BRAIN MAP

CLASS XI

COLLISION

CLASSIFICATION OF COLLISON

On the basis of line of impact

HEAD-ON COLLISION

The velocities of the particles are along the same line before and after the collision.

OBLIQUE COLLISION

The velocities of the particles are along different lines before and after the collision.

Head on Inelastic Collision

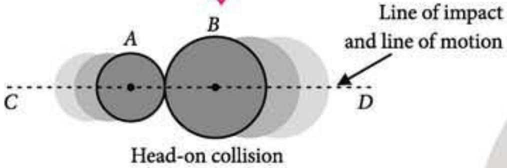
Velocity after collision :

$$v_1 = \left(\frac{m_1 - em_2}{m_1 + m_2}\right)u_1 + \left(\frac{(1+e)m_2}{m_1 + m_2}\right)u_2$$

$$v_2 = \left(\frac{(1+e)m_1}{m_1 + m_2}\right)u_1 + \left(\frac{m_2 - em_1}{m_1 + m_2}\right)u_2$$

Loss in kinetic energy :

$$(\Delta K) = \frac{1}{2}\left(\frac{m_1 m_2}{m_1 + m_2}\right)(1-e^2)(u_1 - u_2)^2$$

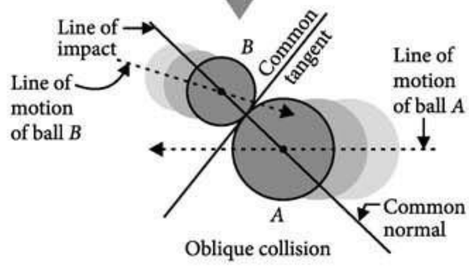


Head-on collision

In Case of Smooth Surfaces

Common normal :
Force is exerted in common normal direction only. Momentum changes in common normal direction.

Common tangent :
$F = 0$
Neither momentum nor velocity changes in common tangent direction.



Oblique collision

On the basis of kinetic energy

INELASTIC COLLISION

If the kinetic energy after and before collision are not equal, the collision is said to be inelastic.

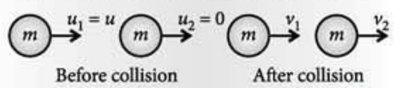
PERFECTLY INELASTIC COLLISION

If velocity of separation just after collision becomes zero, then the collision is perfectly inelastic.

ELASTIC COLLISION

If the kinetic energy after and before collision is same, the collision is said to be perfectly elastic.

- **Velocities after inelastic collision :**



$$\therefore \frac{v_1}{v_2} = \frac{1-e}{1+e}$$

- **Coefficient of Restitution (e)**

$$e = \frac{\text{Velocity of separation along line of impact}}{\text{Velocity of approach along line of impact}}$$

By substituting $e = 1$, we get $\Delta K = 0$

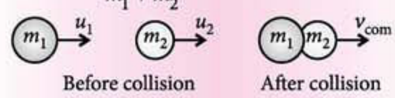
Rebounding of Ball After Collision

- **After first rebound**
  - **Speed :** $v_1 = ev_0 = e\sqrt{2gh_0}$
  - **Height :** $h_1 = e^2 h_0$
- **After n^{th} rebound :**
  - **Speed :** $v_n = e^n v_0$
  - **Height :** $h_n = e^{2n} h_0$
- **Total distance travelled by the ball before it stops bouncing :**
  $H = h_0[(1+e^2)/(1-e^2)]$

Perfectly Inelastic Collision

- **When the colliding bodies are moving in the same direction :**

$$v_{com} = \frac{m_1 u_1 + m_2 u_2}{m_1 + m_2}$$



Loss in kinetic energy

$$\Delta K = \frac{1}{2}\left(\frac{m_1 m_2}{m_1 + m_2}\right)(u_1 - u_2)^2$$

- **When the colliding bodies are moving in the opposite direction :**

$$\therefore v_{com} = \frac{m_1 u_1 - m_2 u_2}{m_1 + m_2}$$

Loss in kinetic energy

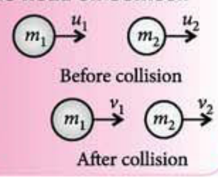
$$\Delta K = \frac{1}{2}\left(\frac{m_1 m_2}{m_1 + m_2}\right)(u_1 + u_2)^2$$

Elastic or Perfectly Elastic Head on Collison

Velocity after collision :

$$v_1 = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)u_1 + \frac{2m_2 u_2}{m_1 + m_2}$$

$$v_2 = \left(\frac{m_2 - m_1}{m_1 + m_2}\right)u_2 + \frac{2m_1 u_1}{m_1 + m_2}$$



Special Cases

If projectile and target are of same mass
For $m_1 = m_2 \Rightarrow v_1 = u_2$ and $v_2 = u_1$
i.e., their velocities get interchanged.

If massive projectile collides with a light target
For $m_1 >> m_2 \Rightarrow v_1 = u_1$ and $v_2 = 2u_1 - u_2$
Sub case : For $u_2 = 0$, *i.e.*, target is at rest
$v_1 = u_1$ and $v_2 = 2u_1$

If light projectile collides with a heavy target
For $m_1 << m_2 \Rightarrow v_1 = -u_1 + 2u_2$ and $v_2 = u_2$
Sub case : For $u_2 = 0$, *i.e.*, target is at rest
$v_1 = -u_1$ and $v_2 = 0$, the ball rebounds with same speed.

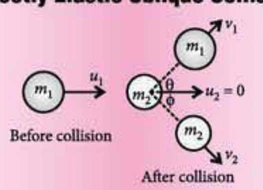
If $m_2 = nm_1$ and $u_2 = 0$
The fractional kinetic energy transferred by projectile

$$\frac{\Delta K}{K} = \frac{4n}{(1+n)^2}$$

Fractional kinetic energy retained by the projectile

$$\left(\frac{\Delta K}{K}\right)_{\text{Retained}} = 1 - \text{fractional kinetic energy transferred by projectile}$$

Perfectly Elastic Oblique Collison



After perfectly elastic oblique collision of two bodies of equal masses, the scattering angle $(\theta + \phi)$ would be 90°.

MasterJEE
IIT-JEE | Medical | Foundations