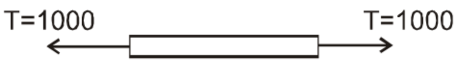
TOPIC : NEWTON'S LAWS OF MOTION
EXERCISE # 1
PART – I

SECTION (A)

1. Experimental fact.

2. Force exerted by string is always along the string and of pull type. When there is a contact between a point and a surface the normal reaction is perpendicular to the surface and of push type.

3.


4. Component of weight along incline plane is mg sin θ as θ decreases mg sin θ will decrease.

9. $\vec{F} = m\vec{a}$

10. While the horse pulling a cart, the horse exerts a force on the ground, therefore from the third law of newton, the ground will also exerts a force on the horse that causes the horse to move forward.

11. Inertia of rest keeps the upper part of body at rest while lower part of the body moves forward with the horse

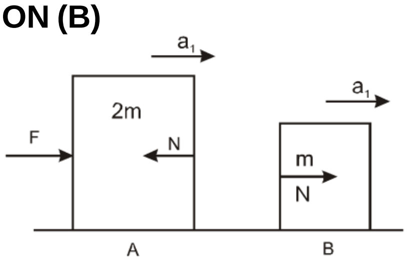
12. Particle will move with uniform velocity due to inertia.

14. $\vec{F} = m\vec{a}$ $\Rightarrow$ $\vec{a} = \frac{d\vec{v}}{dt}$

15. $2mg\cos\theta = Mg$ $\Rightarrow$ $\cos\theta = \frac{M}{2m} < 1$ $\Rightarrow$ $M < 2m$

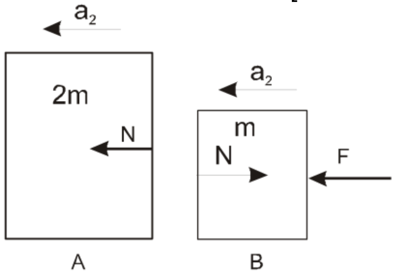
17. Due to inertia of motion upper part of body continues to be in motion in forward direction while feet come to rest as soon as they touch the road

SECTION (B)

1.


$F - N = 2\,ma$, [Newton`s II law for block A]

$N = ma_1$ [Newton`s II law for block B] $\Rightarrow$ $N = \frac{F}{3}$

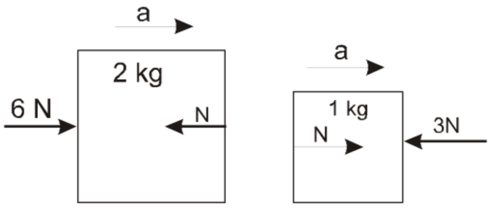


$N = 2\,ma_2$ [Newtons II law for block A]

$F - N = m_2a$ [Newtons II law for block B]

$\Rightarrow$ $N = 2F/3$ so the ratio is 1 : 2

2.



Both blocks are constrained to move with same acceleration.

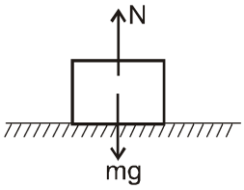
$6 - N = 2a$ [Newtons II law for 2 kg block]

$N - 3 = 1a$ [Newtons II law for 1 kg block] $\Rightarrow$ N = 4 Newton

3. $v = u + at$

$\Rightarrow \quad 30 = 0 + \frac{F}{m} \times t \Rightarrow \quad 30 = \frac{6}{1} \times t \quad \Rightarrow \quad t = 5$ sec.

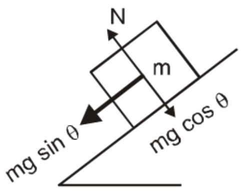
4.



At equilibrium N = mg = 40 × 980 = 39200 dyne

5. When bird starts flying in the cage, the weight of the bird is not measured. Therefore, weight of the bird cage assembly is now 1.5 kg or 1500 g.

6.

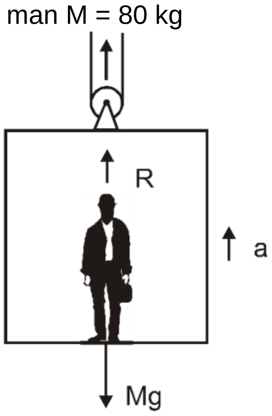


$N = mg \cos\theta$ → force exerted by plane on the block.

7. Mass is independent on frame of refrace

8. When acclerated upward $N - mg = ma \Rightarrow N = m(g + a)$

9. **Key Idea :** When lift is moving upwards, it weighs more than actual weight of man by a factor of ma.
Mass of man M = 80 kg



acceleration of lift, a = 5 m/s^2

When lift is moving upwards, the reading of weighing scale will be equal to R. The equation of motion gives

$R - Mg = Ma$

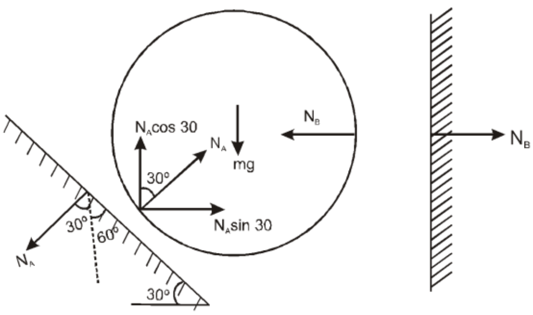
or $R = Mg + Ma = M(g + a)$

∴ $R = 80(10 + 5) = 80 \times 15 = 1200$ N

10. Apparent weight of an object in a lift going upward with acceleration 'a' is
$W' = m(g + a) = 10 \times (9.8 + 2) = 10 \times 11.8 = 118$ newton

11. Mass of the boy m = 50
Acceleration of lift (downwards) a = 9.8 m/s^2
The apparent weight of the boy when the lift is moving downwards
w = m (g – a) = 50 (9.8 – 9.8) = 0

12. Mass measured by physical balance remains unaffected due to variation in acceleration due to gravity.

13.


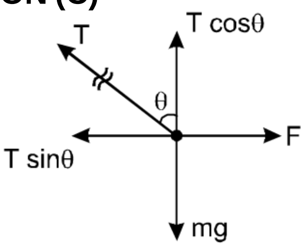
$mg - N_A \cos 30 = 0$ [Equilibrium in vertical direction]

$\Rightarrow \quad N_A = \dfrac{mg}{\cos 30} \quad \Rightarrow \quad N_A = \dfrac{1000}{\sqrt{3}}$ N

$N_B - N_A \sin 30 = 0$ [Equilibrium in horizontal]

$\Rightarrow \quad N_B = N_A \sin 30 \quad \Rightarrow \quad N_B = \dfrac{1000}{\sqrt{3}} \dfrac{1}{2} \quad \Rightarrow \quad N_B = \dfrac{500}{\sqrt{3}}$ N

SECTION (C)

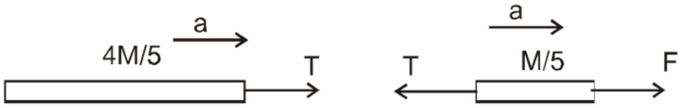
1.


Point A is massless so net force on it must be zero otherwise it will have ∞ acceleration.

$\Rightarrow \quad F - T\sin\theta = 0$

[Equilibrium of A in horizontal direction]

$\Rightarrow \quad T = \dfrac{F}{\sin \theta}$

2.


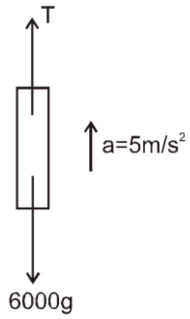
Equation of motion

$F - T = \dfrac{M}{5} \times a$ ....(1)

$T = \dfrac{4M}{5} \times a$ ....(2)

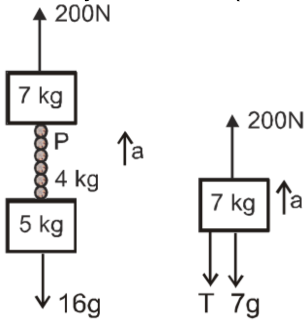
Solving (1) and (2)

T = 4 N



3. $T - 6000g = 6000 \times 5 \quad \Rightarrow \quad T = 90000$ N

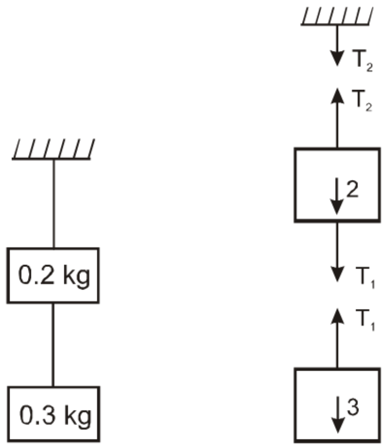
4. Equation of motion of system $200 - (7+4+5)\,g = (7+4+5)\,a$



$\Rightarrow \quad a = 40/16 \text{ m/s}^2$

Equation of motion of 7kg block $200 - T - 7\times g = 7\times a = 7 \times (40/6) = 35/2$

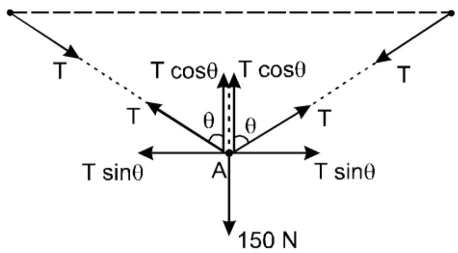
$\Rightarrow \quad 200 - 35/2 - 70 = T \qquad \Rightarrow \quad T = 112.5$ N



6.

$T_1 - 3 = 0$ [Equilibrium of lower block]

$\Rightarrow \quad T_2 - T_1 - 2 = 0$ [Equilibrium of upper block] $\Rightarrow \quad T_2 = 5$ N



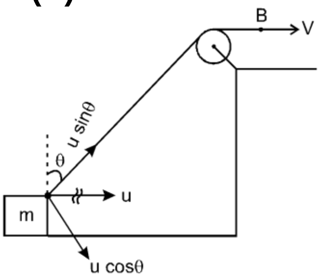
7.

$T\cos\theta + T\cos\theta - 150 = 0$ [Equilibrium of point A]

$2T\cos\theta = 150 \qquad T = \dfrac{75}{\cos\theta}$ When string become straight θ becomes 90º

Section (D)

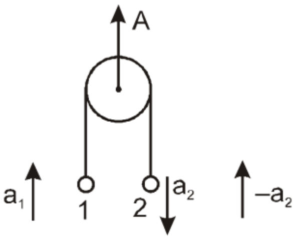
1.



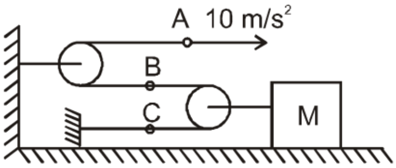
The length of string AB is constant. ⇒ speed A and B along the string are same u sinθ = V

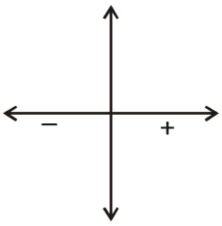
u sin θ = V $\quad$ u = $\frac{V}{\sin\ \theta}$

2. A = $\frac{a_1 - a_2}{2}$



3.





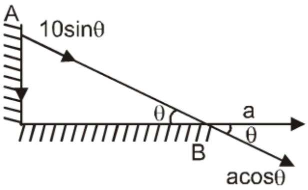
using the above coordinate system

$a_A + a_B = 0$ (Pulley is fixed)

$10 + a_B = 0 \Rightarrow a_B = -10$

$a_C + a_B = 2a_M \Rightarrow 0 - 10 = 2a_M \Rightarrow a_M = -5$

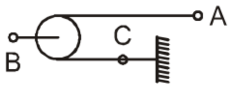
4.

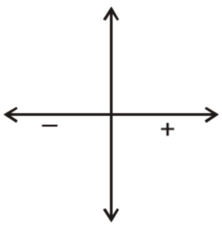


From constrained relation 10sin θ = acosθ ⇒ a = 10 tanθ

5. See sol of Q.80 , Exercise 2 for solution

6.



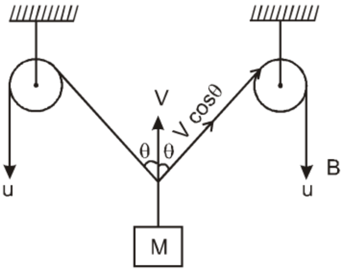


using the above coordinate system

$2a_B = a_A + a_C \Rightarrow 2a_B = a_A$ (as c is fixed so $a_c = 0$) So, $\frac{a_A}{a_B} = 2$

7. $(a)_{system} = \frac{20-10}{3} = \frac{10}{3} = \frac{g}{3}$

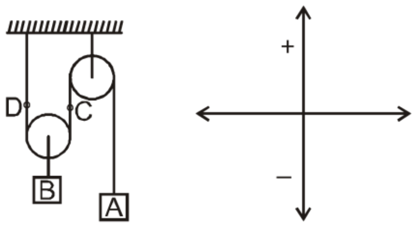
8.



By symmetry we can conclude that block will move only in vertical direction.
Length of string AB remains constant
∴ Velocity of point A and B along the string is same.

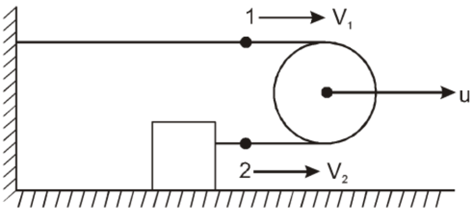
$V\cos\theta = u \Rightarrow V = \frac{u}{\cos\theta}$

9.



using the above coordinate system, we have
$a_A + a_C = 0$ (as pulley is fixed)
$a_C + a_D = 2a_B$
$a_C = 2a_B$ (as D is fixed) So, $-a_A = 2a_B$ hence Magnitude of $a_A = 2a_B$

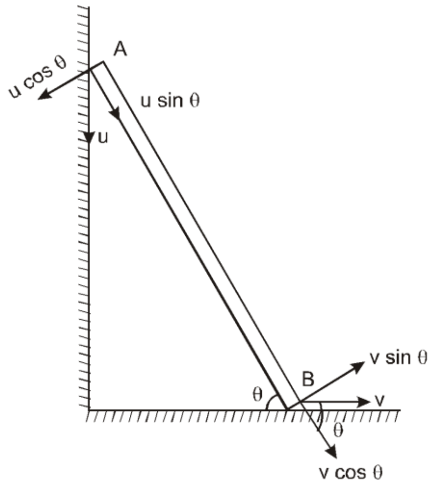
10.



Velocity of point 1 is V_1 which is 0 because string is fixed.

Velocity of point 2 is $V_2 \Rightarrow \frac{V_1+V_2}{2} = u \Rightarrow \frac{0+V_2}{2} = u \Rightarrow V_2 = 2u$

11. Since rod is rigid, its length can't increase. ∴ velocity of approach of A and B point of rod is zero.
$\Rightarrow u\sin\theta - v\cos\theta = 0 \Rightarrow v = u\tan\theta$

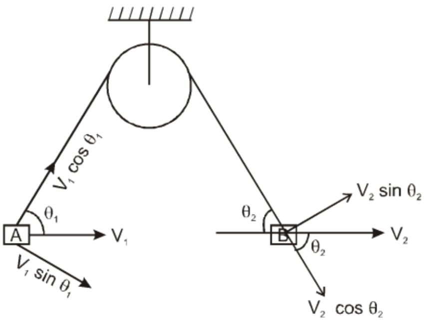


12. $1 + \frac{2+a_A}{2}$ ⇒ $a_A = 0$ take upward direction positive
a of pulley at right hand side

$3 = \frac{1+a}{2}$ ⇒ a = 5 m/2

$5 = \frac{-2+a_B}{2}$ ⇒ a_B = 12 m/s2

13.



Since string is inextensible length of string can’t change
∴ rate of decreases of length of left string = rate of increase of length of right string

⇒ $V_1 \cos\theta_1 = V_2 \cos\theta_2$ ⇒ $\frac{V_1}{V_2} = \frac{\cos\theta_2}{\cos\theta_1}$

SECTION (E)

1. F = $\frac{dp}{dt}$ = 0 + 2yt So, F is proportional to t

4. $P_L = 25$, $P_f = 0$, $\Delta t = 0.05$

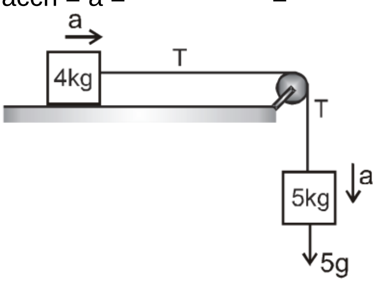
$F = \frac{\Delta P}{\Delta t} = \frac{25}{0.05} = \frac{2500}{5}$ = 500 N

5. $\vec{F} = m\vec{a}$

6. For atwood machine

accn = $a = \frac{(m_2 - m_1)g}{m_1 + m_2} = \frac{(10-5)g}{5+10} = \frac{g}{3}$

7.



$a = \frac{\text{net driving force}}{\text{total mass in motion}} = \frac{5g}{5+4} = \frac{5g}{9}$

8. Here : Mass of ship m = 2 × 107 kg,
Force F - 25 × 105 N
Displacement s = 25 m
According to the Newton’s second law of motion

F = ma or $a = \frac{F}{m} = \frac{25\times10^5}{2\times10^7}$

The relation for final velocity is
$v^2 = u_2 + 2as$

or $v^2 = 0 + 2 \times (12.5 \times 10^{-2}) \times 25$ or $v^2 = \sqrt{6.25} = 2.5$ m/s

9. $F = ma = m \times \frac{\Delta v}{\Delta t} = 0.1 \times \frac{10}{0.1} = 10$ N

10. Resultant force is zero, as three forces acting on the particle can be represented in magnitude and direction by three sides of a triangle in order. Hence, by Newton's 2nd law $\left(\vec{F} = m\frac{d\vec{v}}{dt}\right)$, particle velocity ($\vec{v}$) will be same.

12. (2) $u = 100 \text{ m/s}, v = 0, s = 0.06 \text{ m}$

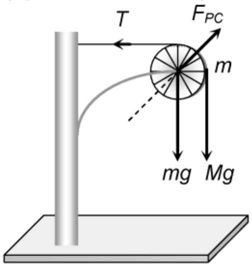
Retardation $= a = \frac{u^2}{2s} = \frac{(100)^2}{2 \times 0.06} = \frac{1 \times 10^6}{12}$ $\therefore$ Force $= ma = \frac{5 \times 10^{-3} \times 1 \times 10^6}{12} = \frac{5000}{12} = 417 \text{ N}$

13. (2) $F = u\left(\frac{dm}{dt}\right) = 400 \times 0.05 = 20 \text{ N}$

14. (1) Opposing force $F = u\left(\frac{dm}{dt}\right) = 2 \times 0.5 = 1 \text{N}$ $\left(\text{As}, F = u\frac{du}{dt}\right)$

So same amount of force is required to keep the belt moving at 2 m/s

15. (4) Force on the pulley by the clamp



$F_{pc} = \sqrt{T^2 + [(M+m)g]^2}$ $\Rightarrow$ $F_{pc} = \sqrt{(Mg)^2 + [(M+m)g]^2}$ $\Rightarrow$ $F_{pc} = \sqrt{M^2 + (M+m)^2}g$

16. $\Delta P = 2mv = 2 \times 10 \times 10^{-3} \times 5 = 10^{-1}$

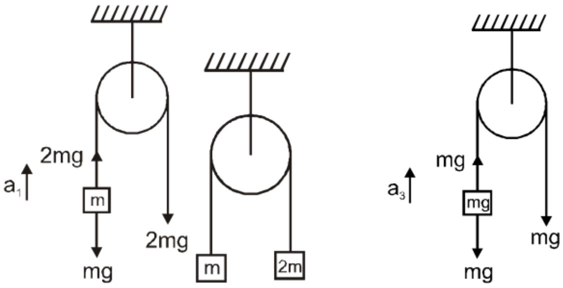
$\Delta t = 10^{-2}$

$F = \frac{\Delta P}{\Delta t} = \frac{10^{-1}}{10^{-2}} = 10$ N

17. $F_1 \Delta t_1 + F_2 \Delta t_2 + F_3 \Delta t_3 = \Delta p$ $\Rightarrow$ $7 \times 1.5 + 5 \times 1.7 + 10 \times 3 = m(\Delta V) = 10(\Delta V) \Rightarrow \Delta V = 4.9$ m/s

18. $F = \frac{2mv \cos\theta}{\Delta t} = \frac{2 \times 1 \times 1}{0.1}\frac{\sqrt{3}}{2} = \frac{\sqrt{3}}{0.1} = 10\sqrt{3}$ N

19.



$a_1 = \frac{2mg - mg}{m}$ $\Rightarrow$ $a_2 = \frac{(2m - m)g}{2m + m}$ $\Rightarrow$ $a_3 = 0$ $\Rightarrow a_1 = g$ $\Rightarrow$ $a_2 = \frac{g}{3}$

So, $a_1 > a_2 > a_3$

20. $T = \frac{2m_1m_2g}{m_1+m_2} = \frac{2\times 6\times 10\times 10}{6+10} = \frac{1200}{16} = \frac{300}{4}$ = 75

21. $a = \frac{F}{m} = \frac{5\times 10^4}{3\times 10^7} = \frac{5}{3}\times 10^{-3}$ m/s^2

$v = \sqrt{2as} = \sqrt{2\times\frac{5}{3}\times 10^{-3}}$ = 0.1 m/s

22. 12 g – 2T = 12a

T – 4g sin 30° = 4b

T – 4 sin 30° = 4(2a)

$a = \frac{2g}{7}$

Tension inthe string connecting by 12 kg = T' = 2T = $\frac{60g}{7}$

23. $a = \frac{m_2}{m_1+m_2}\times g = \frac{5}{4+5}\times 9.8 = \frac{49}{9} = 5.44\ \ m/s^2$

24. Key Idea : The force imparted (or impulse) by the ball to the hands of the player equal to the rate of change of linear momentum.

Force imparted = Rate of change of momentum

or $F = \frac{\Delta p}{\Delta t}$ or $F = \frac{p_1 - p_2}{\Delta t}$ or $F = \frac{m(v_1 - v_2)}{\Delta t}$

Here m = 0.150 kg, v_1 = 20 m/s v_2 = 0

Δt = 0.1 s ∴ $F = \frac{0.150\times(20-0)}{0.1}$ = 30 N

25. **Key Idea :** Force applied on the object is rate of change of momentum.

According to Newton's 2nd law, force applied on an object is equal to rate of change of momentum.

That is $\vec{F} = \frac{d\vec{p}}{dt}$ or $\vec{F} = m\frac{d\vec{v}}{dt}$ ......(i)

Given, m = 3 kg, t = 3s, $\vec{F} = (6t^2\ \hat{i} + 4t\ \hat{j})$ N

Substituting these values in Eq. (i), we get

$F = (6t^2\ \hat{i} + 4t\ \hat{j}) = 3\frac{d\vec{v}}{dt}$ or $d\vec{v} = \frac{1}{3}(6t^2\ \hat{i} + 4t\ \hat{j})\ dt$

Now, taking integration of both sides, we get

$$\int d\vec{v} = \int_0^t \frac{1}{3}(6t^2\ \hat{i} + 4t\ \hat{j})\ dt$$

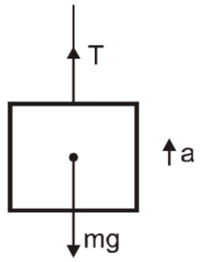
$$\vec{v} = \frac{1}{3}\int_0^3 (6t^2\ \hat{i} + 4t\ \hat{j})\ dt$$

but t = 3s (given) ∴ $\vec{v} = \frac{1}{3}\int_0^3 (6t^2\ \hat{i} + 4t\ \hat{j})\ dt$

or $\vec{v} = \frac{1}{3}\left[\frac{6t^2}{3}\ \hat{i} + \frac{4t^2}{2}\ \hat{j}\right]_0^3$ or $v = \frac{1}{3}[2(3)^2\hat{i} + 2(3)^2\hat{j}]$

or $\vec{v} = \frac{1}{3}[54\hat{i} + 15\hat{j}]$ or $\vec{v} = 18\hat{i} + 6\hat{j}$

26. Key Idea : The tension in the string during upward motion increases from weight of lift due to its upward acceleration.



when lift moves upward with same acceleration then

$T - mg = ma$ or $T = m(g + a)$

Given m = 1000 kg, a = 1 m/s^2, g = 9.8 m/s^2

Thus $T = 1000\,(9.8 + 1) = 1000 \times 10.8 = 10800$ N

27. Here the tension in the cord is given by

$T = mg + ma$

(Here : upwards acceleration = a, mass of sphere = m, T = 4 mg)

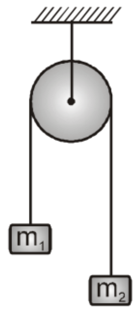
So $4\,mg = mg + ma$

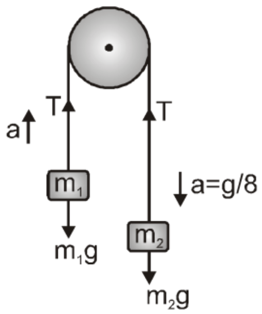
$3\,mg = ma$

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

28. $F = ma = m \times \frac{\Delta v}{\Delta t} = 0.1 \times \frac{10}{0.1} = 10$ N

29. FBD of system





Considring $m_2 > m_1$

$m_2g - T = m_2a$ ....(i)

$T - m_1g = m_1a$ ....(ii)

$a = \frac{(m_2 - m_1)}{m_1 + m_2}g$

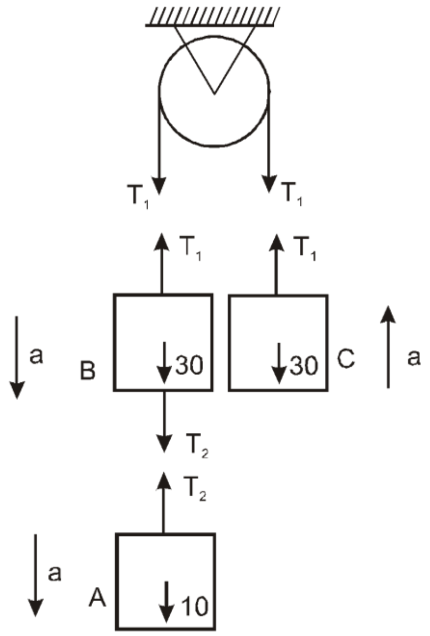
Given, a = g/8

$\Rightarrow \frac{g}{8} = \left(\frac{m_2 - m_1}{m_1 + m_2}\right)g$

$m_1 + m_2 = 8(m_2 - m_1)$

$7m_2 = 4m_1$

$\frac{m_2}{m_1} = \frac{9}{7}$ **Ans. 9 : 7**



30.

$10 - T_2 = 1\,a$ [Newton's II law for A]

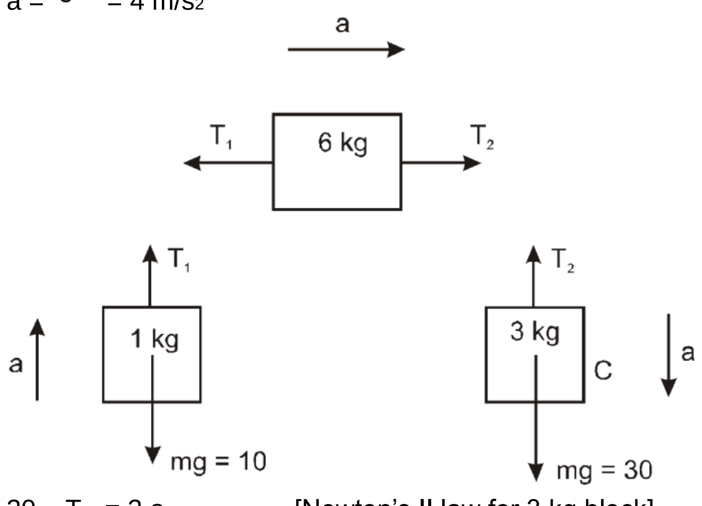
$T_2 + 30 - T_1 = 3\,a$ [Newton's II law for B]

$T_1 - 30 = 3a$ [Newton's II law for C]

$\Rightarrow \quad a = \frac{g}{7} \qquad \Rightarrow \quad T_2 = \frac{6g}{7}$

31. $a = \frac{m_2 g - m_1 g \sin 30^\circ}{m_1 + m_2}$

$a = \frac{2}{5}g = 4\ m/s^2$



32.

$30 - T_2 = 3\,a$ [Newton's II law for 3 kg block]

$T_2 - T_1 = 6\,a$ [Newton's II law for 6 kg block]

$T_1 - 10 = 1\,a$ [Newton's II law for 1 kg block]

By adding three equations

$30 - 10 = 10\,a \quad \Rightarrow \quad a = 2\ m/s^2$.

33. $T - mg = ma \quad \Rightarrow \quad T = m\,(g + a) = 3000\,(10 + 5) = 45000\ N$

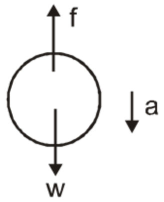
34. (1) For equilibrium of system,

$F_1 = \sqrt{F_2^2 + F_3^2}$ As pw¡fd $\theta = 90^\circ$

In the absence of force F_1, Acceleration $= \dfrac{\text{Net force}}{\text{Mass}} = \dfrac{\sqrt{F_2^2 + F_3^2}}{m} = \dfrac{F_1}{m}$

35. $T - mg = ma \quad \Rightarrow T = m(g + a) = 500(9.8 + 2) = 5900$ N

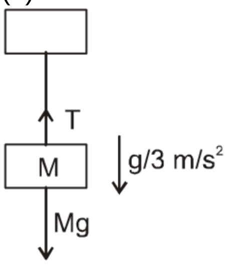
36.



$w - f = ma$ $\qquad w - ma = f$

$w\left\{1 - \dfrac{m}{w}a\right\} = f \qquad w\left\{1 - \dfrac{m}{mg}a\right\} = f \qquad w\left\{1 - \dfrac{a}{g}\right\} = f$

37. (2) $(a)_{system} = \dfrac{F_{driving}}{M_{system}} = \dfrac{2Mg - Mg}{M + M + M} = \dfrac{Mg}{3M} = \dfrac{g}{3}$



From the above free body diagram we can write

$Mg - T = Ma$

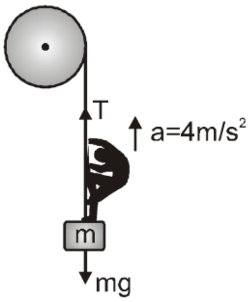
$\Rightarrow T = Mg - Ma$

$\Rightarrow T = Mg - \dfrac{Mg}{3} = \dfrac{2Mg}{3}$ (a = g/3 as shown in the FBD)

So substituting M = 2 kg and g = 10 m/s^2 we have T = 2 × 2 × 10/3 = $\dfrac{40}{3}$N

38. (a,c) In region AB and CD, slope of the graph is constant i.e. velocity is constant. It means no force acting on the particle in this region.

39. FBD



$T - mg = ma$

$360 - 60 \times 10 = 60 \times a$

i.e. slip through the rope with a minimum acceleration 4m/s^2 .

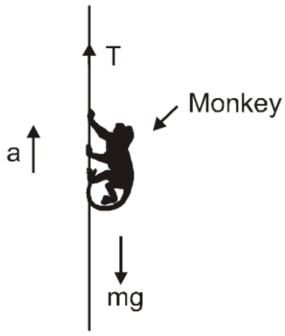
Ans. **4 m/s^2**

40. Maximum bearable tension in the rope

T = 25 × 10 = 250 N

From the figure,

$T - mg = ma$

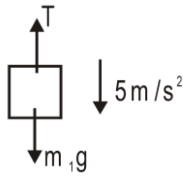


or ;k $a = \frac{T - mg}{m}$

Given $m = 20$ kg, $g = 10$ m/s^2,
$T = 250$ N

Hence $a = \frac{250 - 20 \times 10}{20} = \frac{50}{20} = 2.5$ m/s^2

41. FBD of m_1



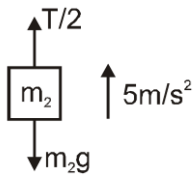
$m_1g - T = m_1.5$

$\Rightarrow$ $T = 5m_1$ ....(i)

By symmetry acceleration of block C and B will be same.

By constraint acceleration of B will be 5 m/sec^2 upwards.

Now, FBD of B



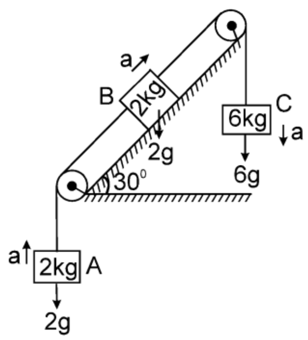
$\frac{T}{2} - m_2g = 5m_2$

$\Rightarrow$ $\frac{T}{2} = 15\ m_2$

$\Rightarrow$ $T = 30\ m_2$ ....(ii)

by (1) and (2)

$5m_1 = 30m_2$ = $\frac{m_1}{m_2} = 6$ **Ans.**



42. All the blocks will be having the same acceleration along the length of the string.

So, Applying Newtons law along the string on A,B & C.

⇒ $6g - 2g\sin 30^\circ - 2g = (6 + 2 + 2)a$ ⇒ $3g = 10a$ ⇒ $a = \frac{3g}{10}$

or $a = 3\ m/s^2$ **Ans. $a = 3\ m/s^2$**

43. (3) At 11th second lift is moving upward with acceleration

$a = \frac{0-3.6}{2} = -1.8 m/s^2$

Tension in rope, $T = m(g + a) = 1500(9.8 - 1.8) = 12000N$

44. (4) Distance travelled by the lift =Area under velocity time graph

$= \left(\frac{1}{2}\times 2\times 3.6\right) + (8\times 3.6) + \left(\frac{1}{2}\times 2\times 3.6\right) = 36m$

45. Impulse = Change in momentum = $m(v_2 - v_1)$ …(i)

Again impulse = Area between the graph and time axis

$= \frac{1}{2}\times 2\times 4 + 2\times 4 + \frac{1}{2}(4+2.5)\times 0.5 + 2\times 2.5 = 4 + 8 + 1.625 + 5$ ...(ii)

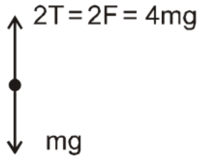
From (i) and (ii), $m(v_2 - v_1) = 18.625$ ⇒ $v_2 = \frac{18.625}{m} + v_1 = \frac{18.625}{2} + 5 = 14.25\ m/s$

46. The vertical component of acceleration of mass 1 and mass 2 are

$a_1 = g\sin^2 60$, $a_2 = g\sin^2 30$

since vertical displacement for both masses is 1m, the block with larger acceleration will reach the base of wedge first. Hence block of mass m_1 shall reach base of wedge first.

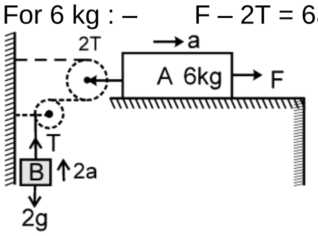
47. F.B.D. of block ⇒ $2T - mg = ma$



$a = 3g$

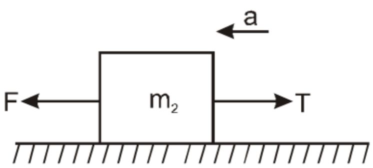
48. $a = \frac{v^2}{2s} = \frac{25}{10} = 2.5\ m/s^2$

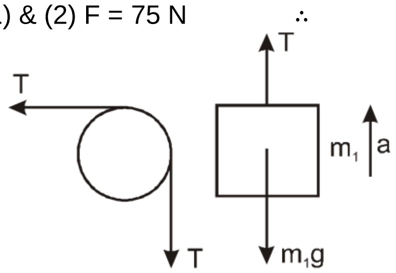
For 6 kg : – $F - 2T = 6a$



For 2 kg : – $T - 2g = 2(2a)$ From (1) & (2) F = 75 N ∴ $\frac{F}{15} = 5$.

49.





It is obevious that acceleration of both the blocks is same in magnitude.

$F - T = m_2a$ [Newtons second law for m_2]

$T - m_1g = m_1a$ [Newtons second law for m_1]

After adding the above equations.

$F - m_1g = (m_2 + m_1)a$

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

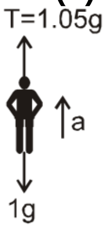
$\Rightarrow a = -\frac{m_1 g}{2(m_1 + m_2)}$

The value of a is –ve it means

$a = \frac{m_1 g}{2(m_1 + m_2)}$ in the direction opposite to assumed direction

SECTION (F)

1.



$1.05\ g - 1 \times g = 1 \times a \quad \Rightarrow \quad a = 0.5\ m/s^2$

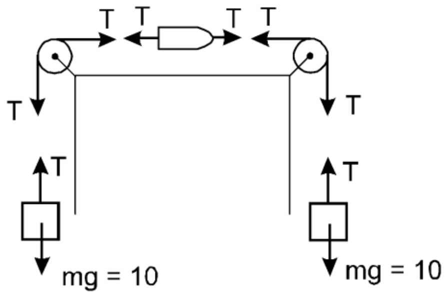
2. $1\ ms^{-2}$

F – T = m.a

20 – T = 6 (1)

T = 14 N

3.



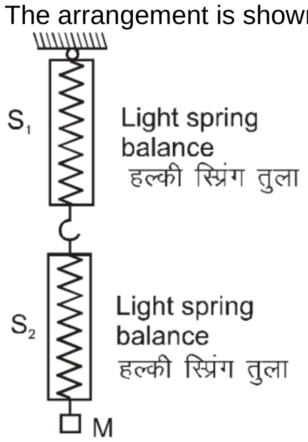
T – mg = 0 [Equilibrium of block]

T – 10 = 0

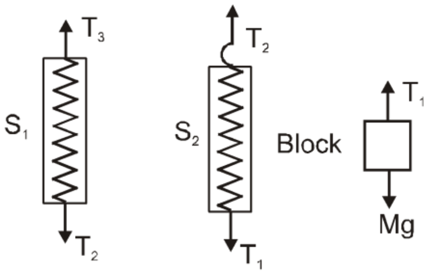
T = 10

Reading of spring balance is same as tension is spring balance.

4. The arrangement is shown in figure

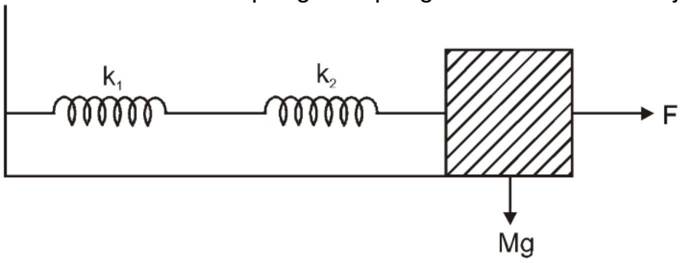


Now draw the free body diagram of the spring balances and block.



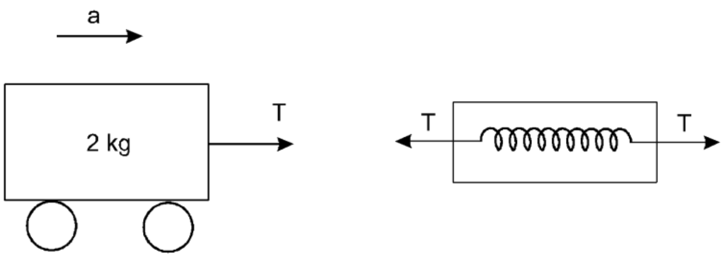
For equilibrium of block, $T_1 = Mg$
where T_1 = Reading of S_2
For equilibrium of S_2, $T_2 = T_1$
where T_2 = Reading of S_1
For equilibrium of S_1, $T_2 = T_3$
Hence $T_1 = T_2 = Mg$
So, both scales read M kg.

5. Let us consider two springs of spring constants k_1 and k_2 joined in series as shown in figure.



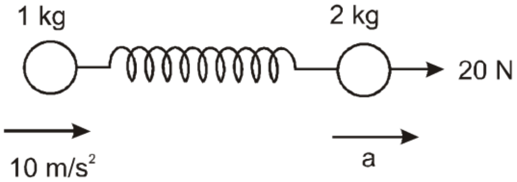
Under a force F, they will stretch by y_1 and y_2
So $y = y_1 + y_2$
or $\frac{F}{k} = \frac{F_1}{k_1} + \frac{F_2}{k_2}$
but as springs are massless, so force on them must be same i.e., $F_1 = F_2 = F$.
So $\frac{1}{k} = \frac{1}{k_1} + \frac{1}{k_2}$ or $k = \frac{k_1 \; k_2}{k_1 + k_2}$

6.



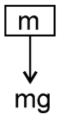
Reading of spring balance is same as tension in the balance.
⇒ $T = 10\,g = 98$ N
$T = 2\,a$ [Newton's II law for 2 kg block] ⇒ $a = 49$ m/s^2

7.



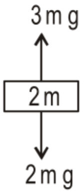
$F = m_1a_1 + m_2a_2$ [Newton's law for system]
$20 = 1 \times 10 + 2 \times a$ $a = 5$ m/s^2.

8. After string is cut, FBD of m



$a = \frac{mg}{m} = g \downarrow$

FBD of 2m (when string is cut tension in the spring takes finite time to become zero. How ever tension in the string immediately become zero.)

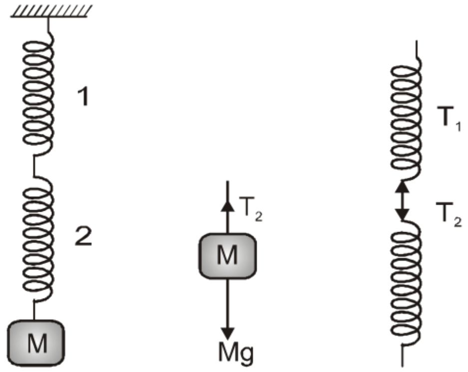


$a = \frac{3mg - 2mg}{2m} = \frac{g}{2} \uparrow$

9. When cap is opened some drink gets acclerated upwards so weight increases then finaly decrease to actual value

10. When man jumps, he gets acclerated upwards so reading increases.

11.



$T_1 = T_2$

Since springs are massless.

$T_1 = T_2 = Mg$. **Ans. M kg**

12. If m_1 and m_2 are masses of blocks then tension T in the string as well as spring are

$T = \frac{2\ m_1\ m_2}{m_1 + m_2} g$

$T_1 = 2g$ $\quad T_2 = 2.4$ g $\quad T_3 = 1.33$ g

$\therefore \quad T_2 > T_1 > T_3$ $\quad$ or $\quad x_2 > x_1 > x_3$

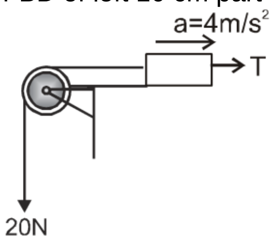
13. Since downward force along the inclined plane = $mg\sin\theta = 5 \times 10 \times \sin 30^\circ$ = 25 N

14. a > 0, N > Mg in both cases. Hence both are true.

SECTION (G)

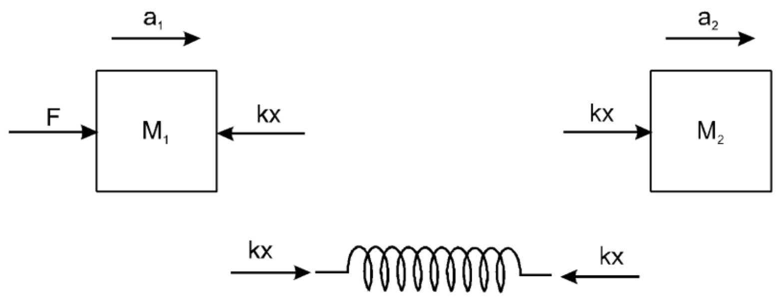
1. $a = \frac{32 - 20}{3} = 4\ m/s^2$

2. FBD of left 10 cm part of rod.



T – 20 = 1 × 4

T = 24 N

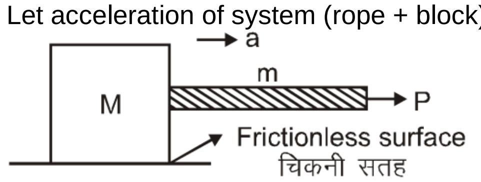


3.

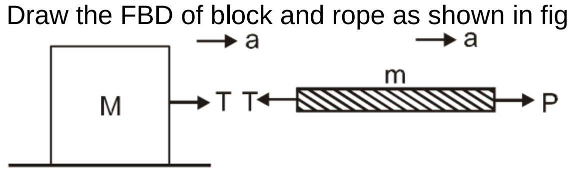
$F - kx = M_1 a_1$ [Newton's II law for M_1]
$kx = M_2 a_2$ [Newton's II law for M_2]
By adding both equations.

$F = M_1 a_1 + M_2 a_2 \Rightarrow a_2 = \frac{F - M_1 a_1}{M_2}$

4. Let acceleration of system (rope + block) is a along the direction of applied force. Then



Draw the FBD of block and rope as shown in figure.



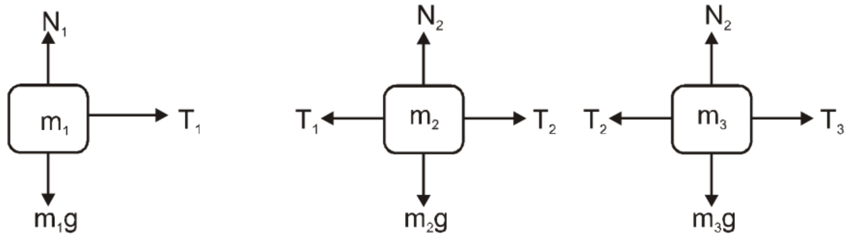
where, T is the required parameter

For block $T = Ma \Rightarrow T = \frac{MP}{M+m}$

5. $F = ma \Rightarrow F = m \times 4$ also, $F = 2\,mb \Rightarrow m \times 4 = 2\,mb = b = 2 m/s^2$

6. $(a)_{system} = \frac{10}{2+3+5} = 1$ So, $T_1 = (3 + 5)\,(1)_{system} = 8 \times 1 = 8$ N

7. Let N_1, N_2, N_3 be normal reactions on masses m_1, m_2 and m_3 respectively. The free body diagrams of m_1, m_2 and m_3 are as shown below



For mass m_1, m_2 and m_3 to be in vertical equilibrium
$N_1 = m_1 g$, $N_2 = m_2 g$ and $N_3 = m_3 g$

Now vc $T_1 = m_1 a$ ....(1)
$T_2 - T_1 = m_2 a$ ....(2)
$T_3 - T_2 = m_3 a$ ....(3)

where a be the common acceleration of the system.
Now adding Eq. (1), (2) and (3), we get

$a = \frac{T_3}{m_1 + m_2 + m_3}$ ....(4)

Given : $T_3 = 60$ N, $m_1 = 10$ kg, $m_2 = 20$ kg and $m_3 = 30$ kg.
Putting the given values in Eq. (4), we get

∴ $a = \frac{60}{10+20+30} = \frac{60}{60} = 1\ m/s^2$ ∴ From Eq. (1),

$T_1 = m_1a = 10 \times 1 = 10$ N

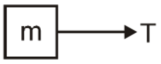
Again from Eq. (2),

$T_2 = T_1 + m_2a = 10 + 20 \times 1 = 10 + 20 = 30$ N

8.

$a_{system} = \frac{F}{M+m}$

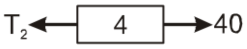
FBD of m m



$T = ma_{system} = \frac{mF}{M+m}$

9. Acceleration of system $a = \frac{40}{20} = 2$

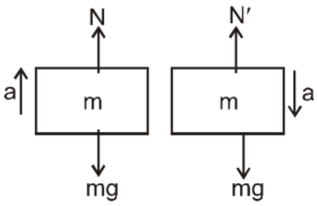
From FBD of block m_3



$40 - T_2 = 4 \times 2$

$T_2 = 32$ N

10.



$N = m(g + a)$

$N' = m(g - a)$

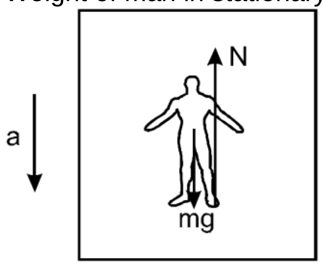
$N' = \frac{10}{100} \times N$ ⇒ $m(g - a) = \frac{m(g+a)}{10}$

$10g - 10a = g + a$

$9g = 11a$ ⇒ $a = \frac{9g}{11}$

SECTION (H)

1. Weight of man in stationary lift is mg.

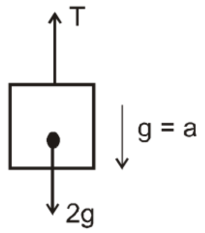


$mg - N = ma$ [Newton's II law for man]

⇒ $N = m(g - a)$

Weight of man in moving lift is equal to N.

⇒ $\frac{m\ g}{m\ (g-a)} = \frac{3}{2}$ ⇒ $a = \frac{g}{3}$

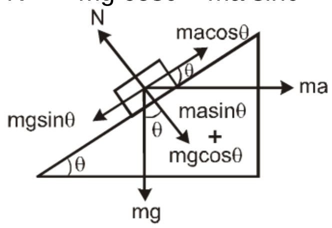


2. Reading of spring balance is tension
2g – T = 2 a
2g – 2a = T (a = g)
0 = T

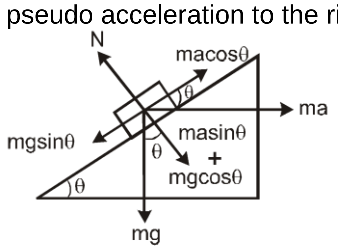
4. Pseudo force depends on mass of object and acceleration of observer (frame) which is zero in this problem.
⇒ Pseudo force is zero.

5. ma cosθ = mg sinθ
a = g tanθ

$N = mg\cos\theta + ma\sin\theta = mg\cos\theta + \frac{mg\sin^2\theta}{\cos\theta} = \frac{mg}{\cos\theta}$

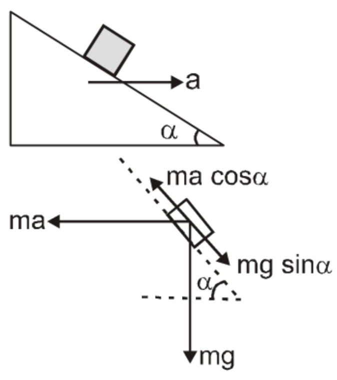


6. Let an acceleration to the wedge is given towards left, then the block (being in non-inertial frame) has a pseudo acceleration to the right because of which the block is not slipping



At equillibrium
mg sinθ = ma cosθ ⇒ a = g tanθ
N = ma sinθ + mg cosθ = m (g tanθ) sinθ + mg cosθ = mg/cosθ

7.



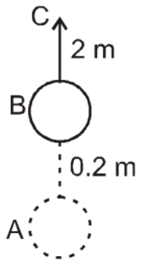
FBD of Block

For block to be stationary
macosα = mg sinα **Ans. a = g tanα.**

8. In the frame of wedge acceleration = (g + a) sin θ = 7 m/s^2
Normal reaction m (g + a) cos θ = $7\sqrt{3}$ N

EXERCISE # 2

1.



At position B & C

$V_2 = u_2 - 2gs$

$0 = u_2 - 2 \times 10 \times 2$

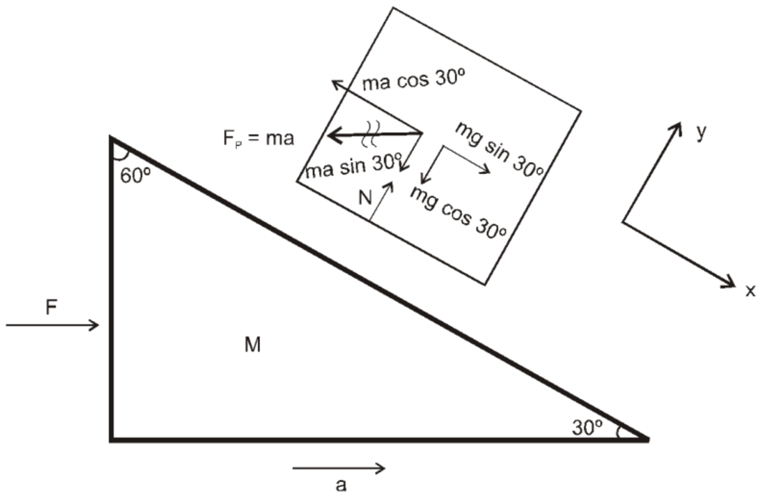
$u_2 = 40$

Acceleration = $\frac{F - mg}{m} = \left(\frac{F-2}{0.2}\right)$ and $V_B^2 = u_A^2 + 2as$

$40 = 0 + 2 \times \frac{(F-2)}{0.2} \times 0.2$

$F = 20 + 2 = 22$ N.

2.



F.B.D. of wedge is w.r.t. ground and
F.B.D. of block is w.r.t. wedge.
Let a is the acceleration of wedge due to force F.
F_P is pseudo force on block

mg sin 30º – ma cos 30º = 0 [Equilibrium of block in x direction w.r.t. wedge]

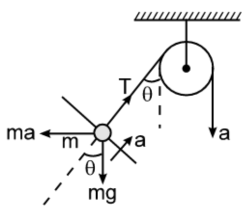
a = g tan 30º

F = (M + m)a [Newtons II law for the system of block and wedge in horizontal direction]

⇒ F = (M + m) g tan 30º.

3. $T = mg_{eff} = W_{eff} = 5\,(10 + 2)$
$= 60$ N $= 6$ kg f

4.



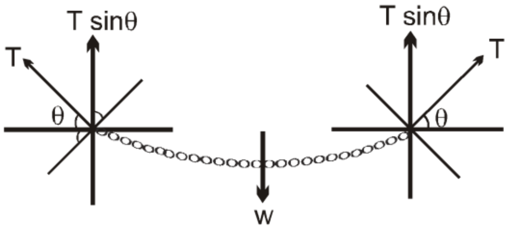
(Force diagram in the frame of the car). Applying Newton's law perpendicular to string

mg sinθ = ma cos θ ⇒ $\tan\theta = \frac{a}{g}$

Applying Newton's law along string ⇒ $T - m\sqrt{g^2 + a^2} = ma$ **$T = m\sqrt{g^2 + a^2} + ma$ Ans.**

5. $a_A = 0$, $a_B = 0$ hence $\frac{a_A}{a_B} = \frac{0}{0}$ Hence it is not defined

6. N cos 30° = g m_A sin 30° + m_B g sin 30°
N = 30N

7.


$2T \sin\theta = \omega$

$T = \frac{\omega}{2} \operatorname{cosec}\theta$

8. Let AB = ℓ, B = (x , y)

$\vec{v}_B = v_x\hat{i} + v_y\hat{j}$

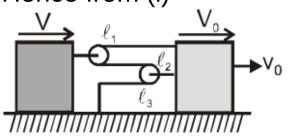
$\vec{v}_B = \sqrt{3}\,\hat{i} + v_y\hat{j}$ → (i)

$x^2 + y^2 = \ell^2$

$2x\,v_x = 2y\,v_y = 0$ ⇒ $\sqrt{3} + \frac{y}{x} v_y = 0$

⇒ $\sqrt{3} + (\tan 60^0)\,v_y = 0$ ⇒ $v_y = -1$

Hence from (i) $\vec{v}_B = \sqrt{3}\,\hat{i} - \hat{j}$ Hence v_B = 2 m/s

9.


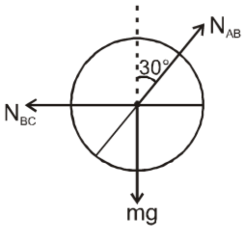
$\ell'_1 + \ell'_2 + \ell'_3 = 0$

$(-v + v_0) + (-v + v_0) + (0 + v_0) = 0$

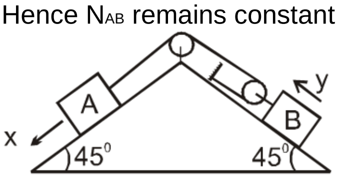
$3v_0 = 2v \Rightarrow v = \frac{3v_0}{2}$ ⇒ $V_{AB} = V_A - V_B = V - V_0 = \frac{3V_0}{2} - V_0 = \frac{V_0}{2}$

10. The free body diagram of cylinder is as shown.
Since net acceleration of cylinder is horizontal,

$N_{AB}\cos 30° = mg$ or $N_{AB} = \frac{2}{\sqrt{3}}\,mg$ .... (1)



and $N_{BC} - N_{AB}\sin 30° = ma$ or $N_{BC} = ma + N_{AB}\sin 30°$ .... (2)
Hence N_{AB} remains constant and N_{BC} increases with increase in a.

11.


By string constraint

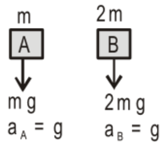
$a_A = 2a_B$ ....(1) equation for block A.

$10 \times 10 \times \frac{1}{\sqrt{2}} - T = 10\, a_A$ ......(2) equation for block B.

$2T - \frac{400}{\sqrt{2}} = 40\, a_B$ ....(3) solving equation (1), (2) & (3) we get

$a_A = \frac{-5}{\sqrt{2}}$ m/s^2 $\Rightarrow$ $a_B = \frac{-5}{2\sqrt{2}}$ m/s^2 $\Rightarrow$ $T = \frac{150}{\sqrt{2}}$ N

12. In this case spring force is zero initially
F.B.D. of A and B



EXERCISE # 3
PART - I

1. **Key Idea :** According to Newton's second law of motion force = mass × acceleration.

Here, $\vec{F} = 6\hat{i} - 8\hat{j} + 10\hat{k}$

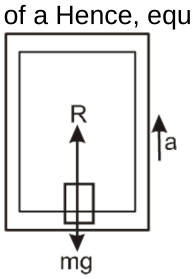
$|F| = \sqrt{36 + 64 + 100} = 10\sqrt{2}$ N

$a = 1$ ms^{-2} $\therefore$ $m = \frac{10\sqrt{2}}{1} = 10\sqrt{2}$ kg

2. When stone hits the ground momentum $P = m\sqrt{2gh}$

when some stone dropped from 2h (100% of initial) then momentum $P' = m\sqrt{2g(2h)} = \sqrt{2}P$
Which is is changed by 41% of initial.

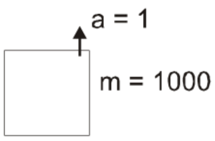
3. Apparent weight > actual weight, then the lift is accelerating upward. Here, It is accelerating upward at the rate of a Hence, equation of motion is written as



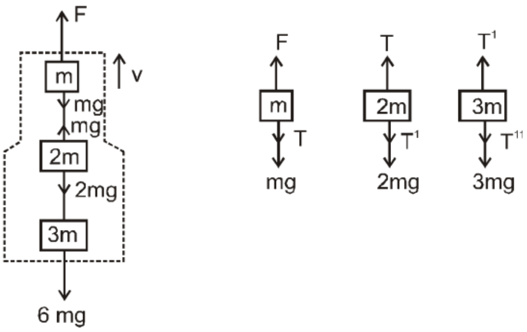
$R - mg = ma$

$28000 - 20000 = 2000\, a$ $\Rightarrow$ $a = \frac{8000}{2000} = 4$ms^{-2} upwards

4.



$T - 1000g = 1000 \times 1$
$T = 1000 \times 11$

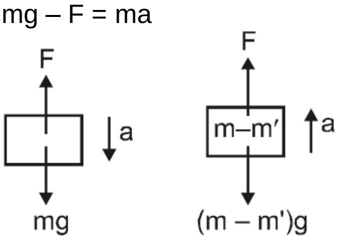


5.
f = 6 mg
as $an_n = 0$
f 6mg = 6ma = 0
f = 6 mg ∴ T = 5 mg
$T_1 = 3$ mg
$T_{11} = 0$
F_{net} = on 2 m = $T - T_1 - 2$ mg = 0

Alternate :
∵ v = constant
So a = 0
Hence $F_{net} = ma = 0$

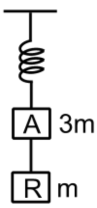
6. $\Delta P = \left(\frac{1}{2}\right)(2)(6) - (3)(2) + (4)_2(3)$
= 6 – 6 + 12
= 12

7. mg – F = ma .....(1)

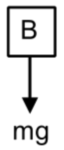


F – (m – m')g = (m – m')a
from (1)
F – mg + m′g = ma – m′a
mg – ma – mg + m′g = ma – m′a
m′(g + a) = 2ma
$m' = \frac{2ma}{g+a}$

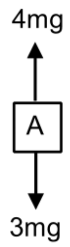
8. (1) $a_c = \frac{14}{7} = 2m/sec^2$
Contact fore as B will provide accleration to (sec) so constact fore = 3 × 2 = 6 N



9.
Tension is spring initially = 4 mg tension in string initially = mg after culting string



$a = \frac{mg}{m} = g$



$a = \frac{4mg - 3mg}{3m} = \frac{g}{3}$ $\frac{g}{3}, g$

10. Pieces of spring after cutting the original spring will have new force constant

$K_1 = 6K$

$K_2 = 3K$

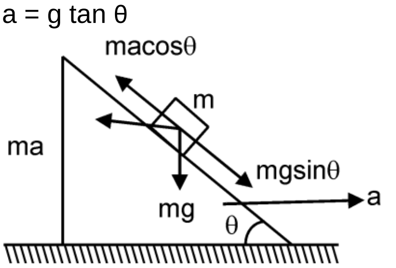
$K_3 = 2K$ as $K \propto \frac{1}{\text{length}}$

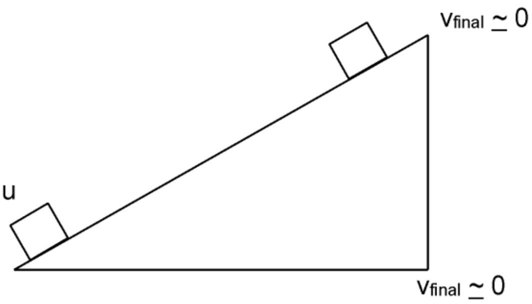
In parallel $K_{net} = 6K + 2K + 3K = 11K$

In series $K_{net} = K$ Hence correct option (3).

11. ma cosθ = mg sinθ

a = g tan θ





12.

$v^2_{final} = u^2 - 2(g\sin\theta)x$

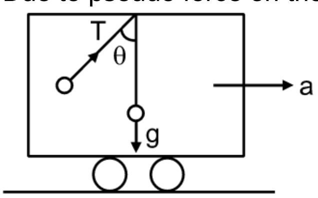
$x_1 = \frac{u^2}{2g\sin\theta_1}$ ⇒ $x_2 = \frac{u^2}{2g\sin\theta_2}$

$\frac{x_1}{x_2} = \frac{\sin\theta_2}{\sin\theta_1} = \frac{\sin 30}{\sin 60} = \frac{1}{\sqrt{3}}$

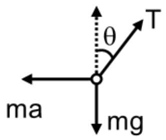
13. Net force on the particle is zero $\therefore \vec{a} = 0$

$\vec{v}$ = remains constant

14. Due to pseudo force on the bob it will tilt to left.



F.B.D.



$T\sin\theta = ma$ ...(i)

$T\cos\theta = mg$ ...(ii)

By dividing equation (i) & (ii) $\tan\theta = \frac{a}{g}$ $\Rightarrow$ $\theta = \tan^{-1}\left(\frac{a}{g}\right)$

PART - II

1. $V_1 = \left(\frac{dx}{dt}\right)_1 = \frac{2}{2} = 1$ $\Rightarrow$ $V_2 = \left(\frac{dx}{dt}\right)_2 = -1$

Impulse = $|\Delta P|$ = $|m(V_2 - V_1)|$ = $|0.4\,(-1 -1)|$ = 0.8 Ns

2. Vertical component of acceleration of A

$a_1 = (g \sin\theta).\sin\theta = g \sin 60^o . \sin 60^o = g . \frac{3}{4}$

That for B

$a_2 = g \sin 30^o . \sin 30^o = g\,\frac{1}{4}$ $\therefore$ $(a_{AB})_\perp = \frac{3g}{4} - \frac{g}{4} = \frac{g}{2} = 4.9\ m/s^2$

3. K.E. = ct

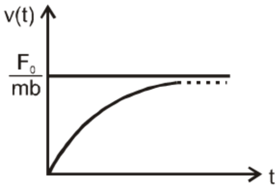
$\frac{1}{2} mv^2 = ct$ $\Rightarrow$ $\frac{P^2}{2m} = ct$

$P = \sqrt{2ctm}$

$F = \frac{dP}{dt} = \sqrt{2cm}\,\frac{1}{2} \times \frac{1}{\sqrt{t}}$ $\Rightarrow$ $F \propto \frac{1}{\sqrt{t}}$.

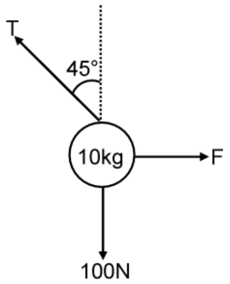
4. $F = ma = F_0\, e^{-bt}$

$\frac{dv}{dt} = \frac{F_0}{m} e^{-bt}$ $\Rightarrow$ $\int_0^v dv = \frac{F_0}{m}\int_0^t e^{-bt}dt$



$v = \frac{F_0}{m}\left[\frac{e^{-bt}}{-b}\right]_0^t$ $\Rightarrow$ $v = \frac{F_0}{mb}\left(1 - e^{-bt}\right)$

5.



$\frac{T}{\sqrt{2}} = 100$

$\frac{T}{\sqrt{2}} = F$

F = 100 N

6. $F = \frac{dp}{dt}$ $\Rightarrow$ $Kt = \frac{dp}{dt}$

$\int_P^{3P} dP = \int_0^t Ktdt$ $\Rightarrow$ $3P - P = \frac{Kt^2}{2}$ $\Rightarrow$ $t = 2\sqrt{\frac{P}{K}}$