2+b^2)}{12}$ (Uniform)

Square Plate



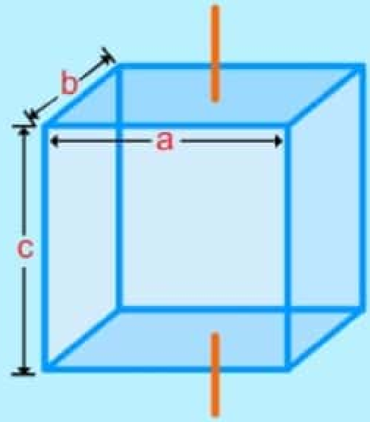
$$I_{AB} = I_{CD} = I_{EF}$$

$= \frac{Ma^2}{12}$ (Uniform)



$\frac{Ma^2}{6}$ (Uniform)

Cuboid



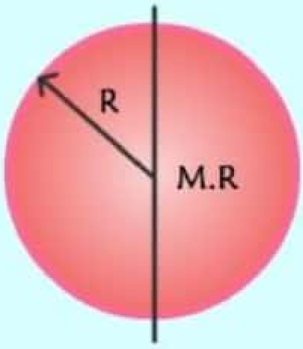
$\frac{M(a^2+b^2)}{12}$

(Uniform)

MOMENT OF INERTIA

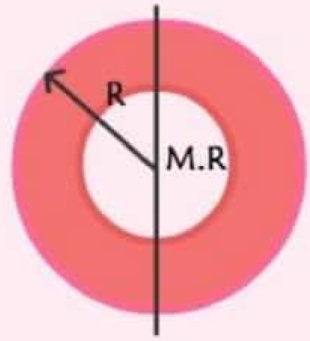
Part II

Solid Sphere



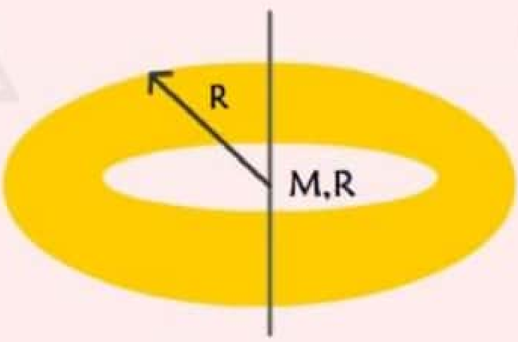
$I = \frac{2}{5} MR^2$ (Uniform)

Hollow Sphere



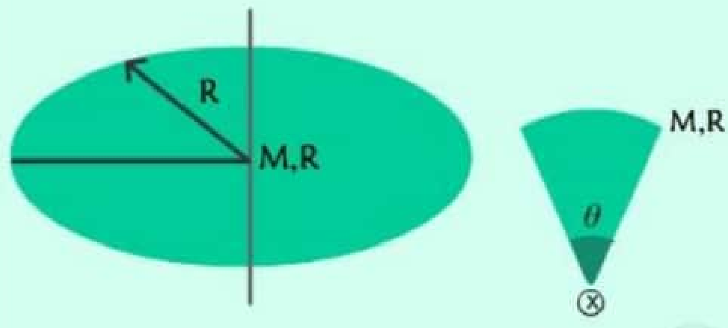
$I = \frac{2}{3} MR^2$ (Uniform)

Ring



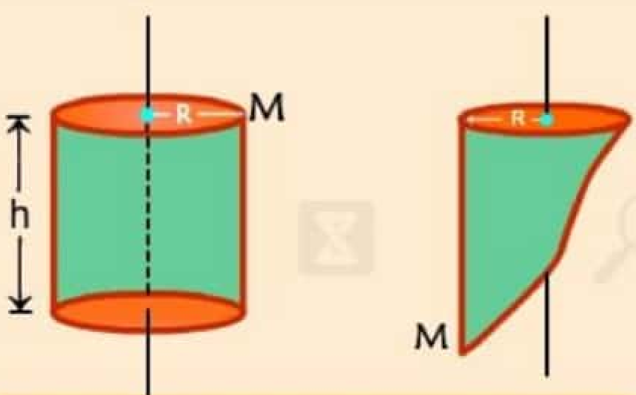
$I = MR^2$ (Uniform or Non Uniform)

Disc



$I = \frac{MR^2}{2}$ (Uniform)

Hollow cylinder



$I = MR^2$ (Uniform or Non Uniform)

Solid cylinder

$I = \frac{MR^2}{2}$ (Uniform)