①

Given

$m_{ball} = 150gm$; velocity $u = 20$ m/s

Time of catching $t = 0.04s = 4\times10^{-2}s$

From Newton's 2nd law $F = ma$ or $m\frac{du}{dt}$

$\Rightarrow F = 150\times10^{-3} \times \frac{\cancel{20}\,5}{\cancel{4}\times10^{-2}}$

$= 75N$

From $F = ma$ $\Rightarrow a = \frac{F}{m} = \frac{150\times10^{-3}}{71}$

$= \frac{75}{150\times10^{-3}} = \frac{1000}{2} = 500\, m/s^2$

∴ From $S = ut + \frac{1}{2}at^2$

$\Rightarrow S = 20\times4\times10^{-2} - \frac{1}{2}500\times \cancel{16}\,8\times10^{-4}$

$= 80\times10^{-2} + 40\times10^{-2} \Rightarrow 120\times10^{-2}$

$S = 0.4m$ ball is in retardation → C

②

Given $m = 0.05$ kg ; initial velocity $u = 4$ m/s

$= 5\times10^{-2}$ kg ; Final velocity $v = -4$ m/s

Contact time $dt = 0.01s \Rightarrow 10^{-2}$ sec.

∴ From Newton's 2nd law $F = m\frac{du}{dt}$

$\Rightarrow F = 5\times10^{-2}\frac{[-4-4]}{10^{-2}} = 5\times(-8)$

$= -40N$ → D

Here force is resistive force

(3)

let $m_1 = 6kg$; $m_2 = 4kg$

$u_1 = 2 m/s$ $u_2 = -1.5 m/s$

After collision two bodies get struck, they move with common velocity $V_{com} = V_1 = V_2$

According to law of conservation of linear momentum

Momentum Before collision = momentum After collision

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

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

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

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

(4)

let $m_1 = 6 kg$ mass of 2nd body = m_2

$u_1 = u$ $u_2 = 0$

After collision $V_1 = V_2 = \frac{1}{3} u_1 = \frac{1}{3} u$

According to law of conservation of linear momentum

$P_{Before} = P_{After}$

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

$\Rightarrow 6u + m_2(0) = 6(\frac{1}{3}u) + m_2(\frac{u}{3})$

$\Rightarrow 6\cancel{u} = \frac{\cancel{u}}{3}[6 + m_2]$

$\Rightarrow 18 = 6 + m_2$

$\Rightarrow m_2 = 18 - 6 = 12 kg$ → C.

(5)

let $m \rightarrow$ mass of shot

$M \rightarrow$ mass of wooden block. $= 13\,m$

$u_1 \rightarrow$ velocity of shot $= 140$ m/s ; $u_2 = 0$

After collision both block and shot moves with same velocity $v_1 = v_2 = v_{com}$.

According to law of conservation of linear momentum

$$m u_1 + M u_2 = m v_1 + M v_2$$

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

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

$$\Rightarrow v_{com} = \frac{140}{14} = 10 \text{ m/s} \rightarrow B$$

(6)

let $m_1 = 2$ kg, $m_2 = 4$ kg are masses of two bodies

$u_1 = 6$ m/s ; $u_2 = 2$ m/s velocities before collision.

After collision velocity of 2nd body $v_2 = 4$ m/s

$\therefore$ According to law of conservation of linear momentum

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

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

$$\Rightarrow 12 + 8 = 2 v_1 + 16$$

$$\Rightarrow 2 v_1 = 20 - 16$$

$$\Rightarrow 2 v_1 = 4$$

$$\Rightarrow v_1 = 2 \text{ m/s} \rightarrow B$$

(7)

No mass $m = 50$ gm $= 50 \times 10^{-3}$ kg.

speed $u = 1000$ m/s

Force $F = 180$ N.

let 'N' be the Number of bullets fired per sec.

$\therefore$ From Newton's 2nd law $F = N\, m \frac{du}{dt}$

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

$\Rightarrow \frac{N}{t} = \frac{180}{50}$ per sec

But they are asking Per min $= \frac{180}{50} \times 60$

$= 216 \rightarrow c$

(8)

mass of air $m_{air} = \cdot 2$ gm $= 2 \times 10^{-3}$ kg

$v_{air} = 2$ m/s

$t = 5$ sec

From Newton's 2nd law $F = m \frac{dv}{dt}$

$\Rightarrow F = 2 \times 10^{-3} \times \frac{2}{5} = \frac{4}{5} \times 10^{-3}$

$= 0.8 \times 10^{-3}$

$F = 8 \times 10^{-4}$ N $\rightarrow$ A

(15), (16)

Given $m_1 = 1$ kg ; $m_2 = 3$ kg

Their initial velocities $u_1 = 9$ m/s ; $u_2 = 3$ m/s

Final velocity of 2nd body $v_2 = 9$ m/s

Before collision Total momentum $= m_1 u_1 + m_2 u_2$

$= 1 \times 9 + 3 \times 3 =$

$= 18$ kg m/s

According to law of conservation of linear momentum

Momentum Before collision = momentum After collision

$\Rightarrow 18 = m_1 v_1 + m_2 v_2$

$\Rightarrow 18 = 1 v_1 + 3 \times 2$

$\Rightarrow v_1 = 12 \, m/s$

L Task

(1)

According to Newton's 2nd law

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

$\Rightarrow dp = F \times dt$

For same force and time, the change in momentum of the two bodies is same.

(2)

Action and reaction forces acts on different bodies. when an object exerts a force on a second object. the second object also exerts an equal and opposite force back on the first object.

(4)

Newton's 3rd law says For every action there is an equal and opposite reaction

∴ when the gun fires bullet, gun recoil due to the force which fires the bullet in the forwarding direction while the other force reacts in backward direction.

when the man applies force on the water surface, then according to Newton's third law, a reaction force will act on him to the shore.

(7)

we know momentum $p = mv \Rightarrow v = \frac{p}{m}$

As momentum is constant, so less mass will give more velocity.

Thus the car has more velocity than lorry.

Acceleration $a = \frac{F}{m}$.

As force is constant, so less mass body has more acceleration

Thus the car has more acceleration than that of the lorry.

Hence car will travel more distance comes to rest than that of lorry

(9)

we know momentum $p = m \times v$.

∴ By reducing either mass to half, velocity to half (or) mass be doubled $(2m)$, velocity quadrabled $(\frac{v}{4})$, momentum becomes half of its original value

If $m = \frac{m}{2}$ $p' = \frac{m}{2}v = \frac{1}{2}p$

$v = \frac{v}{2} \Rightarrow p' = m\frac{v}{2} = \frac{1}{2}p$

If $m' = 2m$, $v = \frac{1}{4}v \Rightarrow p' = 2m\frac{v}{4_2} = \frac{mv}{2} = \frac{p}{2}$.

Scanned with OKEN Scanner

Jee mains level

①

Given $m = 300\ gm = 300 \times 10^{-3}\ kg \rightarrow$ It is at rest $u = 0$

$m_1 =$ mass of I^{st} Part $= 200\ gm \rightarrow$ It's velocity $V_1 = 12(-\hat{i})$

$m_2 \rightarrow$ mass of 2^{nd} Part $= 300\ gm$

According to law of conservation of linear momentum

$P_{Before\ explosion} = P_{After\ explosion}$

$\Rightarrow M(u) = m_1 V_1 + m_2 V_2$

$\Rightarrow 300(0) = 200 \times (12)(-\hat{i}) + 100\ V_2$

$\Rightarrow V_2 = \dfrac{200 \times 12(+\hat{i})}{100} = 24\hat{i} \rightarrow$ towards east

$\hat{i}, -\hat{i}$ are one unit vectors along East and west direction

②

Given

$m_{shot} = 2\ kg$; $m_{cannon} = 198\ kg$

$V_{shot} = 50\ m/s$

According to law of conservation of linear momentum

Recoil velocity of cannon $V_{recoil} = -\dfrac{m_{shot} V_{shot}}{M_{cannon}}$

$\Rightarrow V_{recoil} = -\dfrac{2 \times 50}{198} = -\dfrac{100}{198} \simeq 0.5\ m/s$

③

let Given mass of shell $= M$; It's velocity $= V$

After explosion I^{st} part mass $m_1 = m \rightarrow$ It is at rest $V_1 = 0$

2^{nd} part mass $m_2 = M - m \rightarrow$ It's velocity

let it be V_2

3rd continuation

According to law of conservation of linear momentum

$P_{Before\ explosion} = P_{After\ explosion}$

$$MU = m_1 V_1 + m_2 V_2$$

$$\Rightarrow MV = m(0) + (M-m) V_2$$

$$\Rightarrow MV = (M-m) V_2$$

$$\Rightarrow V_2 = \frac{MV}{M-m}$$

(4)

Given $m_{bullet} = 40\ gm = 40\times10^{-3}\ kg$

$M_{Riffle} = 16\ kg$; $V_{bullet} = 100\ m/s$

$$\therefore V_{recoil} = -\frac{m_{bullet} \times V_{bullet}}{M_{Riffle}}$$

$$= \frac{40\times10^{-3}\times100}{16}$$

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

(5)

let $m_1 = 6\ kg$, $m_2 = 8\ kg$ are masses

$u_1 = 4\ m/s$; $u_2 = 2\ m/s$ are their velocities before collision

$V_2 = 8\ m/s$ is the velocity of 2nd body after collision

According to law of conservation of linear momentum

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

$$\Rightarrow 6\times4 + 8\times2 = 6V_1 + 8\times8$$

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

$$\Rightarrow 40 = 6V_1 + 64$$

$$\Rightarrow 6V_1 = -24$$

$$\Rightarrow V_1 = -4\ m/s$$

(6)

Given $m_{bullet} = 100\ gm = 0.1\ kg.$

$V_{bullet} = 600\ m/s$ No. of bullets - $N = 10$

$M_{gun} = 12\ kg.$

we know Recoil velocity $V = -N \frac{m_{bullet} \times V_{bullet}}{M_{gun}}$

$V_{recoil} = - \frac{10 \times 0.01 \times \cancel{600}^{50}}{\cancel{12}}$

$V_{recoil} = -50\ m/s$

(7)

$m_{bullet} = 100\ gm$, $V_{bullet} = 60\ m/s$

$= 0.1\ kg.$

$M_{gun} = ?$ $V_{gun} = -2\ m/s$ [Recoil velocity]

We know Recoil velocity

$$V = - \frac{m_{bullet} \times V_{bullet}}{M_{gun}}$$

$\Rightarrow \cancel{-}2 = \cancel{-} \frac{0.1 \times 60}{M_{gun}}$

$\Rightarrow M_{gun} = \frac{6}{2} = 3\ kg$

(8) (6)

Given $m_A = 2\ kg$; $m_B = 3\ kg$

Their initial velocities $u_A = 5\ m/s$; $u_B = -4\ m/s$

After collision their final velocities

$v_A = -2\ m/s$ (left) $v_B = ?$

According to law of conservation of linear momentum

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

$$\Rightarrow 2 \times 5 + 3(-4) = 2(-2) + 3 v_B$$

$$\Rightarrow 10 - 12 = -4 + 3 v_B$$

$$\Rightarrow 2 = 3 v_B$$

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