6th advanced

WS-9 Newton's 3rd law

Tbank

(1)

$M_{shell} = 0.01\,kg$ $M_{gun} = 10\,kg$. $V_{shell} = 50\,m/s$.

According to law of conservation of linear momentum

$$V_{recoil} = -\frac{M_{shell}\,V_{shell}}{M_{gun}}$$

$$= -\frac{0.01}{10} \times 50$$

$$= -0.05\,m/s$$

(2)

$M_{boat} = 500\,kg$. $u = 10\,m/sec$. $M_{man} = 50\,kg$

After man jumped into boat both man and boat move with same velocity.

$$V_{boat} = V_{man} = V_{com}.$$

According to law of conservation of linear momentum

$$M_{boat}\,u_{boat} = M_{boat}V_{boat} + M_{man}\,V_{man}$$

$$\Rightarrow 500 \times 10 = 500\,V_{com} + 50\,V_{com}$$

$$\Rightarrow \overset{100}{\cancel{500}} \times 1\cancel{0} = \overset{11}{\cancel{55}\cancel{0}}\,V_{com} \Rightarrow V_{com} = \frac{100}{11}\,m/s$$

(3)

(3)

$M_{bullet} = 30\ gm = 30 \times 10^{-3}\ kg$: $u_{bullet} = 150\ m/sec$

$M_{gun} = 3 kg$ $\quad V_{recoil} = ?$

According to law of conservation of linear momentum

$$V_{recoil} = -\frac{M_b}{M_g} \times u_b$$

$$= -\frac{30 \times 10^{-3}}{3} \times 150$$

$$= 1.5\ kg\ m/sec$$

(4)

$M_g = 40\ kg$: $u_g = 5\ m/s.$

$M_{cart} = 3\ kg$ $\quad u_c = ?$

As the cart starts moving $V_{girl} = V_{cart} = V_{com}$

According to law of conservation of linear momentum

$$\Rightarrow M_g u_g = M_g V_g + M_{cart} V_{cart}$$

$$\Rightarrow 40 \times 5 = 40 V_{com} + 3 V_{com}$$

$$\Rightarrow 200 = 43 V_{com}$$

$$\Rightarrow V_{com} = \frac{200}{43} = 4.6\ m/sec$$

(5)

$M_R = 4\ kg$; $M_{bullet} = 50 \times 10^{-3}\ kg$; $V_{bullet} = 35\ m/sec$

According to law of conservation of linear momentum

$$\Rightarrow V_{recoil} = -\frac{M_b}{M_R} \times V_b = -\frac{50 \times 10^{-3}}{4} \times 35$$

$$V_{recoil} = -0.4375\ m/s$$

⑥

$M_{bullet} = 10\ gm$ $\qquad u_{bullet} = 200\ m/sec$

$= 10^{-2}\ kg$

$M_{Target} = 2\ kg$ $\qquad u_{target} = 0.$

After firing both bullet and target move with same velocity $V_{target} = V_{bullet} = V_{com}$.

According to law of conservation of linear momentum

$$M_{bullet} u_{bullet} + M_{Target} u_{target} = M_{bullet} V_{bullet} + M_{target} V_{target}$$

$$\Rightarrow 10^{-2} \times 200 + 2 \times 0 = 10^{-2} V_{com} + 2 V_{com}$$

$$\Rightarrow 2 = (2.01) V_{com} \Rightarrow V_{com} = \frac{2}{2.01} = \frac{200}{201}\ m/sec$$

⑦

$M_A = 1500\ kg$ $\quad u_A = 25\ m/s$; $m_B = 1000\ kg$, $u_B = 15\ m/s$

$V_A = 20\ m/s$

According to law of conservation of linear momentum

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

$$\Rightarrow 1500 \times 25 + 1000 \times 15 = 1500 \times 20 + 1000\ V_B$$

$$\Rightarrow 15 \times 25 + 10 \times 15 = 15 \times 20 + 10 V_B$$

$$\Rightarrow 15 \times 25 - 15 \times 20 + 10 \times 15 = 10 V_B$$

$$\Rightarrow 15 \times 5 + 10 \times 15 = 10 V_B$$

$$\Rightarrow 15 + 30 = 2 V_B \Rightarrow V_B = \frac{45}{2} = 22.5\ m/s$$

(8)

$m_{bullet} = 10\ gm = 10^{-2}\ kg$; $u_{bullet} = 300\ m/s$

$M_{gun} = 6\ kg$; $V_{gun} = ?$

According to law of conservation of linear momentum

$$V_{recoil} = -\frac{M_{bullet}}{M_{gun}} \times u_{bullet}$$

$$= -\frac{10^{-2}}{6} \times 300$$

$$= -50 \times 10^{-2} = -0.5\ m/s$$

(9)

$m_{bullet} = 10gm$, $u_{bullet} = 400\ m/s$; $m_{block} = 900gm$

$u_{block} = 0$

After firing bullet is embedded in block.

$$V_{bullet} = V_{block} = V_{com}$$

According to law of conservation of linear momentum

$$m_{bullet} u_{bullet} + M_{block} u_{block} = M_{bullet} V_{bullet} + M_{block} V_{block}$$

$$\Rightarrow 10 \times 400 + 900 \times 0 = 10 V_{com} + 900 V_{com}$$

$$\Rightarrow 10 \times 400 = 910 V_{com}$$

$$\Rightarrow u_{com} = \frac{4000}{910} = \frac{400}{91} = 4.39 \simeq 4\ m/s$$

(10)

$M_1 = 1$ kg : $u_1 = 2$ m/s. $m_2 = 2$ kg : $u_2 = 1$ m/sec

$v_1 = 1$ m/sec ; $V_2 = ?$

According to law of conservation of linear momentum

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 V_2$$

$\Rightarrow$ $1 \times 2 + 2 \times 1 = 1 \times 1 + 2 V_2$

$\Rightarrow$ $2 + 2 = 1 + 2V_2 \Rightarrow 2V_2 = 3$

$\Rightarrow V_2 = \frac{3}{2} = 1.5$ m/s

(11)

The rocket pushes the gases out, it gets propelled according to the newton's third law of action reaction.

Thrust make it move forward. This force is created by the engine, also known as the propulsion system.

A: false R is true.

(12)

when a gun fires bullet, the gun exerts force (action) on the bullet But according to law of conservation of linear momentum (or) Newton's third law for every action there is an equal and opposite reaction

the bullet also exert an equal and opposite force on gun so the gun gives a kick in backward direction.

(16), (17), (18)

$m_1 = 1\,kg$; $u_1 = 10\,m/sec$, $m_2 = 5\,kg$, $u_2 = 0$

After collision both are moving with same velocity

$v_1 = v_2 = v_{com}$

Momentum Before collision $= m_1 u_1 + m_2 u_2$

$= 1 \times 10 + 5 \times 0 = 10\,kgm/sec$

According to law of conservation of linear momentum

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

$\Rightarrow \quad 10 = 1 v_{com} + 5 v_{com}$

$\Rightarrow \quad 10 = 6 v_{com} \quad \Rightarrow v_{com} = \frac{10}{6} = \frac{5}{3} = 1.66\,m/s$

Momentum After collision $= m_1 v_1 + m_2 v_2$

$= (m_1 + m_2)\, v_{com}$

$= (1+5) \times 1.66$

$\Rightarrow 26 \times \frac{5}{3} = 10\,Ns$

(19)

$m_b = 50\,gm$; $u_b = 35\,m/s$ $\quad M_g = 4\,kg$

$= 50 \times 10^{-3}\,kg$

$v_{recoil} = ?$

According to law of conservation of linear momentum

$v_{recoil} = -\frac{M_b u_b}{M_g} = -\frac{50 \times 10^{-3} \times 35}{4}$

$= -437.5 \times 10^{-3}\,m/s$

$= -0.437\,m/s = -0.44\,m/s$

'-ve' sign shows gun gives a kick in backward direction

(20)

$m_1 = m_2 = 5$ kg

$u_1 = 3$ m/s ; $u_2 = -3$ m/s

After collision both bodies move with same velocity

$v_1 = v_2 = v_{com}$

According to law of conservation of linear momentum

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

$$\Rightarrow 5 \times 3 + 5 \times (-3) = 5 v_{com} + 5 v_{com}$$

$$\Rightarrow 15 - 15 = 10 v_{com} \Rightarrow v_{com} = 0 \text{ m/s}$$

LTask

SAQ's

(1)

let original mass $= M$: initial velocity $u = 0$

$m_1 = 1x$; $m_2 = 2x$. $v_2 = 5$ m/s

According to law of conservation of linear momentum

$$m_1 v_1 = -m_2 v_2$$

$$\Rightarrow v_1 = -\frac{m_2 v_2}{m_1} = -\frac{2x}{1x} \times 5 = -10 \text{ m/s}$$

(2)

$m_{bullet} = 40$ gm $= 40 \times 10^{-3}$ kg ; $M_{gun} = 8$ kg

$v_{bullet} = 800$ m/s

According to law of conservation of linear momentum

$$v_{recoil} = -\frac{M_b u_b}{M_g} = \frac{40 \times 10^{-3} \times 800}{8}$$

$$= -4 \text{ m/s}$$

Scanned with OKEN Scanner

(3)

$m_1 = 10$ kg : $m_2 = 20$ kg ; $u_1 = 4$ m/s ; $u_2 = 1$ m/s

After collision both bodies move with common velocity $v_1 = v_2 = v_{com}$.

According to law of conservation of linear momentum

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

$$\Rightarrow 10 \times 4 + 20 \times 1 = 10 v_{com} + 20 v_{com}$$

$$\Rightarrow 40 + 20 = 30 v_{com}$$

$$\Rightarrow v_{com} = \frac{60}{30} = 2 \text{ m/s}$$

(4)

$M_g = 5$ kg ; $m_{bullet} = 25$ gm $= 25 \times 10^{-3}$ kg ; $u_{bullet} = 500$ m/s ; $v_{recoil} = ?$

According to law of conservation of linear momentum

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

$$= -\frac{25 \times 10^{-3} \times 500}{5} = -2.5 \text{ m/s}$$

(5)

$m_{boy} = 35$ kg ; $m_{trolley} = 70$ kg ; $u_{boy} = 2$ m/s ; $u_{trolley} = 0$

After jumping boy and trolley move with same velocity

$$v_{boy} = v_{trolley} = v_{com}$$

According to law of conservation of linear momentum

$$m_{boy} u_{boy} + m_{trolley} u_{trolley} = M_{boy} v_{boy} + M_{trolley} v_{trolley}$$

5^{th} continuation

$\Rightarrow \quad 35 \times 2 + 70 \times 0 = 35 V_{com} + 70 V_{com}$

$\Rightarrow \quad 70 + 0 = 105 V_{com}$

$\Rightarrow \quad V_{com} = \frac{70}{105} = 0.666 \text{ m/s} \simeq 0.7 \text{ m/s}$

(6)

$m_{bullet} = 50 \text{ gm}$ $\quad u_{bullet} = 400 \text{ m/s}$

$= 50 \times 10^{-3} \text{ kg}$ $\quad M_{gun} = 6 \text{ kg}$

According to law of conservation of linear momentum

$$V_{recoil} = -\frac{m_{bullet} u_{bullet}}{M_{gun}}$$

$$= -\frac{50 \times 10^{-3} \times 400}{6}$$

$$= -\frac{20}{6} = -3.3 \text{ m/s}$$

(7)

$m_{boy} = 60 \text{ kg}$; $u_{boy} = 3 \text{ m/s}$: $m_{trolley} = 140 \text{ kg}$

$u_{trolley} = 1.5 \text{ m/s}$

After the boy jumping into trolley, both move with same velocity $V_{boy} = V_{trolley} = V_{com}$

According to law of conservation of linear momentum

$$m_{boy} u_{boy} + m_{trolley} u_{trolley} = m_{boy} V_{boy} + m_{trolley} V_{trolley}$$

$\Rightarrow \quad 60 \times 3 + 140 \times 1.5 = 60 V_{com} + 140 V_{com}$

$\Rightarrow \quad 180 + 210 = 200 V_{com}$

$\Rightarrow \quad V_{com} = \frac{390}{210} = \frac{39}{21} = \frac{13}{7} = 1.9 \text{ m/s}$

(8)

$m_{bullet} = 20$ gm $= 20 \times 10^{-3}$ kg

$u_{bullet} = 300$ m/s

$m_{block} = 880$ gm

$u_{block} = 0$

After bullet was fired both bullet and block move with same velocity

$$V_{bullet} = V_{block} = V_{com}$$

According to law of conservation of linear momentum

$$m_{bullet} u_{bullet} + M_{block} u_{block} = m_{bullet} V_{bullet} + M_{block} V_{block}$$

$$\Rightarrow 20 \times 300 + 880 \times 0 = 20 V_{com} + 880 V_{com}$$

$$\Rightarrow 6000 = 900 V_{com}$$

$$\Rightarrow V_{com} = \frac{60}{9} \text{ m/s} = 6.6 \text{ m/s}$$

(9)

$M_{girl} = 50$ kg ; $M_{boat} = 30$ kg

$u_{girl} = 3$ m/s $V_{boat} = ?$

According to law of conservation of linear momentum

$$P_{girl} = -P_{boat}$$

$$\Rightarrow M_{girl} V_{girl} = -M_{boat} V_{boat}$$

$$\Rightarrow V_{boat} = -\frac{M_{girl} V_{girl}}{M_{boat}}$$

$$= -\frac{50}{30} \times 3$$

$$= -5 \text{ m/s}$$

(10).

$M_{car} = 1000$ kg ; $u_{car} = 10$ m/s

$m_B = 500$ kg $u_B = ?$

Given After collision Both A & B stops

i.e. $V_A = V_B = 0$.

$\therefore m_A V_A + m_B V_B = 0$

According to law of conservation of linear momentum

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

$$\Rightarrow 1000 \times 10 + 500 \times u_B = 0$$

$$\Rightarrow 500\, u_B = -1000 \times 10$$

$$u_B = -20 \text{ m/s}$$

(16), (17), (18)

$m_{ball} = 0.25$ kg ; $u_{ball} = 4.5$ m/s [Right] ; $V_1 = -2$ m/s [left]

$m_2 = 0.3$ kg $u_2 = -5$ m/s [left] ; $V_2 = ?$

Momentum Before collision $= m_1 u_1 + m_2 u_2$

$$\Rightarrow 0.25 \times 4.5 + 0.3 \times (-5)$$

$$= 1.125 - 1.5 = -0.375 \text{ NS}$$

According to Law of conservation of linear momentum

momentum After collision = momentum Before collision

$$= -0.375 \text{ NS.}$$

$\Rightarrow \quad m_1 v_1 + m_2 v_2 = -0.375$

$\Rightarrow 0.25 \times (-2) + 0.3 V_2 = -0.375$

$\Rightarrow -0.5 + 0.3 V_2 = -0.375$

$\Rightarrow 0.3 V_2 = -0.375 + 0.5$

$\Rightarrow 0.3 V_2 = 0.125$

$\Rightarrow V_2 = \frac{0.125}{0.3} = 0.416 \simeq 0.42 m/s$ (Right)

(19)

$m_1 = 100 gm \;\; ; u_1 = 2 m/s \;\; ; v_1 = 1.67 m/s$

$m_2 = 200 gm \;\; ; u_2 = 1 m/s \;\; ; v_2 = ?$

According to law of conservation of linear momentum

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

$\Rightarrow 100 \times 2 + 200 \times 1 = 100 \times 1.67 + 200 V_2$

$\Rightarrow 400 = 167 + 200 V_2$

$\Rightarrow 200 V_2 = 233 \Rightarrow V_2 = \frac{233}{200} = 1.65 m/s$

(20)

$m_t = 3000 kg \quad u_t = 10 m/s$

$m_c = 1000 kg \quad u_c = 0 \; ; \; V_{car} = 12 m/s$

According to law of conservation of linear momentum

$\Rightarrow m_t u_t + m_c u_c = m_t V_t + m_c V_c$

$\Rightarrow 3000 \times 10 + 1000 \times 0 = 3000 V_t + 1000 \times 12$

$\Rightarrow 30 = 3V_t + 12 \Rightarrow 3V_t = 18 \Rightarrow V_t = 6 m/s$