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

Ans→ $V_G = \dfrac{m_B V_B}{m_G} = \dfrac{0.02 \times 150}{20} = -0.15 ms^{-1}$

-ve sign because the gun recoils.

$F = nMV = 10 \times 20 \times 0.15 = 30 N$

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

Ans→ According to the law of conservation of linear momentum, for an object, the total momentum of the system is always conserved if no external force acts on them. The mathematical representation is

$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$

Proof:-

Consider collision between two balls. The momentum of these two balls before collision is given as:

$P1_i = m_1 u_1$

$P2_i = m_2 u_2$

The total momentum of the balls before the collision is given as:

$$P_i = P_{1i} + P_{2i}$$

$$P_i = m_1 u_1 + m_2 u_2$$

F_{12} is the force exerted by the m_1 during the collision on m_2.

F_{21} is the force exerted by the m_2 during the collision on m_1.

Therefore, $F_{12} = F_{21}$

There is a change in the velocity of these balls after the collision which is given as:

$$P_{1f} = m_1 v_1$$

$$P_{2f} = m_2 v_2$$

The total momentum of the balls after collision is:

$$P_f = P_{1f} + P_{2f}$$

$$P_f = m_1 v_1 + m_2 v_2$$

From Newton's second law:

Force = change in momentum / time interval

$$F_{12} = m_2 v_2 - m_2 u_2 / t$$

$$F_{21} = m_1 v_1 - m_1 u_1 / t$$

From Newton's third law:

$$F_{12} = F_{21}$$

So, we get:

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

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

i) The total momentum after collision = 7.5 kg m/s

ii) The velocity of the combination of these objects after collision = 1.15 m/s