

①

$$m_f = 20 \text{ kg/sec}$$

$$u_g = 10^3 \text{ m/s}$$

$$\begin{aligned} F_{up} &= m_f \frac{du_g}{dt} \\ &= 20 \times 10^3 \\ &= 2 \times 10^4 \text{ N} \end{aligned}$$

②

$$\text{when } m = \frac{1}{100} m_f = \frac{1}{100} 20$$

$$u = u \ln \frac{m_0}{m}$$

$$u = 10^3 \ln \frac{m_0}{\frac{1}{100} m_0}$$

$$\begin{aligned} u &= 10^3 \ln 100 \\ &= 10^3 \times (4.6) = 4.6 \times 10^3 \text{ m/s} \end{aligned}$$

②

$$m_0 = 6 \times 10^3 \text{ kg}$$

$$\frac{m_{gas}}{t} = 200 \text{ kg/s}$$

$$u_{gas} = 800 \text{ m/s}$$

$$t = 5 \text{ sec}$$

$$F = \frac{m_{fuel} \frac{du_{gas}}{dt}}{200}$$

$$\Rightarrow F = 200 \times 800$$

$$F = 16 \times 10^4 \text{ N}$$

After 5 sec.

$$m_{max} = m_0 - M_{gas} \times t \Rightarrow 32 \text{ m/s}^2$$

$$= 6000 - 200 \times 5$$

$$= 6000 - 1000$$

$$= 5000 \text{ kg}$$

$$\therefore a = \frac{F}{m}$$

$$= \frac{16 \times 10^4}{5000}$$

③

$$M_{Rocket} = 20 \text{ kg}; m_{fuel} = 180 \text{ kg}$$

$$u_{gas} = 1.6 \text{ km/sec}$$

$$\begin{aligned} F_{upthrust} &= m_{fuel} \frac{du_{gas}}{dt} \\ &= 180 \times 1.6 \\ &= 18 \times 16 \text{ N} \end{aligned}$$

$$u = u \ln \frac{m_0}{m}$$

$$u = 1.6 \ln \frac{1809}{20}$$

$$= 1.6 \ln 9$$

$$= 1.6 \ln 3^2$$

$$\Rightarrow 1.6 \times 2 \ln 3$$

$$\Rightarrow 3.2 \ln 3$$

$$\approx 3.7 \text{ km/sec}$$

(4)

$$N_U = 900 \text{ N} = m(g+a)$$

$$N_L = 300 \text{ N} = m(g-a)$$

$$\Rightarrow \frac{N_U}{N_L} = \frac{900}{300}$$

$$\Rightarrow \frac{m(g+a)}{m(g-a)} = 3$$

$$\Rightarrow g+a = 3(g-a)$$

$$\Rightarrow g+a = 3g-3a$$

$$\Rightarrow 4a = 2g$$

$$\Rightarrow a = \frac{2g}{4} = \frac{2 \times 10}{4} = 5 \text{ m/s}^2$$

From

$$N_U = m(g+a)$$

$$\Rightarrow 900 = m(10+5)$$

$$\Rightarrow 9000 = m \times 15$$

$$\Rightarrow m = 60 \text{ kg}$$

(5)

when lift is moving up

with an acceleration $a = 2.45 \text{ m/s}^2$

$$N_U = m(g+a)$$

$$= 60(10+2.45)$$

$$\% \text{ change in wt} = \frac{N_U - mg}{mg} \times 100$$

$$= \frac{m(g+a) - mg}{mg} \times 100$$

$$= \frac{mg + ma - mg}{mg} \times 100$$

$$= \frac{ma}{mg} \times 100 = \frac{a}{g} \times 100$$

$$= \frac{2.45}{9.8} \times 100 = 25$$

$$= 25\%$$

(6)

when lift is moving down

with an acceleration $a = \frac{g}{4}$

$$T = m(g-a); T = 9000 \text{ N}$$

$$\Rightarrow 9000 = m(g - \frac{g}{4}) = \frac{3mg}{4}$$

$$\Rightarrow mg = 4 \times 3000$$

when lift is moving up with

an acceleration $a = \frac{g}{3}$

$$T = m(g+a) = m(g + \frac{g}{3})$$

$$= \frac{4mg}{3} = \frac{4}{3} \times 4 \times 3000$$

$$= 16000 \text{ N}$$

(7)

$$\text{From } T = m(g-a)$$

$$\text{Given } T = \frac{3}{4} mg$$

$$\therefore \frac{3}{4} mg = m(g-a)$$

$$\frac{3g}{4} = g-a$$

$$\Rightarrow a = g - \frac{3g}{4}$$

$$\Rightarrow a = \frac{g}{4}$$



(2)

(8)

Breaking strength

$$N = m(g - a)$$

Given $N = 80g$; $m = 100$

$$80g = 100(g - a)$$

$$\Rightarrow 80 \times 10 = 100(g - a)$$

$$\Rightarrow 4g = 5g - 5a$$

$$\Rightarrow 5a = 5g - 4g$$

$$= 1g$$

$$5a = 5g - 4g$$

$$\Rightarrow a = \frac{g}{5} = \frac{9.8}{5} = 1.96 \text{ m/s}^2$$

(9)

$$\text{If } a_1 = \frac{g}{3}$$

$$W = m(g + a_1)$$

$$W = m(g + \frac{g}{3}) = \frac{4}{3}mg \rightarrow (1)$$

$$\text{If } a_2 = \frac{g}{2}$$

$$W' = m(g - a_2)$$

$$= m(g - \frac{g}{2})$$

$$W = \frac{mg}{2} = \frac{1}{2}mg$$

From (1) $mg = \frac{3W}{4}$

$$\therefore W = \frac{1}{2} \cdot \frac{3W}{4} = \frac{3W}{8}$$

(14)

$$\frac{m_{\text{fuel}}}{t} = 50 \text{ kg/s}$$

$$u_{\text{gas}} = 2 \text{ km/s} = 2 \times 10^3 \text{ m/s}$$

$$F_{\text{up}} = m \frac{du}{dt}$$

$$= 50 \times 2 \times 10^3$$

$$= 100 \times 10^3 \text{ N}$$

$$v = u \ln \frac{m_0}{m} ; m = \frac{1}{10} m_0$$

$$= 2 \ln \frac{m_0}{\frac{1}{10} m_0}$$

$$= 2 \ln 10$$

$$= 4.06 \text{ km/s}$$

$$= 4.06 \times 10^3 \text{ m/s}$$

(15) Given (15)

Given $m = 10^3 \text{ kg}$; $a = 1 \text{ m/s}^2$

$$T = m(g + a)$$

$$= 10^3(10 + 1)$$

$$= 11 \times 10^3 \text{ N}$$

(16)

$m = 70 \text{ kg}$; $a = 3 \text{ m/s}^2$

$$N = m(g + a)$$

$$= 70(10 + 3)$$

$$= 70 \times 13 = 910 \text{ N}$$



(18), (19), (20)

Given $m = 75 \text{ kg}$; $a = 2 \text{ m/s}^2$

For downward motion

$$N = m(g+a) \quad (\text{upward motion})$$

$$= 75(10+2)$$

$$= 900 \text{ N}$$

$$N = m(g-a)$$

$$= 75(10-2)$$

$$= 75 \times 8$$

$$= 600 \text{ N}$$

For uniform motion $a = 0$

$$N = mg$$

$$= 75 \times 10$$

$$= 750 \text{ N}$$

Task SAQ's

(1)

$$M_R = 500 \text{ kg}$$

$$u_{\text{gas}} = 250 \text{ m/s}$$

$$a = 20 \text{ m/s}^2$$

$$F_{\text{up}} = m \frac{u_g}{t}$$

$$\Rightarrow M_R a = \frac{m g}{t} u_g$$

$$\Rightarrow 500 \times 20 = \frac{m g}{t} \times 250$$

$$\Rightarrow \frac{m}{t} = 60 \text{ kg/s}$$

(2)

$$M_R = 8000 \text{ kg}$$

$$u_g = 800 \text{ m/s}$$

$$F_{\text{up}} = \frac{m g}{t} \times u_g$$

$$\Rightarrow M_R g = \frac{m g}{t} \times u_g$$

$$\Rightarrow 8000 \times 10 = \frac{m}{t} \times 800$$

$$\Rightarrow \frac{m}{t} = 10 \times 10 = 100 \text{ kg/s}$$

(3)

$$\text{Force on floor} = w_m + w_B$$

$$= 75 \times 10 + 40$$

$$= 750 + 40$$

$$= 790 \text{ N}$$

(4)

$$\text{Given } a = 4 \text{ m/s}^2; m = 10 \text{ kg}$$

$$N = m(g+a)$$

$$= 10(10+4)$$

$$= 140 \text{ N}$$



(5)

Given weight $mg = 300 \text{ N}$

$$\Rightarrow m = \frac{300}{9.8} = 30 \text{ kg}$$

For upward motion

$$N = m(g + a)$$

$$\Rightarrow 400 = 30g + ma$$

$$\Rightarrow 400 = 300 + 30a$$

$$\Rightarrow 100 = 30a$$

$$\Rightarrow a = 3.3 \text{ m/s}^2$$

(6)

$$a = 2.45 \text{ m/s}^2; N = 50 \text{ N}$$

For upward motion

$$N = m(g + a)$$

$$\Rightarrow 50 = m(9.8 + 2.45)$$

$$\Rightarrow 50 = m \times 12.25$$

$$\Rightarrow m = \frac{50}{12.25} \text{ kg}$$

$$\text{True weight} = mg$$

$$= \frac{50}{12.25} \times 9.8 = 40 \text{ N}$$

(7)

Given $m = 80 \text{ kg}$

$$u = 8 \text{ m/s}; v = 0$$

$$s = 20 \text{ m}$$

$$\text{From } v^2 - u^2 = 2as$$

$$\Rightarrow 0^2 - 8^2 = 2 \times a \times 20$$

$$\Rightarrow -64 = 40a$$

$$\Rightarrow a = -\frac{64}{40}$$

$$\Rightarrow a = -1.6 \text{ m/s}^2$$

$$\text{Apparent weight} = m(g + a)$$

$$= 80(10 - 1.6)$$

$$= 80 \times 8.4$$

$$= 672 \text{ N}$$

(8)

Given $m = 2.5 \text{ kg}; a = 19.6 \text{ m/s}^2$

For downward motion

$$N = m(g - a)$$

$$\Rightarrow N = 2.5(9.8 - 19.6)$$

$$= 2.5 \times 9.8$$

$$= 24.5 \text{ N}$$

(9)

Given $m = 70 \text{ kg}; a = 4 \text{ m/s}^2$

For upward motion

$$T = m(g + a)$$

$$= 70(10 + 4)$$

$$= 980 \text{ N}$$

(10)

Given $m = 80 \text{ kg}$

$u = 8 \text{ m/s}; v = 0; s = 16 \text{ m}$

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

$\Rightarrow 0^2 - 8^2 = 2a \times 16$

$\Rightarrow -64 = 32a$

$\Rightarrow a = \frac{-64}{32} = -2 \text{ m/s}^2$

For upward motion

$N = m(g+a)$

$= 80(9.8 - 2)$

$= 80 \times 7.8 = 624 \text{ N}$

(15)

$m = 1500 \text{ kg}$

$a = \frac{v}{b} = \frac{-3.6}{12-10} = -\frac{3.6}{2}$

$a = -1.8 \text{ m/s}^2$

For upward motion

$N = m(g+a)$

$= 1500(9.8 - 1.8)$

$= 1500 \times 8$

$= 12000 \text{ N}$

(16)

Area of graph

$s = \frac{1}{2} \times 8 \times 3.6 + \frac{1}{2} \times 12 \times 3.6$

$= \frac{1}{2} (8+12) 3.6$

$= 36 \text{ m}$

(17)

Given $M_p = 100 \text{ kg}; M_{cr} = 25 \text{ kg}$

(18)

$N = F = 450 \text{ N}$

Free body diagram for points

$N \uparrow \quad T \uparrow \quad F = N + T - m_p g$
 $m_p a = N + T - m_p g \rightarrow (1)$

For whole system

$2T - (m_p + m_{cr})g = (m_p + m_{cr})a \rightarrow (2)$



By multiplying eqn (1) with 2

$2[N + T - m_p g] = 2m_p a$

$\Rightarrow 2N + 2T - 2m_p g = 2m_p a \rightarrow (3)$

By doing (2) - (3) we get

$\Rightarrow 2N + 2T - 2m_p g - 2T + (m_p + m_{cr})g = 2m_p a - (m_p + m_{cr})a$

$\Rightarrow 2N - 2m_p g + (m_p + m_{cr})g = (2m_p - m_p - m_{cr})a$

$= 2 \times 450 - 2 \times 100 \times 10 + (100 + 25) \times 10 = (100 - 25)a$

$= 900 - 750 = 75a$

$a = \frac{150}{75} = 2 \text{ m/s}^2$

⑪, ⑫ continuation

From ①

$$M_p a = N + T - M_p g$$

$$\Rightarrow 6M_p(a+g) = N + T$$

$$\Rightarrow 100(2+10) = 450 + T$$

$$\Rightarrow 1200 = 450 + T$$

$$\Rightarrow T = 750 \text{ N.}$$