

Foundation

WS-5 3rd law

Task

①

$$m_{\text{ball}} = 150 \text{ g} : u = 20 \text{ m/s} : t = 0.048 = 4 \times 10^{-2} \text{ s}$$
$$= 150 \times 10^{-3} \text{ kg}$$

$\therefore$ from Newton's 2nd law

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

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

$$= 75 \text{ N}$$

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

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

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

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

$$= 0.8 + 0.4 = 1.2 \text{ m}$$

Distance upto which force acts on ball

$$S = 1.2 \text{ m}$$
$$= 1.2 \times 10^{-2}$$
$$= 0.8 \text{ m}$$

②

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

$$u = 4 \text{ m/s} \quad v = -4 \text{ m/s} \quad dt = 0.018 = 10^{-2} \text{ s}$$

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

$$F = 5 \times 10^{-2} \left[\frac{(-4-4)}{10^{-2}} \right]$$

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

$$= 5 \times (-8) = -40 \text{ N}$$

Force is opposing force.

(3)

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

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

After collision two bodies
separated with

$\therefore$ They move with same velocity after collision

$$v_A = v_B = v_{\text{com}}$$

According to law of conservation of linear momentum

$$m_A u_A + m_B u_B = m_A v_A + m_B v_B$$

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

$$\Rightarrow 12 - 6 = 10 v_{\text{com}} \Rightarrow 10 v_{\text{com}} = 6$$

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

(4)

$$m_1 = 6 \text{ kg} \quad u_2 = 0$$

$$\text{After collision } v_2 = \frac{1}{3} u_1, \quad m_2 = ?$$

According to law of conservation of linear momentum

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

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

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

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

(5)

mass of shot $m_1 = m$, let its velocity be $u_1 = 140 \text{ m/s}$
 mass of block $m_2 = M = 13 \text{ m}$; $u_2 = 0$
 After firing both shot and block travel with same velocity
 According to law of conservation of linear momentum

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

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

$$\Rightarrow m \times 140 = 14 m v_{\text{cm}}$$

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

⑥

$$m_1 = 2 \text{ kg}; u_1 = 6 \text{ m/s}; m_2 = 4 \text{ kg}; u_2 = 2 \text{ m/s}.$$

$$u_2 = 4 \text{ m/s}.$$

According to law of conservation of linear momentum

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

$$\Rightarrow 2 \times 6 + 4 \times 2 = 2 v_1 + 4 \times 4$$

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

⑦

$$m_b = 150 \text{ gm}$$

$$= 150 \times 10^{-3} \text{ kg}; u = 20 \text{ m/s}; t = 0.04 \text{ s}; u_1 = 4 \times 10^{-2} \text{ s}$$

From Newton's 2nd law $F = m \frac{du}{dt} = 150 \times 10^{-3} \times \frac{20}{4 \times 10^{-2}}$

$$F = -75 \text{ N}$$

From $F = ma \Rightarrow a = \frac{F}{m} = \frac{-75}{150 \times 10^{-3}} = -500 \text{ m/s}^2$

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

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

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

(7)

$$m_{\text{bullet}} = 50 \text{ gm} = 50 \times 10^{-3} \text{ kg} \quad u_{\text{bullet}} = 1000 \text{ m/s}$$

$$F = 180 \text{ N}$$

$$F = n \frac{m \Delta u}{\Delta t}$$

$$\Rightarrow 180 = n \times \frac{50 \times 10^{-3} \times 1000}{\Delta t}$$

$$\Rightarrow \frac{n}{\Delta t} = \frac{180}{50} \text{ per sec}$$

$$= \frac{180 \times 60}{50} \text{ per min}$$

$$= 216$$

(8)

$$m_{\text{air}} = 2 \text{ gm} = 2 \times 10^{-3} \text{ kg} \quad u_{\text{air}} = 2 \text{ m/s} \quad t = 5 \text{ sec}$$

$$F = m \frac{du}{dt} = 2 \times 10^{-3} \times \frac{2}{5} = \frac{4}{5} \times 10^{-3}$$

$$= 8 \times 10^{-4} \text{ N}$$

(9)

$$m_1 = 1 \text{ kg} \quad m_2 = 3 \text{ kg} \quad u_1 = 2 \text{ m/s} \quad u_2 = 3 \text{ m/s}$$

$$v_2 = 2 \text{ m/s}$$

Total momentum of the body before collision

$$= m_1 u_1 + m_2 u_2 = 1 \times 2 + 3 \times 3 = 2 + 9 = 11 \text{ kg m/s}$$

According to law of conservation of linear momentum

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

$$\Rightarrow 11 = 1 \times v_1 + 3 \times 2$$

$$\Rightarrow 11 = v_1 + 6$$

$$\Rightarrow v_1 = 11 - 6 = 5 \text{ m/s}$$

Task

See marks level

③

1)

$$M = 300 \text{ gm} \quad u = 0$$

$$m_1 = 200 \text{ gm} \quad u_1 = 12 \text{ m/s} \left(-\hat{i}\right) \quad \left[-\hat{i} \text{ a vector towards west}\right]$$

$$m_2 = 100 \text{ gm} \quad u_2 = ?$$

According to law of conservation of linear momentum,

$$mu = m_1 u_1 + m_2 u_2$$

$$\Rightarrow M(0) = 200(-12\hat{i}) + 100 u_2$$

$$\Rightarrow 200 \times 12\hat{i} = 100 u_2$$

$$u_2 = 24\hat{i} \rightarrow \text{towards East}$$

$$= 24 \text{ m/s}$$

2)

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

According to law of conservation of linear momentum

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

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

3)

$$M_{\text{shell}} = M \quad ; \quad u = v$$

$$m_1 \text{ is at rest } u_1 = 0 \quad m_2 = (M - m) \quad ; \quad u_2 = ?$$

According to law of conservation of linear momentum

$$Mu = m_1 u_1 + m_2 u_2$$

$$\Rightarrow Mu = m(0) + (M - m) u_2$$

$$\Rightarrow u_2 = \frac{Mu}{M - m}$$

5)

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

$$M_R = 16 \text{ kg}$$

$$v_R = ?$$

According to law of conservation of linear momentum

$$\begin{aligned} v_{\text{ recoil }} &= - \frac{m_b u_b}{M_R} \\ &= - \frac{40 \times 10^{-3} \times 100}{16} \\ &= - \frac{1}{4} = -0.25 \text{ m/s} \end{aligned}$$

6)

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

$$v_1 = 2 \text{ m/s} \quad ; \quad v_2 = 8 \text{ m/s}$$

According to law of conservation of linear momentum

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

$$6 \times 4 + 8 \times 2 = 6 v_1 + 8 \times 8$$

$$24 + 16 = 6 v_1 + 64$$

$$6 v_1 = 40 - 64 = -24 \quad ; \quad v_1 = -4 \text{ m/s}$$

7)

$$m_b = 100 \text{ g} \quad ; \quad v_b = 60 \text{ m/s} \quad ; \quad v_{\text{ recoil }} = 2 \text{ m/s} \quad ; \quad M_g = 2$$

According to law of conservation of linear momentum

$$M_g v_{\text{ recoil }} = - m_b v_b$$

$$2 M_g (v) = - (100) (60)$$

$$2 M_g = 6000 \text{ g} = 6 \text{ kg}$$

(7)

$$m_1 = 3 \text{ kg}; m_2 = 6 \text{ kg}; u_1 = 1 \text{ m/s}; u_2 = 2 \text{ m/s}.$$

$$u_2 = 6 \text{ m/s}; v_1 = ?$$

According to law of conservation of linear momentum

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

$$\Rightarrow 3 \times 1 + 6 \times 2 = 3v_1 + 6 \times 6$$

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

$$3v_1 = -21 \Rightarrow v_1 = -7 \text{ m/s}$$

(8)

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

$$M_{\text{can}} = 0.5 \text{ quintal}$$

$$= 50 \text{ kg}.$$

After jumping into can

both man & can moving with same velocity

According to law of conservation of linear momentum

$$M_m u_m + M_{\text{can}} v_{\text{can}}$$

$$\approx 40 \times 12 = 40 v_{\text{com}} + 50 v_{\text{com}}$$

$$\approx 40 \times 12 = 90 v_{\text{com}}$$

$$\approx v_{\text{com}} = \frac{480}{90} = 5.33 \text{ kmph}$$

19.

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

$$m_{\text{gun}} = ?$$

$$v_{\text{recoil}} = -1 \text{ m/s}$$

According to law of conservation of momentum

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

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

$$\Rightarrow M_g = 1500 \text{ gm} = 1.5 \text{ kg}$$

20.

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

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

For $n = 4$ per sec.

According to law of conservation of linear momentum

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

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

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