

JEE-MAIN

TOPIC

N.L.M,  
FRICTION

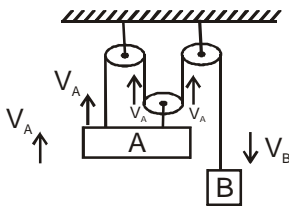
# SOLUTIONS

## NEWTONS LAWS OF MOTION, FRICTION

### Exercise-I

1. (B)  
2. (B) Action and Reaction are equal and opposite

3. (C)  
 $V = \text{Constant} \quad a = 0$   
 $F_{\text{net}} = 0$



$$P - 300 = 0$$

$$P = 300\text{N}$$

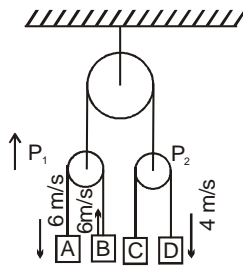
$$2000 - 2S = 0$$

$$\Rightarrow S = 1000\text{N}$$

4. (A)  
 $-v_A - v_A - v_A + v_B = 0$   
From constrained  
 $-5 - 5 - 5 + v_B = 0$   
 $v_B = 15 \text{ m/s} \downarrow$

5. (A)  
From constrained  
 $+2 - v_B - v_B + 1 = 0$   
 $v_B = 3/2 \text{ m/s} \uparrow$

6. (B)



$$v_{P1} = \frac{-6 + 6}{2} = 0$$

$$\Rightarrow |v_{p1}| = |v_{p2}| = 0$$

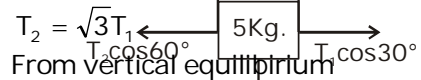
$$v_D = -v_C$$

$$\therefore \text{velocity of C is}$$

$$= 4 \text{ m/s}$$

7. (B)  
From horizontal equilibrium

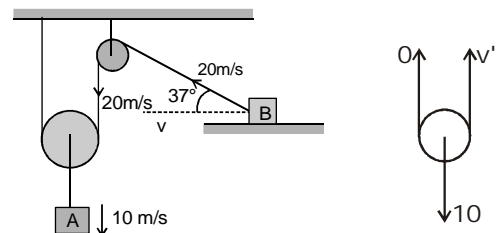
$$\frac{T_2}{2} = \frac{T_1\sqrt{3}}{2} \quad T_2 \sin 60^\circ \quad T_1 \sin 30^\circ$$



From vertical equilibrium

$$\frac{T_2\sqrt{3}}{2} + \frac{T_1}{2} = 50 \quad \Rightarrow T_1 = 25\text{N}, T_2 = 25\sqrt{3}\text{N}$$

8. (A)



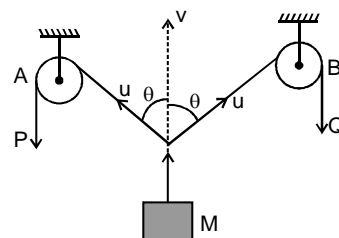
$$\frac{v' + 0}{2} = 10$$

Here Resultant vel. of block 'B' is  $v$   
So component of resultant in the direction of  $v'$  is

$$v \cos 37^\circ = v' \quad , \quad v \cos 37^\circ = 20$$

$$v = \frac{20 \times 5}{4} = 25 \text{ m/s}$$

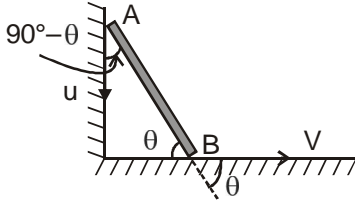
9. (D)



From constrained  
The resultant vel. of the Block M is  $v$  in vertical direction.  
So component of ' $v$ ' is direction of  $u$  is

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

10. (C)

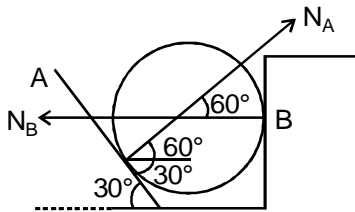


From constrained Motion - (along the rod vel of each particle is same so component of the velocity in the direction rod is)  
 $v \cos \theta = u \sin \theta$   
 $v = u \tan \theta$

11. (B)

Component of force in y direction is  $N_A \sin 60^\circ = 500$

$$N_A = \frac{1000}{\sqrt{3}}$$

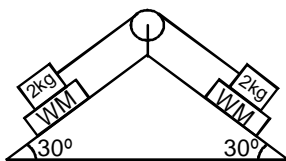


Component of force in x direction is

$$N_A \cos 60^\circ = N_B \Rightarrow N_B = \frac{500}{\sqrt{3}}$$

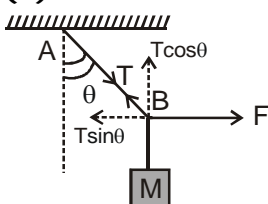
12. (A)

Weighing Machine always Measure Normal force



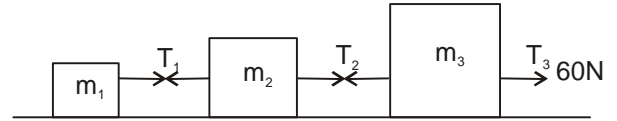
$$N = 20 \cos 30^\circ = 10\sqrt{3}$$

13. (B)



$$T \cos \theta = Mg, \quad T = \frac{Mg}{\cos \theta}$$

14. (C)



Take a system  $(m_1 + m_2 + m_3)$

$$T_3 = (m_1 + m_2 + m_3) a$$

$$60 = 60 a$$

$$a = \frac{60}{60} = 1 \text{ m/s}^2$$

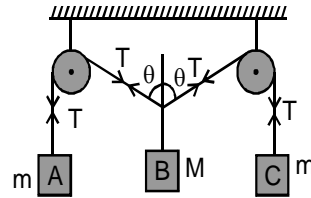
For body  $m_3$

$$T_3 - T_2 = m_3 a$$

$$60 - T_2 = 30$$

$$T_2 = 30 \text{ N}$$

15. (B)



$$T = mg \quad \dots (i)$$

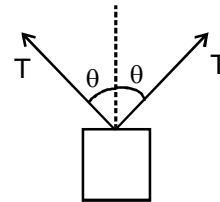
$$2T \cos \theta = Mg \quad \dots (ii)$$

From equation (i) and (ii)

$$\Rightarrow 2mg \cos \theta = Mg$$

$\theta$  always  $> 0$  so  $M < 2m$

16. (C)



$$(A) 2T = W, \quad T = W/2$$

$$(B) W = 2T \cos \theta$$

$$T = \frac{W}{2 \cos \theta}$$

In (C) option  $\theta$  is greater so

$\sec \theta \uparrow, T \uparrow$

If tension is more then string may be break-

17. (B)

$$F = \frac{dP}{dt} \Rightarrow \int F dt = \Delta P$$

$$\Rightarrow \int_0^8 F dt = 0$$

$$\Delta P = 0$$

18. (C)

$$\vec{F} = \frac{d\vec{P}}{dt}, \quad \vec{F} = \frac{d}{dt} (2 \cos t \hat{i} + 2 \sin t \hat{j})$$

$$\vec{F} = -2 \sin t \hat{i} + 2 \cos t \hat{j}$$

$$\vec{P} = 2 \cos t \hat{i} + 2 \sin t \hat{j}$$

$$\vec{F} \cdot \vec{P} = FP \cos \theta$$

$$-4 \cos t \sin t + 4 \cos t \sin t = FP \cos \theta$$

$$\cos \theta = 0$$

$$\theta = 90^\circ$$

19. (A) Relative acceleration Man and car is zero during the journey

$$N = 0$$

20. (A)

$$\text{At } t = 2 \text{ sec} \Rightarrow a = \frac{10}{2} = 5 \text{ m/s}^2$$

$$\text{So, } F = ma = \frac{50}{1000} \times 5 = 0.25 \text{ N}$$

$$\text{At } t = 4 \text{ sec}$$

$$a = 0 \text{ So } F = 0$$

$$\Rightarrow \text{At } t = 6 \text{ sec,}$$

$$\Rightarrow a = -5 \text{ m/s}^2 \Rightarrow F = -0.25 \text{ N}$$

21. (B)



$$\text{Acceleration} = \frac{F}{3m}$$

$$\text{contact force } N_1 = \frac{mF}{3m} = \frac{F}{3}$$

$$N_2 = \frac{2mF}{3m} = \frac{2}{3}F \Rightarrow \therefore N_1 : N_2 = 1 : 2$$

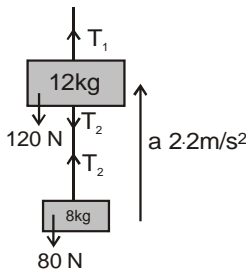
22. (C)

$$T_2 - 80 = 8(2.2) \dots (1)$$

$$T_1 - T_2 - 120 = 12(2.2) \dots (2)$$

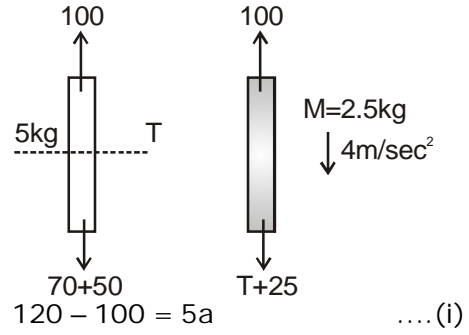
After solving (1) to (2)

[take  $g = 9.8 \text{ m/s}^2$ ]



$$T_1 = 240 \text{ N} \Rightarrow T_2 = 96 \text{ N}$$

23. (B)



$$120 - 100 = 5a \dots (i)$$

$$a = \frac{20}{5} \Rightarrow a = 4 \text{ m/s}^2$$

$$T + 25 - 100 = 2.5 \times 4 \dots (ii)$$

$$T = 85 \text{ N}$$

24. (C)

$$T - mg = ma \dots (1)$$

$$Mg - T = Ma \dots (2)$$

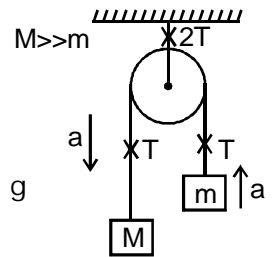
from (1) and (2)

$$a = \left( \frac{M-m}{M+m} \right) g$$

$$\text{Put } M \gg m \Rightarrow a = g$$

$$\therefore T = 2mg,$$

$$2T = 4mg$$



25. (C)

Case (i)

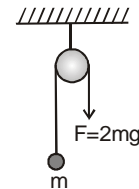
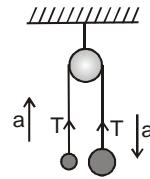
$$T - mg = ma$$

$$2mg - T = 2ma$$

On solving

$$a = g/3$$

case (ii) here  $F = T$

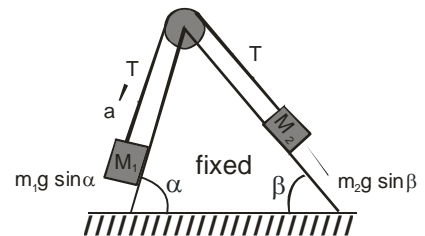


$$T - mg = ma$$

$$T = 2mg, a = g$$

On comparing a of case of (i) < case of (ii)

26. (C)



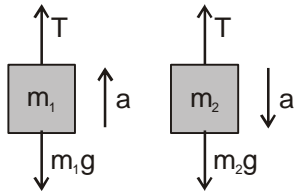
Let  $M_1 > M_2$

$$M_1 g \sin \alpha - T = M_1 a \dots (i)$$

$$T - M_2 g \sin \beta = M_2 a \dots (ii)$$

$$\text{On solving } T = \frac{M_1 M_2 (\sin \alpha + \sin \beta) g}{M_1 + M_2}$$

27. (C)



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

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

On solving equation (i) and (ii)

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

28. (B)

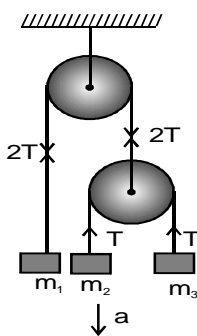
Acceleration of B and C is same so they can be treated as a system.  $a = (2m - m)$

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

$$mg - T = mg$$

$$T = 2mg/3 = 40/3 \approx 13N$$

29. (C)



$$2T = m_1g \quad \dots (1)$$

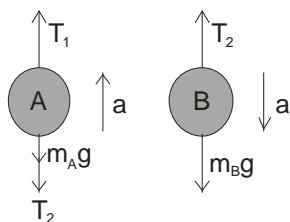
$$m_2g - T = m_2a \quad \dots (2)$$

$$T - m_3g = m_3a \quad \dots (3)$$

on solving

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

30. (A)



$$T_1 - T_2 - m_Ag = m_Aa$$

$$T_2 - m_Bg = m_Ba$$

$$T_1 - (m_A + m_B)g = (m_A + m_B)a$$

$$T_2 = m_B(a + g)$$

$$\frac{T_1}{T_2} = \frac{m_A + m_B}{m_B}$$

31. B

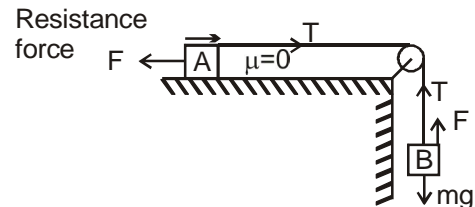
$$T = \frac{2m_1m_2g}{(m_1 + m_2)} \Rightarrow T = \frac{2 \times 5 \times 1 \times 10}{6} = \frac{50}{3}$$

$$2T = \frac{100}{3} \approx 33.33\text{kg}$$

The spring balance reads

$$2T = 33.33\text{kgwt} < 60\text{kgwt}$$

32. (B)



at Block B

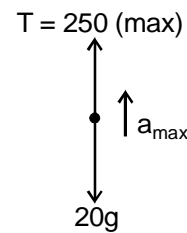
$$T + F = mg \quad \dots (1)$$

at Block A

$$T = F \quad \dots (2)$$

$$T = \frac{mg}{2}$$

33. (D)



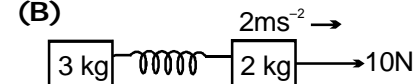
$$T_{\text{max}} = m_{\text{max}}g$$

$$= 25 \times 10 = 250$$

$$250 - 200 = 20 a_{\text{max}}$$

$$a_{\text{max}} = 2.5 \text{ m/s}^2$$

34. (B)



$$10 - kx = 2 \times 2$$

$$kx = 6 \text{ N} \quad \frac{2 \text{ m/s}^2}{}$$

$$kx \leftarrow \boxed{2\text{kg}} \rightarrow 10\text{N}$$

$$\therefore \text{Acceleration of 3 kg} = \frac{6}{3} = 2 \text{ m/s}^2$$

35. (B)

$$18\text{kg at rest} \Rightarrow 180 = 2F$$

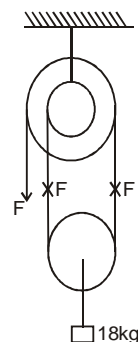
$$F = 90\text{N}$$

36. (C)

$$(a) T = mg + ma$$

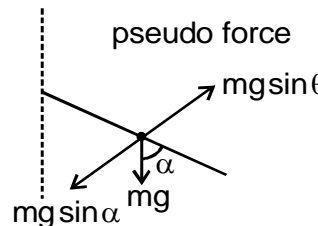
$$(b) T = mg - ma$$

$$T = mg$$



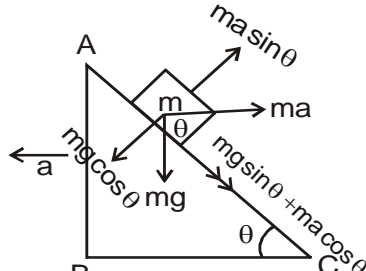
37. (A)  
 $\theta = \downarrow \Rightarrow \sin \theta \downarrow$   
 $mg \sin \theta \downarrow$

38. (A)



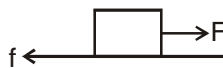
From trolley frame  
 $mg \sin \alpha = mg \sin \theta$   
 $\theta = \alpha$

39. (C)



Mass m falls freely  
 $N = 0$   
 $mg \cos \theta = ma \sin \theta$   
 $a = g \cot \theta$

40. (A)  
 $F < f_{smax}$   
 friction = F  
 For  $F > f_{max}$   
 friction constant

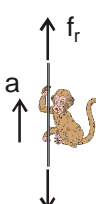


41. (A)

42. (D)  
 $m_A g \sin 30 = \mu m_A g \cos 30$   
 $m_B g \sin 40 = \mu m_B g \cos 40$   
 Does not depend on mass so all three are possible.

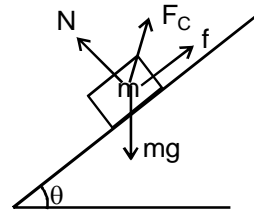
43. (C)  
 $v = u + at \Rightarrow a_A = -\mu g$   
 $a_B = -\mu g \Rightarrow a = \text{same} \Rightarrow u = \text{same}$   
 Time taken to stop is also same  
 Does not depend on mass.

44. (A)  
 Monkey is moving up due to friction force  
 $f_r - mg = ma$   
 $f_r = m(a+g)$   
 towards up.



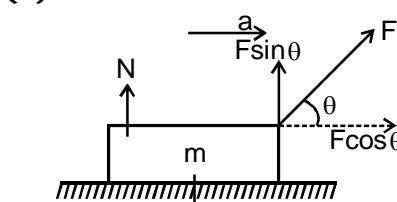
45. (B)  
 $f_{max} > mg \sin \theta$

$\theta \uparrow \sin \theta \uparrow$   
 at this condition block remains rest when  
 $mg \sin \theta > f_{max}$   
 slipping slant



For  $\theta < \text{angle of repose}$   
 $F_c = mg$   
 For  $\theta > \text{angle of repose}$   
 as  $\theta \uparrow f = \mu mg \cos \theta \downarrow$   
 $N = mg \cos \theta \downarrow$

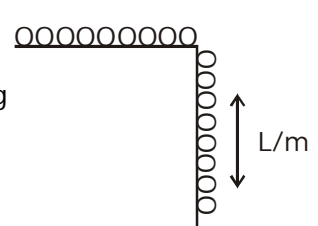
46. (C)



or  
 $F \sin \theta + N = mg$  ... (1)  
 $N = mg - F \sin \theta$  ... (2)  
 $f_r = \mu N$  ... (3)  
 $F \cos \theta - f_r = ma$  ... (3)  
 on solving (1), (2) & (3)  
 $a = \frac{F \cos \theta - \mu(mg - F \sin \theta)}{m}$

$$a = \frac{F}{m} (\cos \theta + \mu \sin \theta) - \mu g$$

47. (B)

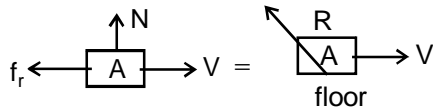


$\mu \lambda L \left(1 - \frac{1}{n}\right) g = \lambda \frac{L}{n} g$   
 $\mu = \frac{1}{n-1}$

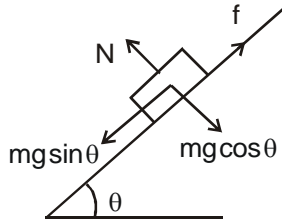
48. (A)  
 move with a constant velocity  
 So  $ma = m \mu g$  (in negative direction)  
 $a = \mu g$   
 $\Rightarrow v^2 - u^2 = 2as \quad v_f^2 = v_i^2 + 2as$   
 $v = \sqrt{2\mu g s}$  here  $v_f = 0, v_i = v$

49. B  
 $f_{max} = \mu mg \cos \theta$   
 $f_{smax} = 0.7 \times 2 \times 9.8 \times \frac{\sqrt{3}}{2} = 7\sqrt{3}$   
 $mg \sin \theta = 9.8$   
 As  $mg \sin \theta < f_{smax}$  so friction required is  $mg \sin \theta$ .

50. (C)  
Floor will provide the normal force and friction force the net reaction is provide by the floor is R.



51. (A)



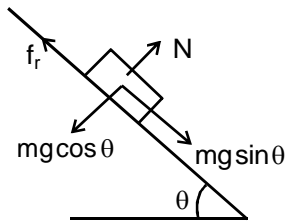
$$N = mg \cos \theta$$

$$f_s \leq \mu N$$

$$mg \sin \theta \leq \mu mg \cos \theta$$

$$\mu \geq 1$$

52. (A)



Let length is  $l$  of inclined plane, then  
 $f_r = \mu N = \mu mg \cos \theta$  (when friction is present)

$$mg \sin \theta - f_r = ma$$

$$a = g(\sin \theta - \mu \cos \theta)$$

$$mg \sin \theta - \mu mg \cos \theta = ma \dots (1)$$

Now

$$l = \frac{1}{2} at_1^2 = \frac{1}{2} g(\sin \theta - \mu \cos \theta) t_1^2$$

Now  $l_1 = l_2 = l$

Without friction  
 $ma = mg \sin \theta$ ,  $a = g \sin \theta$

$$l_2 = l = \frac{1}{2} g \sin \theta t_2^2$$

$$t_1 = 2t_2, t_1^2 = 4t_2^2 \text{ and } t_2 = t/2$$

$$\frac{1}{2} g(\sin \theta - \mu \cos \theta) t^2 = \frac{1}{2} g(\sin \theta - 0 \times \cos \theta) \left(\frac{t^2}{4}\right)$$

$$4(\sin \theta - \mu \cos \theta) = \sin \theta \Rightarrow \mu = \frac{3}{4} = 0.75$$

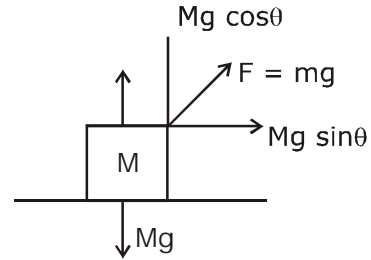
53. (D)

$$N = Mg - Mg \cos \theta, f_{\max} = \mu N$$

$$f_{\max} = \mu Mg(1 - \cos \theta)$$

$$Mg \sin \theta \geq f_{\max}$$

$$Mg \sin \theta \geq \mu Mg(1 - \cos \theta)$$



$$\mu \leq \sin \theta / (1 - \cos \theta)$$

$$\mu \leq \frac{2 \sin \frac{\theta}{2} \cos \frac{\theta}{2}}{2 \cos^2 \frac{\theta}{2}}$$

$$\mu \leq \tan \frac{\theta}{2}$$

54. (A)

$$V^2 = 2 \times g \sin \theta \times l$$

$$\frac{V^2}{n^2} = 2 \times (g \sin \theta - \mu g \cos \theta) l$$

$$\sin \theta \left(1 - \frac{1}{n^2}\right) = \mu \cos \theta$$

$$\mu = \tan \theta \left(1 - \frac{1}{n^2}\right)$$

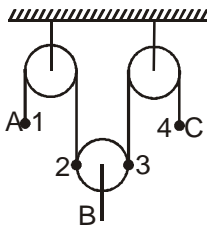
55. A

Friction not depend on surface Area  
so angle remain same.

$\therefore$  Angle =  $30^\circ$

Exercise-II

1. (A)



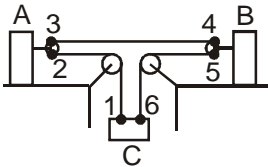
From constrained

$$a_1 + a_2 + a_3 + a_4 = 0$$

$$-a - a_B - a_B + f = 0$$

$$a_B = \left(\frac{f}{2} - \frac{a}{2}\right) = \frac{1}{2}(f - a) \uparrow$$

2. (A)



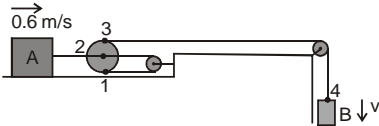
From constrained

$$a_1 + a_2 + a_3 + a_4 + a_5 + a_6 = 0$$

$$-a_c + 2 + 2 - 1 - 1 - a_c = 0$$

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

3. (A)



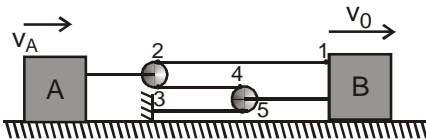
From constrained

$$v_1 + v_2 + v_3 + v_4 = 0$$

$$v - 0.6 - 0.6 - 0.6 = 0$$

$$v = 1.8 \text{ m/s}$$

4. (B)



From constrained

$$v_1 + v_2 + v_3 + v_4 + v_5 = 0$$

$$V_0 - V_A - V_A + V_0 + V_0 = 0$$

$$V_A = \frac{3V_0}{2} \Rightarrow V_{AB} = V_A - V_B = \frac{3V_0}{2} - V_0$$

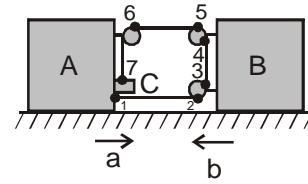
$$= \frac{V_0}{2} \text{ (towards Right)}$$

5. (A)

Let

$$C = c_x \hat{i} + c_y \hat{j}$$

$$C_x = a \rightarrow$$



From constrained

$$a_1 + a_2 + a_3 + a_4 + a_5 + a_6 + a_7 = 0$$

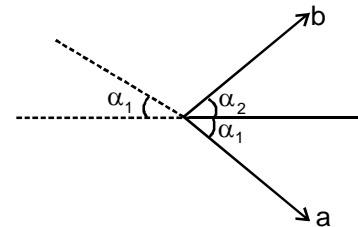
$$-a - b + 0 + 0 - b - a + c = 0$$

$$c_y = (2a + 2b) \downarrow \text{ (By constrain Motion)}$$

In ground frame

$$\therefore C = a\hat{i} - (2a + 2b)\hat{j}$$

6. (A)

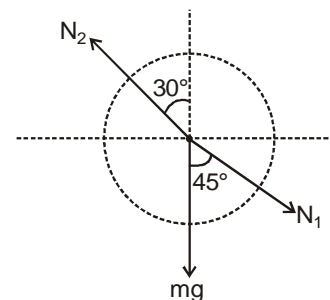
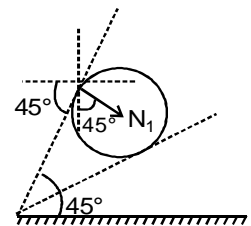
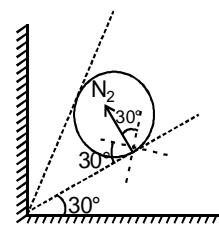
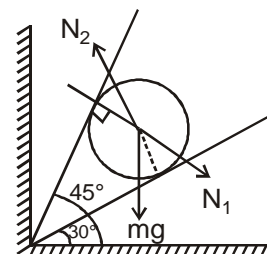


In horizontal direction net acceleration is zero.

$$\text{So, } b \cos \alpha_2 = a \cos \alpha_1$$

$$b = \frac{a \cos \alpha_1}{\cos \alpha_2}$$

7. (A)



In vertical direction

$$50 + \frac{N_1}{\sqrt{2}} = \frac{N_2\sqrt{3}}{2} \quad \dots(1)$$

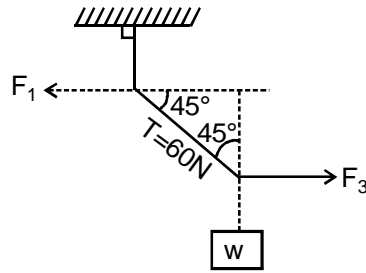
In horizontal direction

$$\frac{N_1}{\sqrt{2}} = \frac{N_2}{2} \quad \dots(2)$$

On solving eq<sup>n</sup> (1) and (2) we get

$$N_1 = 96.59 \text{ N}, N_2 = 136.6 \text{ N}$$

8. (D) &  
9. (A)

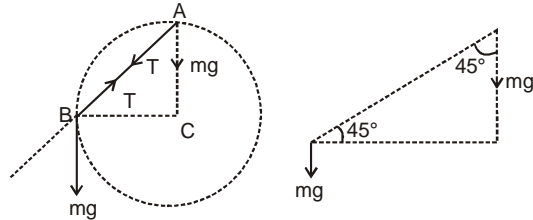


$$F_1 = F_3 = T \cos 45^\circ = 60 \times \frac{1}{\sqrt{2}} = \frac{60}{\sqrt{2}} \text{ N}$$

$$w = T \cos 45^\circ = \frac{T}{\sqrt{2}} = \frac{60}{\sqrt{2}}$$

$$W = \frac{60}{\sqrt{2}} \text{ N}$$

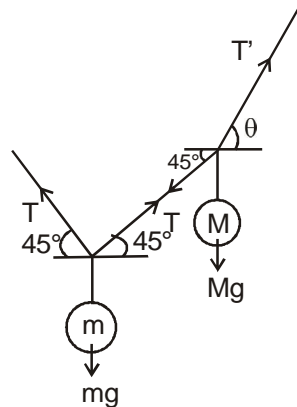
10. (B)



Force along the rod is same

$$= mg \cos 45^\circ = \frac{mg}{\sqrt{2}}$$

11. (A)



$$\frac{2T}{\sqrt{2}} = mg \Rightarrow T = \frac{mg}{\sqrt{2}} \quad \dots(i)$$

$$T' \cos \theta = \frac{T}{\sqrt{2}} \quad \dots(ii)$$

$$\Rightarrow T' \sin \theta = \frac{T}{\sqrt{2}} + Mg \quad \dots(iii)$$

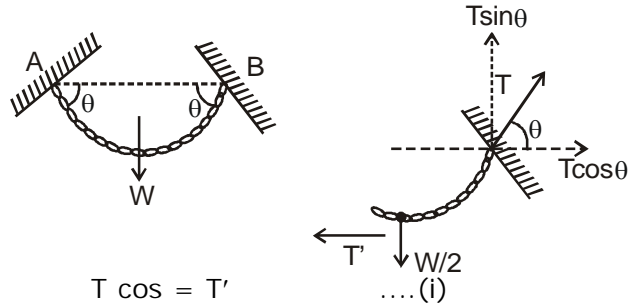
from eq<sup>n</sup> (ii) and (iii)

$$\frac{T}{\sqrt{2}} (\tan \theta - 1) = Mg \quad \dots(iv)$$

from eq<sup>n</sup> (i) and (iv) we get

$$\Rightarrow \tan \theta = 1 + \frac{2M}{m}$$

12. (C)



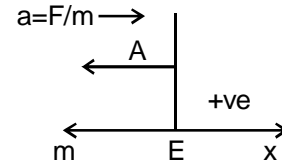
$$T \cos \theta = T'$$

$$T \sin \theta = \frac{W}{2} \quad \dots(ii)$$

From equation (i) and (ii) we get

$$\Rightarrow T' = \frac{W}{2} \cot \theta$$

13. (A)



$$A = \frac{1}{2} at^2 \Rightarrow t = \sqrt{\frac{2}{a} A} \Rightarrow \text{Here } a = \frac{F}{m}$$

So

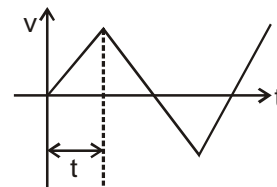
$$\therefore t = \sqrt{\frac{2mA}{F}} \quad \therefore F = ma$$

Total time T = 4t

(for one oscillation/ period of motion)

$$\therefore T = 4 \left( \sqrt{\frac{2mA}{F}} \right)$$

14. (A)



$v = u + at$   
(initial velocity  $u = 0$ )

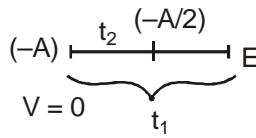
$$v = at \quad \xrightarrow{+}$$

$$v = \frac{F}{m} t$$



15. (B)

$t_1 \rightarrow$  to reach  $(-A)$  to 0



$t_1 = \sqrt{\frac{2mA}{F}} \Rightarrow t_2 \rightarrow$  to reach  $(-A)$  to  $-A/2$

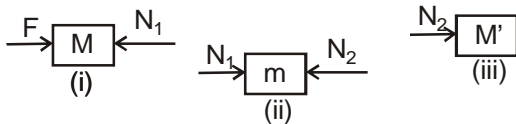
$$\frac{A}{2} = \frac{1}{2} at_2^2$$

$$t_2 = \sqrt{\frac{mA}{F}}$$

So time to reach  $(-\frac{A}{2})$  to '0' is

$$\Rightarrow t_1 - t_2 = \sqrt{\frac{mA}{F}}(\sqrt{2} - 1)$$

16. (B)



$$F - N_1 = Ma \quad \dots (i)$$

$$N_1 - N_2 = ma \quad \dots (ii)$$

$$N_2 = M'a \quad \dots (iii)$$

From eq<sup>n</sup> (i), (ii) and (iii) we get

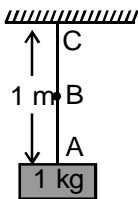
$$F = (M + m + M') a$$

Put in eq<sup>n</sup> (i)

$$N_1 = (M' + m) a$$

$$\therefore M' > M \Rightarrow N_1 > N_2$$

17. (A)



Tension at A

$$T_A = mg = 10 \text{ N}$$

18. (B)

Tension at B

$$(\text{mass of length AB} = \frac{1}{2} \text{ Kg})$$

$$T_B = 1g + 0.5g = 15 \text{ N}$$

19. C

(mass of length AC = 1 Kg)

Force exertd by support =  $T_c$

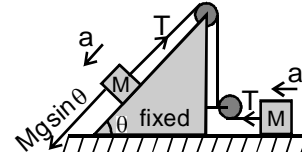
$$= 1g + 1g = 20 \text{ N}$$

20. (C)

$$Mg \sin \theta - T = Ma \quad \dots (1)$$

$$T = Ma \quad \dots (2)$$

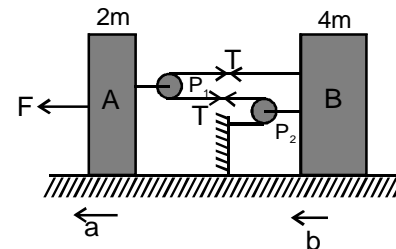
Now eq. (1) - eq. (2)



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

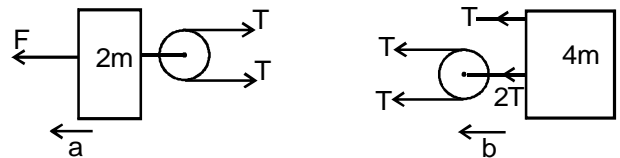
$$T = \frac{Mg \sin \theta}{2}$$

21. (A)



From Constrain equation

$$2a = 3b \quad \dots (1)$$



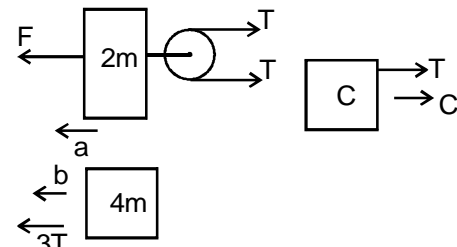
$$F - 2T = 2ma \quad \dots (2)$$

$$3T = 4mb \quad \dots (3)$$

On solving (1), (2) & (3)

$$b = \frac{3F}{17}$$

22. (B)



$$\text{constrain equation } 2a = 3b + c \quad \dots (1)$$

$$F - 2T = 2ma \quad \dots (2)$$

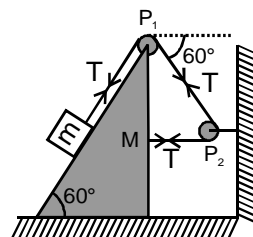
$$T = mc \quad \dots (3)$$

$$3T = 4mb \quad \dots (4)$$

on solving above four equation

$$b = \frac{3F}{21m} \text{ m/s}^2$$

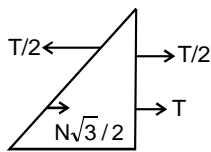
23. (A)



From Constrain equation

$$-b + 0 + 0 - b/2 + b \frac{\sqrt{3}}{2} + a - b \frac{\sqrt{3}}{2} = 0$$

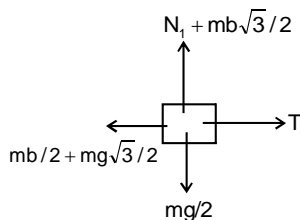
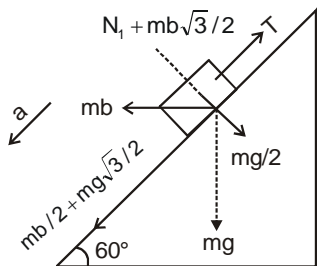
$$a = \frac{3b}{2} \quad \dots(1)$$



F.B.D of 8 kg block

$$T + \frac{N\sqrt{3}}{2} = 8b \quad \dots(2)$$

F.B.D of 2 kg block



$$mg \frac{\sqrt{3}}{2} + \frac{mb}{2} - T = ma \quad \dots(3)$$

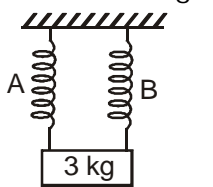
$$N + mb \frac{\sqrt{3}}{2} = \frac{mg}{2} \quad \dots(4)$$

On solving above four equation, we get

$$b = \frac{30\sqrt{3}}{23} \text{ m/s}^2$$

24. (A)

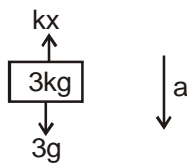
Before cutting



$$2kx = 3g$$

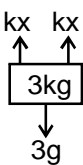
$$kx = 15$$

after cut the spring A.

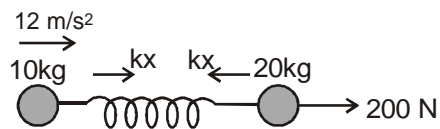


$$a = \frac{3g - kx}{3} = \frac{15}{3} = 5 \text{ m/s}^2$$

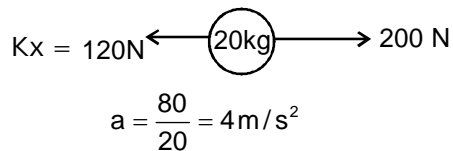
After cutting



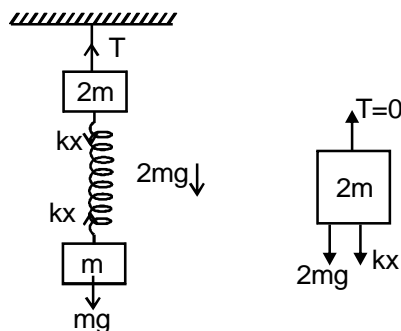
25. (B)



Force on 10 kg block  $Kx = ma$   
 $= 12 \times 10 = 120 \text{ N}$   
 So



26. (B)



$$T = Kx + 2mg \quad \dots(i)$$

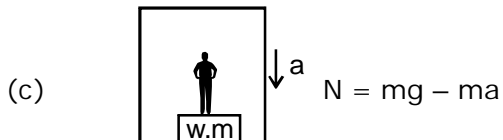
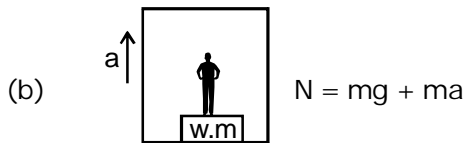
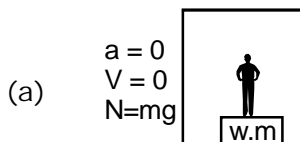
$$Kx = mg \quad \dots(ii)$$

$$T = 3mg$$

After cutting  $T = 0$   
 downwards net force

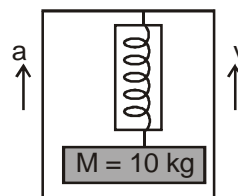
$$\therefore a = \frac{3mg}{2m} = \frac{3g}{2}$$

27. (i) A, (ii) A, (iii) C, (iv) D, (v) B, (vi) D, (vii) B, (viii) B



Independent of the direction of velocity.

28. (i) A, (ii) A, (iii) A, (iv) C, (v) B, (vi) C, (vii) C, (viii) B

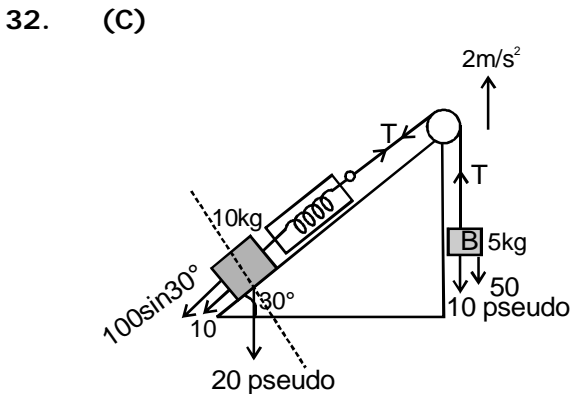


- (a)  $v = 0$  or  $v = \text{constant}$ ,  $a = 0$   
 $w = m(g + a)$   
 $= 10(g + 0)$   
 $= 100 \text{ N}$
- (b)  $v = 0$  or  $v = \text{constant}$   
 $a = \text{upward} = 2\text{m/s}^2$   
 $w = m(g + a)$   
 $= 120 \text{ N}$
- (c)  $v = 0$  or  $v = \text{constant}$   
 $a = \text{downward} = 2\text{m/s}^2$   
 $w = m(g - a)$   
 $= 80 \text{ N}$

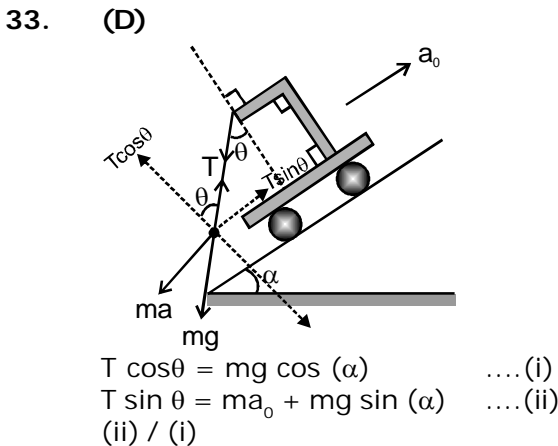
29. (A)  
 $S_1$  is accelerating frame so psuedo force act opposite to frame acceleration  
 $F_{\text{Pseudo}} = \text{mass of analyzing body} \times \text{acceleration of frame}$   
 $= 2(-5\hat{i} - 10\hat{j}) = -10\hat{i} - 20\hat{j}$

30. (B)  
 $S_2$  is inertial frame  
 $F = ma$   
 So  $F = 10\hat{i} + 20\hat{j}$

31. (A)  
 With respect to  $S_1$  frame  
 Net force = zero.



Tension in the string is 60N.  
 So spring balance reading = 6 kg or 60 N



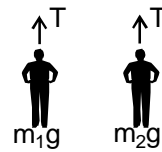
$$\tan \theta = \frac{a_0 + g \sin \alpha}{g \cos \alpha}$$

34. (C)  
 Pulley is fixed from the ceiling  
 If pulley is frictonless then there is no effect of mass of pulley.

35. (B)  
 In upward motion  
 as  $v \downarrow$   
 Force  $\downarrow$   
 acceleration  $\downarrow$   
 and takes less time to reach at top.

Diagram description: A dot representing a mass with an upward arrow labeled 'u' and a downward arrow labeled 'mg + bv'.

36. (A, B, D)

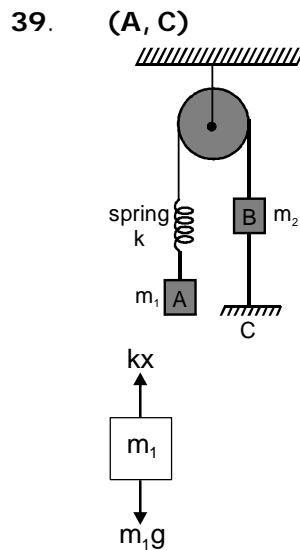


- (A)  $T = m_1g < m_2g$   
 $\therefore$  Acceleration of  $m_2$  is  $\downarrow$
- (B)  $T = m_2g > m_1g$   
 $\therefore$  acceleration of  $m_1$  is  $\uparrow$
- (C) Masses is different  
 $\therefore$  Not possible
- (D)  $T - m_1g = m_1a$   
 $m_2g - T = m_2a$

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

37. (C)  
 (A)  $40 \cos 30^\circ = 20\sqrt{3} \text{ N}$   
 (B) weight = 5 kg  
 (C) Net = zero

38. (B)  
 If  $v = 0$  or  $v = \text{constant}$  then frame is inertial.



$$m_1 g = kx \quad a = \frac{kx - m_2 g}{m_2}$$

$$a = 0$$

Before Burnt  
 $T = kx = m_1 g$   
 Just after burning just at 1 sec  
 (A)  $m_2$  will be upwards.  
 (B)  $m_1$  will be = 0

40. (A, B, C)

$$F = \alpha t$$

$$ma = \alpha t$$

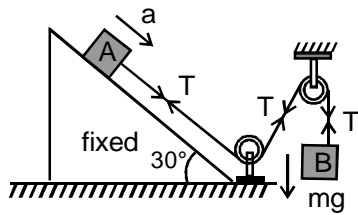
$$a = \frac{\alpha t}{m} \Rightarrow a \propto t \quad \dots (1) \text{ St. line}$$

$$\frac{dv}{dt} = \frac{\alpha t}{m} \Rightarrow v = \frac{\alpha t^2}{m \cdot 2}$$

$$\Rightarrow v \propto t^2 \quad \dots (2) \text{ Pa- parabola}$$

on solving (1) & (2)  
 $v \propto a^2$  Parabola.

41. (B, D)



$$T + mg \sin \theta = ma \quad \dots (1)$$

$$mg - T = ma \quad \dots (2)$$

on solving (1) & (2)  $a = \frac{3g}{4}$

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

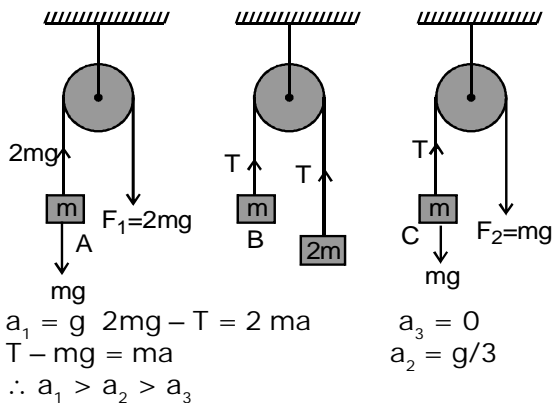
42. (A, B, C)

Slope of  $x - t$  curve gives velocity  
 In region AB, BC, CD have constant slope.  
 $\Rightarrow a = 0 \Rightarrow$  net force = 0

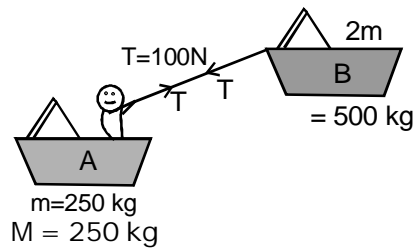
43. (B)

$F_1$  may be equal to  $F_2$

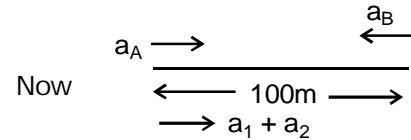
44. (B)



45. (B)



$$a_A = \frac{F}{m} = \frac{100}{250} = \frac{2}{5} \quad \text{and} \quad a_B = \frac{100}{500} = \frac{1}{5}$$



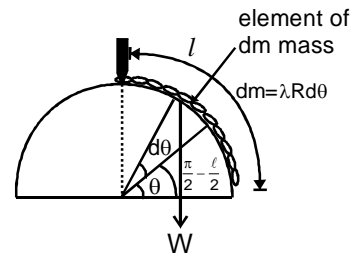
$$a_{AB} = a_1 + a_2 = \frac{2}{5} + \frac{1}{5} = \frac{3}{5}$$

$$100 = \frac{1}{2}(a_1 + a_2)t^2 \Rightarrow 100 = \frac{1}{2}\left(\frac{3}{5}\right)t^2$$

$$t^2 = 333.33$$

$$t = 18.25 = 18.3 \text{ sec}$$

46. (B)



$$F = \int_{\pi/2 - l/r}^{\pi/2} \ell rg \cos \theta d\theta$$

$$F = \lambda rg \left[ 1 - \cos \frac{\ell}{r} \right]$$

$$a = \frac{m}{l} \cdot \frac{rg}{m} \left[ 1 - \cos \frac{\ell}{r} \right]$$

$$a = \frac{rg}{\ell} \left[ 1 - \cos \frac{\ell}{r} \right]$$

47. (C)

Given

$$\vec{a} + \vec{b} + \vec{c} + \vec{d} + \vec{e} = 3\hat{i} \quad \dots (1)$$

$$\vec{b} + \vec{c} + \vec{d} + \vec{e} = -\hat{i} \quad \dots (2)$$

$$\vec{a} + \vec{c} + \vec{d} + \vec{e} = 24\hat{j} \quad \dots (3)$$

$$(1) - (2) \Rightarrow \vec{a} = 4\hat{i}$$

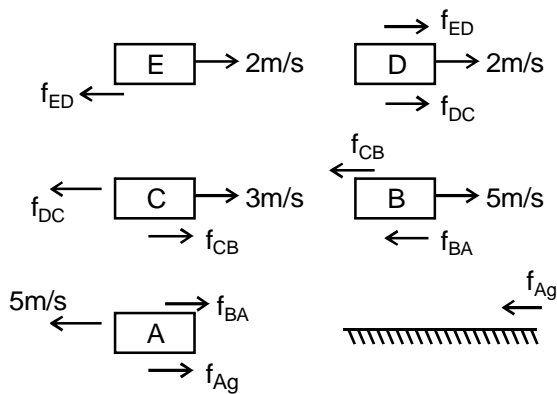
$$(1) - (3) \Rightarrow \vec{b} = 3\hat{i} - 24\hat{j}$$

$$\text{Now } \vec{a} + \vec{b} = 7\hat{i} - 24\hat{j}$$

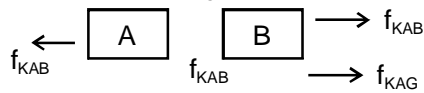
$$|\vec{a} + \vec{b}| = \sqrt{49 + (24)^2} = 25$$

**FRICTION**

48.

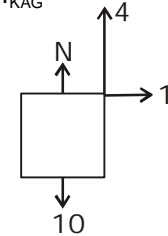


49. Direction of kinetic friction depends on relative velocity, not on the force

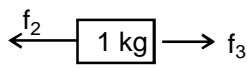
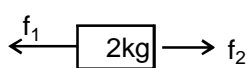
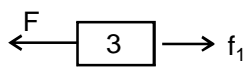
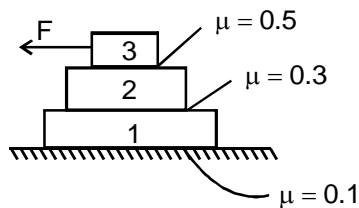


50. (A)

$N = 10 - 4 = 6 \text{ N}$   
 $f_{\text{max}} = 0.3 \times 6 = 1.8 \text{ N}$   
 But required =  $1 \text{ N} \leftarrow$   
 Force of friction =  $-\hat{i}$

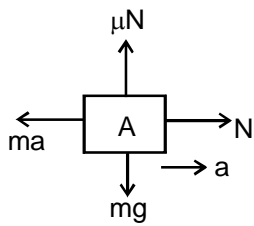


51. (C)



$f_{1 \text{ max}} = 15 \text{ N}, f_{2 \text{ max}} = 15 \text{ N}, f_{3 \text{ max}} = 6 \text{ N}$

52. (C)



If A and B are moving without slipping  
 $m_c g - T = m_c a \dots (1)$   
 $T = 3ma \dots (2)$   
 w.r.t. B

$m_c g = (3m + m_c)a, \mu = g/a$

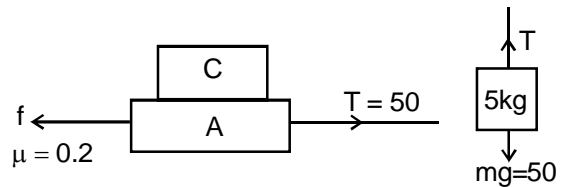
So  $m_c = \left( \frac{3m + m_c}{\mu} \right); m_c = \frac{3m}{\mu - 1}$

$N = ma$   
 $m_c g = \mu ma \Rightarrow a = g/a$

$m_c g - \frac{3mg}{u} = m_c g / \mu \Rightarrow m_c = \frac{3m}{\mu - 1}$

53. (A)

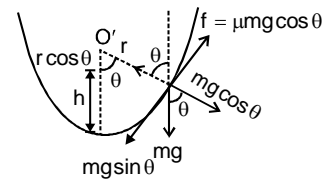
System is at rest contract  
 So,



At rest

$f = T = \mu N$   
 $N = 50/0.2 = 250 \text{ newton}$   
 $m_A g + m_c g = 250$   
 $10 \times 10 + m_c \times 10 = 250$   
 so  $m_c = 15 \text{ kg}$

54. (B)



$h = r - r \cos \theta$   
 $\mu mg \cos \theta = mg \sin \theta$   
 $\tan \theta = \mu$

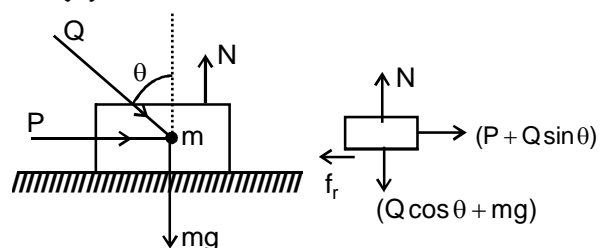
$\cos \theta = \frac{1}{\sqrt{1 + \mu^2}}$

$h = r(1 - \cos \theta) = r \left[ 1 - \frac{1}{\sqrt{1 + \mu^2}} \right]$

55. (B)

$\frac{1}{2} m v_0^2 = \mu mgL; v_0 = \sqrt{2\mu gL}$

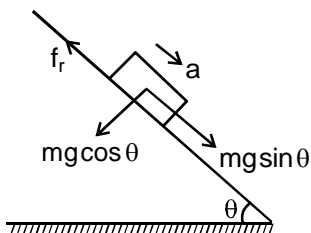
56. (A)



$f_r = \mu N = \mu (mg + Q \cos \theta)$   
 $f_r = P + Q \sin \theta$

$$\mu = \frac{(P + Q \sin \theta)}{(mg + Q \cos \theta)}$$

57. (A)



$$mg \sin \theta - f_r - mg \cos \theta = m$$

$$g[\sin \theta - \mu \cos \theta] = a$$

$$a = \frac{v dv}{dx}$$

$$\Rightarrow \frac{v dv}{dx} = g[\sin \theta - \mu_0 x \cos \theta] \quad [\because \mu = \mu_0 x]$$

[Here  $v = 0$ ]

[Here initial & final velocity is zero]

$$\therefore g[\sin \theta x - \mu_0 \frac{x^2}{2} \cos \theta] = 0 \Rightarrow x = \frac{2}{\mu_0} \tan \theta$$

58. (A)

$$\int_0^{x/2} g(\sin \theta - \mu_0 x \cos \theta) dx = \int_0^v v dv$$

$$g[\sin \theta \cdot \frac{x}{2} - \frac{\mu_0}{2} \left(\frac{x}{2}\right)^2 \cos \theta] = \frac{v^2}{2}$$

Keeping the value

$$x = \frac{2}{\mu_0} \tan \theta \Rightarrow v = \sqrt{\frac{g \tan \theta \sin \theta}{\mu_0}}$$

59. (D)

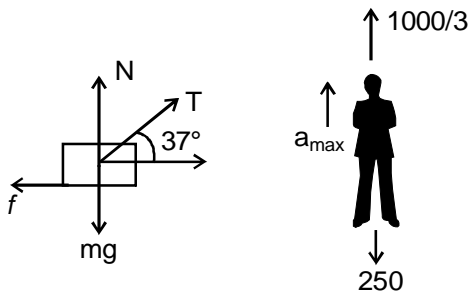
$$a = g \sin \theta - \mu g \cos \theta$$

At the  $x$  increases,  $u \uparrow$   $a \downarrow$

so when  $a = 0$  instant give maximum speed  
 $g \sin 37^\circ - (0.3) x g \cos 37^\circ = 0$

$$6 - \frac{3}{10} \times x \times 8 = 0 \Rightarrow x = \frac{60}{3 \times 8} = \frac{20}{8} = 2.5 \text{ m}$$

60. (B)



$$T \cos 37^\circ = f$$

$$N + T \sin 37^\circ = mg$$

$$\therefore N = 100 g - T \sin 37^\circ = 100 g - \frac{3T}{5}$$

and  $T \cos 37^\circ = \mu N$

$$T \cos 37^\circ = \mu \left(100 g - \frac{3T}{5}\right)$$

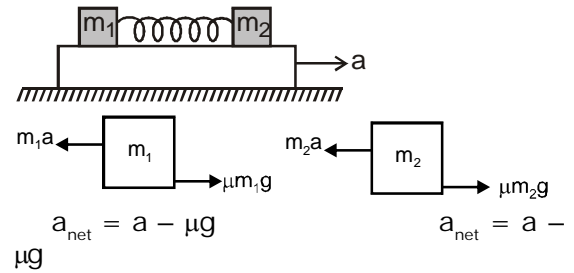
on solving  $T = \frac{1000}{3}$  ( $\mu = \frac{1}{3}$ )

$$T - Mg = ma_{\max}$$

$$\frac{1000}{3} - 250 = 25 \times a_{\max}$$

$$a_{\max} = \frac{g}{3} = \frac{10}{3} \text{ m/s}^2$$

61. (D)

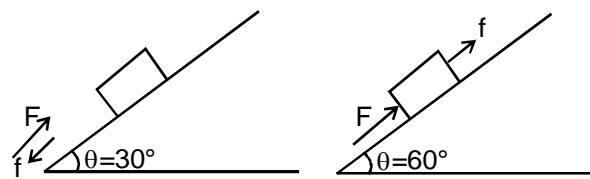


$\therefore f_r$  static and  $f_r$  kinetic both provide same acceleration to  $m_1$  and  $m_2$ .

So no relative motion between them

$\therefore x = 0$  (Always)

62. (C)



$$F = mg \sin 30^\circ + \mu mg \cos 30^\circ$$

$$= \frac{mg}{2} [1 + \mu\sqrt{3}] \quad \dots (1)$$

$$F + f = mg \sin 60^\circ$$

$$F = \frac{mg}{2} [\sqrt{3} - \mu] \quad \dots (2)$$

Now (1) = (2)

$$1 + \mu\sqrt{3} = \sqrt{3} - \mu \Rightarrow \mu = \frac{(\sqrt{3} - 1)}{(\sqrt{3} + 1)}$$

63. (a) B, (b) D, (c) A

(a)  $T - mg \sin 45^\circ = ma$

$$T - \frac{mg}{\sqrt{2}} = \frac{mg}{5\sqrt{2}} \quad \text{Given}$$

$$a = \frac{g}{5\sqrt{2}}$$

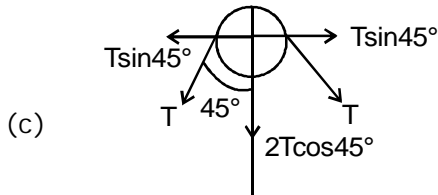
$$T = \frac{6mg}{5\sqrt{2}}$$

(b)  $3mg \sin 45^\circ - T - \mu N = 3ma$

$$\frac{3mg}{\sqrt{2}} - \frac{6mg}{5\sqrt{2}} - \frac{3mg}{5\sqrt{2}} = \mu (3mg \cos 45^\circ)$$

$$3mg \left[ \frac{1}{\sqrt{2}} - \frac{2}{5\sqrt{2}} - \frac{1}{5\sqrt{2}} \right] = 3mg \times \frac{\mu}{\sqrt{2}}$$

$$\mu = \frac{2}{5}$$

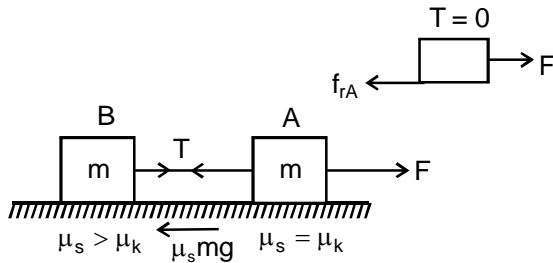


So  $2T \cos 45^\circ = F$

$$2 \times \frac{6mg}{5\sqrt{2}} \times \frac{1}{\sqrt{2}} = F$$

$\therefore F = \frac{6mg}{5}$  downward

64. (A)



Initially

$$F - f_{rA} = 0 \Rightarrow t - \mu_s mg = 0 \Rightarrow t = \mu_s mg$$

[till or  $f_{rB} = \mu_s mg$   $t - \mu_s mg = \mu_s mg$   
 $t = 2\mu_s mg$  ]

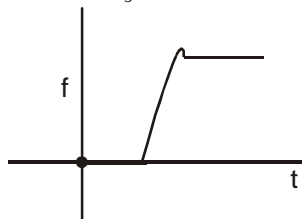
$$T = F - f_{rA} = f_{rB}$$

$$T = t - \mu_s mg = f_{rB}$$

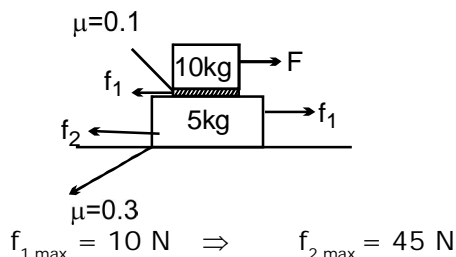
$t = \mu_s mg$  block B will not move  
 $\mu_s mg < t \leq 2\mu_s mg$  block A will not move, static friction will work  
 after  $t > 2\mu_s mg$  kinetic friction will work

$$a = \frac{F - \mu_s mg - \mu_k mg}{m}$$

So  $T = F - \mu_s mg - ma$  after  $t = 2\mu_s mg$



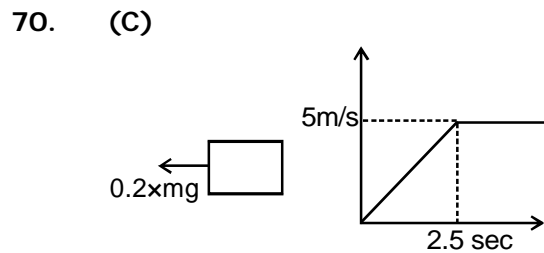
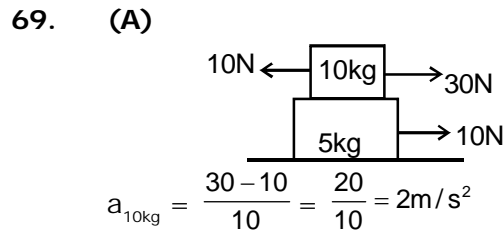
65. (A)



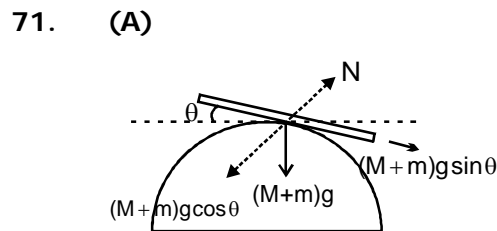
66. (A)  
 If  $F = 2 \text{ N}$   
 there will be no motion  
 the required frictional force is  $2 \text{ N}$

67. (A)  
 There will be no motion of  $5 \text{ kg}$  because  $(f_2 > f_1)$   
 The maximum  $F$  which will not cause motion  
 $F = 10 \text{ N}$

68. (C)  
 Acceleration is zero  
 (For any value of  $F$   $5 \text{ kg}$  block will not move)



For  $t < 1 \text{ sec} \therefore a_B = 2 \text{ m/s}^2$   
 and velocity of truck is  $5 \text{ m/s}$   
 $\therefore$  Friction will act after  $1 \text{ sec}$  due to relative motion between block and truck  
 $5 = 2 \times t, \quad t = 2.5 \text{ sec.}$



For equilibrium condition  
 $(M+m)g \sin \theta = \mu (M+m)g \cos \theta$   
 $\tan \theta = \mu$   
 Here  $\mu \rightarrow$  coefficient of friction between board & log.

72. (A)

$\{ a = \mu g = 0.2 \times 10 = 2 \}$   
 acceleration =  $2 \text{ m/s}^2$   
 So,  $4 = 2 \times t \Rightarrow t = 2 \text{ sec}$   
 $\therefore S = \frac{1}{2} \cdot 2 \cdot (2)^2 = 4 \text{ m}$

73. (A, B)

$$f_{\text{static}_{\text{max}}} = 15 = \mu_s N$$

$$\mu_s = \frac{15}{N} = \frac{15}{mg} = \frac{15}{25} = 0.6$$

Now let  $\mu_k$  then

$$15 - f_r = ma \Rightarrow 15 - \mu_k 25 = 2.5 a$$

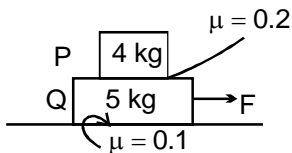
$$\mu_k = \frac{15 - 2.5a}{25} \dots(1)$$

$$\text{Now } x = ut + \frac{1}{2} at^2 \Rightarrow 10 = 0 + \frac{1}{2} \times a \times (5)^2$$

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

$$\therefore \mu_k = \frac{15 - 2.5 \times 4/5}{25} = 0.52$$

74. (C)



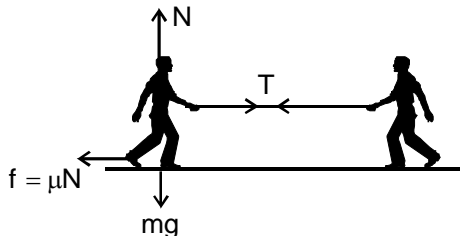
$$f_1 = 0.2 \times 40 = 8 \text{ N}$$

$$f_2 = 0.1 \times 90 = 9 \text{ N}$$

$$\text{Max. acceleration for system } a = \frac{8}{4} = 2 \text{ m/s}^2$$

Minimum force needed to cause system to move = 9 N

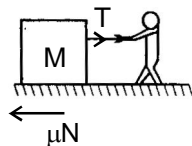
75. (B)



Friction force will more then man will not slip.

N is More

76. (A, B, C)

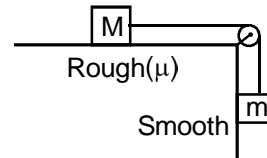


$$T - \mu N = ma$$

As  $T \uparrow$  man

Can have tendency to move

77. (C)



$$mg > \mu M g$$

$$m > \mu M$$

78. (A, C)

(A)  $m < \mu M$

system is at rest  $T = mg$

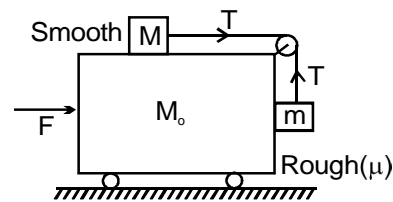
$$mg - T = ma \Rightarrow T = mg - ma$$

$$\& \quad T - \mu M g = Ma \quad \{m > \mu M\}$$

$$\Rightarrow T = Ma + \mu M g$$

on analysing  $\mu M g < T < mg$

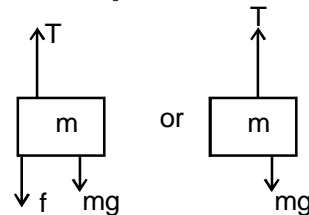
79. (A, D)



(A) When  $F = 0$

No friction b/w  $m$  &  $M_0$  so system move.

(B) When  $F$  is applied then friction develope a range for which  $M$  and  $m$  are stationary w.r.t  $M_0$ , such that

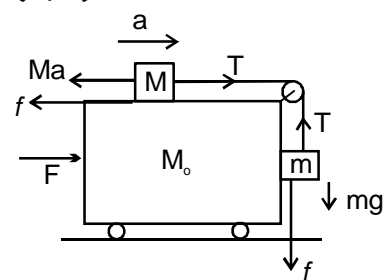


(C) Limiting friction between  $M_0$  &  $m$  is  $\mu ma$

$\therefore$  Dependent on  $a$

(D) When Pseudo acts on  $M$  is equal to  $T$  then  $f = 0$

80. (B, C)



Use Pseudo concept

$$T = Ma \dots(1)$$

$$T = f + mg \Rightarrow T = \mu ma + ma \dots(2)$$

On using (1) & (2)

$$Ma = \mu ma + mg$$

$$a = \frac{Mg}{M - \mu m}$$

(B) then

$$F = \frac{(M_0 + M + m)mg}{M - \mu m}$$

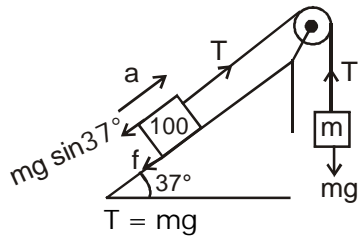


(A) Net Possible because  $T > 0$   
 (only Possible when  $T = 0$  at  $m$  block)  
 $\mu ma = mg \Rightarrow a = g/\mu$   
 but  $T > 0$ , to move the upper block.  
 (C) When  $f = 0$   
 $T = Ma, T = mg, a = mg/M$

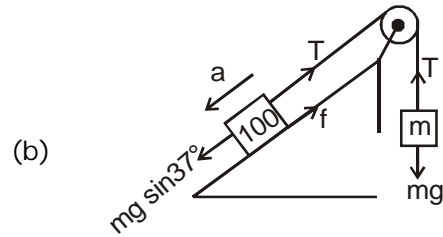
$F = (M_0 + M + m) \frac{mg}{M}$   
 when friction is zero, then only single value of  $F$  for which both  $M$  and  $m$  are rest w.r.t  $M_0$ .

81. (A, B)  
 (A) If  $F = 0$ , the block cannot remain stationary  
 (B) For one unique value of  $F$ , the blocks  $M$  and  $m$  remain stationary with respect to block  $M_0$ .

82. (B, C)



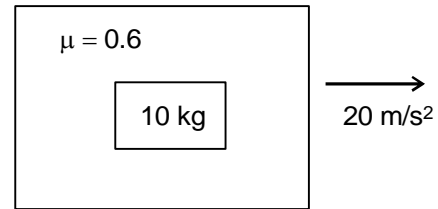
$T = mg$   
 $T = 100 mg \sin 37^\circ + 0.3 \times 100 g \cos 37^\circ$   
 [Put  $g = 9.8$ ]  
 $T = 588 + 235.2$   
 $mg = 823.2 \Rightarrow m = 82.33 = 83 \text{ kg}$



(b)  
 $T + f = ma$   
 $T + 235.2 = 588$   
 $T = 588 - 235.2 = 352.8$   
 $m = 35.28 \text{ kg}$

83. (B, D)  
 $f_c = N$  (Given)  
 $\therefore f_c = \sqrt{N^2 + f^2}$   
 Acceleration to condition  $f = 0 \Rightarrow f_c = N$

84. (A, B, C, D)



(A) Acceleration of box =  $20 \text{ m/s}^2$   
 (when consider as system)

Force on Box

$F = 200 \text{ N}$

$N = 200 \text{ N}$

$f_{\text{max}} = \mu N = 0.6 \times 200 = 120 \text{ N}$

(B)  $f_{\text{required}} = mg = 10 \times 10 = 100 \text{ N}$

(C)  $f_c = \sqrt{f^2 + N^2} = \sqrt{(100)^2 + (200)^2} = 100\sqrt{5} \text{ N}$

Exercise-III

Level - I

1.

$T = 2a_2$   
 $T = a_1$   
 $40 - 2T = 4 \cdot a_3$  ... (1)  
 $T = a_1 = 2a_2 \Rightarrow a_1 = 2a_2$  ... (2)  
 $a_3 = \frac{a_1 + a_2}{2}$  ... (3)  
 $a_3 = \frac{3}{2} a_2$  ... (4)  
 Solving eq<sup>n</sup> (1) (2) (3) and (4) We get  
 $T = 8 \text{ N}$ ,  $a_1 = 8 \text{ m/s}^2$   
 $a_2 = 4 \text{ m/s}^2$   
 $a_3 = 6 \text{ m/s}^2$

2.

$a_m = (g/6 - a)$   
 $T - \frac{m}{2}g = \frac{m}{2}a$  ... (1)  
 $T - mg = m(g/6 - a)$  ... (2)  
 Eq. (2) - (1)  
 $a = \frac{4g}{9}$  &  $T = \frac{13Mg}{18}$

3.

(i)  $M + m = 20 \text{ kg}$   
 $(M + m)g = 200 \text{ N}$   
 $2T = 200 \text{ N}$   
 $T_A = 100 \text{ N}$   
 (ii)  $2T - (M + m)g = (M + m)a$   
 $2T = (M + m)(g + a)$   
 $T = \frac{20(10+2)}{2} \Rightarrow T_A = 120 \text{ N}$   
 $T_B = 2T_A = 240 \text{ N}$

4.

$\frac{g}{2} \cos 60^\circ = \frac{g}{4}$   
 $\frac{g}{2}$   
 $\frac{g}{2}$

length of oA = 5,  $a = \frac{g}{4}$   
 $s = \frac{1}{2} at^2 \Rightarrow 5 = \frac{1}{2} \times \frac{g}{4} \cdot t^2 \Rightarrow t = 2 \text{ sec}$

5.

(a)  $T_1 = 20 \text{ N} = kx_1$   
 (b)  $T - 20 = 2a \Rightarrow 30 - T = 3a$   
 On solving  $a = 2 \text{ m/s}^2$   
 $T = 24 \text{ N} = kx_2$   
 (c)  $T - 10 = a$   
 $20 - T = 2a$   
 On solving  $a = 10/3 \text{ m/s}^2$  &  $T = \frac{40}{3} \text{ N} = kx_3$   
 So  $x_1 = \frac{20}{K}$ ,  $x_2 = \frac{24}{K}$ ,  $x_3 = \frac{13.3}{K}$   
 $x_2 > x_1 > x_3$   $x_1 : x_2 : x_3 = 15 : 18 : 10$

6.

$N = mg \cos \theta = 2.5g \cos 37^\circ$   
 $N \sin 37^\circ = F$   
 $F = 2.5 \times 10 \times \cos 37^\circ \times \sin 37^\circ = 12 \text{ Newton}$

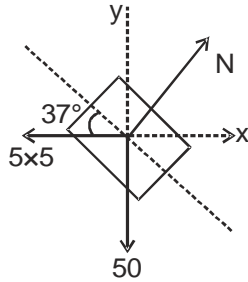
7.

$50 - 40 = 5 \times a$   
 $a = 2 \text{ m/s}^2$   
 $40 - m_1g = m_1 \times 2$   
 $m_1 = \frac{10}{3} \text{ kg}$

8.

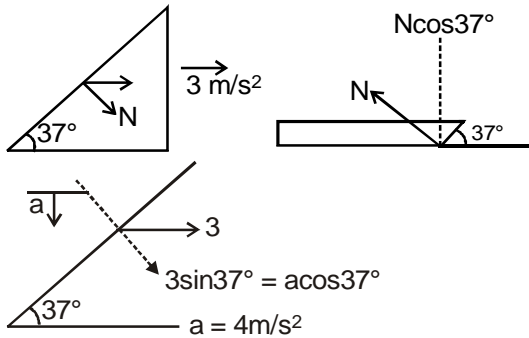
Net force diagram  
  
 $3T = 900 \text{ N}$ ,  $T = 300 \text{ N}$

9.



$$N = 50 \cos 37^\circ + 25 \sin 37^\circ = 55$$

10.



$$a = \frac{9}{4} \text{ m/s}^2$$

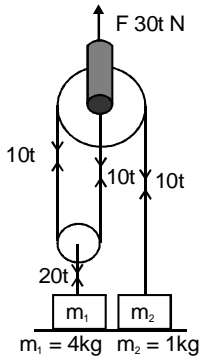
$$N \sin 37^\circ = 1 \times 3$$

$$N \times \frac{3}{5} = 1 \times 3, \quad N = 5 \text{ N}$$

$$mg - 5 \cos 37^\circ = m \times \frac{9}{4}$$

$$m = \frac{16}{31} \text{ Kg}$$

11.



$$20t = 40 \Rightarrow t = 2 \text{ sec}$$

12.

$$\text{Net force on } 40 \text{ kg block} = 4F_1 - F_2$$

$$\text{so } a_{\text{net}} = \frac{4F_1 - F_2}{40}$$

$$\text{at } t = 2 \text{ sec } F_2 = 10; F_1 = 30; a_{\text{net}} = \frac{11}{4} \text{ m/sec}^2$$

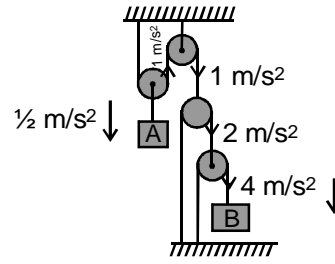
$$t = 4 \text{ sec } F_2 = 20; F_1 = 30; a_{\text{net}} = \frac{10}{4} \text{ m/sec}^2$$

$$t = 0 \rightarrow 2 \quad v = 1.5 + \frac{11}{4} \times 2 = 7 \text{ m/s}$$

$$t = 2 \rightarrow 4 \quad v = 7 + \frac{10}{4} \cdot 2 = 12 \text{ m/s}$$

$$v = 12 \text{ m/s}$$

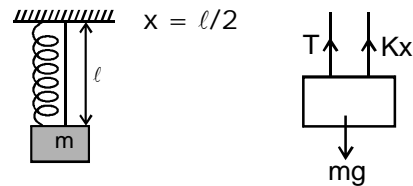
13.



$$y_A = \frac{t^2}{4}, \quad V_A = \frac{t}{2}$$

$$\text{So } a_A = \frac{1}{2} \text{ m/s}^2 \downarrow, a_B = 4 \text{ m/s}^2 \downarrow$$

14.



$$T = mg - kx = mg - \frac{k\ell}{2}$$

$$\text{If } K > 2mg/\ell, Kx > mg$$

$$T = 0$$

15.

$$T - m_T g = m_T a_{\text{cm}} = [m_A a_A + m_B a_B + m_C a_C]$$

$$T = m_T g + m_A a_A + m_B a_B + m_C a_C$$

$$= 330 + 10 \times (-2) + 15 \times 1.5 + 8 \times 0$$

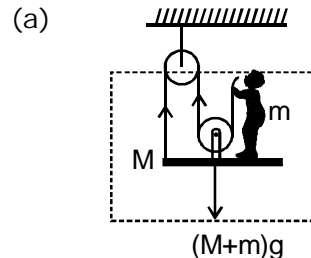
$$= 330 + 22.5 - 20$$

$$= 332.5 \text{ N}$$

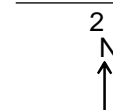
$$\text{Where } m_T \rightarrow \text{Total mass} = 10 + 15 + 18 = 33 \text{ Kg.}$$

$$a_c = 0 \text{ m/s}^2$$

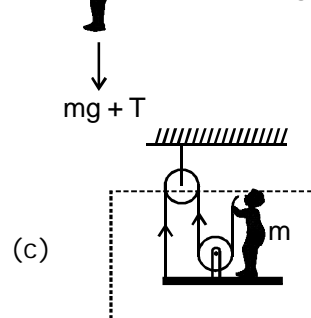
16.

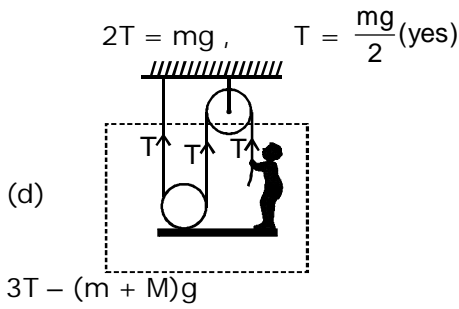


$$2T - (m + M)g = (m + M) a, \quad T = \frac{(m + M)(g + a)}{2}$$

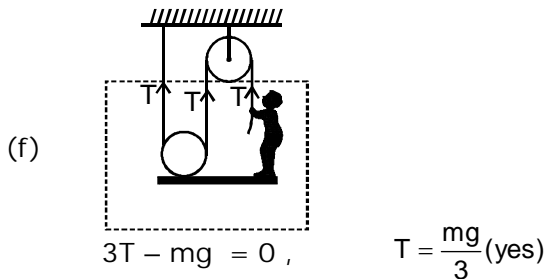
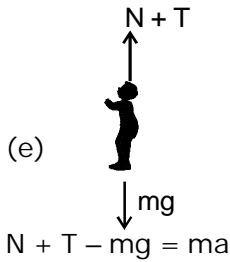


$$N - (mg + T) = ma$$





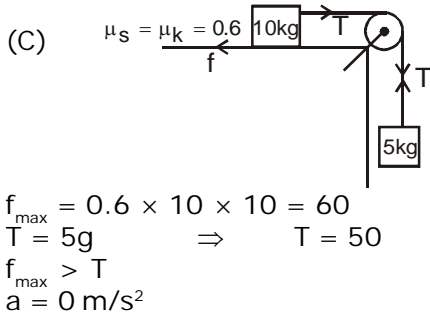
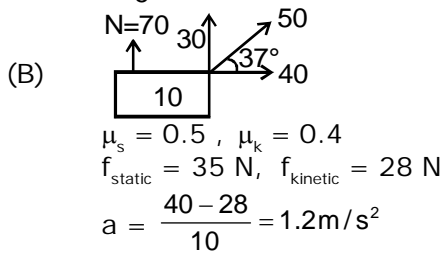
$3T - (m + M)g = (m + M)a, \quad T = \frac{(m + M)(g + a)}{3}$



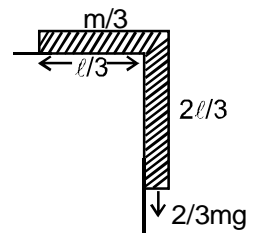
17. (A)  $\mu_s = 0.5, \mu_k = 0.4$   $40\text{N}$

$f_{\text{static}} = 25\text{ N}$   
 $f_{\text{kinetic}} = 20\text{ N}$

So  $a = \frac{40 - 20}{5} = 4\text{ m/s}^2$

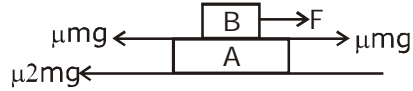


18.  $N = \frac{m}{3}g \Rightarrow f = \mu N$   
 If friction coefficient is



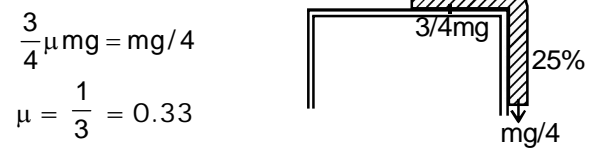
$\mu$  then  $\mu \frac{m}{3}g = \frac{2}{3}mg$   
 $\mu = 2$

- 19.



When  $F \geq \mu_s mg$   
 Then block B is move  
 $F - \mu_k mg = ma$   
 Block a does not move for any value of F

- 20.



- 21.

$\theta =$  angle of Repose

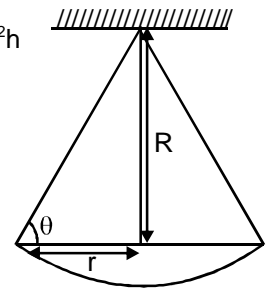
volume of cone =  $\frac{1}{3} \pi r^2 h$

$h = r \tan \theta$

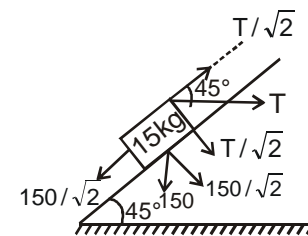
and for just sliding  
 $mg \sin \theta = \mu mg \cos \theta$

$\tan \theta = \mu = \frac{h}{r}$

$v = \frac{1}{3} \pi \mu r^3$



- 22.



$T = 50\text{ N}$

Component of force (in y direction)

$N = \frac{T}{\sqrt{2}} + \frac{150}{\sqrt{2}} \Rightarrow N = 200 / \sqrt{2}$

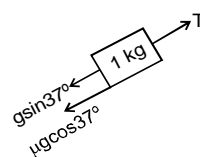
$f = \mu \frac{200}{\sqrt{2}}$

Component of force in x direction

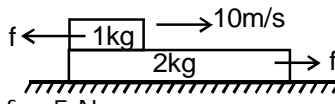
$\frac{150}{\sqrt{2}} = \frac{T}{\sqrt{2}} + f_r$

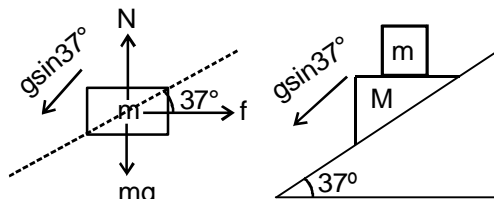
$\frac{150}{\sqrt{2}} - \frac{50}{\sqrt{2}} = \frac{\mu \times 200}{\sqrt{2}} \Rightarrow \mu = \frac{1}{2}$

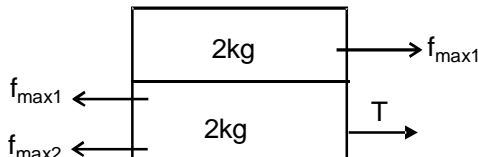
- 23.



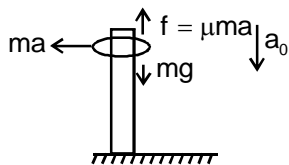
$T = g \sin 37^\circ + \mu g \cos 37^\circ, \quad T = mg$   
 $m = \frac{g \sin 37^\circ + \mu g \cos 37^\circ}{g} = 1\text{ Kg}$

24.   
 $f = 5 \text{ N}$   
 Acc. of block 1 Kg = 5  
 Acc. of block 2 Kg =  $\frac{5}{2}$   
 final velocities block  
 Here 1 Kg is  $v_1$  and 2 Kg is  $v_2$  and  $v_2 = \frac{5}{2} t$   
 and  $v_1 = 10 - 5t$   
 $v_2 = v_1 \Rightarrow \frac{5}{2} \times t = 10 - 5t, \quad t = \frac{4}{3} \text{ sec.}$

25.   
 $mg \sin 37^\circ - N \sin 37^\circ - f \cos 37^\circ = mg \sin 37^\circ$   
 $N \cdot \sin 37^\circ = -f \cos 37^\circ$   
 $N \cdot \frac{3}{5} = -\mu \cdot N \cdot \frac{4}{5}$   
 $N \cdot \frac{3}{5} = -\mu \cdot N \cdot \frac{4}{5} \Rightarrow \mu = \frac{3}{4}$

26.   
 $f_{\max 1} = 20 \times 0.6 = 12 \text{ N}$   
 $f_{\max 2} = 40 \times 0.4 = 16 \text{ N}$   
 $T - 12 - 16 = 2 \times a \Rightarrow T - 28 = 2a$   
 $f_{\max 1} = 2a_{\max}$   
 $[12 = 2a, a = 6 \text{ m/s}^2]$   
 $T = 40 \text{ N}$

27. W.r.t train  
 $mg - \mu ma = ma_0$   
 $(\because a = 4), (\because \mu = \frac{1}{2})$



$$a_0 = g - \mu \times 4 = 10 - 2 = 8 \text{ m/s}^2$$

$$S = ut + \frac{1}{2} at^2 \Rightarrow 1 = \frac{1}{2} \times 8 \times t^2$$

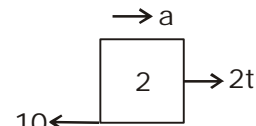
$$t = 2 \text{ sec}$$

28. Condition for move the body

$$2t = \mu m g = \frac{1}{2} \times 2 \times 10$$

$$t_0 = 5 \text{ sec} \quad a = \frac{d^2x}{dt^2}$$

$$5 \text{ sec} < t < 10 \text{ sec}$$



$$2t = 10 + 2a$$

$$a = (t - 5) \Rightarrow \frac{dv}{dt} = t - 5$$

$$v = \frac{t^2}{2} - 5t + \frac{25}{2} \Rightarrow x = \frac{t^3}{6} - \frac{5t^2}{2} + \frac{25}{2} t$$

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

$$x = \frac{125}{6} \text{ m}$$

29.  $f = 0.8 \times 50 = 40 \text{ N}$

$$50 - T - 40 = 5a$$

$$T - 40 = 4a \Rightarrow a = -ve$$

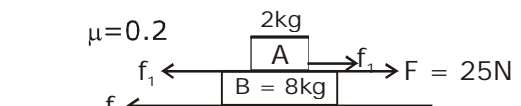
$\therefore$  this direction is not possible

$$40 - T = 4a \Rightarrow T - 90 = 5a$$

$a = -ve \therefore$  this direction is not possible.

$$\therefore a = 0 \Rightarrow \therefore f = 10 \hat{i}$$

- 30.



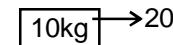
$$f_{1\max} = 0.2 \times 2 \times 10 = 4$$

$$f_{2\max} = 0.5 \times 10 \times 10 = 50$$

firstly applied  $f_2$  then  $f_1$

$$\text{Here } f_{2\max} > 25 \Rightarrow \text{So } f_1 = 0$$

- 31.



$$a_{\max} = 2 \text{ m/s}^2$$

$$F = m_s \times a_{\max} \text{ (block moves together)}$$

$$F = 15 \times 2 = 30 \text{ N}$$

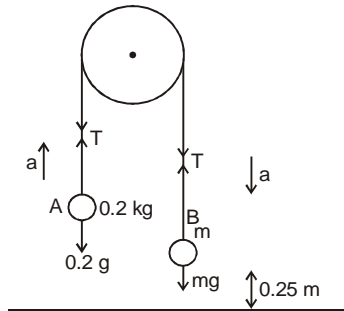
Exercise-III

Level - II

1.  $T - 0.2g = 0.2a \dots(1)$   
 $mg - T = ma \dots(2)$   
 adding (1) and (2)  $mg - 2 = (m + 0.2)a$

$$a = \frac{mg - 2}{m + 0.2} \dots(3)$$

Particle B moves downwards with an acceleration so



$$0.25 = \frac{1}{2}at^2$$

$$0.25 = \frac{1}{2} \left( \frac{mg - 2}{m + 0.2} \right) (0.5)^2 \text{ [Given } t = 0.2 \text{ sec]}$$

$$\Rightarrow m = 0.3 \text{ kg}$$

Now put value  $m = 0.3 \text{ kg}$  is eq. (2) & (1)

We get  $a = 2 \text{ m/sec}^2$ ,  $T = 2.4 \text{ N}$   
 When B touch the ground at this time velocity of particle A is

$$v = 2(0.5) = 1 \text{ m/s}^2$$

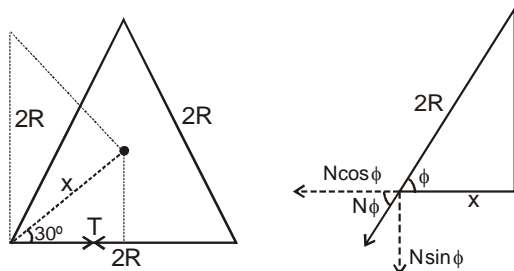
It move upward until the velocity of A is zero.

$$\Rightarrow 0 = 1 - gt, \quad t = 0.1 \text{ sec}$$

B remain at rest on ground for  $t' = 2t$

$$t' = 2 \times 0.1 = 0.2 \text{ sec}$$

2.



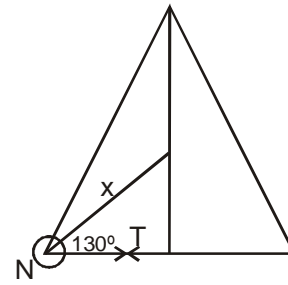
$$x \cos \theta = R$$

$$x = \frac{2R}{\sqrt{3}} \quad \cos \phi = \frac{x}{2R} = \frac{1}{\sqrt{3}}$$

$$\text{Now } 3N \sin \phi = mg$$

$$\Rightarrow N = \frac{2\sqrt{6}}{3 \sin \phi} = \frac{2\sqrt{6}}{3 \cdot \frac{\sqrt{2}}{\sqrt{3}}}$$

$$N = 2 \text{ N}$$



$$\text{Now } 2(T \cos 30^\circ) \cos \phi = N$$

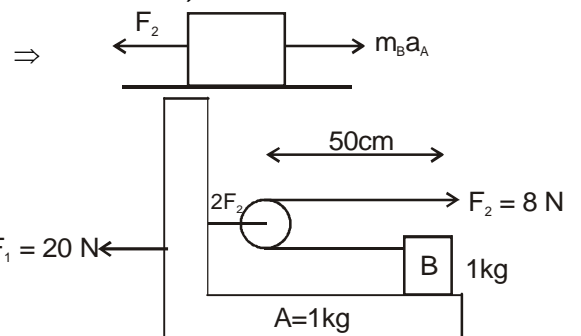
$$2 \times T \times \frac{\sqrt{3}}{2} \left( \frac{1}{\sqrt{3}} \right) = 2 \Rightarrow T = 2 \text{ N}$$

3. First find out acceleration of A so for this

$$\Rightarrow a = 20 - 2F_2 = 20 - 2 \times 8$$

$$a_A = 4 \text{ m/s}^2$$

Now use pseudo concept (in which A is non inertial frame)



$$\Rightarrow 8 - 4 = 4 \text{ m/s}^2$$

$$\text{Now } \frac{50}{100} = \frac{1}{2} \times 4 \times t^2$$

$$t = \frac{1}{2} = 0.5 \text{ sec}$$

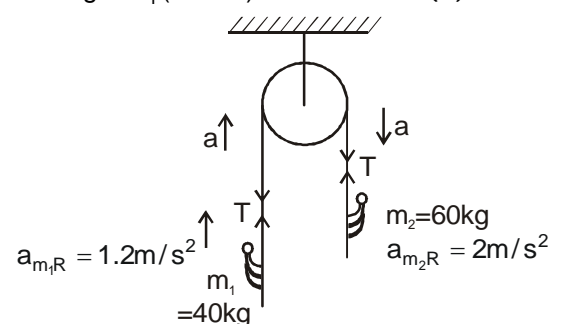
4. for man of mass  $m_1$   $a_{m_1 G} = a_{m_2 R} + a_{R G}$

$$a_{m_1 G} = (1.2 + a)$$

for man of mass  $m_2$   $a_{m_2 G} = a_{m_2 R} + a_{R G}$

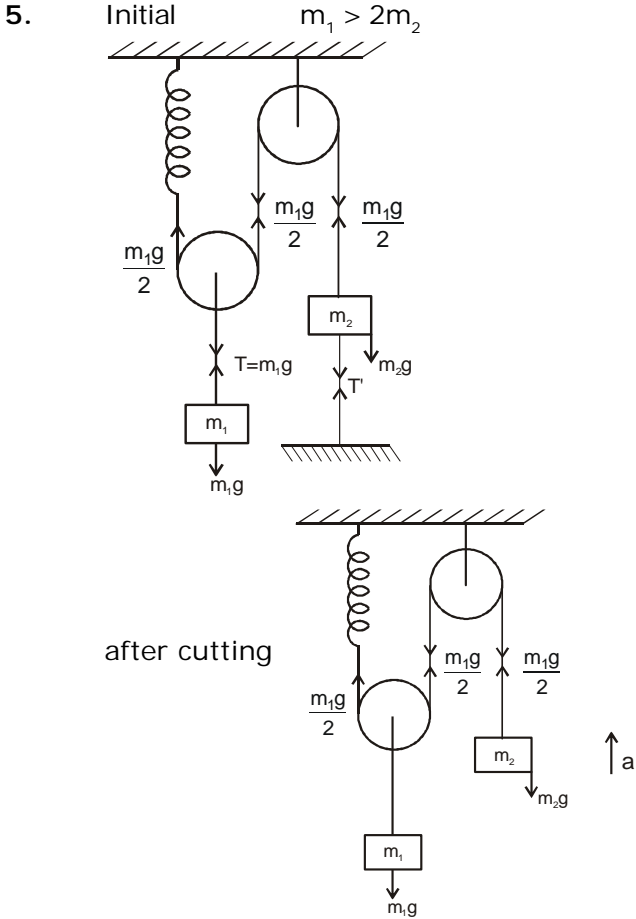
$$= (2 - a), \text{ So now}$$

$$T - mg = m_1(1.2 + a) \dots(1)$$

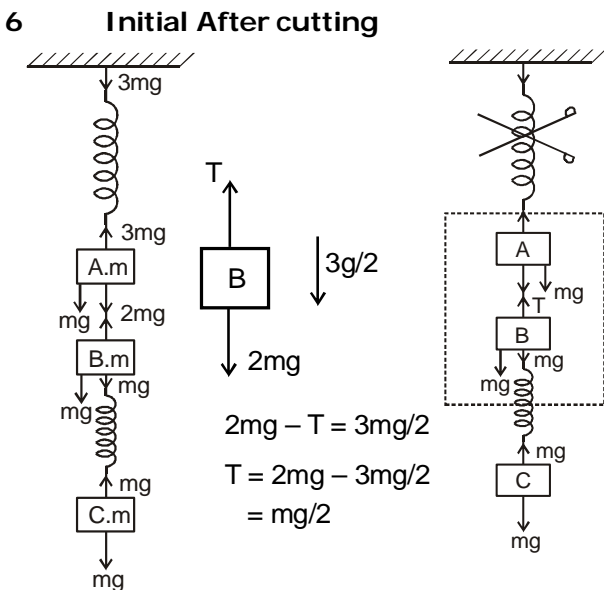


$$T - mg = m_2(2 - a) \quad \dots(2)$$

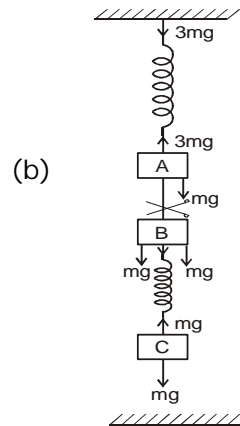
Solve eq. (1) & (2) and put  $m_1 = 40 \text{ kg}$   
 $m_2 = 60 \text{ kg}$   
 you get  $a = 2.72 \text{ m/s}^2$   
 $T = 556.8 \text{ N}$



$$\Rightarrow m_2 a = m_1 g / 2 - m_2 g \Rightarrow a = \left( \frac{m_1 - 2m_2}{2m_2} \right) g \text{ m/s}^2 \uparrow$$



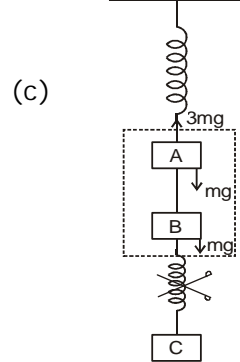
$$a_A = a_B = \frac{3mg}{2m} = 1.5g$$



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

$$a_B = \frac{2mg}{m} = 2g \downarrow$$

$$a_C = 0, T = 0$$



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

$$T - mg = mg/2$$

$$T = 3mg/2$$

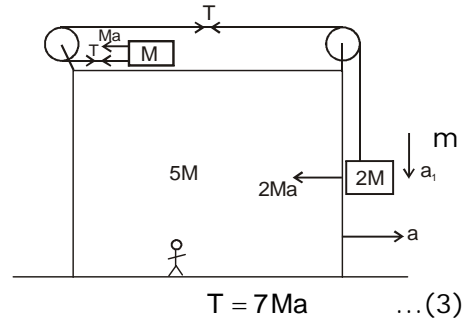
$$a_C = g$$

7

$$\Rightarrow T + Ma = Ma_1 \quad \dots(1)$$

$$2Mg - T = 2Ma_1 \quad \dots(2)$$

$$\{N = 2Ma\} \quad T - 2Ma = 5Ma$$



Using eq. (1), (2), (3)  
 we get  $a = \frac{2}{23} g$

8.

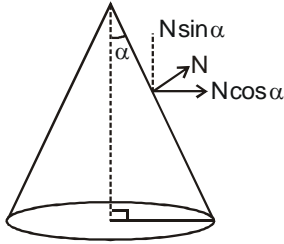
$$\int dN \sin \alpha = \int dm g \quad \dots(1)$$

$$\sum 2T \cdot \sin d\theta = N \cos \alpha$$

$$\sum 2T d\theta = N \cos \alpha$$

$$\sum 2T \left( \frac{dx}{R} \right) = N \cos \alpha$$

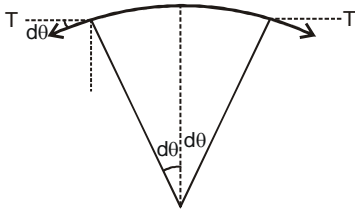
$$2T(\pi R/R) = N \cos \alpha$$



$2\pi T = N \cos \alpha$  ... (2)

from (1) & (2)

$\Rightarrow T = \frac{\cos \alpha mg}{2\pi}$

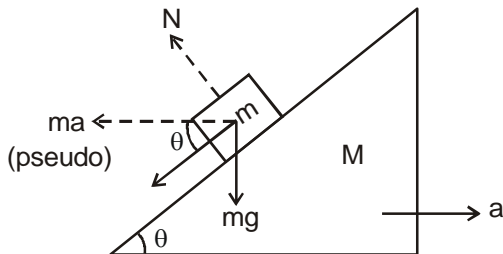


$15 \frac{10}{15} \text{ cm}$

$\Rightarrow T = \frac{10}{15} \times T \text{ cm}$

$\frac{10}{15} \times \frac{\cot \alpha mg}{2\pi} = 1 \text{ cm}$

- 9 (a) Using pseudo concept  
 $m \sin \theta + N = mg \cos \theta$



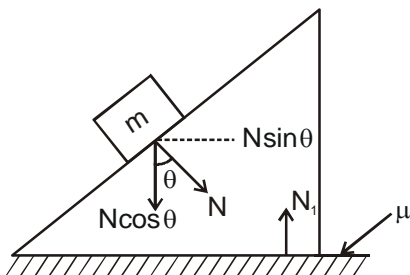
When  $N = 0$

$\Rightarrow a = g \cot \theta$

(b)

$\Rightarrow N_1 = N \cos \theta + Mg \Rightarrow f = \mu N_1$

$= \mu (N \cos \theta + Mg) \therefore N = mg \cos \theta$



$\Rightarrow f = \mu (mg \cos^2 \theta + Mg)$

Wedge not move when

$f = N \sin \theta = mg \cos \theta \sin \theta$

$\Rightarrow \mu (mg \cos^2 \theta + Mg) = Mg \cos \theta \sin \theta$

$\mu = \frac{Mg \cos \theta \sin \theta}{Mg \cos^2 \theta + Mg}$

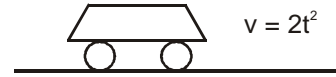
10

at  $t = 1$  sec it start slipping so.

at this moment acceleration of block =  $\mu_s g$

$t = 1 \text{ sec} \quad a = 4(t) = 4(1) = 4 \text{ m/s}^2$

$\Rightarrow 4 = \mu_s g \Rightarrow \mu_s = 0.4$



after that at  $t = 1 \text{ sec} \quad v = 2 \text{ m/sec.}$

at  $t = 2 \text{ sec} \quad v = 8 \text{ m/sec}$

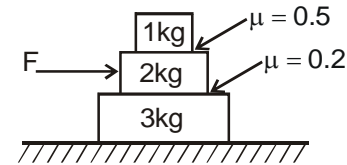
after wards  $a = 0$  so at  $t = 3 \text{ sec} \quad v = 8 \text{ m/sec}$

$a_\mu = \mu_k g$  (sliding),  $v = u + at$

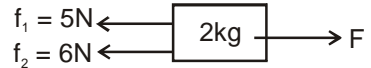
$\Rightarrow 8 = 2 + 10 \mu_k (2) \Rightarrow \frac{6}{10 \times 2} = \mu_k$

$\mu_k = 0.3 \text{ sec} =$

11



force on 1kg block



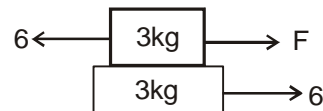
force on 3 kg block



maximum acceleration of block of mass 1 kg =  $5/1 = 5 \text{ m/s}^2$

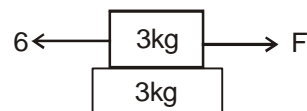
maximum acceleration of block of mass 3 kg =  $6/3 = 2 \text{ m/s}^2$

So block move together only when acceleration of all the block is not greater than  $2 \text{ m/s}^2$



$F - 6 = 3 \times 2 \Rightarrow F = 12 \text{ N}$

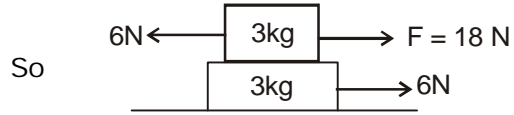
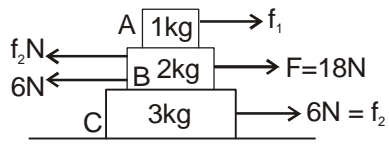
Now sliding starts in both block when acceleration is greater than equal to  $5 \text{ m/s}^2$



$F - 6 = 3 \times 5 \Rightarrow F = 21 \text{ N}$



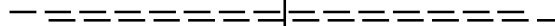
When  $F = 18\text{ N}$  block  $1\text{ kg}$  &  $2\text{ kg}$  move together.



$a_c = 6/3 = 2\text{ m/s}^2$        $f = 6\text{ N}$   
 common acceleration =  $18 - 6 = 3 \times a$

$\Rightarrow a = 4\text{ m/s}^2$

$\Rightarrow$   $f_1 = ?$        $f_i = 4\text{ N}$

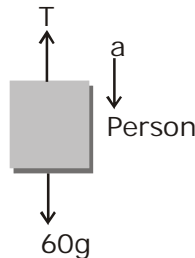


Exercise-IV

Level - I

1. (C)

The free body diagram of the person can be drawn as  
Let the person move down with an acceleration  $a$  then

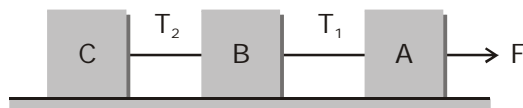


$$60g - T = 60a \Rightarrow 60g - T_{\max} = 60 a_{\min}$$

$$\text{or } a_{\min} = \frac{60g - 360}{60} = 4\text{ms}^{-2}$$

2. (B)

The system of masses is shown below. From the figure.



$$F - T_1 = ma \quad \dots(i)$$

$$\text{and } T_1 - T_2 = ma \quad \dots(ii)$$

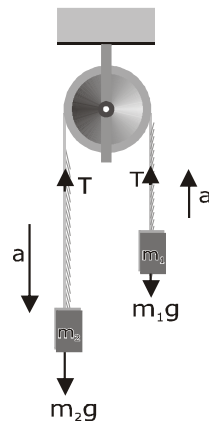
Eq. (i) gives,

$$10.2 - T_1 = 2 \times 0.6$$

$$\Rightarrow T_1 = 10.2 - 1.2 = 9 \text{ N}$$

3. (C)

As the string is inextensible, both masses have the same acceleration  $a$ . Also, the pulley is massless and frictionless, hence the tension at both ends of the string is the same. Suppose the mass  $m_2$  is greater than mass  $m_1$ , so the heavier mass  $m_2$  is accelerating downward and the lighter mass  $m_1$  is accelerating upwards.



$$\text{Therefore, by Newton's 2nd law } T - m_1g = m_1a \quad \dots(i)$$

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

After solving Eqs. (i) and (ii)

$$a = \frac{(m_2 - m_1)}{(m_2 + m_1)} \cdot g = \frac{g}{8} \quad \text{(given)}$$

$$\text{So, } \frac{g}{8} = \frac{m_2(1 - m_1/m_2)}{m_2(1 + m_1/m_2)} \cdot g \quad \dots(iii)$$

$$\text{Let, } \frac{m_1}{m_2} = x$$

Thus, Eq. (iii) becomes

$$\frac{1 - x}{1 + x} = \frac{1}{8}$$

$$\text{or } x = \frac{7}{9} \quad \text{or } \frac{m_1}{m_2} = \frac{9}{7}$$

So, the ratio of the masses is 9:7.

4. (B)

Using the relation

$$\frac{mv^2}{r} = \mu R, R = mg$$

$$\Rightarrow \frac{mv^2}{r} = \mu mg \text{ or } v^2 = \mu rg$$

$$\Rightarrow v^2 = 0.6 \times 150 \times 10$$

$$\text{or } v = 30\text{ms}^{-1}$$

Again from Eq. (ii), we get

$$9 - T_2 = 2 \times 0.6$$

$$\Rightarrow T_2 = 9 - 1.2 = 7.8\text{N}$$

5. (A)

The particle remains stationary under the acting of three forces  $\vec{F}_1, \vec{F}_2$  and  $\vec{F}_3$ , it means resultant force is zero,

$$\vec{F}_1 = -(\vec{F}_2 + \vec{F}_3)$$

Since, in second case  $F_1$  is removed (in terms of magnitude we are talking now), the forces acting are  $F_2$  and  $F_3$  the resultant of which has the magnitude as  $F_1$ , so acceleration of

particle is  $\frac{F_1}{m}$  in the direction opposite to that of  $\vec{F}_1$ .

6. (B)

$$A + B = 18 \quad \dots(i)$$

$$12 = \sqrt{A^2 + B^2 + 2AB \cos \theta} \quad \dots(ii)$$

$$\tan \alpha = \frac{B \sin \theta}{A + B \cos \theta}$$

$$\Rightarrow \tan 90^\circ = \frac{B \sin \theta}{A + B \cos \theta}$$

$$\Rightarrow \cos \theta = \frac{-A}{B} \quad \dots(iii)$$

Solving Eqs. (i), (ii) and (iii),  $A = 5\text{N}, B = 13\text{N}$

7. (C)

Apparent weight of ball

$$w' = w - R$$

$R = ma$  (acting upward)

$$w' = mg - ma$$

$$= m(g - a)$$

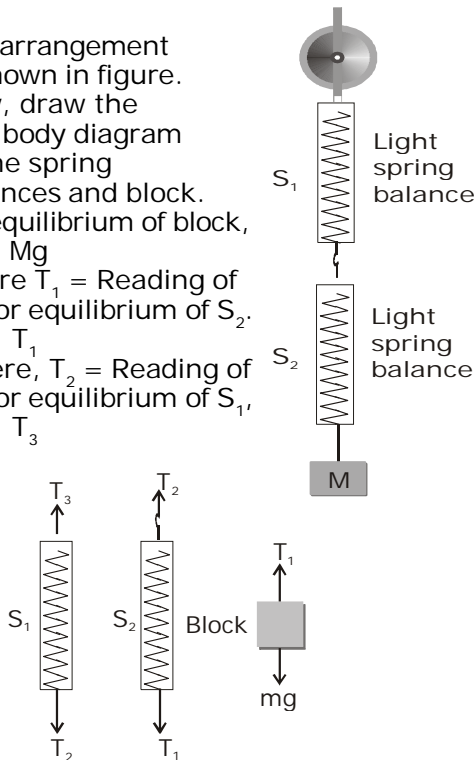
Hence, apparent acceleration in the lift is  $g - a$ . Now, if the man is standing stationary on the ground, then the apparent acceleration of the falling ball is  $g$ .

8. (A)

Here, thrust force is responsible to accelerate the rocket, so initial thrust of the blast =  $ma$   
 $= 3.5 \times 10^4 \times 10$   
 $= 3.5 \times 10^5 \text{ N}$

9. (A)

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  $S_1$ ,  $T_2 = T_3$



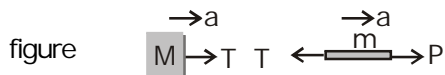
Hence  $T_1 = T_2 = Mg$   
 So, both scales read  $M \text{ kg}$ .

10. (D)

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

$$a = \frac{P}{M + m}$$

Draw the FBD of block and rope as shown in figure



Where,  $T$  is the required parameter.

For block,  
 $T = Ma$

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

11. (C)

Here B is implying A but A is not implying B, as kinetic energy of a system of particles is zero means speed of each and every Particle is zero. which says that momentum of every particle is zero.

But statement A means linear momentum of a system of particles is zero, which may be true even if particles have equal and opposite momentums and hence, having non-zero kinetic energy.

12. (C)

Let coefficient of friction be  $\mu$ , then retardation will be  $\mu g$ .

From equation of motion.

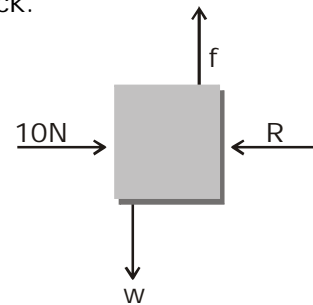
$$v = u + at$$

$$\Rightarrow 0 = 6 - \mu g \times 10$$

$$\text{or } \mu = \frac{6}{100} = 0.06$$

13. (D)

Let  $R$  be the normal contact force by wall on the block.



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

$$f_L = w \text{ and } f = \mu R$$

$$\therefore \mu R = w$$

$$\text{or } w = 0.2 \times 10 = 2 \text{ N}$$

14. (D)

Resultant force is zero, as three forces on the particle can be represented in magnitude and direction by three sides of a triangle in same order. Hence, by Newton's 2nd law

$$\left( \vec{F} = m \frac{d\vec{v}}{dt} \right), \text{ Particle velocity } (\vec{v}) \text{ will be same.}$$

15. (A)

In stationary position, spring balance reading  $\Rightarrow mg = 49$

$$\text{or } m = \frac{49}{9.8} = 5 \text{ kg}$$

When lift moves downward.

$$mg - T = ma$$

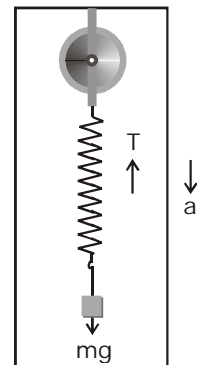
Reading of balance

$$T = mg - ma$$

$$= 5(9.8 - 5)$$

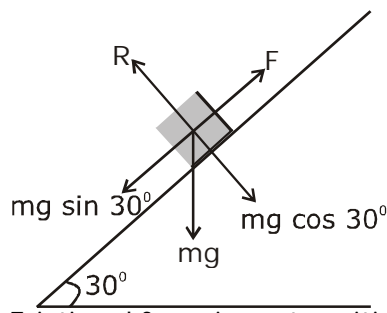
$$= 5 \times 4.8$$

$$= 24.0 \text{ N}$$



16. (A)

Let mass of the block be  $m$ .



Frictional force in rest position

$$F = mg \sin 30^\circ$$

[This is static frictional force and may be less than the limiting frictional force]

$$\therefore 10 = m \times 10 \times \frac{1}{2} \text{ or } m = \frac{2 \times 10}{10} = 2 \text{ kg}$$

17. (A)

On releasing, the motion of the system will be according to figure.

$$m_1 g - T = m_1 a \quad \dots (i)$$

$$\text{and } T - m_2 g = m_2 a \quad \dots (ii)$$

On solving

$$a = \left( \frac{m_1 - m_2}{m_1 + m_2} \right) g \quad \dots (iii)$$

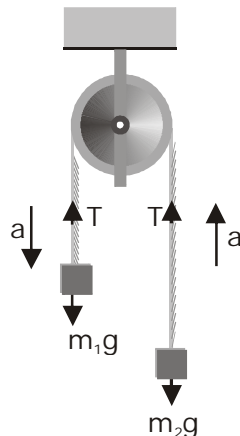
Here

$$m_1 = 5 \text{ kg}, m_2 = 4.8 \text{ kg},$$

$$g = 9.8 \text{ ms}^{-2}$$

$$\therefore a = \left( \frac{5 - 4.8}{5 + 4.8} \right) \times 9.8$$

$$= \frac{0.2}{9.8} \times 9.8 = 0.2 \text{ ms}^{-2}$$



18. (D)

The force exerted by machine gun on man's hand in firing a bullet.

= change in momentum per second on a bullet or rate of change of momentum

$$= \left( \frac{40}{1000} \right) \times 1200 = 48 \text{ N}$$

The force exerted by man on machine gun

= force exerted on man by machine gun

$$= 144 \text{ N}$$

19. (C)

According to work - energy theorem,

$$W = \Delta K = 0$$

=> work done by friction

+ work done by gravity = 0

$$\Rightarrow -(\mu mg \cos \phi) \frac{l}{2} + mgl \sin \phi = 0$$

$$\text{or } \frac{\mu}{2} \cos \phi = \sin \phi$$

$$\text{or } \mu = 2 \tan \phi$$

20. (A)

When friction is absent

$$a_1 = g \sin \theta$$

$$\therefore s_1 = \frac{1}{2} a_1 t_1^2 \quad \dots (i)$$

When friction is present

$$a_2 = g \sin \theta - \mu_k g \cos \theta$$

$$\therefore s_2 = \frac{1}{2} a_2 t_2^2 \quad \dots (ii)$$

From Eqs. (i) and (ii)

$$\frac{1}{2} a_1 t_1^2 = \frac{1}{2} a_2 t_2^2$$

$$a_1 t_1^2 = a_2 (n t_1)^2 \quad (\because t_2 = n t_1)$$

$$\text{or } a_1 = n^2 a_2$$

$$\Rightarrow \frac{a_2}{a_1} = \frac{g \sin \theta - \mu_k g \cos \theta}{g \sin \theta} = \frac{1}{n^2}$$

$$\frac{g \sin 45^\circ - \mu_k g \cos 45^\circ}{g \sin 45^\circ} = \frac{1}{n^2}$$

$$\text{or } 1 - \mu_k = \frac{1}{n^2} \quad \text{or } \mu_k = 1 - \frac{1}{n^2}$$

21. (D)

Since  $\omega$  is constant,  $v$  would also be constant. So, no net force or torque is acting on ring. The force experienced by any particle is only along radial direction, or we can say the centripetal force.

The force experienced by

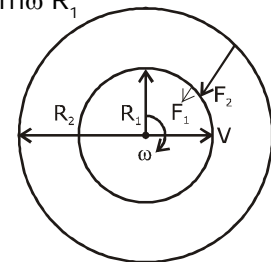
inner part,  $F_1 = m \omega^2 R_1$

and the force experienced by

outer part,

$$F_2 = m \omega^2 R_2$$

$$\Rightarrow \frac{F_1}{F_2} = \frac{R_1}{R_2}$$



22. (D)

Given,  $m = 0.3 \text{ kg}$ ,  $x = 20 \text{ cm}$

and  $k = 15 \text{ N/m}$

$$F = -kx \quad \dots (i)$$

$$\text{and } F = ma \quad \dots (ii)$$

$$\therefore ma = -kx$$

$$\Rightarrow a = -\frac{15}{0.3} \times 20 \times 10^{-2}$$

$$a = -\frac{15}{3} \times 2 = -10 \text{ ms}^{-2}$$

$\therefore$  Initial acceleration,  $a = 10 \text{ ms}^{-2}$

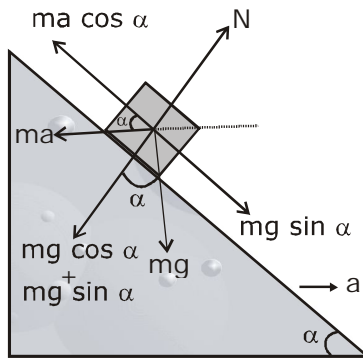
23. (B)

$$s = \frac{v^2}{2\mu_k g} = \frac{100 \times 100}{2 \times 0.5 \times 10}$$

$$= \frac{100 \times 100}{5 \times 2} = 1000 \text{ m}$$

24. (D)

In the frame of wedge, the force diagram of block is shown in figure. From free body diagram of wedge.



For block to remain stationary.  
 $ma \cos \alpha = mg \sin \alpha$   
 or  $a = g \tan \alpha$

25. (C)

This is the question based on impulse momentum theorem.

$$|F \cdot \Delta t| = |\text{change in momentum}|$$

$$\Rightarrow F \times 0.1 |P_f - P_i|$$

As the ball will stop after catching ;

$$P_i = mv_i = 0.15 \times 20 = 3, P_f = 0$$

$$\Rightarrow F \times 0.1 = 3 \quad \Rightarrow F = 30 \text{ N}$$

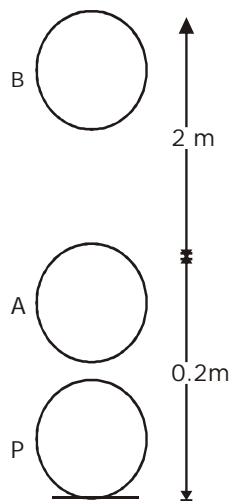
26. (D)

The situation is shown in figure. At initial time, the ball is at P, then under the action of a force (exerted by hand) from P to A and then from A to B let acceleration of ball during PA is  $a \text{ ms}^{-2}$  [assumed to be constant] in upward direction and velocity of ball at A is  $v \text{ m/s}$ .

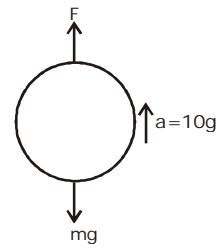
Then for PA,  
 $v^2 = 0^2 + 2a \times 0.2$

For AB,  $0 = v^2 - 2 \times g \times 2$   
 $\Rightarrow v^2 = 2g \times 2$

From above equations,  
 $a = 10g = 100 \text{ ms}^{-2}$



Then for PA, FBD of ball is  $F - mg = ma$   
 [F is the force exted by hand on ball]  
 $\Rightarrow F = m(g+a)$   
 $= 0.2(11g)$   
 $= 22 \text{ N}$



Alternate using work energy theorem

$$W_{mg} + W_F = 0$$

$$\Rightarrow -mg \times 2.2 + F \times 0.2 = 0$$

or  $F = 22 \text{ N}$

27. (D)

Here, the constant horizontal force required to take the body from position 1 to position 2 can be calculated by using work-energy theorem. Let us assume that body is taken slowly so that its speed does not change, then

$$\Delta K = 0$$

$$= W_F + W_{Mg} + W_{tension}$$

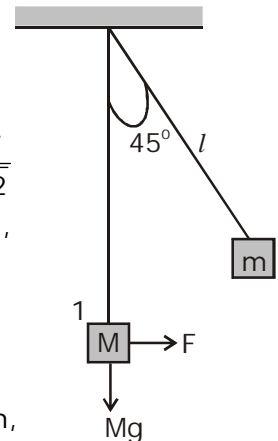
[symbols have their usual meanings]

$$W_F = F \times l \sin 45^\circ = \frac{Fl}{\sqrt{2}}$$

$$W_{Mg} = Mg (l - l \cos 45^\circ),$$

$$W_{tension} = 0$$

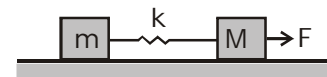
$$\therefore F = Mg(\sqrt{2} - 1)$$



28. (C)

Acceleration of system,

$$a = \frac{F}{m + M}$$



So, force acting on mass,

$$F = ma$$

$$= \frac{mF}{m + M}$$

29. (D)

$$mg \sin \theta = ma$$

$$\therefore a = g \sin \theta$$

where  $a$  is along the inclined plane

$\therefore$  Vertical component of acceleration is  $g \sin^2 \theta$

$\therefore$  Relative vertical acceleration of A with respect to B is

$$g (\sin^2 60^\circ - \sin^2 30^\circ)$$

$$= \frac{g}{2} = 4.9 \text{ ms}^{-2} \text{ (In vertical direction)}$$

30. (B)

From the graph, it is a straight line so, uniform motion, Because of impulse direction of

velocity changes as can be seen from the slope of the graph

$$\text{Initial velocity } v_1 = \frac{2}{2} = 1\text{ms}^{-1}$$

$$\text{Final velocity } v_2 = \frac{2}{2} = -1\text{ms}^{-1}$$

$$\vec{P}_i = mv_1 = 0.4\text{N-s}$$

$$\vec{P}_f = mv_2 = -0.4\text{N-s}$$

$$\vec{J} = \vec{P}_f - \vec{P}_i = -0.4 - 0.4 = -0.8\text{N-s}$$

( $\vec{J}$  = impulse)

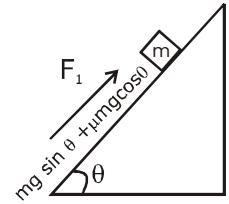
$$\therefore |\vec{J}| = 0.8\text{N-s}$$

31. (D)

$$F_1 = mg(\sin \theta + \mu \cos \theta)$$

$$F_2 = mg(\sin \theta - \mu \cos \theta)$$

$$\begin{aligned} \therefore \frac{F_1}{F_2} &= \frac{\sin \theta + \mu \cos \theta}{\sin \theta - \mu \cos \theta} \\ &= \frac{\tan \theta + \mu}{\tan \theta - \mu} = \frac{2\mu + \mu}{2\mu - \mu} = 3 \end{aligned}$$

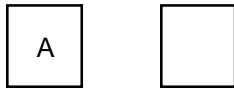


Exercise-IV

Level - II

1.

w.r.t B



$$0.1 \times 10 \times \cos 45^\circ$$

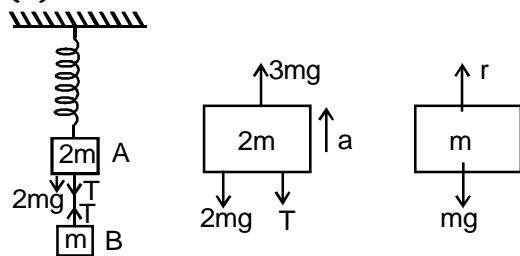
$$a_{AB} = \frac{1}{\sqrt{2}} m/s^2$$

$$\sqrt{2} = \frac{1}{2} \times \frac{1}{\sqrt{2}} t^2$$

$$t = 2 \text{ sec}$$

2.

(B)



when string cut  $T = 0$

$$\Rightarrow ma_2 = mg$$

$$a_2 = g$$

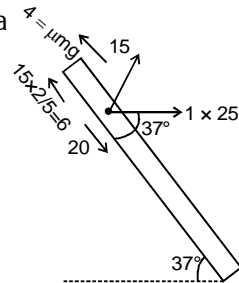
$$3mg - 2mg = 2ma_1$$

$$a_1 = g/2$$

3.

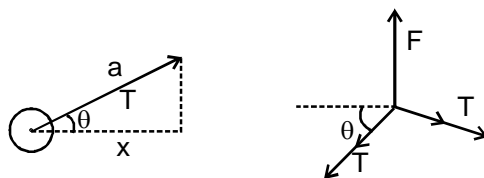
$$20 - 6 - 4 = 1 \times a$$

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



4.

(B)



$$T \cos \theta = ma$$

$$F = 2T \sin \theta$$

$$a = \frac{F}{2 \sin \theta} \cdot \frac{\cos \theta}{m} = \frac{F}{2m} \cot \theta$$

$$a = \frac{F}{2m} \cdot \frac{x}{\sqrt{a^2 - x^2}}$$

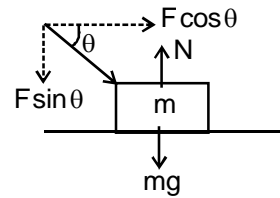
5.

(B)

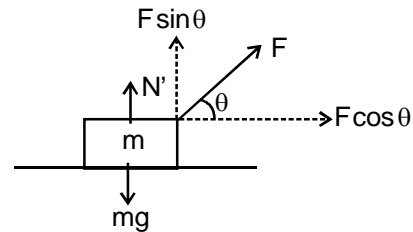
Due to inertia particles left at their places when we pull the clock suddenly.

6.

(B)



$$[N = mg + F \sin \theta]$$



$$[N' = mg - F \sin \theta]$$

$$f = \mu N$$

7.

(B)

8.

(A)

9.

$$mg \sin \theta + \mu mg \cos \theta = 3$$

$$(mg \sin \theta - \mu mg \cos \theta)$$

$$\sin \theta = \cos \theta \text{ at } 45^\circ$$

$$1 + \mu = 3(1 - \mu)$$

$$4\mu = 2 \Rightarrow \mu = 0.5$$

$$N = 10$$

$$\mu = 5$$

10.

(A, C)

Components of 1N force :  $1 \cos \theta$  along the incline opposite to  $mg \sin \theta$  and  $1 \sin \theta$  perpendicular to the incline.

If  $\theta = 45$  the  $\cos \theta = \sin \theta$ .

If  $\theta > 45$  then  $\cos \theta < \sin \theta$  so frictional force acts towards Q.

If  $\theta < 45$  then  $\cos \theta > \sin \theta$  so frictional force acts towards P.