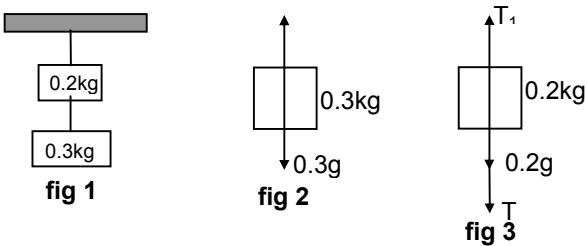


## SOLUTIONS TO CONCEPTS CHAPTER – 5

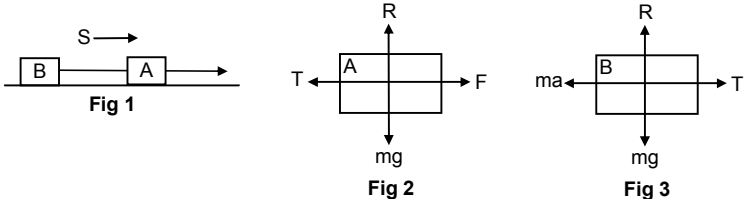
1.  $m = 2\text{kg}$   
 $S = 10\text{m}$   
 Let, acceleration =  $a$ , Initial velocity  $u = 0$ .  
 $S = ut + \frac{1}{2}at^2$   
 $\Rightarrow 10 = \frac{1}{2}a(2^2) \Rightarrow 10 = 2a \Rightarrow a = 5\text{ m/s}^2$   
 Force:  $F = ma = 2 \times 5 = 10\text{N}$  (Ans)

2.  $u = 40\text{ km/hr} = \frac{40000}{3600} = 11.11\text{ m/s}$ .  
 $m = 2000\text{ kg}$  ;  $v = 0$  ;  $s = 4\text{m}$   
 acceleration ' $a$ ' =  $\frac{v^2 - u^2}{2s} = \frac{0^2 - (11.11)^2}{2 \times 4} = -\frac{123.43}{8} = -15.42\text{ m/s}^2$  (deceleration)  
 So, braking force =  $F = ma = 2000 \times 15.42 = 30840 = 3.08 \times 10^4\text{ N}$  (Ans)

3. Initial velocity  $u = 0$  (negligible)  
 $v = 5 \times 10^6\text{ m/s}$ .  
 $s = 1\text{cm} = 1 \times 10^{-2}\text{m}$ .  
 acceleration  $a = \frac{v^2 - u^2}{2s} = \frac{(5 \times 10^6)^2 - 0}{2 \times 1 \times 10^{-2}} = \frac{25 \times 10^{12}}{2 \times 10^{-2}} = 12.5 \times 10^{14}\text{ ms}^{-2}$   
 $F = ma = 9.1 \times 10^{-31} \times 12.5 \times 10^{14} = 113.75 \times 10^{-17} = 1.1 \times 10^{-15}\text{ N}$ .

4. 

$g = 10\text{m/s}^2$        $T - 0.3g = 0 \Rightarrow T = 0.3g = 0.3 \times 10 = 3\text{ N}$   
 $T_1 - (0.2g + T) = 0 \Rightarrow T_1 = 0.2g + T = 0.2 \times 10 + 3 = 5\text{N}$   
 $\therefore$  Tension in the two strings are 5N & 3N respectively.

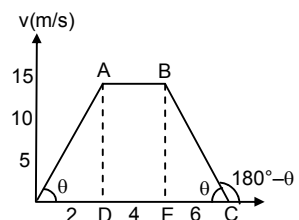
5. 

$T + ma - F = 0$        $T - ma = 0 \Rightarrow T = ma \dots\dots\dots(i)$   
 $\Rightarrow F = T + ma \Rightarrow F = T + T$       from (i)  
 $\Rightarrow 2T = F \Rightarrow T = F / 2$

6.  $m = 50\text{g} = 5 \times 10^{-2}\text{ kg}$   
 As shown in the figure,

Slope of OA =  $\tan\theta = \frac{AD}{OD} = \frac{15}{3} = 5\text{ m/s}^2$

So, at  $t = 2\text{sec}$  acceleration is  $5\text{m/s}^2$   
 Force =  $ma = 5 \times 10^{-2} \times 5 = 0.25\text{N}$  along the motion



At  $t = 4$  sec slope of AB = 0, acceleration = 0 [  $\tan 0^\circ = 0$  ]

$\therefore$  Force = 0

At  $t = 6$  sec, acceleration = slope of BC.

$$\text{In } \triangle BEC = \tan \theta = \frac{BE}{EC} = \frac{15}{3} = 5.$$

Slope of BC =  $\tan (180^\circ - \theta) = -\tan \theta = -5 \text{ m/s}^2$  (deceleration)

Force =  $ma = 5 \times 10^{-2} \times 5 = 0.25 \text{ N}$ . Opposite to the motion.

7. Let,  $F \rightarrow$  contact force between  $m_A$  &  $m_B$ .

And,  $f \rightarrow$  force exerted by experimenter.

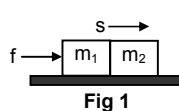


Fig 1

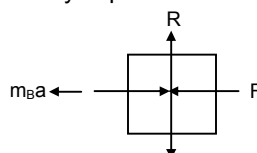


Fig 2

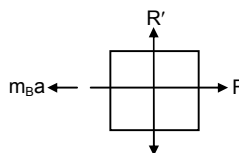


Fig 3

$$F + m_A a - f = 0$$

$$\Rightarrow F = f - m_A a \dots\dots\dots(i)$$

From eqn (i) and eqn (ii)

$$\Rightarrow f - m_A a = m_B a \Rightarrow f = m_B a + m_A a \Rightarrow f = a (m_A + m_B).$$

$$\Rightarrow f = \frac{F}{m_B} (m_B + m_A) = F \left( 1 + \frac{m_A}{m_B} \right) \text{ [because } a = F/m_B]$$

$$\therefore \text{The force exerted by the experimenter is } F \left( 1 + \frac{m_A}{m_B} \right)$$

8.  $r = 1 \text{ mm} = 10^{-3}$

$$'m' = 4 \text{ mg} = 4 \times 10^{-6} \text{ kg}$$

$$s = 10^{-3} \text{ m.}$$

$$v = 0$$

$$u = 30 \text{ m/s.}$$

$$\text{So, } a = \frac{v^2 - u^2}{2s} = \frac{-30 \times 30}{2 \times 10^{-3}} = -4.5 \times 10^5 \text{ m/s}^2 \text{ (decelerating)}$$

Taking magnitude only deceleration is  $4.5 \times 10^5 \text{ m/s}^2$

$$\text{So, force } F = 4 \times 10^{-6} \times 4.5 \times 10^5 = 1.8 \text{ N}$$

9.  $x = 20 \text{ cm} = 0.2 \text{ m}$ ,  $k = 15 \text{ N/m}$ ,  $m = 0.3 \text{ kg}$ .

$$\text{Acceleration } a = \frac{F}{m} = \frac{-kx}{m} = \frac{-15(0.2)}{0.3} = -\frac{3}{0.3} = -10 \text{ m/s}^2 \text{ (deceleration)}$$

So, the acceleration is  $10 \text{ m/s}^2$  opposite to the direction of motion

10. Let, the block  $m$  towards left through displacement  $x$ .

$$F_1 = k_1 x \text{ (compressed)}$$

$$F_2 = k_2 x \text{ (expanded)}$$

They are in same direction.

$$\text{Resultant } F = F_1 + F_2 \Rightarrow F = k_1 x + k_2 x \Rightarrow F = x(k_1 + k_2)$$

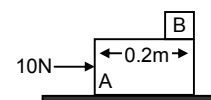
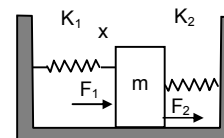
$$\text{So, } a = \text{acceleration} = \frac{F}{m} = \frac{x(k_1 + k_2)}{m} \text{ opposite to the displacement.}$$

11.  $m = 5 \text{ kg}$  of block A.

$$ma = 10 \text{ N}$$

$$\Rightarrow a = 10/5 = 2 \text{ m/s}^2.$$

As there is no friction between A & B, when the block A moves, Block B remains at rest in its position.



Initial velocity of A =  $u = 0$ .

Distance to cover so that B separate out  $s = 0.2$  m.

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

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

$$\Rightarrow 0.2 = 0 + \left(\frac{1}{2}\right) \times 2 \times t^2 \Rightarrow t^2 = 0.2 \Rightarrow t = 0.44 \text{ sec} \Rightarrow t = 0.45 \text{ sec}.$$

12. a) at any depth let the ropes make angle  $\theta$  with the vertical

From the free body diagram

$$F \cos \theta + F \cos \theta - mg = 0$$

$$\Rightarrow 2F \cos \theta = mg \Rightarrow F = \frac{mg}{2 \cos \theta}$$

As the man moves up.  $\theta$  increases i.e.  $\cos \theta$  decreases. Thus  $F$  increases.

- b) When the man is at depth  $h$

$$\cos \theta = \frac{h}{\sqrt{(d/2)^2 + h^2}}$$

$$\text{Force} = \frac{mg}{h} = \frac{mg}{4h} \sqrt{d^2 + 4h^2}$$

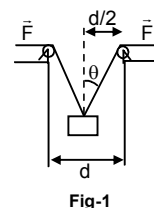
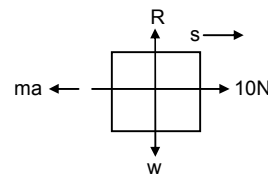


Fig-1

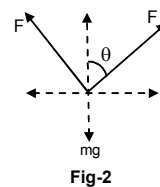
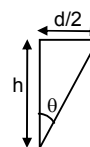


Fig-2



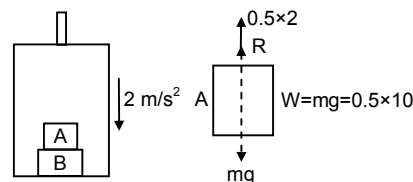
13. From the free body diagram

$$\therefore R + 0.5 \times 2 - w = 0$$

$$\Rightarrow R = w - 0.5 \times 2$$

$$= 0.5 (10 - 2) = 4 \text{ N}.$$

So, the force exerted by the block A on the block B, is 4N.



14. a) The tension in the string is found out for the different conditions from the free body diagram as shown below.

$$T - (W + 0.06 \times 1.2) = 0$$

$$\Rightarrow T = 0.05 \times 9.8 + 0.05 \times 1.2$$

$$= 0.55 \text{ N}.$$

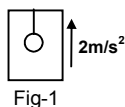


Fig-1

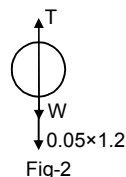


Fig-2

- b)  $\therefore T + 0.05 \times 1.2 - 0.05 \times 9.8 = 0$

$$\Rightarrow T = 0.05 \times 9.8 - 0.05 \times 1.2$$

$$= 0.43 \text{ N}.$$

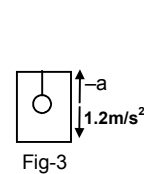


Fig-3

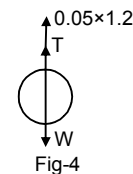


Fig-4

- c) When the elevator makes uniform motion

$$T - W = 0$$

$$\Rightarrow T = W = 0.05 \times 9.8$$

$$= 0.49 \text{ N}$$

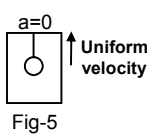


Fig-5



Fig-6

- d)  $T + 0.05 \times 1.2 - W = 0$

$$\Rightarrow T = W - 0.05 \times 1.2$$

$$= 0.43 \text{ N}.$$

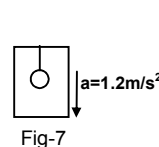


Fig-7

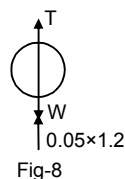


Fig-8

- e)  $T - (W + 0.05 \times 1.2) = 0$

$$\Rightarrow T = W + 0.05 \times 1.2$$

$$= 0.55 \text{ N}$$

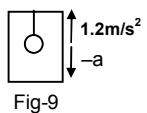


Fig-9

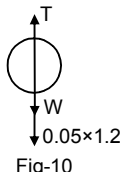
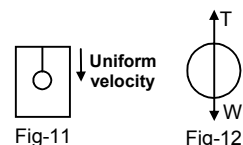


Fig-10

- f) When the elevator goes down with uniform velocity acceleration = 0

$$T - W = 0$$

$$\Rightarrow T = W = 0.05 \times 9.8 \\ = 0.49 \text{ N.}$$



15. When the elevator is accelerating upwards, maximum weight will be recorded.

$$R - (W + ma) = 0$$

$$\Rightarrow R = W + ma = m(g + a) \text{ max.wt.}$$

When decelerating upwards, maximum weight will be recorded.

$$R + ma - W = 0$$

$$\Rightarrow R = W - ma = m(g - a)$$

$$\text{So, } m(g + a) = 72 \times 9.9 \quad \dots(1)$$

$$m(g - a) = 60 \times 9.9 \quad \dots(2)$$

$$\text{Now, } mg + ma = 72 \times 9.9 \Rightarrow mg - ma = 60 \times 9.9$$

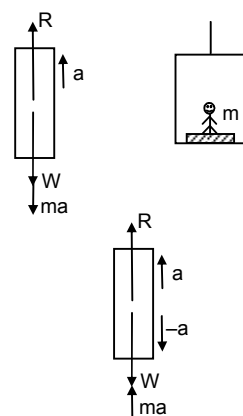
$$\Rightarrow 2mg = 1306.8$$

$$\Rightarrow m = \frac{1306.8}{2 \times 9.9} = 66 \text{ Kg}$$

So, the true weight of the man is 66 kg.

Again, to find the acceleration,  $mg + ma = 72 \times 9.9$

$$\Rightarrow a = \frac{72 \times 9.9 - 66 \times 9.9}{66} = \frac{9.9}{11} = 0.9 \text{ m/s}^2.$$



16. Let the acceleration of the 3 kg mass relative to the elevator is 'a' in the downward direction.

As, shown in the free body diagram

$$T - 1.5g - 1.5(g/10) - 1.5a = 0 \quad \text{from figure (1)}$$

$$\text{and, } T - 3g - 3(g/10) + 3a = 0 \quad \text{from figure (2)}$$

$$\Rightarrow T = 1.5g + 1.5(g/10) + 1.5a \quad \dots (i)$$

$$\text{And } T = 3g + 3(g/10) - 3a \quad \dots (ii)$$

$$\text{Equation (i)} \times 2 \Rightarrow 3g + 3(g/10) + 3a = 2T$$

$$\text{Equation (ii)} \times 1 \Rightarrow 3g + 3(g/10) - 3a = T$$

Subtracting the above two equations we get,  $T = 6a$

Subtracting  $T = 6a$  in equation (ii)

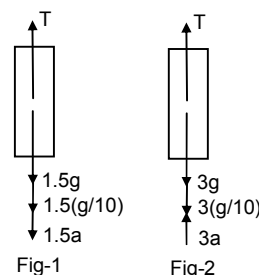
$$6a = 3g + 3(g/10) - 3a.$$

$$\Rightarrow 9a = \frac{33g}{10} \Rightarrow a = \frac{(9.8)33}{10} = 32.34$$

$$\Rightarrow a = 3.59 \therefore T = 6a = 6 \times 3.59 = 21.55$$

$$T^1 = 2T = 2 \times 21.55 = 43.1 \text{ N cut is } T_1 \text{ shown in spring.}$$

$$\text{Mass} = \frac{wt}{g} = \frac{43.1}{9.8} = 4.39 = 4.4 \text{ kg}$$



17. Given,  $m = 2 \text{ kg}$ ,  $k = 100 \text{ N/m}$

From the free body diagram,  $kl - 2g = 0 \Rightarrow kl = 2g$

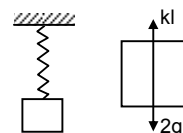
$$\Rightarrow l = \frac{2g}{k} = \frac{2 \times 9.8}{100} = \frac{19.6}{100} = 0.196 = 0.2 \text{ m}$$

Suppose further elongation when 1 kg block is added be  $x$ ,

$$\text{Then } k(1 + x) = 3g$$

$$\Rightarrow kx = 3g - 2g = g = 9.8 \text{ N}$$

$$\Rightarrow x = \frac{9.8}{100} = 0.098 = 0.1 \text{ m}$$



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

$$kl - (2g + 2a) = 0$$

$$\Rightarrow kl = 2g + 2a$$

$$= 2 \times 9.8 + 2 \times 2 = 19.6 + 4$$

$$\Rightarrow l = \frac{23.6}{100} = 0.236 \text{ m} = 0.24 \text{ m}$$

When 1 kg body is added total mass  $(2 + 1)\text{kg} = 3\text{kg}$ .

elongation be  $l_1$

$$kl_1 = 3g + 3a = 3 \times 9.8 + 6$$

$$\Rightarrow l_1 = \frac{33.4}{100} = 0.334 = 0.36$$

Further elongation  $= l_1 - l = 0.36 - 0.12 \text{ m}$ .

19. Let, the air resistance force is  $F$  and Buoyant force is  $B$ .

Given that

$F_a \propto v$ , where  $v \rightarrow$  velocity

$\Rightarrow F_a = kv$ , where  $k \rightarrow$  proportionality constant.

When the balloon is moving downward,

$$B + kv = mg \quad \dots(i)$$

$$\Rightarrow M = \frac{B + kv}{g}$$

For the balloon to rise with a constant velocity  $v$ , (upward)

let the mass be  $m$

$$\text{Here, } B - (mg + kv) = 0 \quad \dots(ii)$$

$$\Rightarrow B = mg + kv$$

$$\Rightarrow m = \frac{B - kv}{g}$$

So, amount of mass that should be removed  $= M - m$ .

$$= \frac{B + kv}{g} - \frac{B - kv}{g} = \frac{B + kv - B + kv}{g} = \frac{2kv}{g} = \frac{2(Mg - B)}{G} = 2\{M - (B/g)\}$$

20. When the box is accelerating upward,

$$U - mg - m(g/6) = 0$$

$$\Rightarrow U = mg + mg/6 = m\{g + (g/6)\} = 7 \text{ mg}/7 \quad \dots(i)$$

$$\Rightarrow m = 6U/7g.$$

When it is accelerating downward, let the required mass be  $M$ .

$$U - Mg + Mg/6 = 0$$

$$\Rightarrow U = \frac{6Mg - Mg}{6} = \frac{5Mg}{6} \Rightarrow M = \frac{6U}{5g}$$

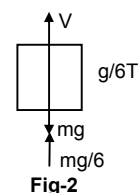
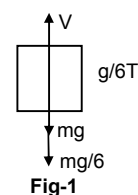
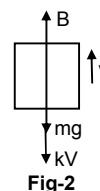
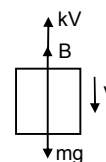
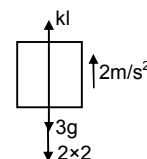
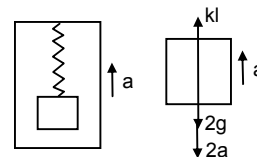
$$\text{Mass to be added} = M - m = \frac{6U}{5g} - \frac{6U}{7g} = \frac{6U}{g} \left( \frac{1}{5} - \frac{1}{7} \right)$$

$$= \frac{6U}{g} \left( \frac{2}{35} \right) = \frac{12}{35} \left( \frac{U}{g} \right)$$

$$= \frac{12}{35} \left( \frac{7mg}{6} \times \frac{1}{g} \right) \quad \text{from (i)}$$

$$= 2/5 \text{ m}.$$

$\therefore$  The mass to be added is  $2m/5$ .



21. Given that,  $\vec{F} = \vec{u} \times \vec{A}$  and  $\vec{mg}$  act on the particle.

For the particle to move undeflected with constant velocity, net force should be zero.

$$\therefore (\vec{u} \times \vec{A}) + \vec{mg} = 0$$

$$\therefore (\vec{u} \times \vec{A}) = -\vec{mg}$$

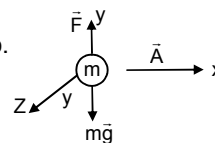
Because,  $(\vec{u} \times \vec{A})$  is perpendicular to the plane containing  $\vec{u}$  and  $\vec{A}$ ,  $\vec{u}$  should be in the  $xz$ -plane.

Again,  $u A \sin \theta = mg$

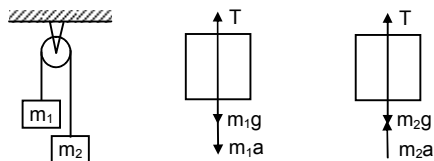
$$\therefore u = \frac{mg}{A \sin \theta}$$

$u$  will be minimum, when  $\sin \theta = 1 \Rightarrow \theta = 90^\circ$

$$\therefore u_{\min} = \frac{mg}{A} \text{ along Z-axis.}$$



- 22.



$$m_1 = 0.3 \text{ kg}, m_2 = 0.6 \text{ kg}$$

$$T - (m_1g + m_1a) = 0 \quad \dots(i) \quad \Rightarrow T = m_1g + m_1a$$

$$T + m_2a - m_2g = 0 \quad \dots(ii) \quad \Rightarrow T = m_2g - m_2a$$

From equation (i) and equation (ii)

$$m_1g + m_1a + m_2a - m_2g = 0, \text{ from (i)}$$

$$\Rightarrow a(m_1 + m_2) = g(m_2 - m_1)$$

$$\Rightarrow a = \frac{m_2 - m_1}{m_1 + m_2} g = 9.8 \left( \frac{0.6 - 0.3}{0.6 + 0.3} \right) = 3.266 \text{ ms}^{-2}$$

$$\text{a) } t = 2 \text{ sec acceleration} = 3.266 \text{ ms}^{-2}$$

Initial velocity  $u = 0$

So, distance travelled by the body is,

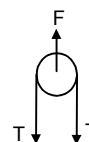
$$S = ut + \frac{1}{2} at^2 \Rightarrow 0 + \frac{1}{2}(3.266) 2^2 = 6.5 \text{ m}$$

$$\text{b) From (i) } T = m_1(g + a) = 0.3 (9.8 + 3.26) = 3.9 \text{ N}$$

c) The force exerted by the clamp on the pulley is given by

$$F - 2T = 0$$

$$F = 2T = 2 \times 3.9 = 7.8 \text{ N.}$$



23.  $a = 3.26 \text{ m/s}^2$

$$T = 3.9 \text{ N}$$

After 2 sec mass  $m_1$  the velocity

$$V = u + at = 0 + 3.26 \times 2 = 6.52 \text{ m/s upward.}$$

At this time  $m_2$  is moving 6.52 m/s downward.

At time 2 sec,  $m_2$  stops for a moment. But  $m_1$  is moving upward with velocity 6.52 m/s.

It will continue to move till final velocity (at highest point) because zero.

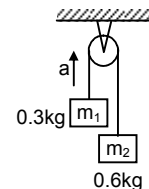
Here,  $v = 0$ ;  $u = 6.52$

$$A = -g = -9.8 \text{ m/s}^2 \text{ [moving up ward } m_1]$$

$$V = u + at \Rightarrow 0 = 6.52 + (-9.8)t$$

$$\Rightarrow t = 6.52/9.8 = 0.66 = 2/3 \text{ sec.}$$

During this period  $2/3$  sec,  $m_2$  mass also starts moving downward. So the string becomes tight again after a time of  $2/3$  sec.



24. Mass per unit length  $3/30 \text{ kg/cm} = 0.10 \text{ kg/cm}$ .

Mass of 10 cm part =  $m_1 = 1 \text{ kg}$

Mass of 20 cm part =  $m_2 = 2 \text{ kg}$ .

Let,  $F$  = contact force between them.

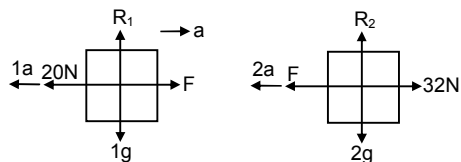
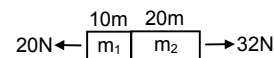
From the free body diagram

$$F - 20 - 10 = 0 \quad \dots(i)$$

$$\text{And, } 32 - F - 2a = 0 \quad \dots(ii)$$

$$\text{From eqa (i) and (ii) } 3a - 12 = 0 \Rightarrow a = 12/3 = 4 \text{ m/s}^2$$

$$\text{Contact force } F = 20 + 1a = 20 + 1 \times 4 = 24 \text{ N.}$$



- 25.

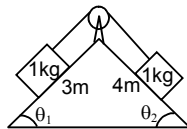


Fig-1

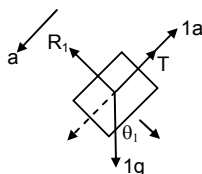


Fig-2

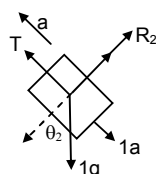


Fig-3

$$\sin \theta_1 = 4/5$$

$$\sin \theta_2 = 3/5$$

$$g \sin \theta_1 - (a + T) = 0$$

$$\Rightarrow g \sin \theta_1 = a + T \quad \dots(i)$$

$$\Rightarrow T + a - g \sin \theta_1 = 0$$

$$T - g \sin \theta_2 - a = 0$$

$$\Rightarrow T = g \sin \theta_2 + a \quad \dots(ii)$$

From eqn (i) and (ii),  $g \sin \theta_2 + a + a - g \sin \theta_1 = 0$

$$\Rightarrow 2a = g \sin \theta_1 - g \sin \theta_2 = g \left( \frac{4}{5} - \frac{3}{5} \right) = g/5$$

$$\Rightarrow a = \frac{g}{5} \times \frac{1}{2} = \frac{g}{10}$$

- 26.

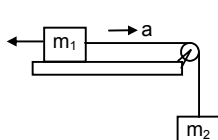


Fig-1

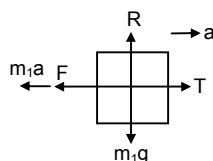


Fig-2

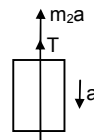


Fig-3

From the above Free body diagram

$$M_1 a + F - T = 0 \Rightarrow T = m_1 a + F \quad \dots(i)$$

From the above Free body diagram

$$m_2 a + T - m_2 g = 0 \quad \dots(ii)$$

$$\Rightarrow m_2 a + m_1 a + F - m_2 g = 0 \quad (\text{from (i)})$$

$$\Rightarrow a(m_1 + m_2) + m_2 g/2 - m_2 g = 0 \quad \{\text{because } f = m^2 g/2\}$$

$$\Rightarrow a(m_1 + m_2) - m_2 g = 0$$

$$\Rightarrow a(m_1 + m_2) = m_2 g/2 \Rightarrow a = \frac{m_2 g}{2(m_1 + m_2)}$$

Acceleration of mass  $m_1$  is  $\frac{m_2 g}{2(m_1 + m_2)}$  towards right.

- 27.

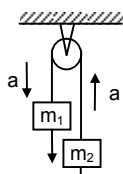


Fig-1

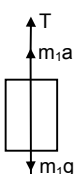


Fig-2

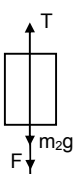


Fig-3

From the above free body diagram

$$T + m_1 a - m(m_1 g + F) = 0$$

From the free body diagram

$$T - (m_2 g + F + m_2 a) = 0$$

$$\Rightarrow T = m_1g + F - m_1a \Rightarrow T = 5g + 1 - 5a \dots (i)$$

$$\Rightarrow T = m_2g + F + m_2a \Rightarrow T = 2g + 1 + 2a \dots (ii)$$

From the eqn (i) and eqn (ii)

$$5g + 1 - 5a = 2g + 1 + 2a \Rightarrow 3g - 7a = 0 \Rightarrow 7a = 3g$$

$$\Rightarrow a = \frac{3g}{7} = \frac{29.4}{7} = 4.2 \text{ m/s}^2 \quad [g = 9.8 \text{ m/s}^2]$$

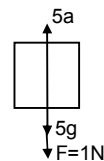
a) acceleration of block is  $4.2 \text{ m/s}^2$

b) After the string breaks  $m_1$  move downward with force  $F$  acting down ward.

$$m_1a = F + m_1g = (1 + 5g) = 5(g + 0.2)$$

$$\text{Force} = 1\text{N, acceleration} = 1/5 = 0.2 \text{ m/s}^2.$$

$$\text{So, acceleration} = \frac{\text{Force}}{\text{mass}} = \frac{5(g + 0.2)}{5} = (g + 0.2) \text{ m/s}^2$$



28.

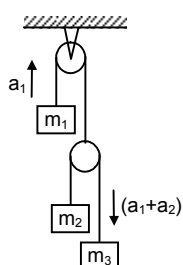


Fig-1

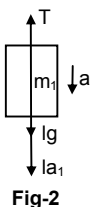


Fig-2

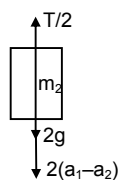


Fig-3

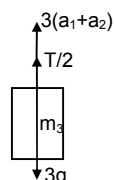


Fig-4

Let the block  $m_1$  moves upward with acceleration  $a$ , and the two blocks  $m_2$  and  $m_3$  have relative acceleration  $a_2$  due to the difference of weight between them. So, the actual acceleration at the blocks  $m_1$ ,  $m_2$  and  $m_3$  will be  $a_1$ .

$(a_1 - a_2)$  and  $(a_1 + a_2)$  as shown

$$T = 1g - 1a_2 = 0 \dots (i) \text{ from fig (2)}$$

$$T/2 - 2g - 2(a_1 - a_2) = 0 \dots (ii) \text{ from fig (3)}$$

$$T/2 - 3g - 3(a_1 + a_2) = 0 \dots (iii) \text{ from fig (4)}$$

$$\text{From eqn (i) and eqn (ii), eliminating } T \text{ we get, } 1g + 1a_2 = 4g + 4(a_1 + a_2) \Rightarrow 5a_2 - 4a_1 = 3g \text{ (iv)}$$

$$\text{From eqn (ii) and eqn (iii), we get } 2g + 2(a_1 - a_2) = 3g - 3(a_1 - a_2) \Rightarrow 5a_1 + a_2 = (v)$$

$$\text{Solving (iv) and (v) } a_1 = \frac{2g}{29} \text{ and } a_2 = g - 5a_1 = g - \frac{10g}{29} = \frac{19g}{29}$$

$$\text{So, } a_1 - a_2 = \frac{2g}{29} - \frac{19g}{29} = -\frac{17g}{29}$$

$$a_1 + a_2 = \frac{2g}{29} + \frac{19g}{29} = \frac{21g}{29} \text{ So, acceleration of } m_1, m_2, m_3 \text{ are } \frac{19g}{29} \text{ (up)} \quad \frac{17g}{29} \text{ (down)} \quad \frac{21g}{29} \text{ (down)}$$

respectively.

$$\text{Again, for } m_1, u = 0, s = 20\text{cm} = 0.2\text{m and } a_2 = \frac{19}{29}g \quad [g = 10\text{m/s}^2]$$

$$\therefore S = ut + \frac{1}{2}at^2 = 0.2 = \frac{1}{2} \times \frac{19}{29}gt^2 \Rightarrow t = 0.25\text{sec.}$$

29.

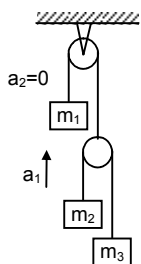


Fig-1



Fig-2

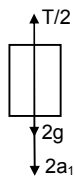


Fig-3

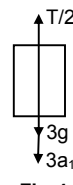


Fig-4



$m_1$  should be at rest.

$$T - m_1g = 0$$

$$\Rightarrow T = m_1g \dots(i)$$

From eqn (ii) & (iii) we get

$$3T - 12g = 12g - 2T \Rightarrow T = 24g/5 = 408g.$$

Putting the value of  $T$  eqn (i) we get,  $m_1 = 4.8\text{kg}$ .

$$T/2 - 2g - 2a_1 = 0$$

$$\Rightarrow T - 4g - 4a_1 = 0 \dots(ii)$$

$$T/2 - 3g - 3a_1 = 0$$

$$\Rightarrow T = 6g - 6a_1 \dots(iii)$$

30.

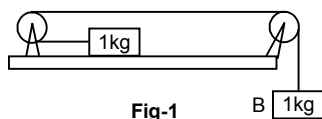


Fig-1

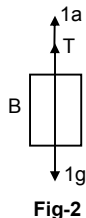


Fig-2

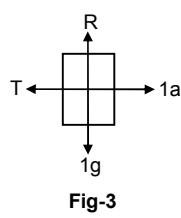


Fig-3

$$T + 1a = 1g \dots(i)$$

From eqn (i) and (ii), we get

$$1a + 1a = 1g \Rightarrow 2a = g \Rightarrow a = \frac{g}{2} = \frac{10}{2} = 5\text{m/s}^2$$

From (ii)  $T = 1a = 5\text{N}$ .

$$T - 1a = 0 \Rightarrow T = 1a \text{ (ii)}$$

31.

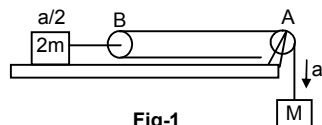


Fig-1

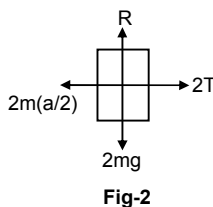


Fig-2



Fig-3

$$Ma - 2T = 0$$

$$\Rightarrow Ma = 2T \Rightarrow T = Ma/2.$$

$$T + Ma - Mg = 0$$

$$\Rightarrow Ma/2 + ma = Mg. \text{ (because } T = Ma/2\text{)}$$

$$\Rightarrow 3Ma = 2Mg \Rightarrow a = 2g/3$$

a) acceleration of mass  $M$  is  $2g/3$ .

$$\text{b) Tension } T = \frac{Ma}{2} = \frac{M}{2} \cdot \frac{2g}{3} = \frac{Mg}{3}$$

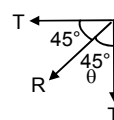
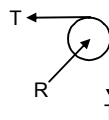
c) Let,  $R^1$  = resultant of tensions = force exerted by the clamp on the pulley

$$R^1 = \sqrt{T^2 + T^2} = \sqrt{2}T$$

$$\therefore R = \sqrt{2}T = \sqrt{2} \cdot \frac{Mg}{3} = \frac{\sqrt{2}Mg}{3}$$

$$\text{Again, } \tan\theta = \frac{T}{T} = 1 \Rightarrow \theta = 45^\circ.$$

So, it is  $\frac{\sqrt{2}Mg}{3}$  at an angle of  $45^\circ$  with horizontal.



32.

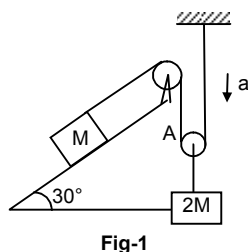


Fig-1

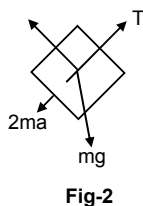


Fig-2

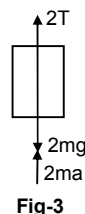


Fig-3

$$2Ma + Mg \sin \theta - T = 0$$

$$\Rightarrow T = 2Ma + Mg \sin \theta \dots(i)$$

$$2T + 2Ma - 2Mg = 0$$

$$\Rightarrow 2(2Ma + Mg \sin \theta) + 2Ma - 2Mg = 0 \text{ [From (i)]}$$

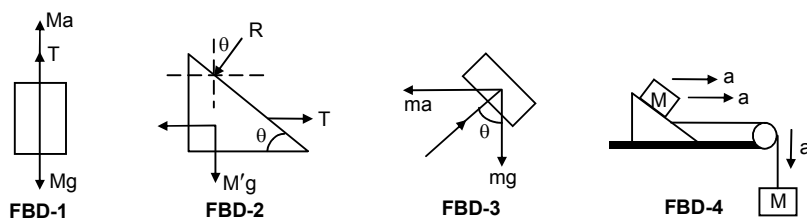
$$\Rightarrow 4Ma + 2Mg \sin \theta + 2Ma - 2Mg = 0$$

$$\Rightarrow 6Ma + 2Mg \sin 30^\circ - 2Mg = 0$$

$$\Rightarrow 6Ma = Mg \Rightarrow a = g/6.$$

Acceleration of mass M is  $2a = s \times g/6 = g/3$  up the plane.

33.



As the block 'm' does not slide over M', it will have same acceleration as that of M'

From the freebody diagrams.

$$T + Ma - Mg = 0 \dots(i) \text{ (From FBD - 1)}$$

$$T - M'a - R \sin \theta = 0 \dots(ii) \text{ (From FBD - 2)}$$

$$R \sin \theta - ma = 0 \dots(iii) \text{ (From FBD - 3)}$$

$$R \cos \theta - mg = 0 \dots(iv) \text{ (From FBD - 4)}$$

Eliminating T, R and a from the above equation, we get  $M = \frac{M' + m}{\cot \theta - 1}$

34. a)  $5a + T - 5g = 0 \Rightarrow T = 5g - 5a \dots(i) \text{ (From FBD-1)}$

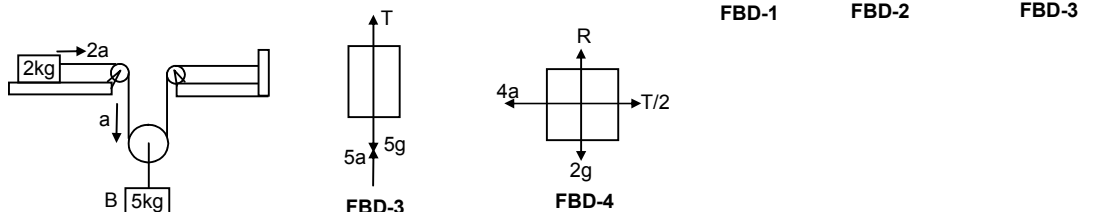
Again  $(1/2) - 4g - 8a = 0 \Rightarrow T = 8g - 16a \dots(ii) \text{ (from FBD-2)}$

From equn (i) and (ii), we get

$$5g - 5a = 8g + 16a \Rightarrow 21a = -3g \Rightarrow a = -1/7g$$

So, acceleration of 5 kg mass is  $g/7$  upward and that of 4 kg mass is  $2a = 2g/7$  (downward).

b)



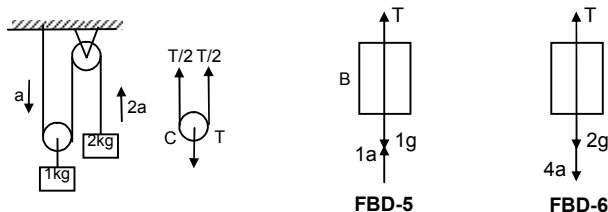
$$4a - T/2 = 0 \Rightarrow 8a - T = 0 \Rightarrow T = 8a \dots(ii) \text{ [From FBD - 4]}$$

$$\text{Again, } T + 5a - 5g = 0 \Rightarrow 8a + 5a - 5g = 0$$

$$\Rightarrow 13a - 5g = 0 \Rightarrow a = 5g/13 \text{ downward. (from FBD - 3)}$$

Acceleration of mass (A) kg is  $2a = 10/13 (g)$  & 5kg (B) is  $5g/13$ .

c)



$$T + 1a - 1g = 0 \Rightarrow T = 1g - 1a \dots(i) \text{ [From FBD - 5]}$$

$$\text{Again, } \frac{T}{2} - 2g - 4a = 0 \Rightarrow T - 4g - 8a = 0 \dots(ii) \text{ [From FBD - 6]}$$

$$\Rightarrow 1g - 1a - 4g - 8a = 0 \text{ [From (i)]}$$

$$\Rightarrow a = -(g/3) \text{ downward.}$$

Acceleration of mass 1kg(b) is  $g/3$  (up)

Acceleration of mass 2kg(A) is  $2g/3$  (downward).

35.  $m_1 = 100g = 0.1\text{kg}$

$$m_2 = 500g = 0.5\text{kg}$$

$$m_3 = 50g = 0.05\text{kg.}$$

$$T + 0.5a - 0.5g = 0 \quad \dots(i)$$

$$T_1 - 0.5a - 0.05g = a \quad \dots(ii)$$

$$T_1 + 0.1a - T + 0.05g = 0 \quad \dots(iii)$$

$$\text{From equn (ii) } T_1 = 0.05g + 0.05a \quad \dots(iv)$$

$$\text{From equn (i) } T_1 = 0.5g - 0.5a \quad \dots(v)$$

$$\text{Equn (iii) becomes } T_1 + 0.1a - T + 0.05g = 0$$

$$\Rightarrow 0.05g + 0.05a + 0.1a - 0.5g + 0.5a + 0.05g = 0 \quad [\text{From (iv) and (v)}]$$

$$\Rightarrow 0.65a = 0.4g \Rightarrow a = \frac{0.4}{0.65} = \frac{40}{65}g = \frac{8}{13}g \text{ downward}$$

Acceleration of 500gm block is  $8g/13g$  downward.

36.  $m = 15 \text{ kg}$  of monkey.  $a = 1 \text{ m/s}^2$ .

From the free body diagram

$$\therefore T - [15g + 15(1)] = 0 \Rightarrow T = 15(10 + 1) \Rightarrow T = 15 \times 11 \Rightarrow T = 165 \text{ N.}$$

The monkey should apply 165N force to the rope.

Initial velocity  $u = 0$ ; acceleration  $a = 1 \text{ m/s}^2$ ;  $s = 5 \text{m}$ .

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

$$5 = 0 + (1/2)1 t^2 \Rightarrow t^2 = 5 \times 2 \Rightarrow t = \sqrt{10} \text{ sec.}$$

Time required is  $\sqrt{10}$  sec.

37. Suppose the monkey accelerates upward with acceleration 'a' & the block, accelerate downward with acceleration  $a_1$ . Let Force exerted by monkey is equal to 'T'

From the free body diagram of monkey

$$\therefore T - mg - ma = 0 \quad \dots(i)$$

$$\Rightarrow T = mg + ma.$$

Again, from the FBD of the block,

$$T = ma_1 - mg = 0.$$

$$\Rightarrow mg + ma + ma_1 - mg = 0 \quad [\text{From (i)}] \Rightarrow ma = -ma_1 \Rightarrow a = a_1.$$

Acceleration '-a' downward i.e. 'a' upward.

$\therefore$  The block & the monkey move in the same direction with equal acceleration.

If initially they are rest (no force is exerted by monkey) no motion of monkey or block occurs as they have same weight (same mass). Their separation will not change as time passes.

38. Suppose A move upward with acceleration a, such that in the tail of A maximum tension 30N produced.

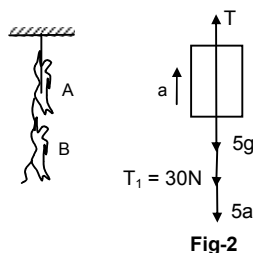


Fig-2

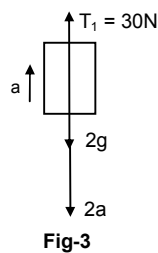


Fig-3

$$T - 5g - 30 - 5a = 0 \quad \dots(i)$$

$$\Rightarrow T = 50 + 30 + (5 \times 5) = 105 \text{ N (max)}$$

So, A can apply a maximum force of 105 N in the rope to carry the monkey B with it.

$$30 - 2g - 2a = 0 \quad \dots(ii)$$

$$\Rightarrow 30 - 20 - 2a = 0 \Rightarrow a = 5 \text{ m/s}^2$$

For minimum force there is no acceleration of monkey 'A' and B.  $\Rightarrow a = 0$

Now equation (ii) is  $T'_1 - 2g = 0 \Rightarrow T'_1 = 20 \text{ N}$  (wt. of monkey B)

Equation (i) is  $T - 5g - 20 = 0$  [As  $T'_1 = 20 \text{ N}$ ]

$$\Rightarrow T = 5g + 20 = 50 + 20 = 70 \text{ N.}$$

$\therefore$  The monkey A should apply force between 70 N and 105 N to carry the monkey B with it.

39. (i) Given, Mass of man = 60 kg.

Let  $R'$  = apparent weight of man in this case.

Now,  $R' + T - 60g = 0$  [From FBD of man]

$$\Rightarrow T = 60g - R' \quad \dots(i)$$

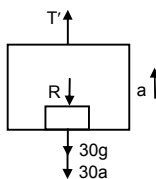
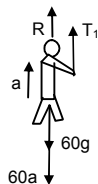
$T - R' - 30g = 0$  ... (ii) [From FBD of box]

$$\Rightarrow 60g - R' - R' - 30g = 0 \quad [\text{From (i)}]$$

$$\Rightarrow R' = 15g \text{ The weight shown by the machine is 15kg.}$$

(ii) To get his correct weight suppose the applied force is ' $T$ ' and so, accelerates upward with ' $a$ '.

In this case, given that correct weight =  $R = 60g$ , where  $g = \text{acc}^n$  due to gravity



From the FBD of the man

$$T^1 + R - 60g - 60a = 0$$

$$\Rightarrow T^1 - 60a = 0 \quad [\because R = 60g]$$

$$\Rightarrow T^1 = 60a \quad \dots(i)$$

From the FBD of the box

$$T^1 - R - 30g - 30a = 0$$

$$\Rightarrow T^1 - 60g - 30g - 30a = 0$$

$$\Rightarrow T^1 - 30a = 90g = 900$$

$$\Rightarrow T^1 = 30a - 900 \quad \dots(ii)$$

From eqn (i) and eqn (ii) we get  $T^1 = 2T^1 - 1800 \Rightarrow T^1 = 1800 \text{ N}$ .

$\therefore$  So, he should exert 1800 N force on the rope to get correct reading.

40. The driving force on the block which n the body to move sown the plane is  $F = mg \sin \theta$ ,

So, acceleration =  $g \sin \theta$

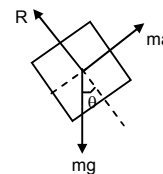
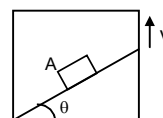
Initial velocity of block  $u = 0$ .

$$s = \ell, a = g \sin \theta$$

$$\text{Now, } S = ut + \frac{1}{2}at^2$$

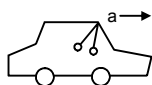
$$\Rightarrow \ell = 0 + \frac{1}{2}(g \sin \theta)t^2 \Rightarrow g^2 = \frac{2\ell}{g \sin \theta} \Rightarrow t = \sqrt{\frac{2\ell}{g \sin \theta}}$$

$$\text{Time taken is } \sqrt{\frac{2\ell}{g \sin \theta}}$$



41. Suppose pendulum makes  $\theta$  angle with the vertical. Let,  $m$  = mass of the pendulum.

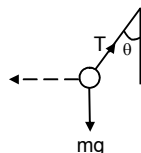
From the free body diagram



$$T \cos \theta - mg = 0$$

$$\Rightarrow T \cos \theta = mg$$

$$\Rightarrow T = \frac{mg}{\cos \theta} \quad \dots(i)$$



$$ma - T \sin \theta = 0$$

$$\Rightarrow ma = T \sin \theta$$

$$\Rightarrow t = \frac{ma}{\sin \theta} \quad \dots(ii)$$

From (i) & (ii)  $\frac{mg}{\cos \theta} = \frac{ma}{\sin \theta} \Rightarrow \tan \theta = \frac{a}{g} \Rightarrow \theta = \tan^{-1} \frac{a}{g}$

The angle is  $\tan^{-1}(a/g)$  with vertical.

(ii)  $m \rightarrow$  mass of block.

Suppose the angle of incline is ' $\theta$ '

From the diagram

$$ma \cos \theta - mg \sin \theta = 0 \Rightarrow ma \cos \theta = mg \sin \theta \Rightarrow \frac{\sin \theta}{\cos \theta} = \frac{a}{g}$$

$$\Rightarrow \tan \theta = a/g \Rightarrow \theta = \tan^{-1}(a/g).$$

42. Because, the elevator is moving downward with an acceleration  $12 \text{ m/s}^2$  ( $>g$ ), the body gets separated. So, body moves with acceleration  $g = 10 \text{ m/s}^2$  [freely falling body] and the elevator move with acceleration  $12 \text{ m/s}^2$

Now, the block has acceleration =  $g = 10 \text{ m/s}^2$

$$u = 0$$

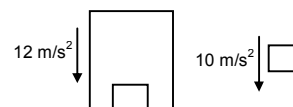
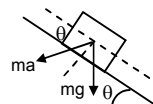
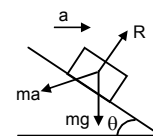
$$t = 0.2 \text{ sec}$$

So, the distance travelled by the block is given by.

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

$$= 0 + \left(\frac{1}{2}\right) 10 (0.2)^2 = 5 \times 0.04 = 0.2 \text{ m} = 20 \text{ cm}.$$

The displacement of body is 20 cm during first 0.2 sec.



\* \* \* \*