8.8.2021

HOMEWORK

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

Sol:- ~~$t = 0$~~ Initial velocity of gun = 0

Initial velocity of bullet = 0

Mass of gun = $m_1 = 20$ kg

Mass of bullet = $m_2 = 0.2$ kg

Final velocity of bullet (v_2) = 150 m/s

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 20\times 0 + 0.2\times 0 = 20v_1 + 0.2\times 150$$

$$\Rightarrow 30 + 20v_1 = 0$$

$$\Rightarrow 20v_1 = -30 \Rightarrow v_1 = \frac{-30}{20} = \frac{-3}{2} \text{ m/s}$$

∴ Recoil velocity of gun is -1.5 m/s.

In 10 sec bullets — 1 sec $\frac{10}{10}$ bullets

1 bullet — $\frac{1}{10}$ sec

$$F = \frac{\Delta P}{\Delta t} =$$

$$Mv = -mu$$

$$\Rightarrow F = \frac{\Delta P}{\Delta t} \Rightarrow F = [n m u]$$

$$\Rightarrow F = \frac{10 \times 2}{10} \times 150 = 300N$$

∴ 300 N force is required to hold the gun.

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

Sol:- Law of conservation of linear momentum:-

The sum of momenta of two objects before collision is equal to the sum of momenta after the collision provided there is no external unbalanced force

acting on them.

Proof:-

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 momenta are $\vec{p}_A$ and $\vec{p}_B$.

Let the bodies collide, get apart and move with final momenta $\vec{p}'_A$ and $\vec{p}'_B$ respectively.

By Newton's second Law

$$\vec{F}_{AB}\,\Delta t = \vec{p}'_A - \vec{p}_A \quad \text{and}$$

$$\vec{F}_{BA}\,\Delta t = \vec{p}'_B - \vec{p}_B$$

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

By Newton's Third Law,

$$\vec{F}_{AB} = -\vec{f}_{BA}$$

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

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

i.e. $$\vec{P}'_A + \vec{P}'_B = \vec{P}_A + \vec{P}_B$$

Therefore, the total final momentum of the isolated system equals its total initial momentum.

Q3. An object of mass 1.5 kg travelling in a straight line with a velocity of 5 m/s collides with a wooden block of mass 5 kg resting on the floor. This object sticks with wooden block after collision and both move together in a straight line.

The total momentum after collision is:- (1) 3.5 kgm/s (2) 1.5 kgm/s (3) 7.5 kgm/s (4) 2 kgm/s

Sol°

$m_1 = 1.5$ kg

$m_2 = 5$ kg

$u_1 = 5$ m/s

$u_2 = 0$, $v_1 = v_2 \Rightarrow v = ?$

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$\Rightarrow \frac{15}{10} \times 5 + 5 \times 0 = (1.5+5)v$

$\Rightarrow 7.5 = 6.5v$

$\Rightarrow v = \frac{7.5}{6.5} = 1.15$ m/s

Therefore total momentum after collision is 7.5 kgm/s. (3)

The velocity of the combination of these objects after collision is

(1) 8.5 m/s (2) 9.5 m/s (3) 1.15 m/s (4) 1.5 m/s

$v = 1.15$ m/s.

∴ Velocity after collision is 1.15 m/s.