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Numericals - conservation of momentum

Q1) A 20 kg bullet can fire 10 bullets/s. mass of each bullet is 0.2 kg. The muzzle speed of the bullet is 150 m/s. what is the recoil velocity of gun? How much force is required to hold the gun.

Ans) By law of conservation of momentum:

$\Rightarrow m_G v_G + m_B v_B = 0 \Rightarrow v_G = -\frac{m_B v_B}{m_G}$

$\Rightarrow -\frac{0.2\text{kg} \times 150\text{m/s}}{20} \Rightarrow -\frac{2\text{kg} \times 150\text{m/s}}{200} \Rightarrow -1.5\text{ m/s}$

The negative sign signifies recoil of gun.

$F = n m_B v_B = 10 \times 0.2 \times 80 \Rightarrow \frac{10 \times 2 \times 80}{10} = 160\text{N}$

Q2) State and prove the law of conservation of linear momentum.

Ans) Consider two bodies A and B of mass m_A and m_B moving with velocities $\vec{v}_A$ and $\vec{v}_B$ respectively. Their initial momentum are P_A and P_B.

* Let the bodies collide, get apart and move with final momentum $\vec{P_A}'$ and $\vec{P_B}'$ respe...

By Newton's 2nd Law —

$$\vec{f}_{AB}\,\Delta t = \vec{P}_A' - \vec{P}_A \quad (i)$$

$$\vec{f}_{BA}\,\Delta t = \vec{P}_B' - \vec{P}_B$$

where Δt is the common interval of time for which the bodies are in contact.

By 3rd Law, $\vec{f}_{AB} = -\vec{f}_{BA}$ or

$$\vec{f}_{AB}\,\Delta t = -\vec{f}_{BA}\,\Delta t.$$

$\Rightarrow$ or $\vec{P}_A' - \vec{P}_A = -(\vec{P}_B' - \vec{P}_B)$

$\rightarrow$ $\vec{P}_A' + \vec{P}_B' = \vec{P}_A + \vec{P}_B$

The above eqn shows that total final momentum of the isolated system equals its total initial momentum.

This is law of conservation of momentum.

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03) A bomb explodes into several parts why these parts fly off in different directions.

Ans → A bomb at rest explodes into two pieces. Let the mass of bomb be M and mass of 2 pieces be m_1 and m_2 respectively. According to conservation of momentum,

$MV = m_1v_1 + m_2v_2$

Here $V = 0$ (bomb at rest) v_1 and v_2 are velocities of 2 parts after explosion

$M(0) = m_1v_1 + m_2v_2$. $\Rightarrow m_1v_1 + m_2v_2 = 0$.

$\Rightarrow m_1v_1 = -m_2v_2$.

Now since mass can't be -ve, that means velocity is -ve and thus it travels in opposite direction.

04) An object of mass 1.5 kg travelling in straight line with a velocity of 5m/s collides with block of mass 5 kg resting on floor. The object sticks with wooden block after collision and both move together in a straight line.

(a) the total momentum after collision

(1) 7.5 kg m/s (2) ~~7.5 kg m/s~~ (3) 7.5 kg m/s

(4) 24 kg m/s

$\Delta P = P_f - P_i$

$0 - 1.5 \times 5 = -7.5 \text{ m/s}$

(b) the velocity of the combination of these objects after collision is

(1) 5 5 m/s (2) 9.5 m/s (3) 1.11 m/s (4) 1.5 m/s

(iii) $V_{comb} = \frac{m[v_i + v_f)}{(m_1 + m_2)} = \frac{1.5 \times 5 + 0}{6.5}$

$= \frac{7.5}{6.5} = 1.15 \text{ m/s}.$