CUBE NOTES

Class 11/12 | AP Physics | IIT JEE | NEET

Elastic Collisions & Derivation of Equations

Elastic Collision: 2 Conditions

For a collision to be called elastic, 2 conditions are to be fulfilled

- Condition 1: Linear Momentum is conserved

$$m_1v_{1i} = m_1v_{1f} + m_2v_{2f}$$

- Condition 2: Kinetic Energy is conserved

$$(1/2)\, m_1v_{1i}^2 = (1/2)\, m_1v_{1f}^2 + (1/2)\, m_2v_{2f}^2$$

Stationary Target Collisions

Conservation of momentum gives:

$$m_1v_{1i} = m_1v_{1f} + m_2v_{2f}$$

Conservation of kinetic energy gives:

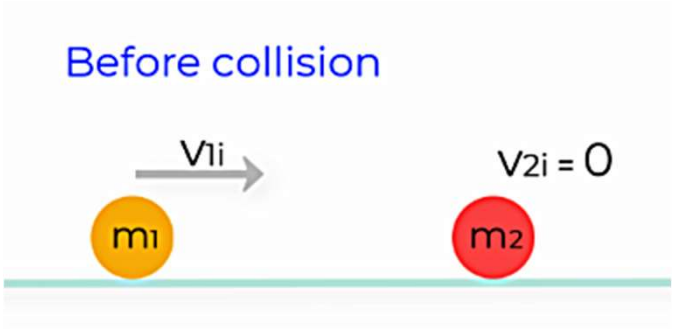
$$(1/2)\, m_1v_{1i}^2 = (1/2)\, m_1v_{1f}^2 + (1/2)\, m_2v_{2f}^2$$

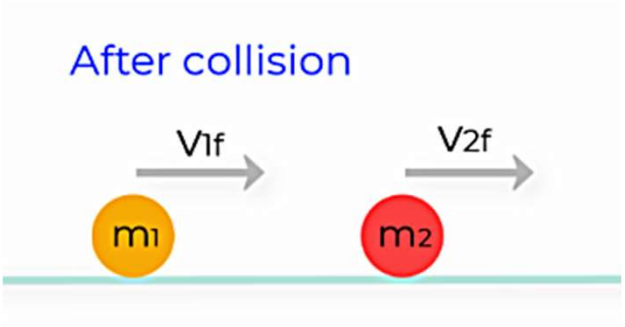
Equations for Final Velocities (from above 2 equations)

For object 1: $v_{1f} = v_{1i}(m_1 - m_2) / (m_1 + m_2)$

For object 2: $v_{2f} = v_{1i}(2m_1) / (m_1 + m_2)$

Always +ve (moves forward)





V1f is +ve if m1> m2 (moves forward) & -ve if m1 < m2 (moves back)

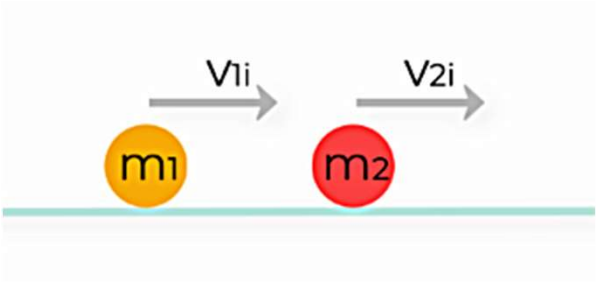
Special Cases *(Continuation of previous slide)*

1. If $m_1 = m_2$ $v_{1f} = 0$ & $v_{2f} = v_{1i}$			m_1 and m_2 exchange velocities after collision
2. If $m_2 >> m_1$ $v_{1f} \approx -v_{1i}$ $v_{2f} \approx (2m_1 / m_2)\, v_{1i}$			- m_1 rebounds back (hence $-v_{1i}$) - m_2 has very small change in vel. Due to its size
2. If $m_1 >> m_2$ $v_{1f} \approx v_{1i}$ $v_{2f} \approx 2\, v_{1i}$			- m_1 rolls on with no change in vel. (due to size) - m_2 moves at twice m_1's vel.

Collisions with Moving Targets

Conservation of momentum gives:

$$m_1v_{1i} + m_2v_{2i} = m_1v_{1f} + m_2v_{2f}$$



Conservation of KE gives:

$$(1/2)\, m_1v_{1i}^2 + (1/2)\, m_2v_{2i}^2 = (1/2)\, m_1v_{1f}^2 + (1/2)\, m_2v_{2f}^2$$

Equations for Final Velocities (from the above 2 equations)

For object 1:

$$v_{1f} = v_{1i}\,(m_1 - m_2) / (m_1 + m_2) \;+\; v_{2i}(2m_2) / (m_1 + m_2)$$

For object 2:

$$v_{2f} = v_{1i}\,(2m_1) / (m_1 + m_2) \;+\; (m_2 - m_1) / v_{2i}\,(m_1 + m_2)$$

If v_{2i} is set = 0, you get the same equations as in slide 3

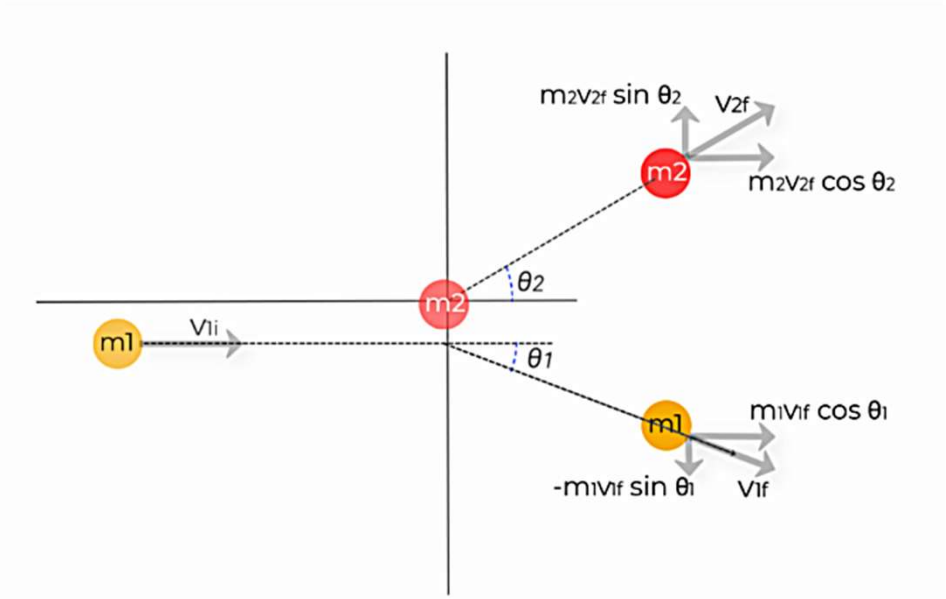
Elastic Collisions: 2D

Conservation of momentum in component form:

1. x-axis: $m_1v_{1i} = m_1v_{1f}\cos\theta_1 + m_2v_{2f}\cos\theta_2$
2. y-axis: $0 = -m_1v_{1f}\sin\theta_1 + m_2v_{2f}\sin\theta_2$

Conservation of kinetic energy in 2D

3. $(1/2)\,m_1v_{1i}^2 = (1/2)\,m_1v_{1f}^2 + (1/2)\,m_2v_{2f}^2$



There are 7 variables in equations 1,2 & 3.
If 4 are known, the 3 equations can be used to find the other 3