నమస్తే తెలంగాణ
నిపుణ III
Guide to Excellence
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పోటీపరీక్షల ప్రత్యేకం
శనివారం 21 అక్టోబర్ 2023

ఏ బిల్లునైనా ద్రవ్యబిల్లు అవునో కాదో నిర్ణయించే అధికారం ఎవరికి ఉంటుంది?
లోక్‌సభ స్పీకర్

ప్రకరణ 109(1) ప్రకారం ద్రవ్యబిల్లును మొదటగా ఏ సభలో ప్రవేశపెట్టరాదు?
రాజ్యసభ

రాజ్యాంగం అమలులోకి వచ్చిన తర్వాత ఏర్పాటైన మొదటి లోక్‌సభ స్పీకర్ ఎవరు?
జీవీ మౌలాంకర్

రాజ్యాంగ సభకు అధ్యక్షత వహించింది ఎవరు?
డా. రాజేంద్రప్రసాద్

Velocity of the First Ball after Collision?

COLLISIONS

Collision: Collision is an interaction between two or more bodies in which sudden changes of momenta takes place.

- The time duration of collision is very small.
- During collision the two colliding bodies may or may not come into physical contact.
- If the colliding bodies move along a straight line joining their center of mass before and after collision such a collusion is called one dimensional or head on collision.
- If the two colliding bodies, move in a plane before and after collision such a collision is called two-dimensional collision.

Law of Conservation of Linear Momentum: Law of conservation of linear momentum states that when no external force acts on a system, the total momentum of the system remains constant both magnitude and direction.

Types of Collisions:

Elastic Collision: The Collision in which both momentum and kinetic energy are conserved is called an elastic collision.

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ and

$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2$

$= \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$

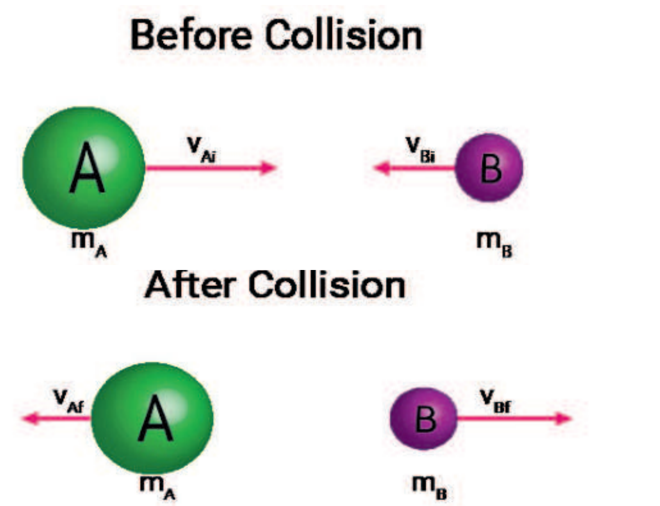
Ex: Collision between ivory balls, atomic particles etc.

ii) **Inelastic Collision:** The collision in which only the momentum is conserved is called as inelastic collision.

i.e., $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

Ex: Collision between two balls of putty, collision between a bullet and a wooden block… etc.

- In one dimensional elastic collision. The relative velo city of approach before colli sion is equal to the relative velocity of separation after collision. i.e., $u_1 - u_2 = v_2 - v_1$ This is known as Newton's formula
- When the body of masses m1 and m2 moving in the same direction along a straight line with velocities u_1, u_2 collide with each other and v_1, v_2 are their velocities after collision (if the collision is elastic) then



Velocity of the first ball after collision

$$v_1 = \left[\frac{m_1-m_2}{m_1-m_2}\right]U_1 + \left(\frac{2m_2}{m_1+m_2}\right)u_2$$

Velocity of the second ball after collision

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

- When a heavy body collides with a light body at rest and the collision is perfectly elastic, the heavy body continues to move with the same velocity where as the light body moves with a velocity equal to double the velocity of the heavy body.
  $M_1 >> m_2 \therefore v_2 = 2u_1$
  $v_1 = u_1$
- When a light body collides with a heavy body at rest and the collision is perfectly elastic, the light body rebounds with the same velocity whereas heavy body remains at rest.
  $M_1 << m_2 \therefore v_1 = u_1 v_2 = 0$

ii) When two bodies of equal masses moving in opposite directions with same speed collide, if the collision is elastic each body rebounds with same speed after collision.

iii) In the case of perfectly elastic collision if the second body is at rest before collision then the velocities of the bodies after collision are

$$V_1 = \left[\frac{m_1-m_2}{m_1+m_2}\right]u_1 : V_2 = \left(\frac{2m_1}{m_1+m_2}\right)u_1 ; \frac{V_1}{V_2} = \left(\frac{m_1-m_2}{2m_1}\right)$$

Note: In the perfectly elastic collision there is no loss of KE of the system but KE of one body is transferred to another body.

- When a body of mass "m1" moving with kinetic energy "E_1" undergoes perfectly elastic collision with another body of mass "m_2" which is at rest.
- The amount of KE transferred from m1 to m_2 is

$$E_2^1 = E_1\frac{4m_1m_2}{(m_1+m_2)^2}$$

ii) The fraction of KE transferred from m_1 to m_2 $\frac{E_2^1}{E_1} = \frac{4m_1m_2}{(m_1+m_2)^2}$

iii) The percentage of KE transferred from m_1 to m_2 is

$$\frac{E_2^1}{E_1} \times 100 = \frac{4m_1m_2}{(m_1+m_2)^2} \times 100$$

- When two bodies of equal masses suffering one dimensional elastic collision. They simply exchange their velocities after collision
  $\therefore v_1 = u_2 ; v_2 = u_1$
- When a body collide with another body of same mass at rest after collision, the first body comes to rest whereas the second body moves with velocity of the first body.
  $\therefore v_1 = 0 ; v_2 = u_1$

Perfectly inelastic collision :

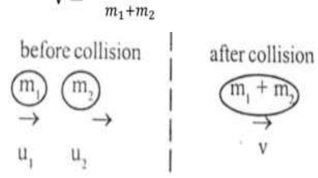
- In this collision two bodies colaces after collision and moves with common velocity.

i) Let two bodies of masses m1, m_2 be moving with the velocity u1 and u_2 in the same direction and undergoes perfectly inelastic collision, there the common velocity after collision

$$(v) = \frac{m_1u_1+m_2u_2}{m_1+m_2}$$

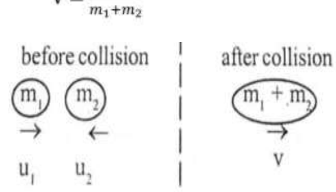
ii) If the bodies moves in opposite direction before collision then

$$V = \frac{m_1u_1-m_2u_2}{m_1+m_2}$$



If the second body is at rest before collision then

$$V = \frac{m_1u_1}{m_1+m_2}$$



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iii) When the bodies of mass m_1 and m_2 be moving along position

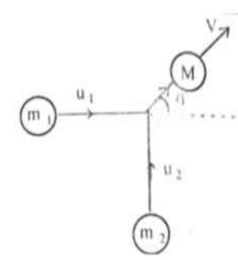
- x-axis and along positive y-axis with the velocity u1 and $u_2$respectly and undergoes perfectly inelastic collision then the common velocity after the collision

$$v = \frac{\sqrt{(m_1u_1)^2+(m_2u_2)}}{M} \text{ where}$$

$M = m_1 + m_2$ and

$$\tan\theta = \frac{P_2}{P_1} = \frac{m_2u_2}{m_1u_1}$$

$$\therefore \theta = \tan^{-1}\left(\frac{m_2u_2}{m_1m_1}\right)$$



Note: In the case of perfectly inelastic collision the system loses some KE in the form of heat energy.

- When a body of mass "m1" moving with the velocity "u1"undergoes perfectly inelastic collision with another object of mass "m_2" which is moving in the same direction with the velocity "u2"then the loss in KE is

$$\Delta k = \frac{1}{2}\frac{m_1m_2}{m_1+m_2}[u_1 - u_2]^2 \text{ (minimum)}$$

- If the second body moves opposite direction then loss in K.E is

$$\Delta k = \frac{1}{2}\frac{m_1m_2}{m_1+m_2}[u_1 + u_2]^2 \text{ (maximum)}$$

- If the second object is at rest before the collision the loss in K.E is

$$\Delta k = \frac{1}{2}\frac{m_1m_2}{m_1+m_2}[u_1]^2$$

- When a body of mass "m_1" moving with the K.E 'E' undergoes perfectly inelastic collision with another body of mass m_2 which is at rest then loss

in K.E is given by $\Delta kE = E\left[\frac{m_2}{m_1+m_2}\right]$

i) Fraction of loss in K.E is given by $\frac{\Delta kE}{kE} = \frac{m_2}{m_1+m_2}$

ii) Percentage of loss in K.E is given by

$$\frac{\Delta kE}{kE} \times 100 = \left[\frac{m_2}{m_1+m_2}\right]100$$

iii) Remaining K.E is given by

$$\Delta kE^1 = E - \Delta k = E\left[\frac{m_1}{m_1+m_2}\right]$$

i) Fraction of loss in K.E is given by $\frac{\Delta kE}{kE} = \frac{m_2}{m_1+m_2}$

ii) Percentage of loss in K.E is given by

$$\frac{\Delta kE}{kE} \times 100 = \left[\frac{m_2}{m_1+m_2}\right]100$$

iii) Remaining K.E is given by

$$\Delta kE^1 = E - \Delta k = E\left[\frac{m_1}{m_1+m_2}\right]$$

iv) Fraction of remaining K.E is given by $\frac{\Delta kE^1}{kE} = \frac{m_1}{m_1+m_2}$

v) Percentage of remaining K.E is given by

$$\frac{\Delta kE^1}{kE} \times 100 = \frac{m}{m_1+m_2}$$

vi) The remaining K.E is shared between "m1" and "m_2" in the direct ratio of their mass.

vii) The K.E of m_1 after collision is given by $kE_1^1 = E\left[\frac{m_1}{m_1+m_2}\right]^2$

viii) The K.E of m2 after collision $kE_2^1 = E\left(\frac{M_1m_2}{(m_1+m_2)^2}\right)$

- **Semielastic collision (or) Inelastic collision :** Let a body of mass m_1 moving with the velocity u1 under goes collision with another body of mass m_2 moving with the velocity u_2 in the same direction. The coefficient of restitution is "e".The velocity of the bodies after the collision is

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

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

If the second body is at rest before collision $v_1 = \left(\frac{m_1-em_2}{m_1+m_2}\right)u_1$

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

$$\therefore \frac{V_1}{V_2} = \left(\frac{m_1-em_2}{m_1+em_1}\right)$$

- If the mass of the two bodies are equal $V_1 = \left(\frac{l-e}{2}\right)u_1 + \left(\frac{l+e}{2}\right)u_2$
  $V_2 = \left(\frac{l+e}{2}\right)u_1 + \left(\frac{l-e}{2}\right)u_2$
- If second body is at rest before collision then
  $V_1 = \left(\frac{l-e}{2}\right)u_1 ; V_2\left(\frac{l+e}{2}\right)u_1$
  $\therefore \frac{V_1}{V_2} = \left(\frac{l-e}{l+e}\right)$

- If second body is at rest before collision then

$$K.E. = \frac{1}{2}\frac{m_1m_2}{m_1+m_2}(1 - e^2)(u_2 - u_1)^2$$

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