SOLUTIONS TO CONCEPTS
CHAPTER – 5

1. $m = 2kg$
   $S = 10m$
   Let, acceleration = a, Initial velocity u = 0.
   $S = ut + 1/2\ at^2$
   $\Rightarrow 10 = ½\ a\ (2^2) \Rightarrow 10 = 2a \Rightarrow a = 5\ m/s^2$
   Force: $F = ma = 2 \times 5 = 10N$ (Ans)

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

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

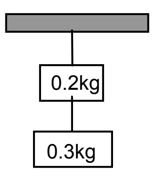
4.


fig 1

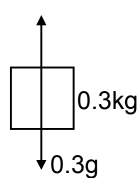


fig 2

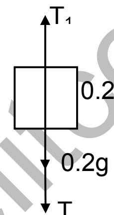


fig 3

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

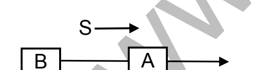
5.


Fig 1

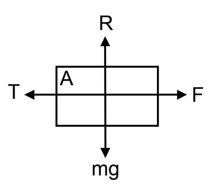


Fig 2

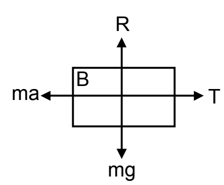
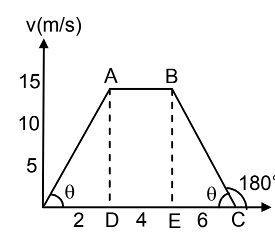


Fig 3

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

6. $m = 50g = 5 \times 10^{-2}$ kg
   As shown in the figure,
   Slope of OA $= \tan\theta\ \dfrac{AD}{OD} = \dfrac{15}{3} = 5\ m/s^2$
   So, at t = 2sec acceleration is $5m/s^2$
   Force $= ma = 5 \times 10^{-2} \times 5 = 0.25N$ along the motion



At t = 4 sec slope of AB = 0, acceleration = 0 [tan 0° = 0]
$\therefore$ Force = 0
At t = 6 sec, acceleration = slope of BC.

In ΔBEC = tan θ = $\frac{BE}{EC} = \frac{15}{3}$ = 5.

Slope of BC = tan (180° – θ) = – tan θ = –5 m/s^2 (deceleration)
Force = ma = 5 × 10^{-2} 5 = 0.25 N. Opposite to the motion.

7. Let, F $\rightarrow$ contact force between m_A & m_B.
And, f $\rightarrow$ force exerted by experimenter.

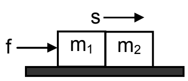


Fig 1

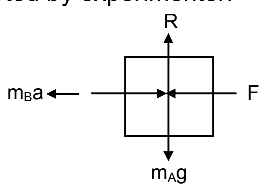


Fig 2

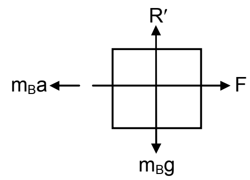


Fig 3

F + m_A a –f = 0 m_B a –f =0
$\Rightarrow$ F = f – m_A a ……….(i) $\Rightarrow$ F= m_B a ……...(ii)
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).

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

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

8. r = 1mm = 10^{-3}
'm' = 4mg = 4 × 10^{-6}kg
s = 10^{-3}m.
v = 0
u = 30 m/s.

So, a = $\frac{v^2-u^2}{2s} = \frac{-30\times30}{2\times10^{-3}}$ = –4.5 × 10^5 m/s^2 (decelerating)

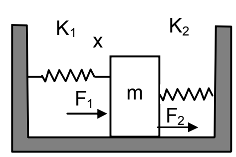
Taking magnitude only deceleration is 4.5 × 10^5 m/s^2
So, force F = 4 × 10^{-6} × 4.5 × 10^5 = 1.8 N

9. x = 20 cm = 0.2m, k = 15 N/m, m = 0.3kg.

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

So, the acceleration is 10 m/s^2 opposite to the direction of motion

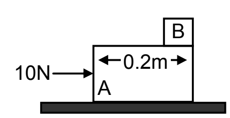
10. Let, the block m towards left through displacement x.



$F_1 = k_1$ x (compressed)
$F_2 = k_2$ x (expanded)
They are in same direction.
Resultant F = $F_1 + F_2 \Rightarrow$ F = k_1 x + k_2 x $\Rightarrow$ F = x(k_1 + k_2)

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

11. m = 5 kg of block A.

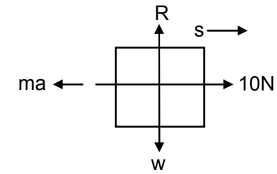


ma = 10 N
$\Rightarrow$ a 10/5 = 2 m/s^2.
As there is no friction between A & B, when the block A moves, Block B remains at rest in its position.

Initial velocity of A = u = 0.
Distance to cover so that B separate out s = 0.2 m.
Acceleration a = 2 m/s^2

$\therefore$ s= ut + ½ at^2

$\Rightarrow$ 0.2 = 0 + (½) ×2 × t^2 $\Rightarrow$ t^2 = 0.2 $\Rightarrow$ t = 0.44 sec $\Rightarrow$ t= 0.45 sec.



12. a) at any depth let the ropes make angle θ 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. θ increases i.e. cos θ decreases. Thus F increases.

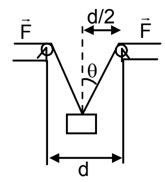


Fig-1

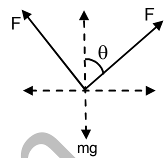
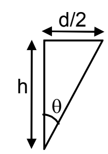


Fig-2

b) When the man is at depth h

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

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



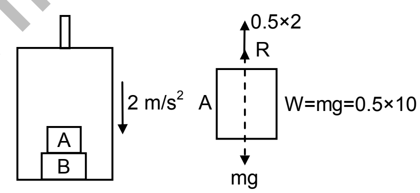
13. From the free body diagram

$\therefore$ R + 0.5 × 2 – w = 0

$\Rightarrow$ R = w – 0.5 × 2

= 0.5 (10 – 2) = 4N.

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 × 1.2) = 0

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

= 0.55 N.

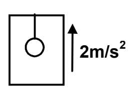


Fig-1

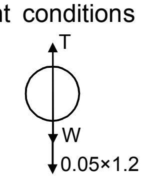


Fig-2

b) $\therefore$ T + 0.05 × 1.2 – 0.05 × 9.8 = 0

$\Rightarrow$ T = 0.05 × 9.8 – 0.05 × 1.2

= 0.43 N.

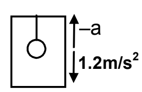


Fig-3

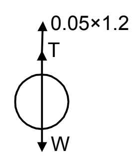


Fig-4

c) When the elevator makes uniform motion

T – W = 0

$\Rightarrow$ T = W = 0.05 × 9.8

= 0.49 N

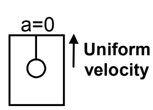


Fig-5

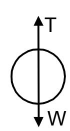


Fig-6

d) T + 0.05 × 1.2 – W = 0

$\Rightarrow$ T = W – 0.05 × 1.2

= 0.43 N.

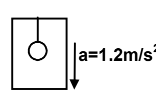


Fig-7

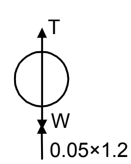


Fig-8

e) T – (W + 0.05 × 1.2) = 0

$\Rightarrow$ T = W + 0.05 × 1.2

= 0.55 N

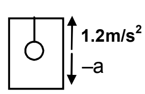


Fig-9

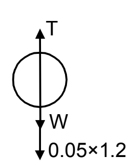


Fig-10

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

$T - W = 0$

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

$= 0.49$ N.

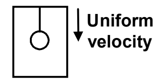


Fig-11

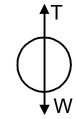


Fig-12

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

$R - (W + ma) = 0$

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

When decelerating upwards, maximum weight will be recorded.

$R + ma - W = 0$

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

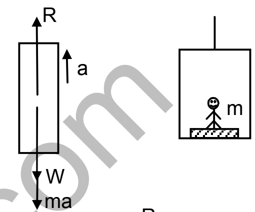
So, $m(g + a) = 72 \times 9.9$ …(1)

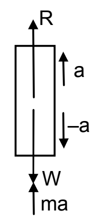
$m(g - a) = 60 \times 9.9$ …(2)

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

$\Rightarrow 2mg = 1306.8$

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





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

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

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

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

$T - 1.5\,g - 1.5(g/10) - 1.5\,a = 0$ from figure (1)

and, $T - 3g - 3(g/10) + 3a = 0$ from figure (2)

$\Rightarrow T = 1.5\,g + 1.5(g/10) + 1.5a$ … (i)

And $T = 3g + 3(g/10) - 3a$ … (ii)

Equation (i) × 2 $\Rightarrow 3g + 3(g/10) + 3a = 2T$

Equation (ii) × 1 $\Rightarrow 3g + 3(g/10) - 3a = T$

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

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

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

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

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

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

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

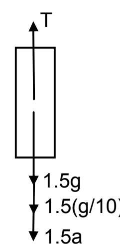


Fig-1

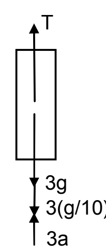
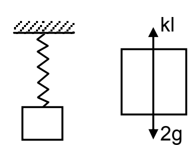


Fig-2

17. Given, m = 2 kg, k = 100 N/m

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

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



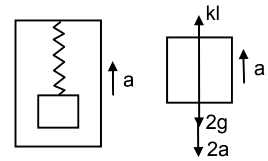
Suppose further elongation when 1 kg block is added be x,

Then $k(1 + x) = 3g$

$\Rightarrow kx = 3g - 2g = g = 9.8$ N

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

18. $a = 2\ m/s^2$



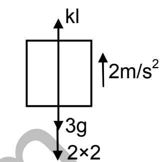
$kl - (2g + 2a) = 0$

$\Rightarrow kl = 2g + 2a$

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

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

When 1 kg body is added total mass (2 + 1)kg = 3kg.



elongation be l_1

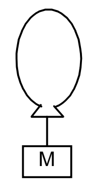
$kl_1 = 3g + 3a = 3 \times 9.8 + 6$

$\Rightarrow l_1 = \dfrac{33.4}{100} = 0.0334 = 0.36$

Further elongation = $l_1 - l = 0.36 - 0.12$ 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,

$B + kv = mg$ …(i)

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

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

let the mass be m

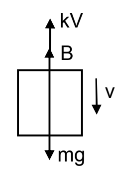


Fig-1

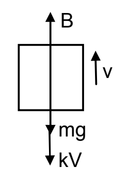


Fig-2

Here, $B - (mg + kv) = 0$ …(ii)

$\Rightarrow B = mg + kv$

$\Rightarrow m = \dfrac{B - kw}{g}$

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

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

20. When the box is accelerating upward,

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

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

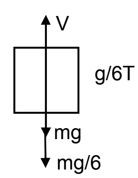


Fig-1

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

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

$U - Mg + Mg/6 = 0$

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

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

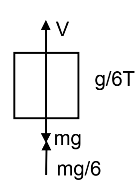


Fig-2

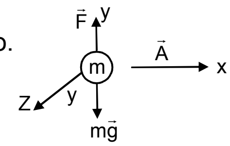
$= \dfrac{6U}{g}\left(\dfrac{2}{35}\right) = \dfrac{12}{35}\left(\dfrac{U}{g}\right)$

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

= 2/5 m.

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

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



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

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

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

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.

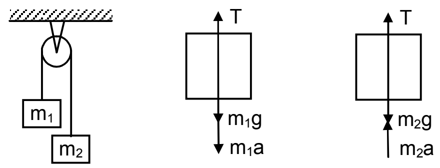
Again, u A sin θ = mg

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

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

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

22.



$m_1 = 0.3$ kg, $m_2 = 0.6$ kg

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

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

From equation (i) and equation (ii)

$m_1g + m_1a + m_2a - m_2g = 0$, from (i)

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

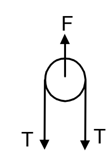
$\Rightarrow a = f\left(\dfrac{m_2 - m_1}{m_1 + m_2}\right) = 9.8\left(\dfrac{0.6 - 0.3}{0.6 + 0.3}\right) = 3.266\ ms^{-2}$.

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

Initial velocity u = 0

So, distance travelled by the body is,

$S = ut + 1/2\ at^2 \Rightarrow 0 + ½(3.266)\ 2^2 = 6.5$ m



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

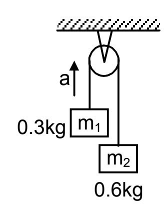
c) The force exerted by the clamp on the pully is given by

F – 2T = 0

F = 2T = 2 × 3.9 = 7.8 N.

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

T = 3.9 N



After 2 sec mass m_1 the velocity

V = u + at = 0 + 3.26 × 2 = 6.52 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

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

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

$\Rightarrow t = 6.52/9.8 = 0.66 = 2/3$ 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.

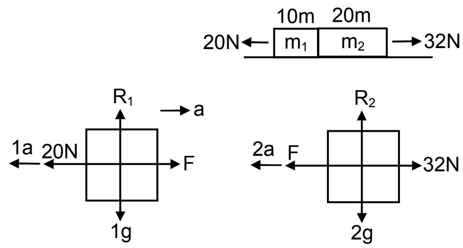
24. Mass per unit length 3/30 kg/cm = 0.10 kg/cm.

Mass of 10 cm part = m_1 = 1 kg

Mass of 20 cm part = m_2 = 2 kg.

Let, F = contact force between them.

From the free body diagram



$F - 20 - 10 = 0$ …(i)

And, $32 - F - 2a = 0$ …(ii)

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

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

25.

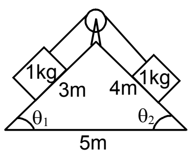


Fig-1

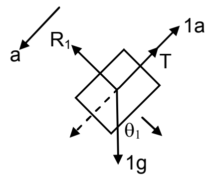


Fig-2

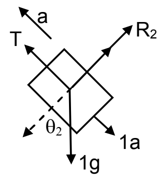


Fig-3

Sin $\theta_1 = 4/5$

sin $\theta_2 = 3/5$

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

$\Rightarrow g$ sing $\theta_1 = a + T$ …(i)

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

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

$\Rightarrow T = g \sin \theta_2 + a$ …(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.

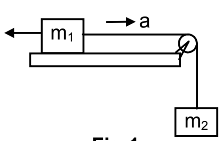


Fig-1

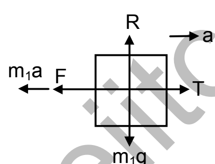


Fig-2

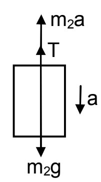


Fig-3

From the above Free body diagram

$M_1a + F - T = 0 \Rightarrow T = m_1a + F$ …(i)

From the above Free body diagram

$m_2a + T - m_2g = 0$ ….(ii)

$\Rightarrow m_2a + m_1a + F - m_2g = 0$ (from (i))

$\Rightarrow a(m_1 + m_2) + m_2g/2 - m_2g = 0$ {because $f = m^2g/2$}

$\Rightarrow a(m_1 + m_2) - m_2g = 0$

$\Rightarrow a(m_1 + m_2) = m_2g/2 \Rightarrow a = \frac{m_2g}{2(m_1 = m_2)}$

Acceleration of mass m_1 is $\frac{m_2g}{2(m_1 = m_2)}$ towards right.

27.

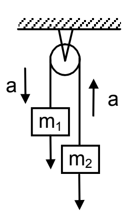


Fig-1

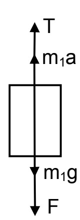


Fig-2

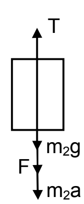


Fig-3

From the above free body diagram

$T + m_1a - m(m_1g + F) = 0$

From the free body diagram

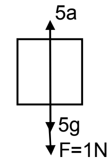
$T - (m_2g + F + m_2a) = 0$

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

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

From the eqn (i) and eqn (ii)

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



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

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

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

$m_1a = F + m_1g = (1 + 5g) = 5(g + 0.2)$ Force = 1N, acceleration = 1/5= 0.2m/s.

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

28.

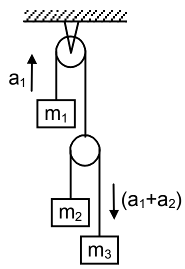


Fig-1

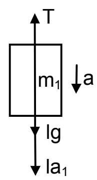


Fig-2

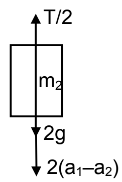


Fig-3

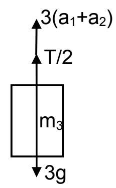


Fig-4

Let the block m+1+ moves upward with acceleration a, and the two blocks m_2 an 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

$T = 1g - 1a_2 = 0$ ...(i) from fig (2)

$T/2 - 2g - 2(a_1 - a_2) = 0$ ...(ii) from fig (3)

$T/2 - 3g - 3(a_1 + a_2) = 0$ ...(iii) from fig (4)

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

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)

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

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

$a_1 + a_2 = \dfrac{2g}{29} + \dfrac{19g}{29} = \dfrac{21g}{29}$ So, acceleration of m_1, m_2, m_3 ae $\dfrac{19g}{29}$ (up) $\dfrac{17g}{29}$ (doan) $\dfrac{21g}{29}$ (down) respectively.

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

$\therefore S = ut + ½ at^2 = 0.2 = \dfrac{1}{2} \times \dfrac{19}{29} gt^2 \Rightarrow t = 0.25$sec.

29.

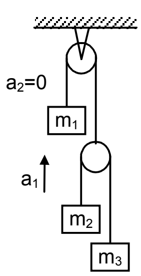


Fig-1

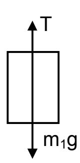


Fig-2

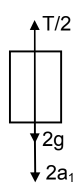


Fig-3

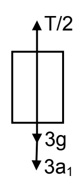


Fig-4

m_1 should be at rest.

$T - m_1g = 0$ $\qquad$ $T/2 - 2g - 2a_1 = 0$ $\qquad$ $T/2 - 3g - 3a_1 = 0$

$\Rightarrow T = m_1g$ …(i) $\qquad$ $\Rightarrow T - 4g - 4a_1 = 0$ …(ii) $\qquad$ $\Rightarrow T = 6g - 6a_1$ …(iii)

From eqn (ii) & (iii) we get

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

Putting yhe value of T eqn (i) we get, $m_1 = 4.8$kg.

30.

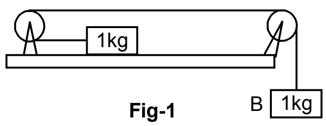


Fig-1

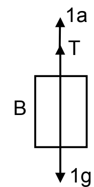


Fig-2

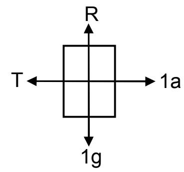


Fig-3

$T + 1a = 1g$ …(i) $\qquad$ $T - 1a = 0 \Rightarrow T = 1a$ (ii)

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) $T = 1a = 5$N.

31.

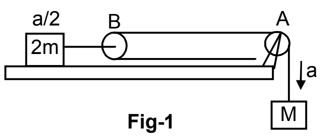


Fig-1

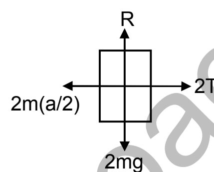


Fig-2

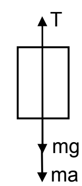


Fig-3

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

$\Rightarrow Ma = 2T \Rightarrow T = Ma/2$. $\qquad$ $\Rightarrow Ma/2 + ma = Mg$. (because $T = Ma/2$)

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

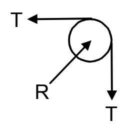
a) acceleration of mass M is 2g/3.

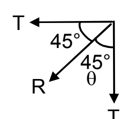
b) Tension $T = \frac{Ma}{2} = \frac{M}{2} = \frac{2g}{3} = \frac{Mg}{3}$

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

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

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





Again, $\tan\theta = \frac{T}{T} = 1 \Rightarrow \theta = 45°$.

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

32.

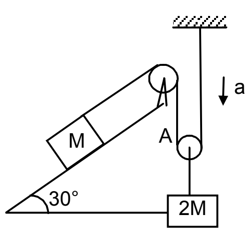


Fig-1

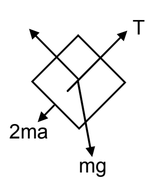


Fig-2

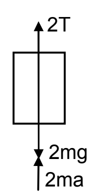


Fig-3

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

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

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

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

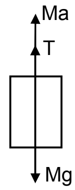
$\Rightarrow 4Ma + 2Mg\sin\theta + 2Ma - 2Mg = 0$

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

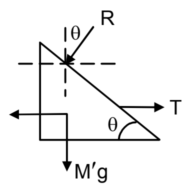
$\Rightarrow 6Ma = Mg \Rightarrow a = g/6$.

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

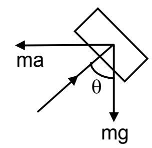
33.



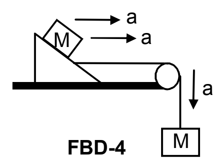
FBD-1



FBD-2



FBD-3



FBD-4

As the block 'm' does not slinover M′, ct will have same acceleration as that of M′

From the freebody diagrams.

$T + Ma - Mg = 0$ ...(i) (From FBD – 1)

$T - M'a - R\sin\theta = 0$ ...(ii) (From FBD -2)

$R\sin\theta - ma = 0$ ...(iii) (From FBD -3)

$R\cos\theta - mg = 0$ ...(iv) (From FBD -4)

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

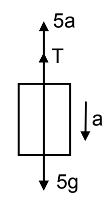
34. a) $5a + T - 5g = 0 \Rightarrow T = 5g - 5a$ ...(i) (From FBD-1)

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

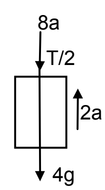
From equn (i) and (ii), we get

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

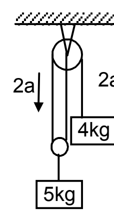
So, acceleration of 5 kg mass is g/7 upward and that of 4 kg mass is 2a = 2g/7 (downward).



FBD-1

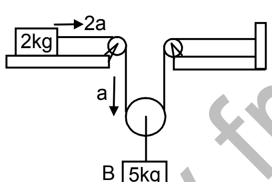


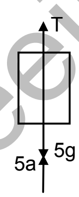
FBD-2



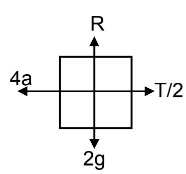
FBD-3

b)





FBD-3



FBD-4

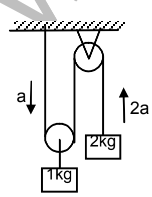
$4a - t/2 = 0 \Rightarrow 8a - T = 0 \Rightarrow T = 8a$ … (ii) [From FBD -4]

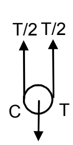
Again, $T + 5a - 5g = 0 \Rightarrow 8a + 5a - 5g = 0$

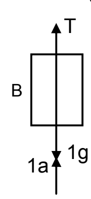
$\Rightarrow 13a - 5g = 0 \Rightarrow a = 5g/13$ downward. (from FBD -3)

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

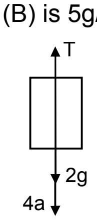
c)







FBD-5



FBD-6

$T + 1a - 1g = 0 \Rightarrow T = 1g - 1a$ …(i) [From FBD – 5]

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

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

$\Rightarrow$ a = –(g/3) downward.

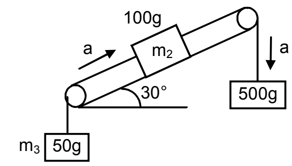
Acceleration of mass 1kg(b) is g/3 (up)

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

35. m_1 = 100g = 0.1kg

m_2 = 500g = 0.5kg

m_3 = 50g = 0.05kg.



T + 0.5a – 0.5g = 0 ...(i)

T_1 – 0.5a – 0.05g = a ...(ii)

T_1 + 0.1a – T + 0.05g = 0 ...(iii)

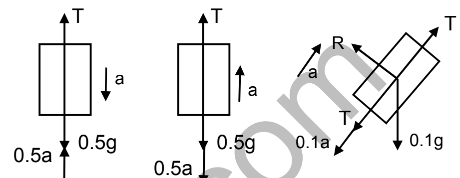
From equn (ii) T_1 = 0.05g + 0.05a ...(iv)

From equn (i) T_1 = 0.5g – 0.5a ...(v)

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 [From (iv) and (v)]

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



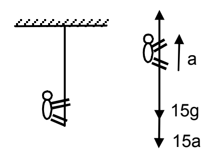
FBD-1 FBD-2 FBD-3

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

36. m = 15 kg of monkey. a = 1 m/s^2.

From the free body diagram

$\therefore$ T – [15g + 15(1)] = 0 $\Rightarrow$ T = 15 (10 + 1) $\Rightarrow$ T = 15 × 11 $\Rightarrow$ T = 165 N.



The monkey should apply 165N force to the rope.

Initial velocity u = 0 ; acceleration a = 1m/s^2 ; s = 5m.

$\therefore$ s = ut + ½ at^2

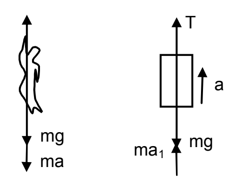
5 = 0 + (1/2)1 t^2 $\Rightarrow$ t^2 = 5 × 2 $\Rightarrow$ t = $\sqrt{10}$ sec.

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 ...(i)



$\Rightarrow$ T = mg + ma.

Again, from the FBD of the block,

T = ma_1 – mg = 0.

$\Rightarrow$ mg + ma + ma_1 – mg = 0 [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 exertied by monkey) no motion of monkey of 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.

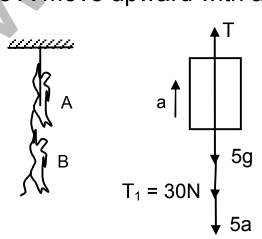


Fig-2

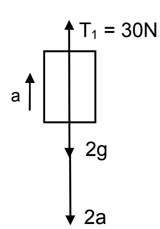


Fig-3

T – 5g – 30 – 5a = 0 ...(i)

$\Rightarrow$ T = 50 + 30 +(5 × 5) = 105 N (max)

30 – 2g – 2a = 0 ...(ii)

$\Rightarrow$ 30 – 20 – 2a = 0 $\Rightarrow$ a = 5 m/s^2

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

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

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

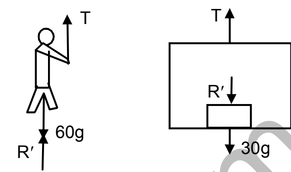
Equation (i) is $T - 5g - 20 = 0$ [As $T'_1 = 20$ N]

$\Rightarrow T = 5g + 20 = 50 + 20 = 70$ 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]

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

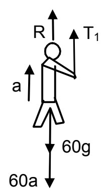
$T - R' - 30g = 0$ ...(ii) [From FBD of box]

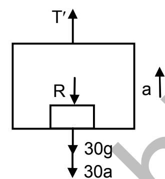
$\Rightarrow 60g - R' - R' - 30g = 0$ [From (i)]

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

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

In this case, given that correct weight = R = 60g, where g = acc^n due to gravity





From the FBD of the man

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

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

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

From the FBD of the box

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

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

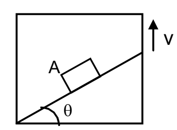
$\Rightarrow T^1 - 30a = 90g = 900$

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

From eqn (i) and eqn (ii) we get $T^1 = 2T^1 - 1800 \Rightarrow T^1 = 1800$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 $F = mg \sin\theta$,



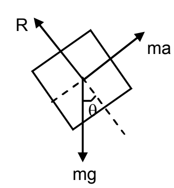
So, acceleration = $g \sin\theta$

Initial velocity of block u = 0.

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

Now, $S = ut + ½ at^2$

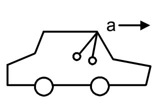
$\Rightarrow \ell = 0 + ½ (g \sin\theta) t^2 \Rightarrow g^2 = \dfrac{2\ell}{g \sin\theta} \Rightarrow t = \sqrt{\dfrac{2\ell}{g \sin\theta}}$

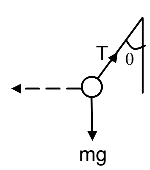


Time taken is $\sqrt{\dfrac{2\ell}{g \sin\theta}}$

41. Suppose pendulum makes θ angle with the vertical. Let, m = mass of the pendulum.

From the free body diagram





$T \cos\theta - mg = 0$

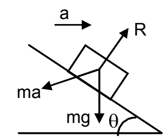
$\Rightarrow T \cos\theta = mg$

$\Rightarrow T = \dfrac{mg}{\cos\theta}$ ...(i)

$ma - T \sin\theta = 0$

$\Rightarrow ma = T \sin\theta$

$\Rightarrow t = \dfrac{ma}{\sin\theta}$ ...(ii)



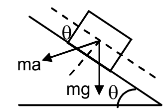
From (i) & (ii) $\frac{mg}{\cos\theta} = \frac{ma}{\sin\theta} \Rightarrow \tan\theta = \frac{a}{g} \Rightarrow \theta = \tan^{-1}\frac{a}{g}$

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

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

Suppose the angle of incline is 'θ'

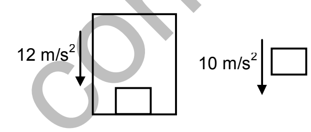
From the diagram



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

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

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



Now, the block has acceleration = g = 10 m/s^2

u = 0

t = 0.2 sec

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

$\therefore$ s = ut + ½ at^2

= 0 + (½) 10 (0.2)^2 = 5 × 0.04 = 0.2 m = 20 cm.

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

* * * *