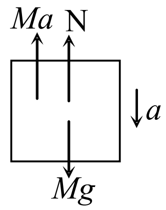
SOLUTIONS TO EXERCISE - I

Sol.1 : F.B.D. of block is as shown



$$Mg = N + Ma$$

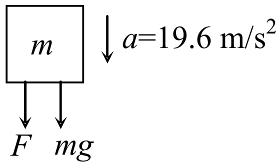
$$Mg = \frac{Mg}{4} + Ma$$

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

$\therefore$ **(c)**

Sol.:2 **(a)**

Sol.3: $F + mg = ma$



$F = m(a - g) = 2\,(19.6 - 9.8) = 19.6$ N

$\therefore$ **(a)**

Sol.4: $f = \mu\,(m_1 + m_2 + m_3)\,g = 0.4\,(3 + 2 + 1) \times 10 = 24$ N

To move the blocks $F \geq f$, $3t \geq 24$, $t \geq 8$s

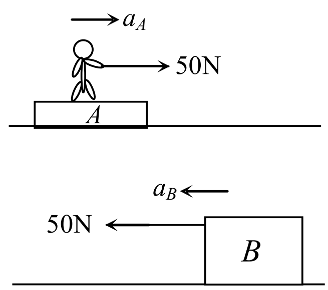
$\therefore$ **(b)**

Sol.5: $a = \dfrac{Mg\sin\theta}{2M}$ and $T = Ma$

$\therefore$ **(c)**

Sol.6: **(a)**

Maximum friction force between block *A* and boy = $0.5 \times 80 \times 10 = 400\,\text{N} > 50\,\text{N}$



So,

$$a_A = \frac{50}{200} = \frac{1}{4}\,\text{m/s}^2$$

$$a_B = \frac{50}{100} = \frac{1}{2}\,\text{m/s}^2$$

So relative *a* = 0.75 m/s²

Relative velocity

$$v = 0 + 0.75 \times 4 = 3\ \text{m/s}$$

Friction between boy and block *A*

$$f = 120 \times \frac{1}{4} = \mathbf{30\ N}$$

$\therefore$ **(a)**

Sol.7: The inclined plane exerts a force of $mg\cos\theta$ perpendicular to inclination and $mg\sin\theta$ along inclination.

$\therefore$ **(a)**

Sol.8: For equilibrium of $\sqrt{2}$ M block

$2T\cos\theta = \sqrt{2}Mg$, $T = Mg$, $\cos\theta = \frac{1}{\sqrt{2}}$, $\theta = 45°$

$\therefore$ **(c)**

Sol.9: Thrust on the block $F = v\frac{dm}{dt} = 5$ N

Acceleration of the block $= \frac{F}{M} = \frac{5}{2}\, ms^{-2}$

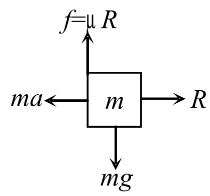
$\therefore$ **(b)**

Sol.10: $\Sigma F_y = 0$, $R = ma$

$Mg = \mu R = \mu ma$

$\mu = \frac{g}{a} = 0.5$

$\therefore$ **(c)**



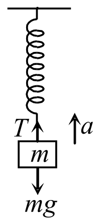
Sol.11: $T - mg = ma$

$T = mg + ma$

$Kx = m(g+a)$

$x = \frac{m(g+a)}{K}$

$\therefore$ **(c)**



Sol.12: $N = m_A(g-a) = 0.5(10-2) = 4$ N

$\therefore$ **(b)**

Sol.13: $mg - \eta mg = ma$, $a = g(1-\eta)$

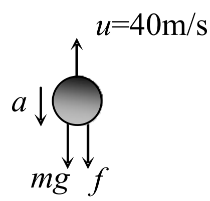
$\therefore$ **(a)**

Sol.14: Let retardation of body is a and air resistance is f

$v = u + at$

$0 = 40 - 3a$

$a = \frac{40}{3}$ m/s^2



$ma = mg + f$

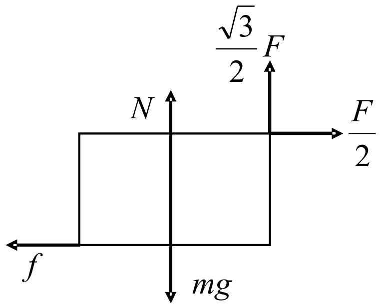
$f = ma - mg = 1.5\left(\frac{40}{3} - 10\right) = 5\text{ N}$

$\therefore$ **(d)**

Sol.15: **(b)** $f = \frac{F}{2} = \mu N$

Also, $N = mg - \frac{\sqrt{3}}{2}F$

$\Rightarrow \quad f = \mu\left(mg - \frac{\sqrt{3}}{2}F\right)$

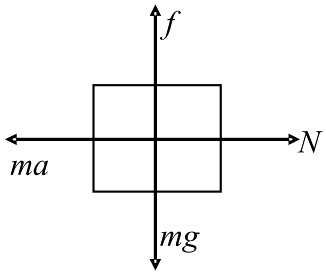


Sol.16: **(a)** $f = \mu N = mg$

Also, $N = ma$

$\Rightarrow \quad \mu ma = mg$

$\Rightarrow \quad a = \frac{g}{\mu}$



Sol.17: $m_1 = 2kg,\ m_2 = 4kg,\ m_3 = 6kg$,

$a = \frac{F - (m_1 + m_2 + m_3)g\sin 53^\circ}{m_1 + m_2 + m_3}$

$a = \frac{120 - 12\times 10\times 4/5}{12}, \quad = \frac{24}{12} = 2\,\text{ms}^{-2}$

$T_1 - m_1 g\sin 53^\circ = m_1 a$,

$T_1 = 4 + 20\times\frac{4}{5} = 20N$

$T_2 - (m_1 + m_2)g\sin 53^\circ = (m_1 + m_2)a$,

$T_2 = 12 + 60\times\frac{4}{5} = 60N, \quad \frac{T_1}{T_2} = \frac{1}{3}$

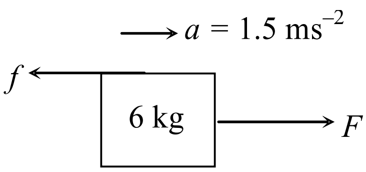
$\therefore$ **(c)**

Sol.18: $f = 0.4\times 2\times 10 = 8N$

$F - 8 = 6\times 1.5$

$F = 17N$

$\therefore$ **(a)**

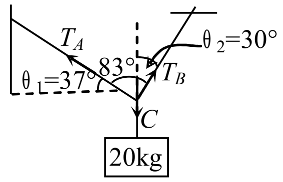


Sol.19: $T_A \cos\theta_1 = T_B \sin\theta_2$

$T_A \cos 37° = T_B \sin 30°$

$T_A \times \frac{4}{5} = T_B \times \frac{1}{2}$; $\frac{T_A}{T_B} = \frac{5}{8}$

∴ **(a)**



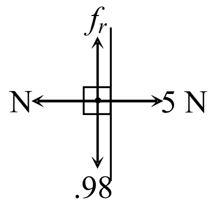
Sol.20: F.B.D. of block is as shown

Maximum frictional force = μN = 0.5 × 5 = 2.5 N

As, maximum friction force > frictional force required to avoid motion

∴ $f_r = mg = 0.98$ N

∴ **(b)**



Sol.21: As weight = 0.3 × 10 = 3 N trying to slide the two block system,

but $f_{max} = 0.5 \times 1 \times 10 + 0.5 \times 1 \times 10 = 10$ N,

Hence the system is in equilibrium, and friction of block *B* is sufficient to balance the weight hence tension between *A* and *B* is zero.

∴ **(d)**

Sol.22: $T \sin\theta = R$

$T \cos\theta = W$

Solving

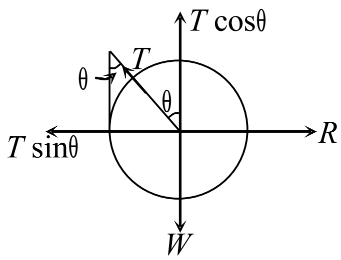
$T^2 = R^2 + W^2$

$R = W \tan\theta$

Vectorially

$R + T + W = 0$

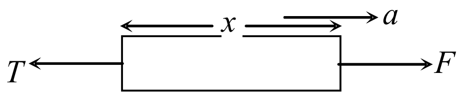
∴ **(c)**



Sol.23: Acceleration $a = \frac{F}{M}$

Drawing F.B.D.

$$F - T = \frac{M}{L}(x)a \quad \Rightarrow \quad T = F\left(1 - \frac{x}{L}\right)$$



∴ **(c)**

Sol.24: During downward motion: $F = mg\sin\theta - \mu mg\cos\theta$

During upward motion: $2F = mg\sin\theta + \mu mg\cos\theta$

Solving above two equations: we get $\mu = \frac{1}{3}\tan\theta$

∴ **(a)**

Sol.25: Frictional force = $\mu R = \mu(mg + Q\cos\theta)$ and horizontal push = $P + Q\sin\theta$

For equilibrium, we have $\mu(mg + Q\cos\theta) = P + Q\sin\theta$

$\therefore \quad \mu = \dfrac{P + Q\sin\theta}{mg + Q\cos\theta}$

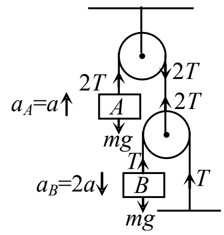
$\therefore$ **(a)**

Sol.26: $2T - mg = ma$ ...(i)

$mg - T = 2ma$ ...(ii)

(i) and (ii) $\Rightarrow \quad a = \dfrac{g}{5}$

$\therefore \quad a_B = \dfrac{2g}{5}$



$\therefore$ **(d)**

Sol 27.: Initially, the weight of load L is the force on the system of mass 8 kg.

Acceleration = $\dfrac{2 \times 10}{8} = \dfrac{20}{8}$ units

Toward the end, force = (2 + 1) × 10 N = 30 N

So, acceleration now is $\dfrac{30}{8}$ units.

$\therefore$ **(b)**

Sol.28: $m_2g - 2T = m_2a$

or $2T = m_2(g - a)$ ..... (i)

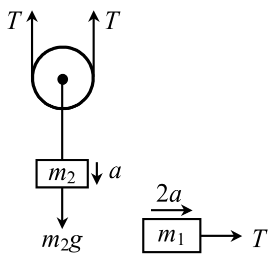
Again, $T = m_1(2a)$

or $2T = 4m_1a$ ..... (ii)

Equating (i) and (ii), $m_2g - m_2a = 4m_1a$

or $(4m_1 + m_2)a = m_2g$

$$a = \frac{m_2 g}{4m_1 + m_2}.$$



$\therefore$ **(a)**

Sol.29: $S = \dfrac{1}{2}\mu g t^2$ or $t \propto \dfrac{1}{\sqrt{\mu}}$.

$\therefore$ **(b)**

Sol.30: On cutting of string QR, the resultant force m_1 remains zero because its weight m_1g is balance by the tension in the spring but on block m_2 a resultant upward force $(m_1 - m_2)g$ is developed. Thus block m_1 will have no resultant acceleration whereas m_2 does have an upward acceleration given by $\dfrac{(m_1 - m_2)g}{m_2}$.

$\therefore$ **(a)**

Sol.31: $R = m(g - a)$ for downward motion of lift

If $a = g$, then $R = 0$ $\therefore$ $F = \mu R = 0$

$\therefore$ **(d)**

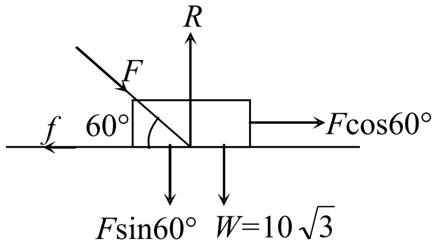
Sol.32: $f = \mu R = \mu\left(W + F\sin 60^\circ\right)$

$F\cos 60^\circ = \mu\,(W + F\sin 60^\circ)$

Substituting $\mu = \dfrac{1}{2\sqrt{3}}$ and $W = 10\sqrt{3}$,

we get $F = 20$ N

$\therefore$ **(a)**



Sol.33: Its velocity becomes $\dfrac{v_0}{2}$ under a retardation of μg in time t_0.

$\therefore$ $\dfrac{v_0}{2} = v_0 - \mu g t_0$ or $\mu g t_0 = \dfrac{v_0}{2}$ or $\mu = \dfrac{v_0}{2g t_0}$

$\therefore$ **(a)**

Sol.34: At equilibrium, let tension in each spring be T. Then

$2T\cos 60^\circ = Mg$

$T = Mg$

When right spring breaks, the net force on the block is T.

$\therefore$ $a = \dfrac{T}{M} = 10\,\text{m/s}^2$

$\therefore$ **(a)**

Sol.35: **(c)**

Sol.36: For $a = 0$, tension is constant throughout

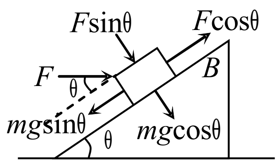
$F = \mu \times (4 + 2 + 3) \times g = 0.5 \times 9 \times 10 = 45N$

$\therefore$ **(c)**

Sol.37: Resultant force on block along the incline plane is =

$F\cos\theta - mg\sin\theta$

$\therefore$ **(b)**



Sol.38: $\mu mg = m\left(\dfrac{mg}{4m}\right) \Rightarrow \mu = \dfrac{1}{4}$

$\therefore$ **(c)**

Sol.39: $a_{\max} = \mu g$

$\therefore$ **(a)**

Sol.40: For constant velocity $F = mg$, so acceleration of man $a = \frac{F}{2m} = \frac{g}{2}$

$\therefore$ **(d)**

Sol.41: Let tension be T then. $T = ma$. For block M, $F - T = MA \Rightarrow A = \frac{F - ma}{M}$

$\therefore$ **(a)**

Sol.42: From constraint relation $v_B = \frac{v}{3}$

$\therefore$ **(c)**

Sol.43: $T_1 = \frac{mg}{\cos\theta}$, $T_2 = mg\cos\theta$

$\frac{T_1}{T_2} = \sec^2\theta = 2$

$\therefore$ **(b)**

Sol.44: $N_A = N_B$

$\therefore$ **(a)**

Sol.45: Maximum friction force is 50 N which is greater than 40 N. Block does not move.

$\therefore$ **(a)**

Sol.46: From constraint relation, $a_B = 8a_A$

$\therefore$ **(c)**

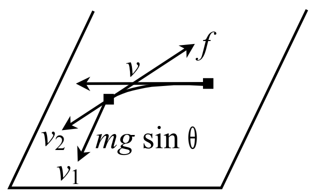
Sol.47: $m_3 g = 2T \Rightarrow m_3 = 1$ kg

$\therefore$ **(a)**

Sol.48:

Here friction force will be

$f = \mu N = \tan\theta \, mg\cos\theta = mg\sin\theta$



At any instant acceleration opposite to motion is equal in magnitude to the acceleration down the incline.

☒ $mg\sin\theta$ is acting down the plane.

So for small interval of time speed the block looses along its direction of motion exactly equals the speed it gain down the incline. Let v_2 be the speed of the block and v_1 is the component of velocity down the incline then

$v_2 + v_1 = \text{Constant} = C$

Initially $v_1 = 0$, so $C = v$

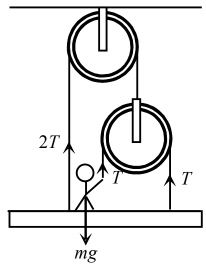
Finally $v_2 = v_1 = v_f$ after long time

$2v_2 = v$

$v_2 = \frac{v}{2} = v_1$

$\therefore$ **(b)**

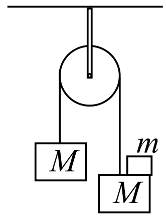
Sol 49: $4T = mg$



$\therefore \quad T = \frac{60 \times 10}{4} = 150$ N

$\therefore$ **(a)**

Sol50: Acceleration of blocks = $\frac{(M+m)g - Mg}{2M+m} = \frac{mg}{2M+m}$



Considering free body diagram of block m only

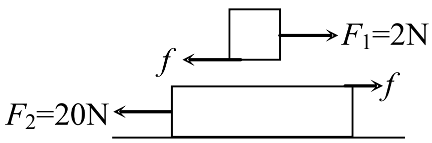
$mg - N = ma$

$N = m(g-a) = m\left[g - \frac{mg}{2M+m}\right]$

$N = \frac{2mMg}{2M+m}$

$\therefore$ **(b)**

Sol.51: Free body diagram of the two bodies are as follows



Let acceleration of both the blocks towards left is a.

Then $a = \frac{f-2}{2} = \frac{20-f}{4}$

or $2f - 4 = 20 - f$ or $f = 8$ N

Maximum friction between the two blocks can be $f_{max} = \mu mg = (0.5)(2)(10) = 10$ N

Now since $f < f_{max}$

Therefore, friction force between the two blocks is 8 N.

$\therefore$ **(a)**

Sol.52: Force at the surface of BC

$N = 2m(a)$, a = acceleration of system $\quad \therefore \quad N = 2m\frac{F}{5m} = \frac{2F}{5}$

To prevent slipping of block B, $\quad \mu N = mg$

$\Rightarrow \quad \frac{\mu 2F}{5} = mg$, $\quad F = \frac{5}{2\mu}mg$

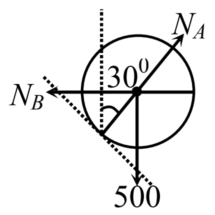
$\therefore$ **(b)**

Sol.53: $N_A \cos 30^0 = 500$

$N_A \sin 30^0 = N_B$

$\sqrt{3} = \dfrac{500}{N_B}$

$N_B = \dfrac{500}{\sqrt{3}}$ N



∴ **(c)**

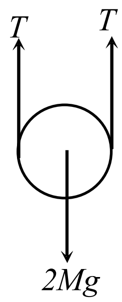
Sol.54: For pulley, $2T - 2Mg = 0 \Rightarrow T = Mg$

For man,

$T = Ma$

$Mg = Ma$

$a = g$



∴ **(d)**

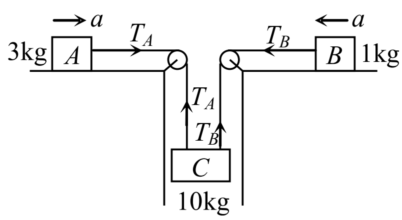
Sol.55: By constraint relation,

aA = aB, aA = aB = aC = a

$T_A = m_A a = 3a$ **and**

$T_B = m_B a = a$

∴ $\dfrac{T_A}{T_B} = 3$ **: 1**



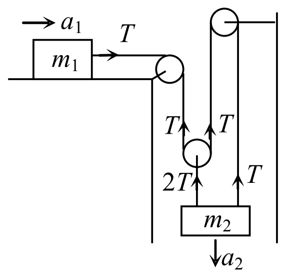
∴ **(a)**

Sol.56: $a_1 = 3a_2$ **…(i)**

$T = m_1 a_1$ **…(ii)**

$m_2 g - 3T = m_2 a_2$ **…(iii)**

$m_1 = m_2 = m$ **…(iv)**



Solving above equation we get,

$a_1 = \dfrac{3g}{10}$, $a_2 = \dfrac{g}{10}$

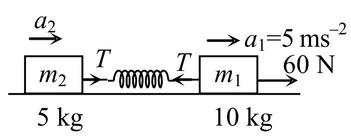
∴ **(c)**

Sol.57: 60 – T = 10 ×5

T = 10 N

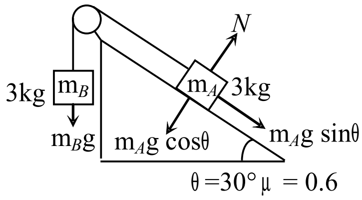
T = 5a2

a2 = 2 ms–2



∴ **(a)**

Sol.58: $m_Bg = 30$ N



$m_Ag \sin\theta = 30 \times \frac{1}{2} = 15$ N

Net pulling force = 30 – 15 = 15 N

$f_l = \mu\, m_Ag \cos\theta$

$= 0.6 \times 30 \times \frac{\sqrt{3}}{2}$

$= 9\sqrt{3} = 9 \times 1.732 = 15.6$ N

∵ f_l > pulling force

∴ f = pulling force = 15 N

∴ **(d)**

Sol.59(c)

Sol.60(b)

Sol.61: $N = mg\cos\alpha$

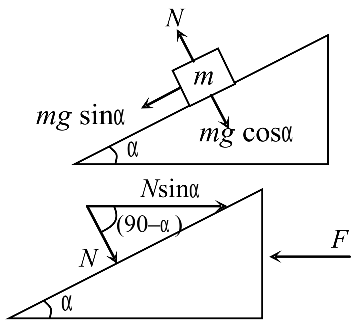
Let F force is required to keep wedge stationary.

From FBD of wedge

$F = N\sin\alpha$

$F = mg\cos\alpha\sin\alpha$

∴ **(d)**



Sol.62: $f_l = \mu_s m_1 g = 25\text{N},\ (a_2)_{max} = \frac{f_l}{m_2} = \frac{5}{6}\ \text{ms}^{-2}$

$a_{combined} = \frac{F}{m_1 + m_2} = 1\,\text{ms}^{-2}$

$(a_2)_{max} < a_{combined}$, ∴ there will be slipping between the blocks.

∴ $f = \mu_k m_1 g = 12\text{N}$

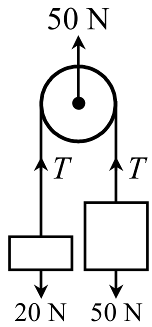
$a_2 = \frac{f}{m_2} = \frac{12}{30} = 0.4\ \text{ms}^{-2}$

∴ **(b)**

Sol.63: $f = \mu R = \mu mg$, where m is mass of the combination, $f = 0.5 \times 10 \times 10$ N = 50 N.

So, a force of 10 N is unable to start the motion of the system. There is no relative motion between A and B.

∴ **(d)**



Sol.64: The masses will be lifted if the tension of the string is more than the gravitational pull on masses.

Here weight of 5 kg mass = 5 × 10 = 50 N and 2 kg mass = 2 × 10 = 20 N

From free body diagram 50 – 2T = 0 or T = 25 N

So 5 kg weight can not be lifted (..... acceleration = 0) but 2 kg weight will be lifted.

$\therefore$ $25 - 20 = 2a$ or $a = \frac{5}{2} = 2.5\ ms^{-2}$

$\therefore$ **(a)**

Sol.65: $F = mg(\sin\theta + \mu\cos\theta)$

$= 10 \times 9.8(\sin 30^\circ + 0.5\cos 30^\circ) = 91.4$ N

$\therefore$ **(b)**

Sol.66: $\therefore$ **(d)**

Sol.67: Total length of string is constant.

$x_2 = 7x_1$

$a_2 = 7a_1$

$\therefore$ **(d)**

Sol.68. (c)

Sol.69: **(b)** $\frac{at}{m_1 + m_2} = \text{acc}$

at sliding pseudo force on m_1 = friction force most

$\therefore$ $\frac{m_1 a t_0}{(m_1 + m_2)} = k m_1 g$

Sol.70: **(b)** $f_L = \mu N = (0.5)(15) = 7.5N$

driving force i.e. weight of block is less than limiting friction. Hence friction force is equal to weight

$f = mg = 0.5 \times 9.8 = 4.9$ N

Sol.: At the top

$T + mg = \frac{mv^2}{L}$

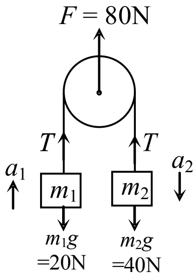
$T < 10mg$

$v < \sqrt{11gL}$

$\sqrt{3gL} < u < \sqrt{13gL}$

$\therefore$ **(c)**

Sol.71: Pulley is ideal



$\therefore \quad 2T = 80 \quad \Rightarrow \quad T = 40$ N

$$a_1 = \frac{40-20}{2} = 10 \text{ m/s}^2 \text{ (upwards)}$$

$$a_2 = \frac{40-40}{4} = 0$$

If acceleration of m_1 and m_2 w.r.t. pulley is a_0 and acceleration of pulley is a then,

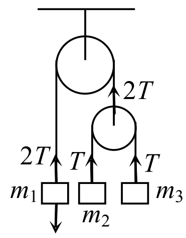
$a_1 = a + a_0 \Rightarrow a + a_0 = 10$

$a_2 = a - a_0 \Rightarrow a = a_0$

$\therefore \quad a_0 = 5$ m/s^2

$\therefore$ **(b)**

Sol.72: If m_1 remains at rest



$2T = m_1g$ …(i)

$$T = \frac{2m_2m_3g}{m_1+m_2} \quad \text{…(ii)}$$

From (i) and (ii)

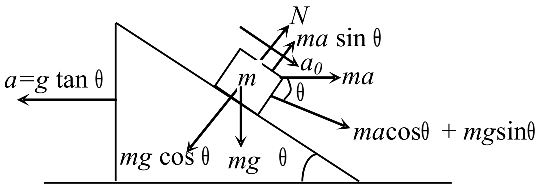
$$\frac{4m_2m_2g}{m_1+m_2} = m_1g$$

$$\frac{1}{m_1} = \frac{m_1+m_2}{4m_2m_3}, \qquad \frac{4}{m_1} = \frac{1}{m_2} + \frac{1}{m_3}$$

$\therefore$ **(b)**

Sol.73: Drawing *FBD* of block *m* from the frame of wedge,

let a_0 is acceleration of block with respect of wedge,



$ma_0 = ma\cos\theta + mg\sin\theta$

$a_0 = g\tan\theta\cos\theta + g\sin\theta$

$a_0 = 2g\sin\theta$

$\therefore$ **(b)**

Sol.74(c)

Friction between rod and bead is less than maximum possible friction.

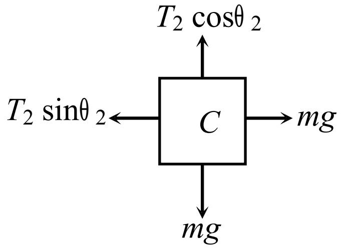
SOLUTIONS - MORE THAN ONE CHOICE

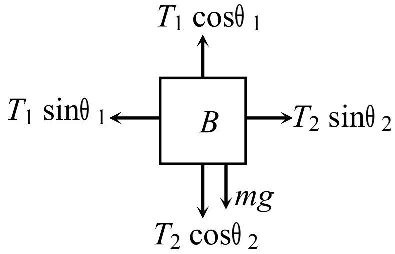
1. $T_2 \sin\theta_2 = mg$ … (i)

$T_2 \cos\theta_2 = mg$ …(ii)

$T_1 \cos\theta_1 = mg + T_2 \cos\theta_2$

$T_1 \sin\theta_1 = T_2 \sin\theta_2$





∴ **(a) (c) and (d)**

2. Resultant force may not be zero for coplanar forces. Hence (a) is not true

Since magnitudes are not equal (b) can not be true. In (c) and (d), net force is zero

∴ **(c, d)**

3. Here $10 - T_2 = 10a$ … (i)

$T_2 - T_1 - 0.3 \times 2g = 3a$ … (ii)

$T_1 - 0.3 \times 2g = 2a$

Summing up $10g - 0.3 \times 4 \times g = 15a$

i.e. $a = 5.86 \text{ ms}^{-2}$

$T_2 = 10 \times 9.8 - 10 \times 5.86 \text{ ms}^{-2} = 41.4 \text{ N}$

$T_1 = 2 \times 5.86 + 0.6 \times 9.8 = 17.7 \text{ N}$

∴ **(a) (b) and (c)**

4. $a_1 > 0$ when $\frac{F}{4} > 50$, $F > 200$

$a_2 > 0$ when $\frac{F}{4} > 100$, $F > 400$

F = 300 N

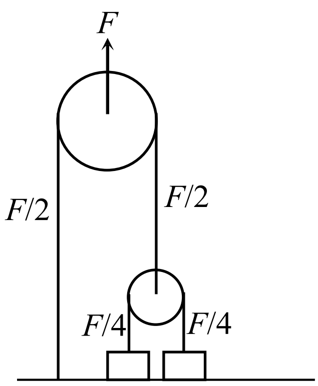
$a_1 = \frac{F/4 - 50}{5} = \frac{300/4 - 50}{5} = 5 \text{ m/s}^2$

$a_2 = 0$

If $F = 500$ N

$a_1 = 15 \text{ m/s}^2$, $a_2 = 2.5 \text{ m/s}^2$

∴ **(a) (b) (c)**



5. (a) (b) (c)

6 Maximum acceleration block $A = \frac{0.5mg}{m} = \frac{g}{2}$

So, if $M = 2m$, $a_A = a_B = \frac{2mg}{4m} = \frac{g}{2}$ and friction force is $\frac{1}{2}mg$.

$\therefore$ **(a), (b) and (c)**

7. Friction maximum = 24 N

So net applied force on P is less than f_{max}.

Hence acceleration is zero and $T_A = 20$ N, $T_B = 40$ N

Contact force $= \sqrt{N^2 + (f)^2} = \sqrt{(40)^2 + (20)^2} = 20\sqrt{5}$ N

$\therefore$ **(a) (b) (c) and (d)**

.

8. **(a) and (b)**

9 If acceleration of the system is

$F = 4ma \Rightarrow a = \frac{F}{4m}$ $\therefore$ since acceleration of each block is $\frac{F}{4m}$

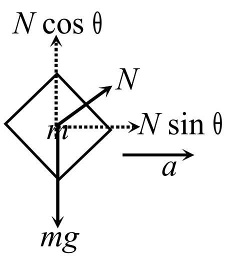
$\therefore$ net force on each block is $\frac{F}{4}$

$\therefore$ **(a) and (b)**

10. $N\cos\theta = mg$

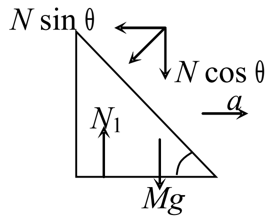
$N\sin\theta = ma$

$a = g\tan\theta$



$N_1 = Mg + N\cos\theta = Mg + mg$

$\therefore$ **(b) and (c)**

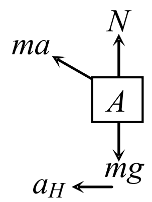


11. From FBD of A with respect to B

$a_v = 0$

$mg = N - ma\sin\theta$

$\Rightarrow N = mg - ma\sin\theta$



$ma\cos\theta = ma_H \Rightarrow a_H = a\cos\theta$

If block B is having friction then, for $a_H =$ 0

$ma\cos\theta \le \mu N = \mu(mg - ma\sin\theta)$

$\mu \ge \dfrac{a\cos\theta}{g - a\sin\theta}$

∴ **(b) and (d)**

12. $F - T - \mu_2 m_2 g = m_2 a$, $T - \mu_2 m_2 g = m_1 a$

for just equilibrium $a = 0$, $F = 2\mu_2 m_2 g = 4\,\text{N}$

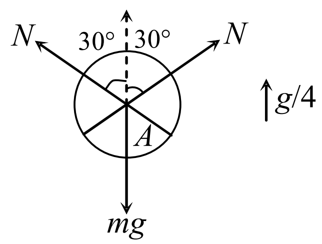
If $F = 6\text{N}$, $a = 1\ \text{m/s}^2 \Rightarrow T = 3\text{N}$

(a), (c) and (d)

13. Net upward force on three spheres applied by bottom

$= 3mg + \dfrac{3}{4}mg = \dfrac{15mg}{4}$

For sphere A, $N\sqrt{3} = mg + \dfrac{mg}{4}$, $N = \dfrac{5mg}{4\sqrt{3}}$



∴ **(b) and (d)**

14. Due to symmetry net force on M is zero. Hence its acceleration is also zero and acceleration of B is $\dfrac{mg}{2m} = \dfrac{g}{2}$.

∴ **(a) and (c)**

15. As the tendency of motion is rightward, so the frictional force on B acts leftward, but on A it has any direction i.e. left or right. Also if F_1 and F_2 are less than limiting friction at A and B, then tension is zero.

∴ **(b), (c) and (d)**

16.

(a) (b) and (c)

17. **(a)**

18. **(c)**

19. **(a) (d)**

Exercise - 3 Solutions

Comprehension - 1

To just start sliding

….(i)

To move down the plane with constant speed

….(ii)

and …(iii)

Solving (i) (ii) and (iii) we get

If man pushes block continuously by force F down the plane then

Minimum force required to just move block up the incline

Force required to move block up the incline at constant speed

=

Comprehension - 2

Sol. When M = 45 acceleration of the system

Friction

System will not slip for any value of M.

Comprehension – 3

Sol. (Q. 9) F. B. D of body

Acceleration decreases continuously as a function of velocity

Ans. (C)

Q. 10 When body attains terminal speed

Q.11 by equation (i) Ans. (C)

Comprehension - 4

Q.12 At a particular value of pseudo force becomes equal to tension, at this time friction will be zero. And maximum value of friction depends on normal Reaction between M and trolley and not on there fore Ans. (A), (B), (C), (D) all are correct.

Q.13

Ans. (A)(B)(C) and (D) are correct.

Q.14 If T < mg 'm' is accelerating downward friction will be

If 'm' is accelerating upwards friction will be

When block m at rest T = mg

Ans. (A)(B)(C) are correct.

Comprehension – 5

Q. 15 Acceleration of system is

Q.16 Tension is given by

…..(i)

…(ii)

….(iii)

Solving (i) (ii) and (iii) we get

Ans (D)

Q.17 Net force = mass acceleration =

Ans. (B)

Match the column

1. A - q; B - r; C - q; D - r

ans

= Ans.

Ans.

Ans.

2. A - r; B - q; C -q s; D - q

To solve this problem just keep in mind if both the ends of a spring are not free to move spring can not change its length suddenly

3. A - q,s; B - s

Friction always try to stop slipping therefore it opposes relative motion.

4. A - p; B - q; C - q,r; D - r

If block is at rest friction is

Normal reaction always =

When block is moving on the plane with constant velocity friction is =

When block is moving on the plane with constant acceleration friction is =

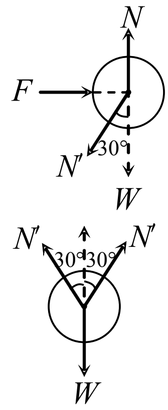
5. (A) - p,q,r,t; (B) - p, q, t; (C) - p,q,r.s,t.; (D) -p, q, t.

Slope of the curve

SOLUTIONS TO EXERCISE - 4

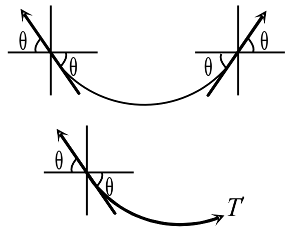
1. For the system to remain in equilibrium, the normal force between the lower cylinders must be zero.
Free body diagram of left lower cylinder
i.e. $F = N'\sin 30°$ ...(i)
Free body diagram of the upper bar
i.e. $W = 2N'\cos 30°$ ...(ii)
From (i) and (ii),

$$F = \frac{W\sin 30°}{2\cos 30°} = \frac{W}{2}\tan 30° = \frac{W}{2\sqrt{3}} = \frac{20\sqrt{3}}{2\sqrt{3}} = 10\text{ N}$$



2. $2T\sin\theta = W$ ...(i)
$T\cos\theta = T'$ ...(ii)
From (i) and (ii)

$$T' = \frac{W\cos\theta}{2\sin\theta} = \frac{W}{2}\cot\theta = 5\text{N}$$

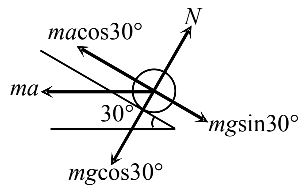


3. When upper spring is cut both the blocks A & B move with same acceleration.

4. $ma\cos 30° = mg\sin 30°$

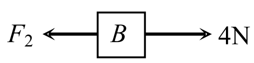
$a = g\tan 30° = \dfrac{g}{\sqrt{3}}$

∴ $n = 10$



5. From constraint relation, $v_C = 5\text{m/s}$ towards left

6. The acceleration of the bracket $= \dfrac{F_1 - 2F_2}{m} = 4$ m/s^2. (m = 1 kg)
Drawing the F.B.D. of the block B



The acceleration of the block with respect to bracket $= \dfrac{F_2 - 4}{1} = 4\text{m/s}^2$
Using, the kinematics of uniformly accelerated motion,

$s = \dfrac{1}{2}at^2$

$50 = \dfrac{1}{2}\times 4\times t^2$

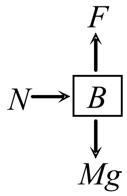
$t = 5$ s

7. Let the acceleration of the rope being a downwards. Then the equation of motion for man A is
$T - mg = m(a + a')$ ...(i)
and for man B being
$mg - T = ma$ ...(ii)
From (i) and (ii)
$ma + ma' = -ma$

i.e. $2ma = ma'$

$$a = \frac{a'}{2} = 5 \text{ m/s}^2$$

8. The system is moving towards right with acceleration. This is also the acceleration of A. The equation of motion of B, being



$$F - Mg = Ma'$$

$$-\frac{Mg}{2} = Ma'$$

$a' = \frac{g}{2}$ in downward direction.

The net acceleration of B being $\sqrt{a^2 + a'^2}$

$$a_B = \sqrt{\frac{g^2}{16} + \frac{g^2}{4}} = \frac{\sqrt{5}\,g}{4}$$

Hence, $\frac{a_A}{a_B} = \frac{g}{4} \times \frac{4}{\sqrt{5}\,g} = \frac{1}{\sqrt{5}}$

$\therefore$ $n = 1$

9. The equation of motion of A and B along the incline and perpendicular to it are given by

The equation of motion of A and B along the incline perpendicular to if are given by

$$Mg\sin 37^\circ - N' = Ma_B \qquad \ldots\text{(i)}$$

$$T - Mg\cos 37^\circ = Ma_A \qquad \ldots\text{(ii)}$$

$$Mg\sin 37^\circ + N' - T = Ma_B \qquad \ldots\text{(iii)}$$

By constraint relation, $a_B = a_A$

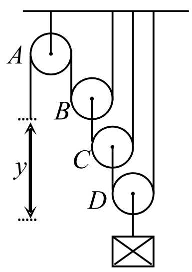
From (i), (ii) and (iii),

$a_B = \frac{4}{3}\text{m/s}^2$ $\qquad \therefore \; n = 3$

10. By constraint relation,

The acceleration of effort = 8 × the acceleration of load

Given,

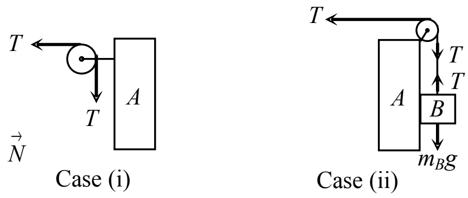


$$\frac{dy}{dt} = 24t^2$$

$$\int_0^y dy = 24\int_0^t t^2 dt$$

$$y = \frac{24t^3}{3} = 8t^3 = 72$$

$t = 3$s



11. In case (i),

$T - N = 40a$ …(i)

$N = 20a$ …(ii)

$m_B g - T = 20a$ …(iii)

Solving we get

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

Hence acceleration of block B will become $\frac{g}{2\sqrt{2}}$.

In case (ii),

$T = 40a$ ...(iv)

$20g - T = 20a$ …(v)

Solving, we get, $a = \frac{g}{3}$

Hence acceleration of block B will become $\frac{g}{3}$.

The required ratio = $\frac{g/2\sqrt{2}}{g/3} = \frac{3}{2\sqrt{2}}$

$n = 1$

12. $2kx = m_1 g$ …(i)

When the string is cut

$Kx - m_2 g = m_2 a$ …(ii)

$$\frac{m_1 g}{2} - m_2 g = m_2 a$$

$$\frac{15}{2}g - 5g = 5a$$

$$\frac{3g}{2} - g = a$$

$$\Rightarrow \quad \frac{g}{2} = a$$

i..e. $a = 5$

13. By constraint relation,

$$v_B = \frac{v_A}{2},\ a_B = \frac{a_A}{2}$$

$$v_B = 50 \text{ cm/s},\ a_B = 1 \text{m/s}^2$$

14. $a_2 = \frac{14}{10} \text{ m/s}^2$

$a_1 = 1 \text{ m/s}^2$

$$a_{1/2} = -\frac{4}{10} \text{m/s}^2$$

$$t^2 = \frac{2s}{a_{1/2}} = \frac{10}{4} \text{s}$$

$$s_2 = \frac{1}{2} \times \frac{14}{10} \times \frac{10}{4} = 175 \text{ cm}$$

15. $a_{m/p} = 0.2 \times 10 + \dfrac{50 \times 0.2 \times 10}{10}$

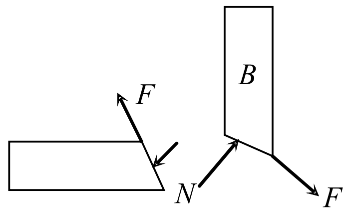
$= 12\ \text{m/s}^2$

$v_{\max} = \sqrt{2 \times 12 \times 150} = 60\ \text{m/s}$

$60\dfrac{t}{2} = 300$

$t = 10$ seconds

16. $N\cos\theta = mg + f\sin\theta$



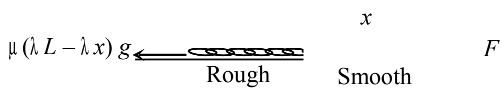
$N\cos\theta = \left(\dfrac{mg}{1-\mu}\right)$

$F \geq f\cos 45^\circ + N\sin 45^\circ$

$= \dfrac{1.4\ \text{mg}}{(1-\mu)}$

$\dfrac{= 1.4 \times 0.6\ g}{0.6} = 14\ \text{N}$

17: $F - \mu(\lambda L - \lambda x)g = \lambda L v\dfrac{dv}{dx}$

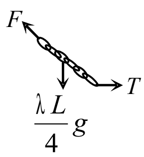


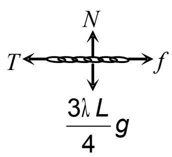
$F\int_0^L dx - \mu\lambda g\int_0^L (L - x)dx = \lambda L\int_0^v v\,dv$

$FL - \mu\lambda g\left(L^2 - \dfrac{L^2}{2}\right) = \dfrac{\lambda L v^2}{2}$

$v = \sqrt{F - L}$

18: $F\cos 37^\circ = \dfrac{\lambda L}{4}g$





(where λ is the mass/length of the chain).

$F\sin 37^\circ = T = f \leq \mu N$

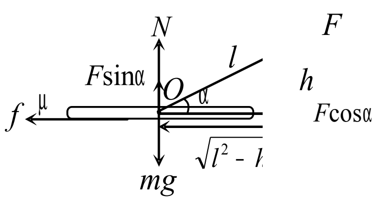
$\Rightarrow \quad \mu \geq \dfrac{1}{4} \quad \Rightarrow$

$\mu_{\min} = \dfrac{1}{4}$

19: $N = mg - F\sin\alpha$

$F\cos\alpha = f = \mu N$

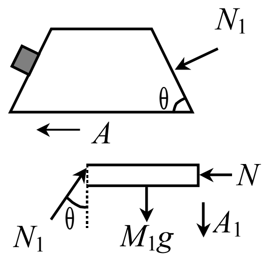
$F\cos\alpha = \mu(mg - F\sin\alpha)$



$\mu = \dfrac{F\cos\alpha}{mg - F\sin\alpha} = \dfrac{F \times \dfrac{\sqrt{l^2 - h^2}}{l}}{mg - F \times \dfrac{h}{l}}$

$$\mu = \frac{F\sqrt{l^2 - h^2}}{mgl - Fh}$$

20: Let M_1 be the mass of the rod.



$M_1 g - N_1 \cos\theta = M_1 A_1$ … (i)

$N_1 \sin\theta = (M + M)A$

… (ii)

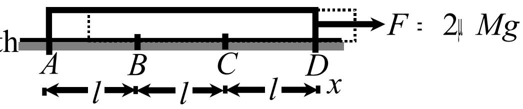
$A = g\tan\theta$ … (iii)

relation between A_1 and A

$A_1 = A\tan\theta$

So by solving these equations $\boldsymbol{M_1 = 3M}$

21.: If the block has moved by distance x,



$$Ma = 2\mu Mg - \left[\frac{\mu Mg}{3} + \frac{2\mu Mg}{3} + \frac{3\mu Mg}{3l}(l - x)\right]$$

$$a = 2\mu g - \left(\frac{\mu g}{3} + \frac{2\mu g}{3} + \frac{3\mu g}{3l}(l - x)\right)$$

$$\frac{da_1}{dx} = \frac{3\mu g}{3l}$$ [for 2nd and 3rd cells similarly]

$\tan\theta_1 : \tan\theta_2 : \tan\theta_3 =$ **3 : 2 : 1**