ws-11 • Newton's 3rd law

Task

(7)

Given Retarding force $F = -150\ N$

Mass $m = 50\ kg$

Initial speed $u = 30\ m/s$: Final speed $v = 0$

From $F = ma$

$\Rightarrow -150 = 50 \times a \quad \Rightarrow a = \frac{-150}{50} = -3\ m/s^2$

From $v = u + at$

$\Rightarrow 0 = 30 + (-3) \times t$

$\Rightarrow -30 = -3t \Rightarrow t = 10\ sec.$

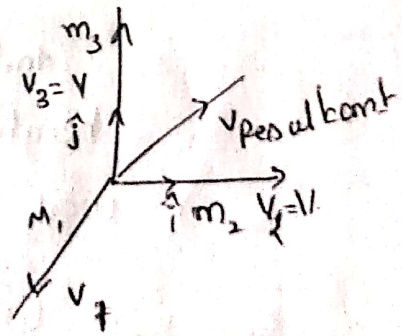
(8)

According to law of conservation of linear momentum

momentum of 3rd piece is in a direction opposite to the resultant momentum of 2 pieces.

let original mass $= M$: speed $u = 0$

$m_1 = \frac{2M}{3}$: $m_2 = \frac{M}{3}$: $m_3 = \frac{M}{3}$



$\therefore$ Acc to LCLM

$Mu = m_1v_1 + m_2v_2 + m_3v_3$

$\Rightarrow 0 = \frac{2M}{3}v_1 + \frac{M}{3}v\hat{i} + \frac{M}{3}v\hat{j}$

$\Rightarrow \frac{2Mv_1}{3} = -\left[\frac{M}{3}v\hat{i} + \frac{M}{3}v\hat{j}\right]$

$\Rightarrow \frac{2M}{3}v_1 = -\frac{Mv}{3}[\hat{i} + \hat{j}]$

$\Rightarrow 2v_1 = -v\sqrt{1^2 + 1^2}$

$\Rightarrow 2v_1 = -v\sqrt{2}$

$\Rightarrow v_1 = -v\frac{\sqrt{2}}{2}$

$\Rightarrow \boxed{v_1 = -\frac{v}{\sqrt{2}}}$

(9)

No. of bullets per sec $\frac{N}{t} = 40$

$m_{bullet} = 35 \times 10^{-3}$ kg

$u_{bullet} = 400$ m/s

$M_{Riffle} = 20$ kg.

According to Law of conservation of linear momentum

$$v_{recoil} = -\frac{m_{bullet} u_{bullet} \times N}{M_{Riffle}}$$

$$= -\frac{35 \times 10^{-3} \times 400 \times 40}{20}$$

$$= -35 \times 800 \times 10^{-3}$$

$$= 28000 \times 10^{-3} = 28 \text{ m/s}$$

Force acting on riffle $= m\frac{dv}{dt}$

For 'N' bullets $F = N m \frac{dv}{dt}$

$$= 4 \times 35 \times 10^{-3} \times 400$$

$$F = -56 \text{ N}$$

(10)

Given

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

initial velocity $u = 1000$ m/s ; Final velocity $v = 500$ m/s

height of riffle $h = 50$ m.

work done against air resistance $W = mgh + \frac{1}{2}m(u^2 - v^2)$

$$W = 10^{-2} \times 10 \times 50 + \frac{1}{2} \times 10^{-2}\left((1000)^2 - (500)^2\right)$$

$$= 5 + \frac{1}{2} \times 10^{-2} \times (1500)(500)$$

$$= 5 + \frac{7500}{2} = 5 + 3750 = 3755 \text{ J}$$

Advanced

(9)

Given $m_{bullet} = 50\ gm = 50 \times 10^{-3}\ kg$

$u_{bullet} = 30\ m/s$

$V_{gun} = 1\ m/s$: $M_{gun} = ?$

According to law of conservation of linear momentum

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

$$\Rightarrow +1 = +\frac{50 \times 10^{-3} \times 30}{M_g}$$

$$\therefore M_{gun} = 0.15\ kg.$$

(10)

Given $m_{gun} = 10\ kg$: $m_{bullet} = 10\ gm = 10 \times 10^{-3}\ kg$

$= 10^{-2}\ kg.$

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

No. of bullets fired $N = 4$.

According to law of conservation of linear momentum

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

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

$$= -1.6\ m/s$$

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