WS-9 Newton's 3rd law 7th advanced

Thank

(1)

$M = 12$ kg at rest It's initial velocity $u = 0$

$m_1 = 4$ kg ; $m_2 = 8$ kg

velocity of 8 kg Piece $V_2 = 6$ m/s

∴ From law of conservation of linear momentum

Momentum Before explosion = momentum After explosion

$\Rightarrow Mu = m_1 V_1 + m_2 V_2$

$\Rightarrow 12(0) = 4(V_1) + 8(6)$

$\Rightarrow 0 = 4V_1 + 48 \Rightarrow 4V_1 = -48 \Rightarrow V_1 = -12$ m/s

since both are moving in opposite direction we get velocity of 4 kg mass as -12 m/s → A

(2)

let $M_1 = 400$ kg → $u_1 = 72$ kmph.

$M_2 = 4000$ kg → $u_2 = 9$ kmph

After crash the velocity of car is $V_1 = -18$ kmph

The velocity of truck $V_2 = ?$

According to law of conservation of linear momentum

· Momentum Before crashing = momentum After crashing

$\Rightarrow m_1 u_1 + M_2 u_2 = M_1 V_1 + M_2 V_2$

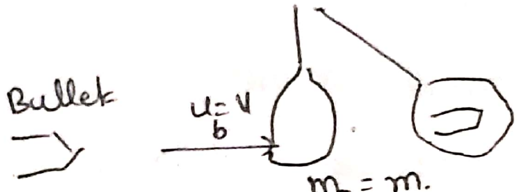
$\Rightarrow 400 \times 72 + 4000 \times 9 = 400(-18) + 4000 V_2$

$\Rightarrow 72 + 10 \times 9 = -18 + 10 V_2$

$\Rightarrow 162 = -18 + 10 V_2 \Rightarrow 10 V_2 = 180 \Rightarrow V_2 = 18$ kmph

→ B

(3)



$u_b = v$, $m_s = m$, $v_b = v_s = v_{com}$

$m_b = \frac{m}{20}$, $u_s = 0$

After firing both bullet and sand are moving with same velocity because bullet is embedded in it.

According to law of conservation of linear momentum

Momentum before firing = momentum After firing.

$$\Rightarrow m_b u_b + m_s u_s = m_b v_b + m_s v_s$$

$$\Rightarrow \frac{m}{20} v + m \times 0 = \frac{m}{20} v_{com} + m v_{com}$$

$$\Rightarrow \frac{mv}{20} = \frac{21}{20} m v_{com}$$

$$\Rightarrow v_{com} = \frac{v}{21} \rightarrow D$$

(4)

$m_{bullet} = 200\ gm = 200 \times 10^{-3}\ kg \rightarrow u_b = 5\ m/s.$

$m_{gun} = 1\ kg.$ $\quad v_{recoil} = ?$

According to law of conservation of linear momentum
The gun recoils after firing the bullet

Momentum of gun = − momentum of bullet

$$\Rightarrow M_g v_{recoil} = -m_b u_b$$

$$\Rightarrow 1\ v_{recoil} = -200 \times 10^{-3} \times 5$$

$$\Rightarrow v_{recoil} = -1\ m/s. \rightarrow C.$$

'−ve' sign shows gun moves back after firing

(5)

$M_{man} = 50$ kg ; $u_{man} = 0$

$m_{stone} = 0.01$ kg ; $u_{stone} = 10$ m/s.

From law of conservation of linear momentum

momentum of man = − momentum of stone

$\Rightarrow M_{man} v_{man} = - m_{stone} v_{stone}$

$\Rightarrow 50\, v_{man} = - 0.01 \times 10$

$\Rightarrow v_{man} = -\frac{1}{50} = -0.02$ m/s → C.

'−ve' sign shows man moves in backward direction after kicking the stone because the stone exerts an equal and opposite force on the leg of man

(6)

Mass of shell $M = 40$ → $u = 80$ m/s.

$m_1 = 32$ kg ; $m_2 = 8$ kg $v_2 = 0$.

According to law of conservation of linear momentum

$Mu = m_1 v_1 + m_2 v_2$

$\Rightarrow 40 \times 80 = 32\, v_1 + 8 \times 0$

$\Rightarrow 3200 = 32\, v_1 \Rightarrow v_1 = 100$ m/s → D

(7)

let mass of railway truck $m_1 = 10^4$ kg and $u_1 = 1$ m/s

" mother railway truck $m_2 = 2m_1$ $u_1 = -0.2$ m/s

After collision both trucks move with same velocity

$v_1 = v_2 = v_{com}$

According to law of conservation of linear momentum

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

7th continuation

$\Rightarrow m_1 \times 1 + (2m_1)(-0.2) = m_1 V_{com} + 2m_1 V_{com}$

$\Rightarrow m_1 - 0.4m_1 = 3m_1 V_{com}$

$\Rightarrow 0.6 m_1 = 3m_1 V_{com}$

$V_{com} = \frac{0.6}{3} = 0.2$ m/s → A

(8)

$M_{Block} = 200$ kg $\quad u_{block} = 10$ m/s

$m_{bullet} = 10$ gm $\quad u_{bullet} = 200$ m/s.

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

let n be the no. of bullets he fired.

According law of conservation of linear momentum

$F_{block} = -F_{Bullet}$ [Newton's 3rd law]

$\Rightarrow$ momentum$_{block}$ = − momentum of Bullet × n

$\Rightarrow m_{Block} \times u_{block} = -M_{bullet} V_{bullet} \times n$

$\Rightarrow 200 \times 10 = -10 \times 10^{-3} \times 200 \times n$

$\Rightarrow 2000 = 2 \times n \Rightarrow n = \frac{2000}{2} = 1000$ → A

−ve' sign shows the block moves back

(9)

$u_1 = 40$ m/s $\quad u_2 = 0 \quad$ After collision $v_1 = v_2 = V_{com} = 30$ m/s

According to law of conservation of linear momentum

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

$\Rightarrow m_1 \times 40 + m_2 (0) = m_1 30 + m_2 30$

$\Rightarrow 40m_1 = 30m_1 + 30m_2$

$\Rightarrow 10m_1 = 30m_2 \quad \Rightarrow \frac{m_1}{m_2} = \frac{3}{1}$ → C.

$\Rightarrow m_1 = 3m_2$

10.

$M_{sphere} = 25\,kg \rightarrow u = 40\,m/s$. $m_2 = 15\,kg$; $u_2 = 0$.

After collision both are moving same velocity

$V_1 = V_2 = V_{com}$.

According to law of conservation of linear momentum

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

$$\Rightarrow 25 \times 40 + 15 \times 0 = 25\,V_{com} + 15\,V_{com}$$

$$\Rightarrow 25 \times 40 = 40\,V_{com}$$

$$\Rightarrow V_{com} = 25\,m/s \rightarrow A.$$

(11)

We know

Linear momentum $\vec{p} = m \times \vec{v}$

So the linear momentum is the measure of the quantity of motion contained by the body.

And impulse of a force is the change in momentum occuring due to the force.

So impulse acts in the same direction as that of momentum.

acceleration $a = \frac{\vec{F}}{m} = \frac{1}{m}\frac{d\vec{p}}{dt}$ so $\vec{a}$ and impulse are in same direction

uniform circular motion corresponds to zero angular acceleration leading to constant angular momentum. linear moment is not conserved when external force is present

(3)

Force is a rate of change of momentum

$F = \frac{dp}{dt} \Rightarrow F \cdot dt = dp$

$\Rightarrow J = F \cdot dt = dp$

change in momentum and impulse are equal.

(4)

According to Newton's 3rd law for every action there is an equal and opposite reaction.

both action and reaction do not act on same body

when $F_{ext} = 0 \Rightarrow$ acceleration $= 0$

$\Rightarrow$ velocity = constant

Since momentum = mass × velocity

as velocity constant, momentum also constant

∴ momentum is conserved.

(6)

Given $m_1 = 1$ kg ; $m_2 = 3$ kg ; $u_1 = 9$ m/s ; $u_2 = 3$ m/s.

$V_2 = 2$ m/s.

momentum before collision: $m_1u_1 + m_2u_2$

$= 1\times9 + 3\times3 = 9+9 = 18$ kg m/s

According to law of conservation of linear momentum

momentum Before collision = momentum after collision

$\Rightarrow 18 = m_1V_1 + m_2V_2$

$\Rightarrow 18 = 1\times V_1 + 3\times2$

$\Rightarrow 18 = V_1 + 6 \Rightarrow V_1 = 18-6 \Rightarrow V_1 = 12$ m/s

(7)

$m_1 = 20 gm$ → $u_1 = 20 cm/s$

m_2 $u_2 = 5 cm/s$ After collision

$v_1 = v_2 = 10 cm/s$

According to law of conservation of linear momentum

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

$\Rightarrow 20 \times 20 + m_2 \times 5 = 20 \times 10 + m_2 \times 10$

$\Rightarrow 400 + 5m_2 = 200 + 10m_2$

$\Rightarrow 5 m_2 = 200 \Rightarrow m_2 = \frac{200}{5} = 40 gm$

(8)

Given $m_1 = 2 kg$ → $u_1 = \hat{i} + 2\hat{j} - 3\hat{k}$ m/s

$m_2 = 3 kg$ → $u_2 = 2\hat{i} + \hat{j} + \hat{k}$ m/s

After collision both are moving with same velocity $V_1 = V_2 = V_{com}$

According to law of conservation of linear momentum

$P_{Before} = P_{After}$

$\Rightarrow 2(\hat{i} + 2\hat{j} - 3\hat{k}) + 3(2\hat{i} + \hat{j} + \hat{k}) = 2V_{com} + 3V_{com}$

$\Rightarrow 2\hat{i} + 4\hat{j} - 6\hat{k} + 6\hat{i} + 3\hat{j} + 3\hat{k} = 5V_{com}$

$\Rightarrow 8\hat{i} + 7\hat{j} - 3\hat{k} = 5V_{com}$

$\Rightarrow V_{com} = \frac{1}{5}[8\hat{i} + 7\hat{j} - 3\hat{k}]$

LTask

CW :

(1)

According to III^{rd} law to every action there is an equal and opposite reaction.

The cannon Provides the force to fire the bullet out and hence the cannon gets the opposite reaction.

(2)

when a man applies force on the water surface, then according to Newton's 3^{rd} law a reaction force will act on the him (or ice) to move him to the shore.

(4)

The initial momentum of the car is same as lorry Final momentum is zero for both vehicles. so change in momentum is same for lorry and the car.

From 2^{nd} law $F = \frac{dp}{dt}$

The distance travelled totally depends on momentum. Body which will have more momentum or inertia will have more tendency to be in it's motion. Here both have same momentum, hence both will cover same distance.

(6)

Since momentum $p = m \times v$

$\therefore$ $p \propto m$ (or) $p \propto v$

To reduce momentum half velocity (or) mass should be reduced to half.

(10)

According to 3rd law for every action there is an equal and opposite reaction.

The boat and fan are systems. so the forces they exert on each other are internal forces. Both the internal forces act on the boat. so the net force on the boat is zero. So it will continue to remain in a state of rest

Jee main level

(1)

let $m_1 = 6$ kg   mass of second body is m_2.

$u_1 = u$ $u_2 = 0$ After collision $v_1 = v_2 = \frac{u_1}{2}$

According to law of conservation of linear momentum

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

$$\Rightarrow 6u + m_2(0) = 6\frac{u}{2} + m\frac{u}{2}$$

$$\Rightarrow 6u = 3u + m\frac{u}{2}$$

$$\Rightarrow 3u = m\frac{u}{2} \Rightarrow m = 3 \times 2 = 6 \text{ kg} \rightarrow B$$

(2)

$M_{gun} = 10kg$; $m_{bullet} = 10gm = 10\times10^{-3}kg$; $u_{bullet} = 200 m/s$

According to law of conservation of linear momentum

$$P_{gun} = -P_{bullet}$$

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

$$\Rightarrow 10 \times V_{recoil} = - 10\times10^{-3} \times 200$$

$$\Rightarrow V_{recoil} = -\frac{2}{10} = -\frac{1}{5} = -0.2 \; m/s \rightarrow B$$

-ve' sign shows gun gives kick in backward direction after firing.

(3)

Given $m_A = 60$ kg ; $m_B = 40$ kg .. $v_B = 4.5 m/s$.

- when A pushes B, A exerts some force on B at the same time B also exerts an equal and opposite force on A so A' moves in a direction opposite to 'B'

∴ According to law of conservation of linear momentum

Momentum of A = - momentum of B

$$\Rightarrow m_A V_A = - m_B V_B$$

$$\Rightarrow 60 V_A = -40 \times 4.5$$

$$\Rightarrow V_A = -\frac{4}{6} \times 4.5 = -\frac{2}{3} \times 4.5$$

$$\Rightarrow V_A = -2 \times 1.5 = -3 \; m/s$$ so A' moves north.

$\rightarrow A$

(4)

$m_1 = 5\,kg$; $m_2 = 6\,kg$

$u_1 = 10\,m/s$ $u_2 = 6 \times 2\,m/s$ (right)

$= -10\,m/s$ (left)

After collision both bodies move with same velocity

$v_1 = v_2 = v_{com}$

According to law of conservation of linear momentum

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

$$\Rightarrow 5(-10) + 6(12) = 5 v_{com} + 6 v_{com}$$

$$\Rightarrow -50 + 72 = 11 v_{com}$$

$$\Rightarrow 22 = 11 v_{com} \Rightarrow v_{com} = \frac{22}{11} = 2\,m/s \rightarrow D$$

(5)

Number of bullets each $n = 5$

$m_{bullet} = 200\,gm = 200 \times 10^{-3}\,kg$

$u_{bullet} = 10\,m/s$; $M_{block} = 3\,kg$

$u_{block} = 0$

Here after firing bullets are embedded in block.

∴ both bullet and block moves with same velocity

$v_{bullet} = v_{block} = v_{com}$.

According to law of conservation of linear momentum

$$n\,m_{bullet} u_{bullet} + m_{block} u_{block} = n\,m_{bullet} v_{bullet} + M_{block} v_{block}$$

$$= 5 \times 200 \times 10^{-3} \times 10 + 3 \times 0 = 5 \times 200 \times 10^{-3} v_{com} + 3 v_{com}$$

$$\Rightarrow 10 = 4 v_{com} \Rightarrow v_{com} = \frac{10}{4} = 2.5\,m/s \rightarrow C.$$

(6)

Given $M_{craft} = M$; $u = u$.

After explosion $m_1 = m$, $v_1 = 0$. Remaining mass $m_2 = M - m$, $v_2 = ?$

According to law of conservation of linear momentum

$$P_{Before} = P_{After}$$

$$\Rightarrow Mv = m_1 v_1 + m_2 v_2$$

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

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

(7)

Given

$m_1 = m$; $m_2 = 2m$; $m_3 = 3m$; $m_4 = 4m$; $m_5 = 5m$

$u_1 = v$; $u_2 = 2v$; $u_3 = 3v$; $u_4 = 4v$; $u_5 = 5v$

After collision all bodies stick together. so

$$v_1 = v_2 = v_3 = v_4 = v_5 = v_{com}$$

According to law of conservation of linear momentum

$$m_1 u_1 + m_2 u_2 + m_3 u_3 + m_4 u_4 + m_5 u_5 = m_1 v_1 + m_2 v_2 + m_3 v_3 + m_4 v_4 + m_5 v_5$$

$$\Rightarrow mv + 2m(2v) + 3m(3v) + (4m)(4v) + 5m(5v) = m v_{com} + 2m v_{com} + 3m v_{com} + 4m v_{com} + 5m v_{com}$$

$$\Rightarrow mv + 4mv + 9mv + 16mv + 25mv = 15m v_{com}$$

$$\Rightarrow \overset{11}{\cancel{55}}\, \cancel{m}\, v = \overset{3}{\cancel{15m}}\, v_{com}$$

$$\Rightarrow v_{com} = \frac{11v}{3} \text{ m/s} \rightarrow B.$$

(8)

$M_{man} = 64kg$ $u_{man} = 5.4\ kmph$: $M_{cart} = 32\ kg$

$u_{cart} = 1.8\ kmph.$

After jumping both man + cart move with same velocity

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

According to law of conservation of linear momentum

P_{Before} = momentum after jumping

$\Rightarrow M_{man} u_{man} + M_{cart} u_{cart} = m_{cart} V_{cart} + M_{man} V_{man}$

$\Rightarrow 64 \times 5.4 + 32 \times 1.8 = 64 \times V_{com} + 32 V_{com}$

$\Rightarrow 32 \times 1.8 [2 \times 3 - 1] = 96 V_{com}$ (0.6; 3)

$\Rightarrow 0.6 \times (6-1) = V_{com} = V_{com} = 0.6 \times 5 = 3$ kmph → A

(9)

Given

$M_{ball} = 2kg$: $M_{cannon} = 198\ kg$

$u_{ball} = 50m/s$

According to law of conservation of linear momentum

$\Rightarrow m_{cannon} u_{cannon} = -M_{ball} u_{ball}$

$\Rightarrow 198\ u_{cannon} = -2 \times 50$

$\Rightarrow u_{cannon} = -\frac{100}{198} \simeq -0.5\ m/s$ → C

'-ve' sign shows the ball given to cannon moves in backward direction after firing the ball

Scanned with OKEN Scanner

According to law

(16), (17), (18)

Given $m_1 = 0.25$ kg $\quad u_1 = 4.5$ m/s $\quad ; \quad v_1 = -2$ m/s

$m_2 = 0.3$ kg $\quad ; \quad u_2 = -5$ m/s (left)

According to law of conservation of linear momentum

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

$\Rightarrow 0.25 \times 4.5 + 0.3 \times (-5) = 0.25(-2) + (0.3) V_2$

$\Rightarrow \quad 1.125 - 1.5 = -0.5 + 0.3 V_2$

$\Rightarrow \quad 0.125 = 0.3 V_2 \Rightarrow V_2 = 0.42$ m/s

momentum Before collision $= m_1 u_1 + m_2 u_2$

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

$= 1.125 - 1.5$

$= -0.375$ kg m/s

momentum after collision $= -0.375$ kg m/s [From law of conservation of linear momentum]

(19)

Given $m_1 = 100\,gm$. $m_2 = 200\,gm$.

$u_1 = 2\,m/s$; $u_2 = 1\,m/s$.

$V_1 = 1.67\,m/s$; $V_2 = ?$

According to law of conservation of linear momentum

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

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

$$\Rightarrow 2 + 2 = 1.67 + 2V_2$$

$$\Rightarrow 4 - 1.67 = 2V_2 \Rightarrow V_2 = \frac{2.33}{2} = 1.165\,m/s$$

(20)

$m_t = 3000\,kg$ $u_t = 10\,m/s$; $u_c = 0$ [Before collision]

$m_c = 1000\,kg$ V_{car} = 12 m/s (After collision)

According to law of conservation of linear momentum

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

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

$$\Rightarrow 30 = 3V_t + 12 \Rightarrow 3V_t = 30 - 12$$

$$\Rightarrow 3V_t = 18$$

$$\Rightarrow V_t = 6\,m/s$$