WS-5 3rd law

Thank

①

$m_{ball} = 150\ gm = 150 \times 10^{-3}\ kg$: $u = 20\ m/s$: $t = 0.04s = 4 \times 10^{-2}\ sec$

∴ From Newton's 2nd law

$$F = m\frac{du}{dt}$$

$$= 150 \times 10^{-3} \times \frac{20}{4 \times 10^{-2}}$$

$$= 75\ N$$

Acceleration $= \frac{F}{m} = \frac{75}{150} \times 10^3 = 500\ m/s^2$

Total distance travelled $S = ut + \frac{1}{2}at^2$

$$\Rightarrow S = 20 \times 4 \times 10^{-2} + \frac{1}{2} \times 500 \times (4 \times 10^{-2})^2$$

$$= 0.8 + \frac{1}{2} \times 500 \times 16 \times 10^{-4}$$

$$= 0.8 + 0.4 = 1.2\ m$$

Distance upto which force acts on ball

$$S = ut$$

$$= 20 \times 4 \times 10^{-2}$$

$$= 0.8\ m$$

②

$m = 0.05\ kg = 5 \times 10^{-2}\ kg$

$u = 4\ m/s$ $v = -u = -4\ m/s$; $dt = 0.01s = 10^{-2}\ sec$

∴ we know $F = \frac{dp}{dt} = m\frac{dv}{dt}$

$$F = 5 \times 10^{-2}\left[\frac{v-u}{dt}\right]$$

$$= 5 \times 10^{-2} \times \frac{[-4-4]}{10^{-2}}$$

$$= 5 \times (-8) = -40\ N$$

Force is opposing force.

(3)

$m_A = 6\ kg$: $u_A = 2\ m/s$

$m_B = 4\ kg$ $\quad u_B = -1.5\ m/s$

After collision two bodies stucked with

$\therefore$ they move with same velocity after collision

$$V_A = V_B = V_{com.}$$

According to law of conservation of linear momentum

$$m_A u_A + m_B u_B = m_A V_A + m_B V_B$$

$$\Rightarrow 6\times 2 + 4\times(-1.5) = 6 V_{com} + 4 V_{com}$$

$$\Rightarrow 12 - 6 = 10 V_{com} \Rightarrow 10 V_{com} = 6$$

$$\Rightarrow V_{com} = \frac{6}{10} = 0.6\ m/s$$

(4)

$m_1 = 6\ kg$ $\quad u_2 = 0$

After collision $V_2 = \frac{1}{3} u_1 = V_1$ $\quad m_2 = ?$

According to law of conservation of linear momentum

$$m_1 u_1 + m_2 u_2 = m_1 V_1 + m_2 V_2$$

$$\Rightarrow 6\times u_1 + m_2(0) = 6\cdot\left(\frac{1}{3} u_1\right) + m_2\left(\frac{1}{3} u_1\right)$$

$$\Rightarrow 6u_1 = 2u_1 + \frac{m_2}{3} u_1$$

$$\Rightarrow 6 = 2 + \frac{m_2}{3} \Rightarrow \frac{m_2}{3} = 6 - 2 \Rightarrow \frac{m_2}{3} = 4 \Rightarrow m_2 = 12\ kg$$

(5)

mass of shot $m_1 = m$, let its velocity be $u_1 = 140$ m/s

mass of block $m_2 = M = 13m$; $u_2 = 0$

After firing both shot and block travel with same velocity

According to law of conservation of linear momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow m \times 140 + m_2(0) = m\,v_{com} + 13m\,v_{com}$$

$$\Rightarrow m \times 140 = 14m\,v_{com}$$

$$\Rightarrow v_{com} = 10 \text{ m/s}$$

(6)

$m_1 = 2$ kg ; $u_1 = 6$ m/s ; $m_2 = 4$ kg ; $u_2 = 2$ m/s.

$u_2 = 4$ m/s.

According to law of conservation of linear momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 2\times6 + 4\times2 = 2v_1 + 4\times4$$

$$\Rightarrow 12 + 8 = 2v_1 + 16 \Rightarrow 2v_1 = 4 \Rightarrow v_1 = 2 \text{ m/s}$$

(i)

$m_b = 150$ gm

$= 150\times10^{-3}$ kg ; $u = 20$ m/s ; $t = 0.04$ sec $= 4\times10^{-2}$ s

From Newton's 2nd law $F = m\frac{du}{dt} = 150\times10^{-3}\times\frac{20}{4\times10^{-2}}$

$F = -75$ N

From $F = ma \Rightarrow a = \frac{F}{m} = \frac{75}{150\times10^{-3}} = -500 \text{ m/s}^2$

From $v^2 - u^2 = 2as$

$\Rightarrow 0 - (20)^2 = -2(500)s$

$\Rightarrow -400 = -1000\,s \Rightarrow s = \frac{400}{1000} = 0.4$ m

(7)

$m_{bullet} = 50\ gm = 50\times10^{-3}\ kg$; $u_{bullet} = 1000\ m/s$

$F = 180\ N$

$$F = n\, m \frac{dy}{dt}$$

$$\Rightarrow 180 = \frac{n}{dt} \times 50\times10^{-3} \times 1000$$

$$\Rightarrow \frac{n}{dt} = \frac{180}{50}\ \text{Per sec}$$

$$= \frac{180\times60}{5}\ \text{Per min}$$

$$= 216$$

(8)

$m_{air} = 2\ gm = 2\times10^{-3}\ kg$ $\quad v_{air} = 2\ m/s$; $t = 5\ sec$

$$F = m\frac{dy}{dt} = 2\times10^{-3}\times\frac{2}{5} = \frac{4}{5}\times10^{-3}$$

$$= 8\times10^{-4}\ N$$

(15)

$m_1 = 1\ kg$; $m_2 = 3\ kg$ $\quad u_1 = 9\ m/s$, $u_2 = 3\ m/s$

$v_2 = 2\ m/s$

Total momentum of the body before collision

$$= m_1u_1 + m_2u_2 = 1\times9 + 3\times3 = 9+9 = 18\ Ns$$

According to law of conservation of linear momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 18 = 1\times v_1 + 3\times2$$

$$\Rightarrow 18 = v_1 + 6$$

$$\Rightarrow v_1 = 18 - 6 = 12\ m/s$$

L Task

Jee mains level

(1)

$M = 300$ gm $\quad u = 0$

$m_1 = 200$ gm $\quad v_1 = 12\,m/s\,(-\hat{i})$ [$-\hat{i}$ a unit vector towards west]

$m_2 = 100$ gm $\quad v_2 = ?$

According to law of conservation of linear momentum

$$mu = m_1 v_1 + m_2 v_2$$

$$\Rightarrow M(0) = 200(-12\hat{i}) + 100\, v_2$$

$$\Rightarrow 200 \times 12\,\hat{i} = 100\, v_2$$

$$v_2 = 24\,\hat{i} \Rightarrow \text{towards East}$$

$$= 24\ m/s$$

(2)

$M_{shot} = 2$ kg $\quad M_{cannon} = 198$ kg $\quad u_{shot} = 50\ m/s$

According to law of conservation of linear momentum

$$v_{recoil} = -\frac{M_{shot}\, u_{shot}}{M_{can}}$$

$$= -\frac{2 \times 50}{198} = -\frac{100}{198} \simeq -0.5\ m/s$$

(3)

$M_{shell} = M \quad u_1 = v$

m_1 is at rest $u_1 = 0 \quad m_2 = (M - m) \quad v_2$.

According to law of conservation of linear momentum

$$Mv = m_1 u_1 + m_2 u_2$$

$$\Rightarrow Mv = m(0) + (M-m)\, v_2$$

$$\Rightarrow v_2 = \frac{Mv}{M-m}$$

(4)

$m_b = 40\ gm = 40 \times 10^{-3}\ kg$; $u_b = 100\ m/s$

$M_R = 16\ kg$ $\quad$ $V_R = ?$

According to law of conservation of linear momentum

$$V_{recoil} = -\frac{m_b u_b}{M_R}$$

$$= -\frac{40 \times 10^{-3} \times 100}{16}$$

$$= -\frac{1}{4} = -0.25\ m/s$$

(5)

$m_1 = 6\ kg$; $m_2 = 8\ kg$; $u_1 = 4\ m/s$; $u_2 = 2\ m/s$

$V_1 = ?$ $\quad$ $V_2 = 8\ m/s$

According to law of conservation of linear momentum

$$m_1 u_1 + m_2 u_2 = m_1 V_1 + m_2 V_2$$

$$\Rightarrow 6 \times 4 + 8 \times 2 = 6 V_1 + 8 \times 8$$

$$\Rightarrow 24 + 16 = 6 V_1 + 64$$

$$\Rightarrow 6 V_1 = 40 - 64 \Rightarrow 6 V_1 = -24 \Rightarrow V_1 = -4\ m/s$$

(6)

$m_b = 100\ gm$; $V_b = 60\ m/s$; $V_{recoil} = 2\ m/s$. $M_g = ?$

According to law of conservation of linear momentum

$$M_g V_{recoil} = -m_b V_b$$

$$\Rightarrow M_g (-2) = -[100][60]$$

$$\Rightarrow M_g = 3000\ gm = 3\ kg$$

(7)

$m_1 = 3\,kg$; $m_2 = 6\,kg$: $u_1 = 1\,m/s$; $u_2 = 2\,m/s$.

$u_2 = 6\,m/s$: $v_1 = ?$

According to law of conservation of linear momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\Rightarrow 3\times1 + 6\times2 = 3v_1 + 6\times6$$

$$\Rightarrow 3 + 12 = 3v_1 + 36$$

$$3v_1 = -21 \Rightarrow v_1 = -7\,m/s$$

(8)

$M_{man} = 40\,kg$; $u_m = 12\,kmph$

$m_{car} = 0.5$ quintal

$= 50\,kg.$ After jumping into car

both man & car moving with same velocity

According to law of conservation of linear momentum

$$M_m u_m + 0 = M_m v_m + m_{car} v_{car}$$

$$\Rightarrow 40\times12 = 40v_{com} + 50v_{com}$$

$$\Rightarrow 40\times12 = 90\,v_{com}$$

$$\Rightarrow v_{com} = \frac{480}{90} = 5.33\,kmph$$

19.

$m_{bullet} = 50\ gm$: $u_b = 30\ m/s$.

$m_{gun} = ?$ $\quad v_{recoil} = -1\ m/s$.

According to law of conservation of momentum

$$v_{recoil} = -\frac{m_{bullet}\, u_b}{M_g}$$

$$\Rightarrow \quad +1 = +\frac{50 \times 30}{M_g}$$

$$\Rightarrow \quad M_g = 1500\ gm = 1.5\ kg$$

20.

$M_g = 10\ kg$: $m_{bullet} = 10\ gm = 10 \times 10^{-3}\ kg = 10^{-2}\ kg$

$u_{bullet} = 400\ m/s$

For $n = 4$ per sec.

According to law of conservation of linear momentum

$$M_g v_g = \frac{n}{b} m_b u_b$$

$$\Rightarrow 10\, v_g = 4 \times 10^{-2} \times 400$$

$$\Rightarrow v_g = \frac{4 \times 4}{10} = 1.6\ m/s.$$