WS-4 7th foundation (Newton's laws of motion)

Thask

①, ②

Given initial velocity $u = 30\ m/s$; $m = 800\ kg$

Final velocity $v = 0$; distance $s = 150m$

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

$\Rightarrow 0^2 - (30)^2 = 2(a)(150)$

$\Rightarrow -900 = 300a \Rightarrow \boxed{a = -3\ m/s^2}$

Resistance (or) frictional force $f = ma$

$\Rightarrow f = 800(3) = 2400\ N$

Retardation = -ve acceleration = $3\ m/s^2$

③

Given $F = 100\ N$. : mass $m = 500\ kg$.

From $F = ma$

$\Rightarrow 100 = 500a \Rightarrow a = \frac{100}{500} = 0.2\ m/s^2$

④

Given $m = 150\ gm$: $u = 20\ m/s$: $v = 12\ m/s$: $t = \frac{1}{25}$ sec.

$= 150 \times 10^{-3}\ kg$

<Force> $= ma = m\left[\frac{v-u}{t}\right] = 150 \times 10^{-3}\left[\frac{12-20}{\frac{1}{25}}\right]$

$= 150 \times 10^{-3}[-8 \times 25] = -30\ N.$

Resistive force

(5)

Given force $= 15N$; $m = 20\,kg$; $t = 8\,sec.$

From $F = ma = m\frac{V}{t}$

$\Rightarrow \cancel{F}\ \cancel{15}^{3} = \cancel{20}^{4}\ \frac{V}{\cancel{8}\ 2}$

$\Rightarrow V = 6\ m/s.$

(6)

Given force $= 100\ dyne = 10^{-3}\ N$

$m = 5\,gm = 5\times10^{-3}\ kg$; $t = 10\ sec$

From $F = ma = \frac{mV}{t}$

$\Rightarrow 10^{-3} = 5\times10^{-3}\times\frac{V}{10}$ $\Rightarrow V = \frac{10}{5} = 2\ m/s$

(7)

$M_{air} = 8\ gm = 8\times10^{-3}\ kg$

$v_{air} = 7\ cm/s$: time $= 5{\cdot}6\ sec$

Average force acting on the balloon

$F = M_{air}\frac{v_{air}}{t}$

$= \frac{8\times7}{5{\cdot}6}$

$= 10\ dynes$

$= 10\times10^{-5}N = 10^{-4}N$

(8)

Given $m_{bullet} = 0.03$ kg $= 3\times10^{-2}$ kg

No. of bullets per second $= \frac{N}{t} = 200$

Velocity $v = 30$ m/s

$$\langle Force \rangle = N \frac{mv}{t} = 200 \times 3\times10^{-2} \times 30$$

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

(9)

$m_{bullet} = 40$ gm $= 40\times10^{-3}$ kg : $V = 1200$ m/s

$F = 144$ N.

Force $= N \frac{mv}{t}$ For 'N' bullets

$$\Rightarrow \overset{12}{\cancel{144}} = \frac{N}{t} \times 4\cancel{0}\times10^{\cancel{-3}} \times 12\cancel{00}$$

$$\Rightarrow 12 = \frac{N}{t} \times 4 \Rightarrow \frac{N}{t} = \frac{12}{4} = 3 \text{ bullets.}$$

(10)

For $m_1 = 0.5$ kg $\rightarrow a_1 = 16$ m/s²

$m_2 = ?$ $\rightarrow a_2 = 4$ m/s²

clearly in all cases Force is same. [F = ma]

Then $\frac{F}{a} =$ Total mass $= m_1 + m_2$

$$\Rightarrow \frac{F}{a} = \frac{F}{a_1} + \frac{F}{a_2}$$

$$\Rightarrow \frac{\cancel{F}}{a} = \cancel{F}\left(\frac{1}{a_1} + \frac{1}{a_2}\right)$$

$$\Rightarrow \frac{1}{a} = \frac{1}{16} + \frac{1}{4} = \frac{1+4}{16} = \frac{5}{16}$$

$$\Rightarrow a = \frac{16}{5} = 3.2 \text{ m/s}^2$$

(11)

Given $m = 2\ kg$; $u = 0$; $t = 4\ sec$; $a = 1.5\ m/s^2$

Gain in momentum $= m(v-u)$

From $v = u+at$ $\therefore$ Gain in momentum

$= m(\cancel{u}+at-\cancel{u})$

$= mat$

$= 2 \times 1.5 \times 4$

$= 12\ NS$

(12)

We know

Momentum $p = mv$.

when velocity remains constant

$p \propto m$

As mass is doubled, momentum also doubled

Ex:- If $m_1 = m \rightarrow P_1 = P$ $\therefore \frac{P_2}{P_1} = \frac{m_2}{m_1}$

$m_2 = 2m \rightarrow P_2 = ?$

$\Rightarrow \frac{P_2}{P} = \frac{2m}{m} = 2$

$\rightarrow P_2 = 2P$

(13)

Given $m = 9.1 \times 10^{-31}\ kg$; $V = 2 \times 10^{7}\ m/s$

$\therefore$ Momentum $= mv$

$= 9.1 \times 10^{-31} \times 2 \times 10^{7}$

$= 18.2 \times 10^{-24}\ kg\ m/s$

$= 1.82 \times 10^{-23} \rightarrow 1.91 \times 10^{-23}\ kg\ m/s$

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(14)

Given $F = 30N$: $a = 2\ m/s^2$

From $F = ma$

$\Rightarrow 30 = m \times 2$

$\Rightarrow m = 15\ kg$

(15)

Given $m = 5 kg$; $a = 4 m/s^2$

Force $F = ma = 5 \times 4 = 20 N$.

(16)

Given $m = 3000 kg$; $F = 4000 N$.

From $F = ma$

$\Rightarrow 4000 = 3000\ a$

$\Rightarrow a = \frac{4}{3} = 1.33\ m/s^2$

Advanced

(23) and (24)

Given $m = 4\ kg$; Initial velocity $u = 7\ m/s$

$t = 0.2\ sec$ Final velocity $v = 8\ m/s$

Initial momentum $P_{Initial} = mu = 4 \times 7 = 28\ kg\ m/s$

Final momentum $P_{Final} = mv = 4 \times 8 = 32\ kg m/s$.

(25)

Given $m = 0.5\ kg$: $u = 4\ m/s$

Momentum $= mv = 0.5 \times 4 = 2\ kg\ m/s$

(26)

Given $F = 50N$: $m = 10\ kg$

$\therefore$ From $F = ma$

$\Rightarrow 50 = 10 \times a$

$\Rightarrow a = 5\ m/s^2$

L Task Jee Mains level

(1)

Given $m = 2000\ kg$ Force $= 5000\ N$

Initial velocity $u = 10\ m/s$ $t = 8\ sec.$

we know From Newton's 2nd law

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

$\Rightarrow dp =$ change in momentum $= F \cdot dt$

$= 5000 \times 8$

$= 40{,}000\ kg\ m/s = 4 \times 10^4\ kg\ m/s$

(2)

Given Force $F = 150N$: $m = 30kg$

From $F = ma$

$\Rightarrow 150 = 3a \Rightarrow a = \frac{150}{30} = 5\ m/s^2$

(3)

Given $F = 8000\ N$; $m = 200\ kg$; $t = 10\ sec$

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

$dp = F \cdot dt$

$= 8000 \times 10 = 8 \times 10^4\ kg\ m/s$

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(4)

Given $F = 10N$; $m = 2\,kg$

From $F = ma$

$\Rightarrow 10 = 2 \times a$

$\Rightarrow a = 5\,m/s^2$

(5)

Given $F = 20N$; $m = 4\,kg$.

let us find acceleration $a = \frac{F}{m} = \frac{20}{4} = 5\,m/s^2$

As acceleration is doubled, (ie) $a' = 2a = 2(5)$

$= 10\,m/s^2$

$\therefore$ Force required $F' = ma'$

$= 4(10) = 40\,N.$

(6)

Given $m = 5kg$; speed $v = 10\,m/s$; $t = 5sec$

$u = 0.$

Force $= \frac{\text{change in momentum}}{\text{time}} = \frac{m(v-u)}{t}$

$\Rightarrow F = \frac{5(10-0)}{\cancel{5}} = 100N.$

(7)

Given $m_1 = 2\,kg$; $m_2 = 3\,kg$.

when same force is applied (ie) $F = \text{constant}$

From $F = ma \Rightarrow m \propto \frac{1}{a}$

$\Rightarrow \frac{a_1}{a_2} = \frac{m_2}{m_1} = \frac{3}{2}$

$\Rightarrow a_1 : a_2 = 3 : 2$

(8)

Given $m = 200\,gm$; $s = 400\,cm$: $t = 2\,sec.$

$= 0.2\,kg$ $= 4\,m$

Initial velocity $u = 0$

$\therefore$ Force $= \dfrac{m(v-u)}{t} = 0.2 \times a \rightarrow (1)$

From $s = ut + \frac{1}{2}at^2$

$\Rightarrow 4 = 0 \times 2 + \frac{1}{2}(a)(2)^2 \Rightarrow 4 = 2a \Rightarrow a = 2\,m/s^2$

From (1)

$\therefore$ $F = 0.2 \times 2 = 0.4\,N$

(9)

$M_{metal} = 2\,kg$ speed of water $= 5\,m/s$

m_{water} per sec $= \dfrac{m_w}{t} = 1\,kg/s$

$\therefore$ From $F = \dfrac{dp}{dt}$

$\Rightarrow M_{metal}\,a = m\dfrac{v}{t}$

$\Rightarrow 2 \times a = 1 \times 5 \Rightarrow a = \frac{5}{2} = 2.5\,m/s^2$

(10)

Given Mass of rain water adding per sec $= \dfrac{m}{t} = 5\,kg/s$

constant velocity $v = 10\,m/s$

Force $= ma = m\dfrac{v}{t}$

$= 5 \times 10$

$= 50N.$

(11)

Given $m = 300\,kg$; $v = 15\,m/s$

Momentum $= mv = 300 \times 15$

$= 4500\,N$.

(12)

Here the velocity of the body is maintained constantly so acceleration $a = 0$

$\therefore$ No force is required

(13)

Given $m = 4 \times 10^{-2}\,kg$; $v = 20\,m/s$; time $= 0.05$ sec.

$t = 5 \times 10^{-2}$ sec

Resistance = Force $= ma$

$= m\frac{v}{t} = 4 \times \cancel{10^{-2}} \times \frac{\cancel{20}^{4}}{\cancel{5} \times \cancel{10^{-2}}}$

$= 16\,N$

Advanced level

(23)

Given $m = 100\,g$; $u = 0$; $v = 40\,m/s$

$= 0.1\,kg$

(i) change in momentum $= m(v-u) =$

$= 0.1(40-0)$

$= 4\,kg\,m/s$

(ii) For $t = 1\,ms = 10^{-3}\,s$

$$Force = \frac{\text{change in momentum}}{\text{time}} = \frac{4}{10^{-3}} = 4 \times 10^{3}$$

$= 4\,kN$

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24

Given momentum = 150 kg m/s

velocity = 30 m/s

$\therefore$ mass = $\frac{\text{momentum}}{\text{velocity}} = \frac{150}{30} = 5$ kg

25

Given $m = 8$ kg ; $a = 6$ m/s^2

From $f = ma$

$= 8 \times 6$

$= 48$ N.