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DPP – 2 (Friction)

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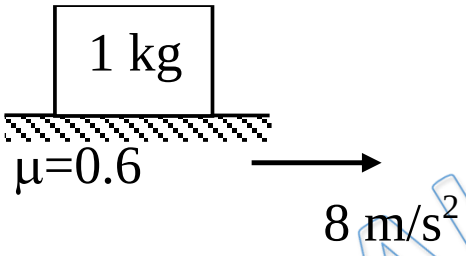
Q 1. If the surface is moving at 8 m/s^2. What is the acceleration of block in m/s^2?



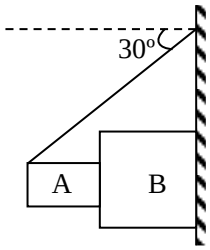
Q 2. A body is placed on a rough inclined plane of inclination θ. As the angle θ is increased from 0°to 90° the contact force between the block and the plane
(a) remains constant
(b) first remains constant then decreases
(c) first decreases then increases
(d) first increases then decreases.

Q 3. A block of mass m slides down an inclined plane of inclination θ with uniform speed. The coefficient of friction between the block and the plane is . The contact force between the block and the plane is:
(a) mg
(b) mg sin θ $\sqrt{1+\mu^2}$
(c) mg sin θ
(d) $\sqrt{(mg\sin\theta)^2+(\mu mg\cos\theta)^2}$

Q 4. A block is placed over a plank. The coefficient of friction between the block and the plank is μ = 0.2. Initially both are at rest, suddenly the plank starts moving with acceleration a_0 = 4 m/s^2. The displacement of the block in 1s is : (g = 10 m/s^2)
(a) 1 m relative to ground (b) 1 m relative to plank
(c) zero relative to plank (d) 2 m relative to ground

Q 5. A block of mass m = 2 kg is resting on a rough inclined plane of inclination 30° . The coefficient of friction between the block and the plane is μ = 0.5. What minimum force F should be applied perpendicular to the plane on the block, so that block does not slip on the plane: (g = 10 m/s^2)
(a) zero (b) 6.24 N
(c) 2.68 N (d) 4.34 N

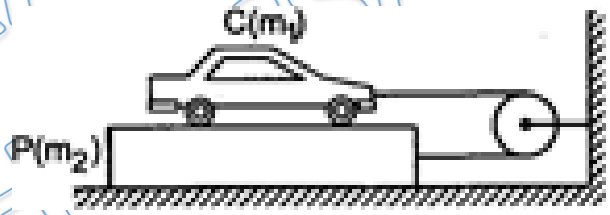
Q 6. Two blocks A and B of mass 10 kg and 20 kg respectively are placed as shown in figure. Coefficient of friction between all the surfaces is 0.2. Then– (g = 10 m/s^2)



(a) tension in the string is 306 N
(b) tension in the string is 132 N
(c) acceleration of block B is 2.6 m/s^2
(d) acceleration of block B is 4.7 m/s^2

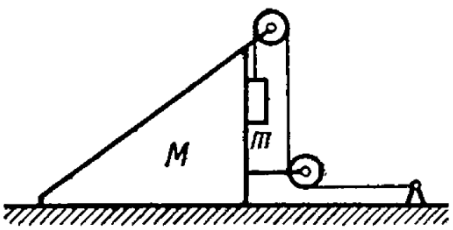
Q 7. A weight W can be just supported on a rough inclined plane by a force P either acting along the plane or horizontally. The limiting angle of friction is f and is q the angle which incline makes with the horizontal. Then –
(A) the incline makes an angle with the horizontal twice the limiting angle of friction i.e. q = 2f
(B) the incline makes an angle with the horizontal equal to the limiting angle of friction i.e. q = f
(C) the ratio of the force to the weight is $\frac{P}{W}$ = cot f
(D) the ratio of the force to the weight is $\frac{P}{W}$ = tan f

Q 8. A car C of mass m_1 rests on a plank P of mass m_2. The plank rests on a smooth floor. The string and pulley are ideal. The car starts and moves towards the pulley with acceleration.



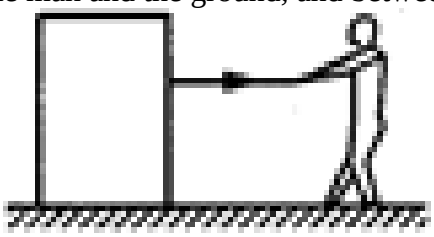
(a) If $m_1 > m_2$, the string will remain under tension.
(c) If $m_1 < m_2$, the string will become slack.
(c) If $m_1 = m_2$, the string will have no tension, and C and P will have accelerations of equal magnitude.
(d) C and P will have accelerations of equal magnitude if $m_1 > m_2$.

Q 9. In the figure shown, friction exists between wedge and block and also between wedge and floor. The system is in equilibrium in the shown position. Which of the following is incorrect



(a) minimum coefficient of friction required to hold the system in equilibrium is $\frac{m}{M+m}$.
(b) frictional force between wedge and block is 0.
(c) frictional force between wedge and surface is mg.
(d) none of these

Q 10. A man pulls a block heavier than himself with a light rope. The coefficient of friction is the same between the man and the ground, and between the block and the ground.



(a) The block will not move unless the man also moves.
(b) The man can move even when the block is stationary.
(c) If both move, the acceleration of the man is greater than the acceleration of the block.
(d) None of the above assertions is correct.

Q 11. For what maximum value of force F, can all the three blocks move together?
(a) 8N (b) 18N (c) 12N (d) 6N

Q 12. If F = 3N, the value of frictional force acting between blocks B and C is
(a) 2N (b) 1N (c) 0.5N (d) Zero

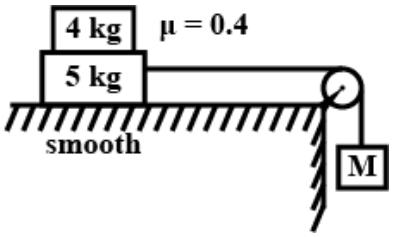
Q 13. If F = 15N, the value of frictional force acting between blocks A and B is
(a) 2N (b) 4N (c) 8N (d) 7N

Q 14. Velocity of the block in time interval t=0 to t=1sec will
A) remains constant B) decreases
C) increases D) none of these

Q 15. Displacement of the block in time interval t=0 to t=3sec
(a) 20 m (b) 30 m (c) 50 m (d) 60 m

Q 16. Velocity of the plank after a long time is
(a)2 m/s (b) 5 m/s
(c) 10 m/s (d) 12 m/s

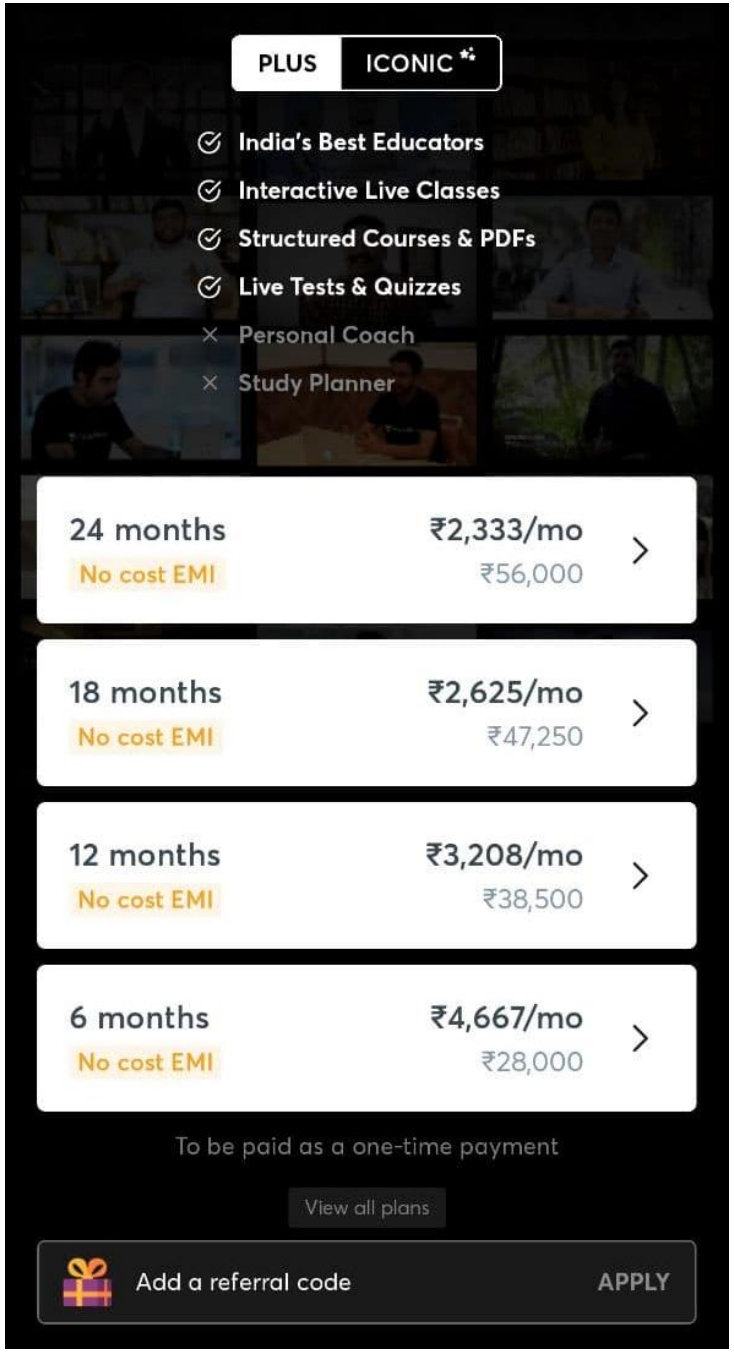
Q 17. What should be the maximum value of M so that the 4 kg block does not slip over the 5 kg block: (Take g=10m/s^2)



(a) 12 kg (b) 8 kg
(c) 10 kg (d) 6 kg

Answer Key

Q.1 6	**Q.2 b**	**Q.3 a**	**Q.4 a,b**	**Q.5 c**
Q.6 a,d	**Q.7 a,d**	**Q.8 A,b,c,d**	**Q.9 d**	**Q.10 a,b,c**
Q.11 c	**Q.12 a**	**Q.13 b**	**Q.14 a**	**Q.15 c**
Q.16 b	**Q.17 d**			



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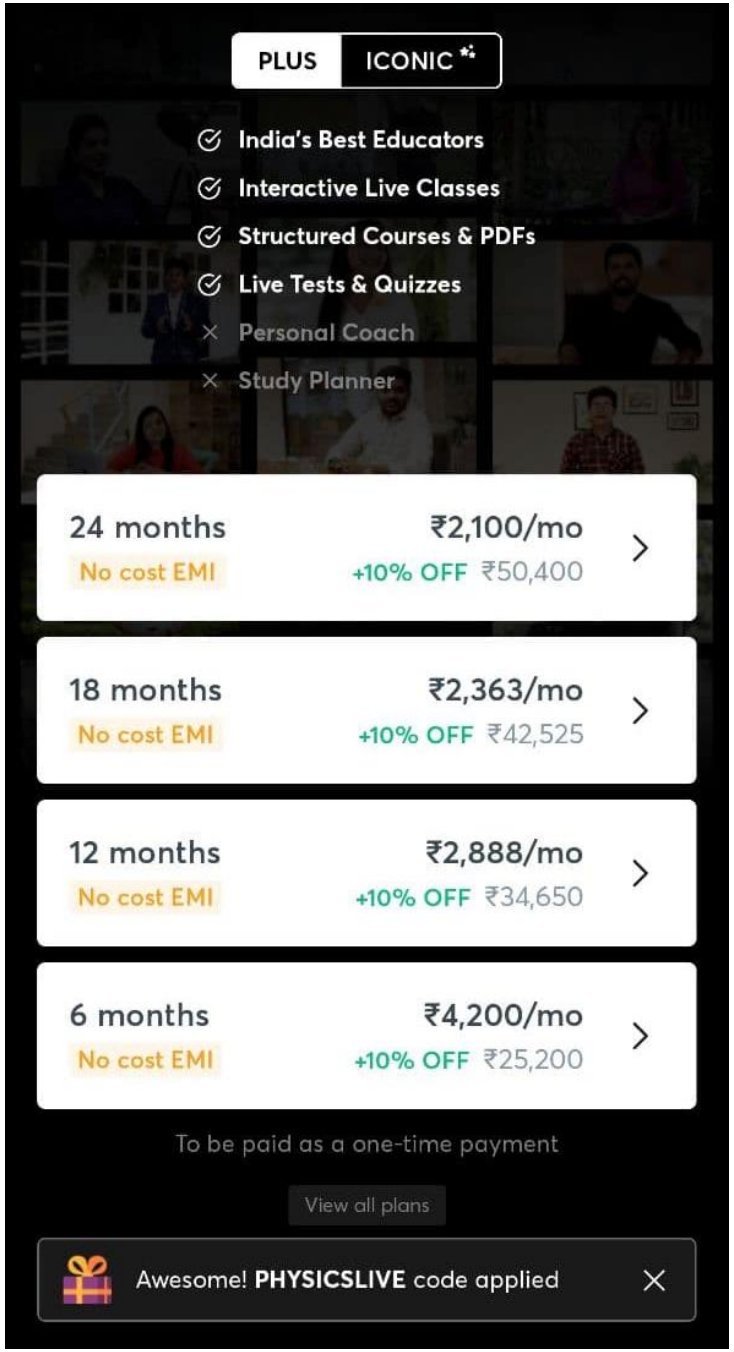
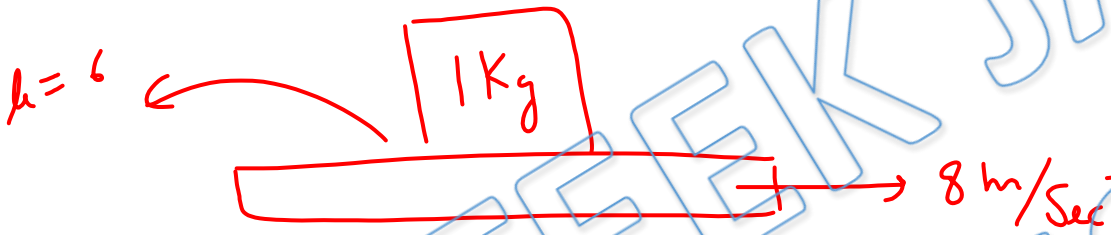


Written Solution

DPP- 2: Friction- Limiting Friction, Angle of repose, Angle of Friction, Block over Block Problems

By Physicsaholics Team

Solution.1



maximum possible friction on block = $\mu mg = .6 \times 1g = 6N$

" " acceleration of block = $6 m/Sec^2$

$\Rightarrow$ block will slide on surface

$\Rightarrow$ Kinetic friction will act in forward direction

$\Rightarrow$ block will move with acceleration $6 m/Sec^2$

Ans(6)

Solution.2

for $\theta \leq \tan^{-1}(\mu)$

$$F_c = \sqrt{N^2 + f^2} = mg\sqrt{\sin^2\theta + \cos^2\theta} = mg$$

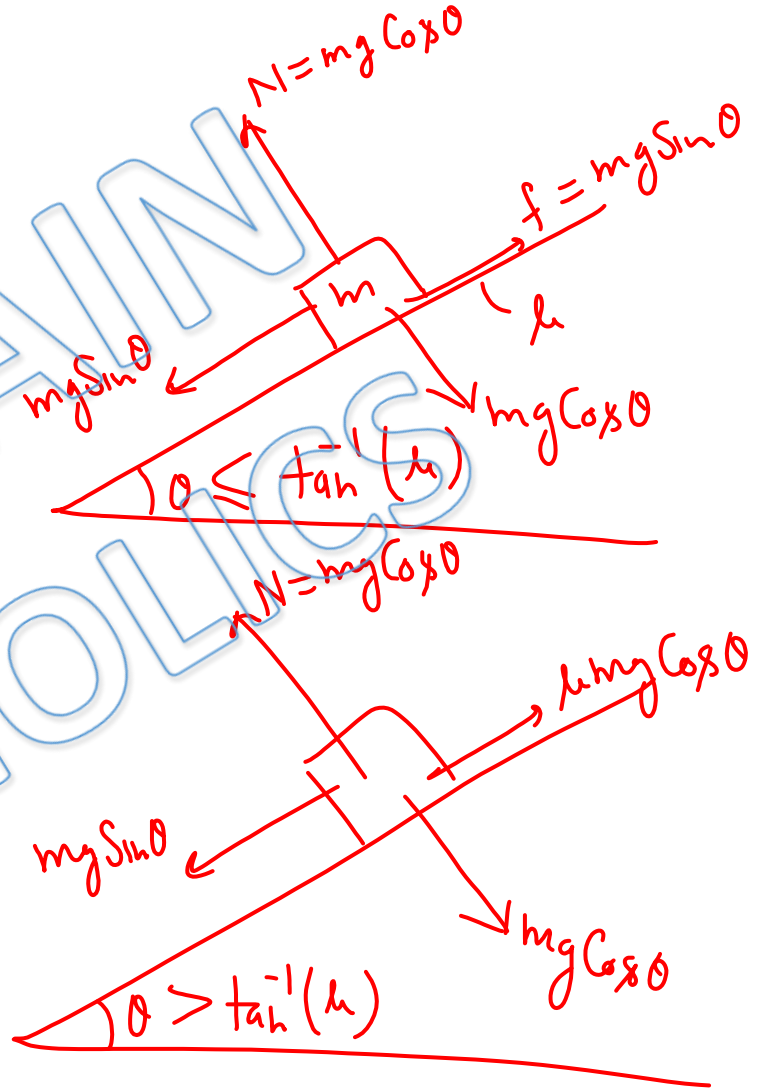
$$= \text{Constant}$$

for $\theta > \tan^{-1}(\mu)$

$$F_c = \sqrt{N^2 + \mu^2 N^2} = N\sqrt{1+\mu^2}$$

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

= decreases on increasing θ.



Ans (b)

Solution.3

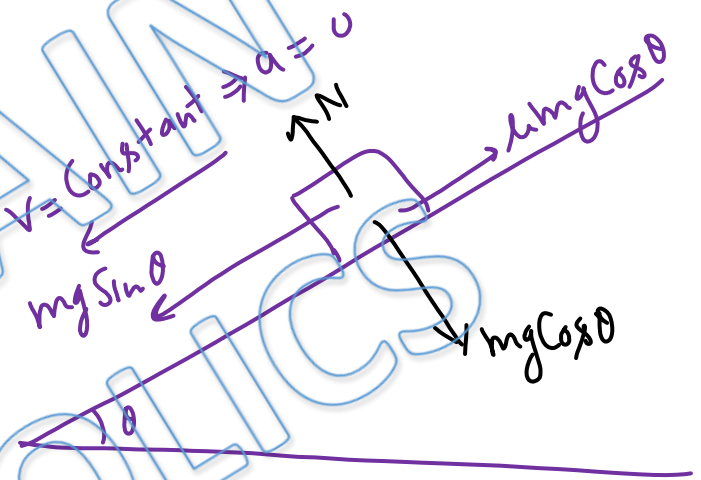
$a = 0 \Rightarrow mg\sin\theta = \mu mg\cos\theta$

Contact force $= \sqrt{N^2 + f_r^2}$

$= \sqrt{(mg\cos\theta)^2 + (\mu mg\cos\theta)^2}$

$= \sqrt{(mg\cos\theta)^2 + (mg\sin\theta)^2}$

$= mg$



$N = mg\cos\theta$

Ans(a)

Solution.4

acceleration of block

$= \frac{\mu mg}{m} = \mu g = 2 m/Sec^2$

Displacement of block

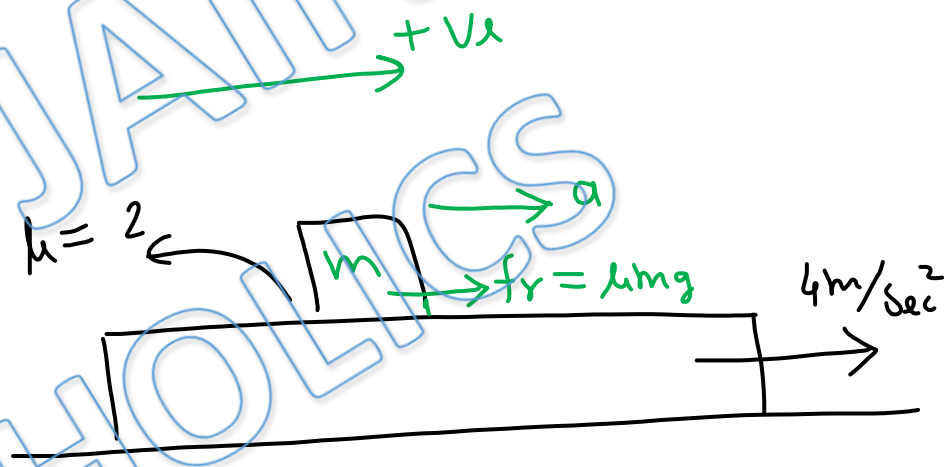
$x = ut + \frac{1}{2}at^2$

$= 0 + \frac{1}{2} \times 2 \times 1^2$

$= 1m$

Displacement of plank in 1 Sec

$= 0 + \frac{1}{2} \times 4 \times 1^2 = 2m$



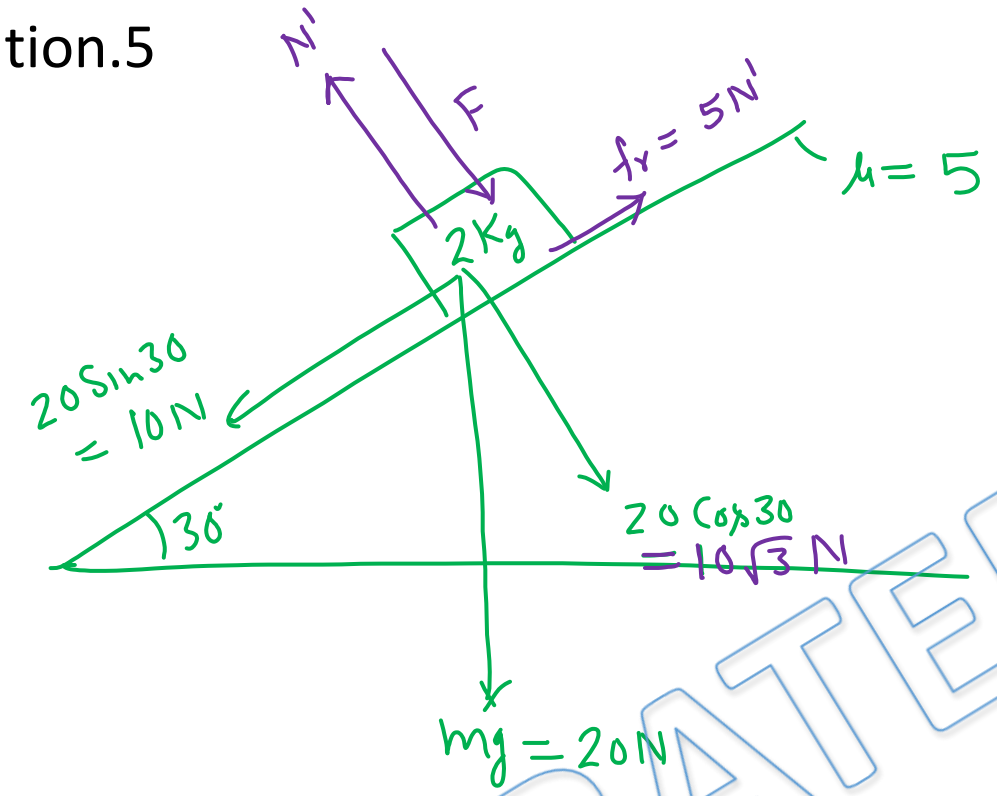
Displacement of block w.r.t. plank

$= D_{b,g} - D_{p,g}$

$= 1 - 2 = -1m = 1m$ left side

Ans (a, b)

Solution.5



$.5N' = 10$

$N' = \frac{10}{.5} = 20$

$N' = F + 10\sqrt{3}$

$20 = F + 10\sqrt{3}$

$\Rightarrow F = 20 - 10\sqrt{3}$

$\simeq 2.68N$

Ans(c)

Solution.6 A will remain stationary Since length of string is Constant

from F B D of A →

$$N_{AB} = \frac{T\sqrt{3}}{2} \quad - - -(1)$$

$$\frac{T}{2} = 100 + \cdot 2\, N_{AB} = 100 + \cdot 2\,\frac{T\sqrt{3}}{2}$$

$$\Rightarrow T(5 - \cdot 173) = 100$$

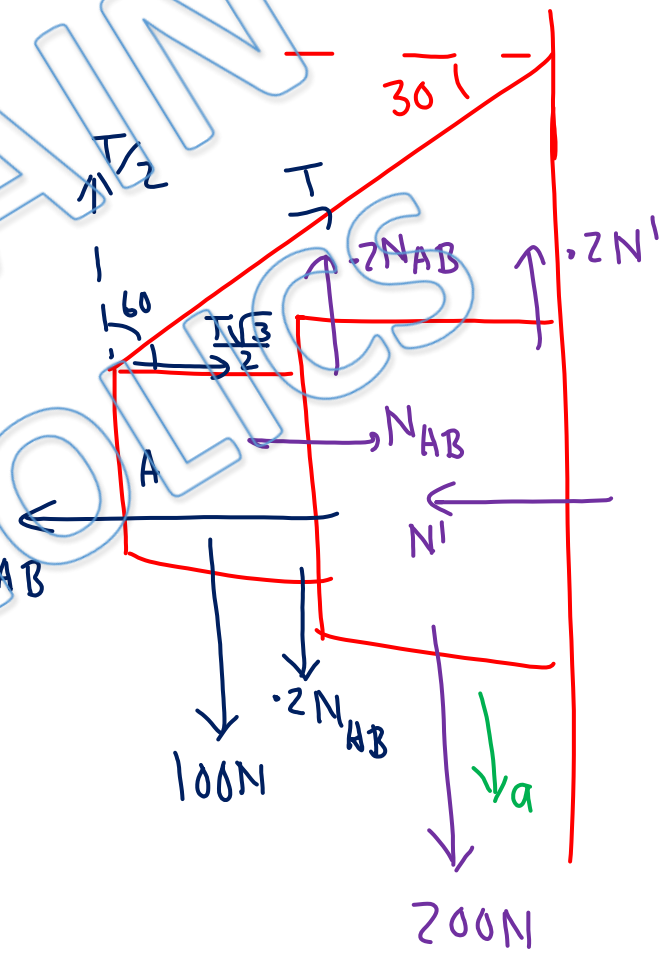
$$\Rightarrow T = 306\ N$$

for B → $200 - 2N_{AB} - \cdot 2N' = 20a$

$$\Rightarrow 20a = 200 - \cdot 4 \times \frac{T\sqrt{3}}{2} = 200 - 106$$

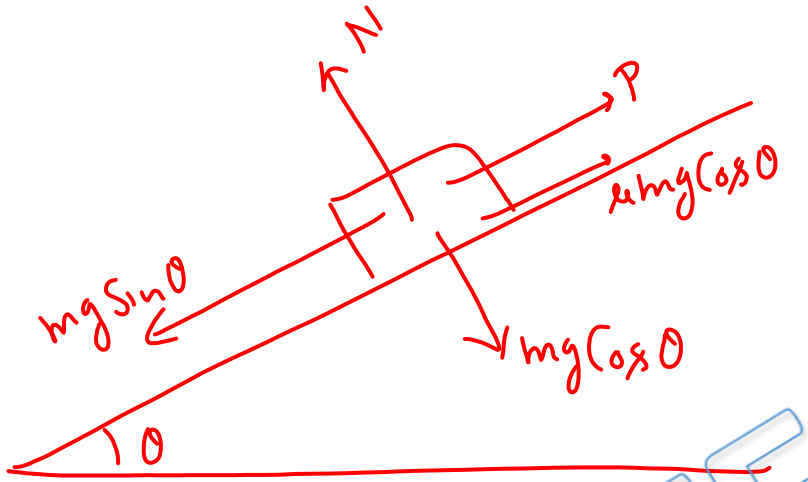
$$\Rightarrow 20a = 94$$

$$a = 4.7\ m/sec^2$$

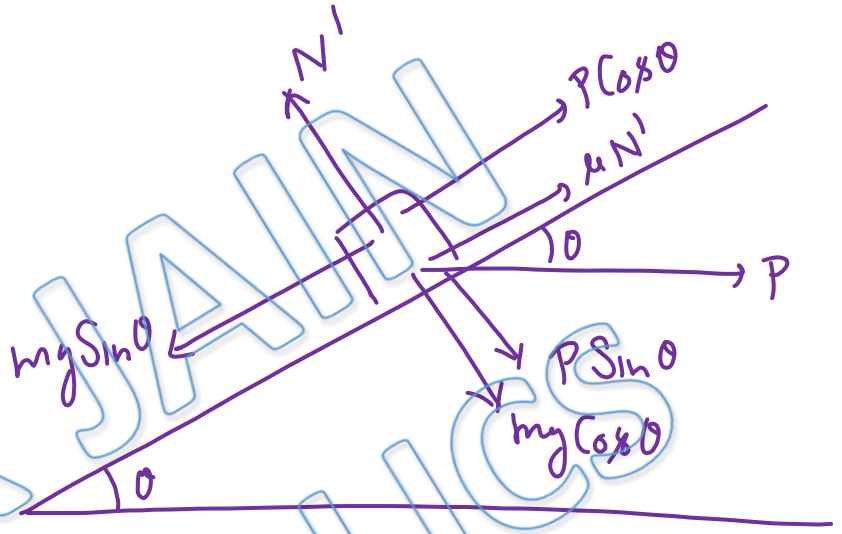


Ans.a,d

Solution.7



$$P = mg(\sin\theta - \mu\cos\theta) \quad --(1)$$



$$N' = P\sin\theta + mg\cos\theta$$

$$mg\sin\theta = \mu N' + P\cos\theta$$

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

$$P = \frac{mg(\sin\theta - \mu\cos\theta)}{\cos\theta + \mu\sin\theta} \quad --(11)$$

from (1) & (11)

$$\cos\theta + \mu\sin\theta = 1$$

$$\Rightarrow \cos\theta + \tan\phi\sin\theta = 1$$

$$\Rightarrow \cos\theta\cos\phi + \sin\theta.\sin\phi = \cos\phi$$

$$\Rightarrow \cos(\theta - \phi) = \cos\phi$$

$$\Rightarrow \theta - \phi = \phi \Rightarrow \theta = 2\phi$$

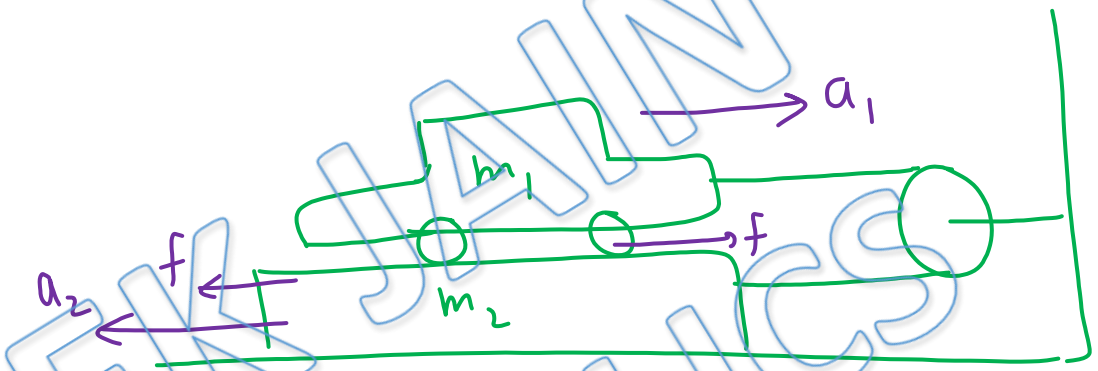
$$\Rightarrow \frac{P}{W} = \frac{P}{mg} = \sin 2\phi - \tan\phi\cos 2\phi$$ Ans.a,d

$$= \frac{\sin 2\phi\cos\phi - \cos 2\phi\sin\phi}{\cos\phi} = \frac{\sin\phi}{\cos\phi} = \tan\phi$$

Solution.8

If string is absent

$a_1 = \frac{f}{m_1}$, $a_2 = \frac{f}{m_2}$



If $m_1 = m_2$

$\Rightarrow a_1 = a_2 \Rightarrow T = 0$ If string is present

f → friction b/w m_1 & m_2

If $m_1 > m_2$

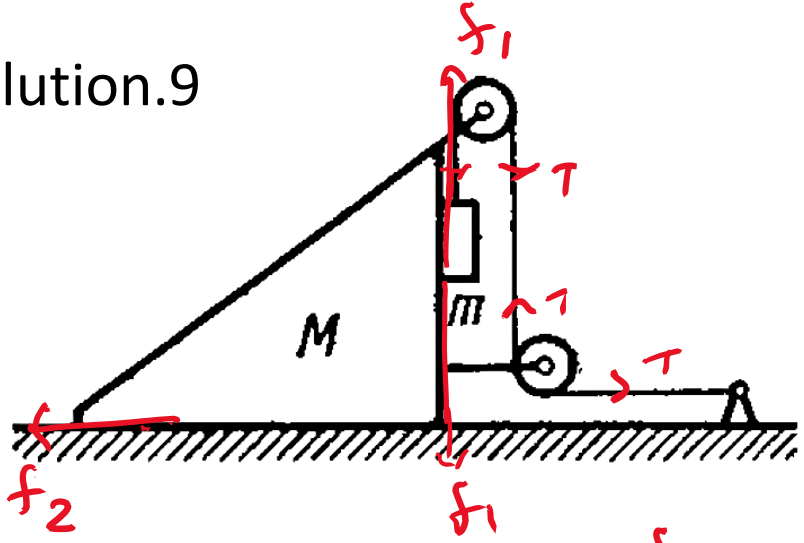
$\Rightarrow a_1 < a_2 \Rightarrow T > 0$ If string is present & both move with same magnitude of acceleration

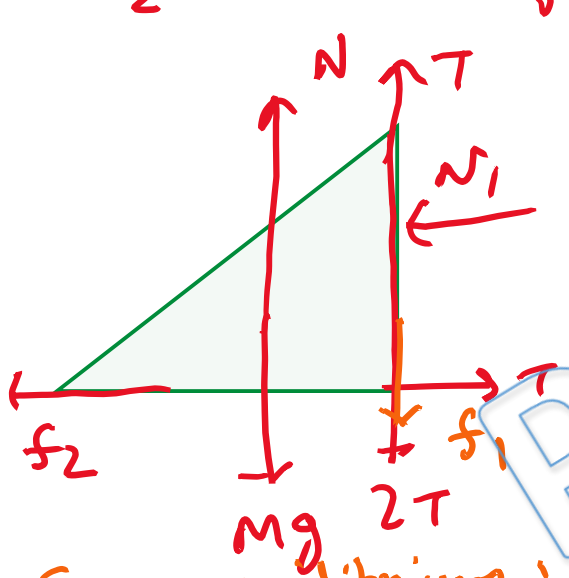
If $m_1 < m_2$

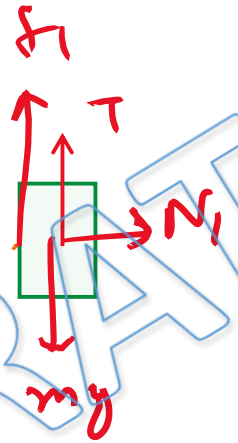
$\Rightarrow a_1 > a_2 \Rightarrow$ string will slack

ANS (a, b, c, d)

Solution.9







For equilibrium :-

on mass m

$N_1 = 0$ — ①

& then; $f_1 = 0$ — ②

and $T = mg$ — ③

on wedge :

$N + T = Mg + 2T + f_1$ (0)

$N = Mg + T = Mg + mg$

$N = (M+m)g$ — ③

& $f_2 + N_1 = T$

$\therefore N_1 = 0$

$f_2 = T$

$f_2 = mg$ — ④

friction coefficient between wedge & floor

$f_2 = \mu N$

$mg = \mu (M+m)g$

$\mu = \frac{m}{M+m}$ — ⑤

Ans.d

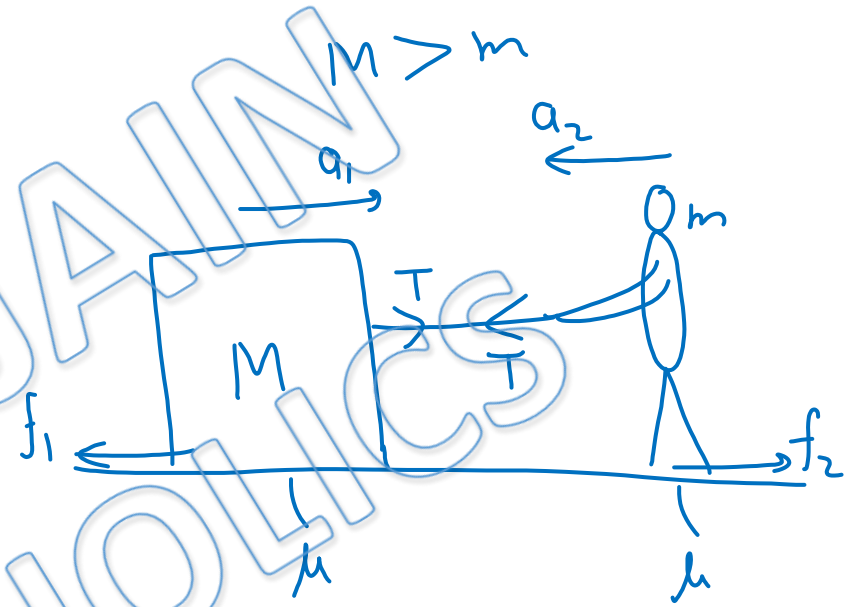
Solution.10

To move block

$T > \mu Mg$

Since $M > m$, $T > \mu mg$

$\Rightarrow$ man will also move



If both move

$$a_1 = \frac{T - \mu Mg}{M} = \frac{T}{M} - \mu g$$

$$a_2 = \frac{T - \mu mg}{m} = \frac{T}{m} - \mu g$$

Since $M > m$, $a_2 > a_1$ $\Rightarrow$ man will move with greater acceleration

Ans.a,b,c

Solution.11

maximum possible acceleration of A

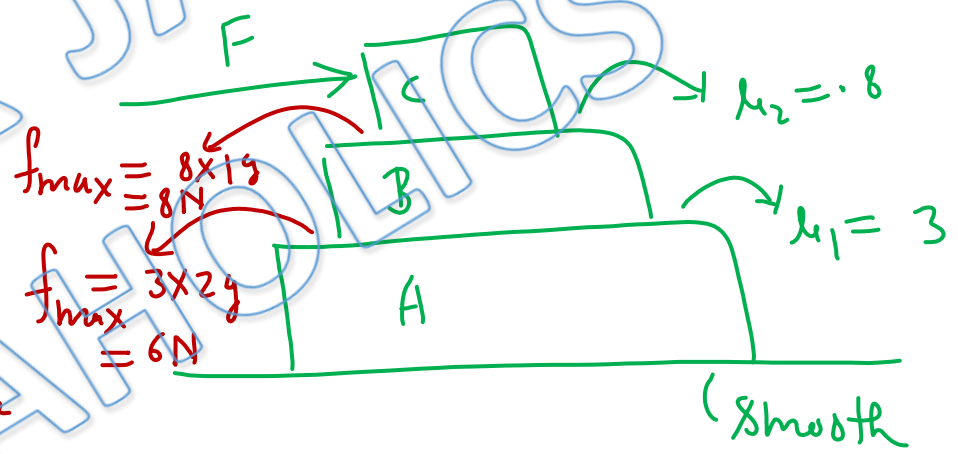
$= \frac{6}{1} = 6 m/Sec^2$

maximum possible acceleration of A & B togather $= \frac{8}{2} = 4 m/Sec^2$

$\Rightarrow$ A & B will always move togather

maximum possible acceleration of (A+B+C) without sliding b/w them $= 4 m/Sec^2$

$\Rightarrow \quad F = 3 \times 4 = 12 N$



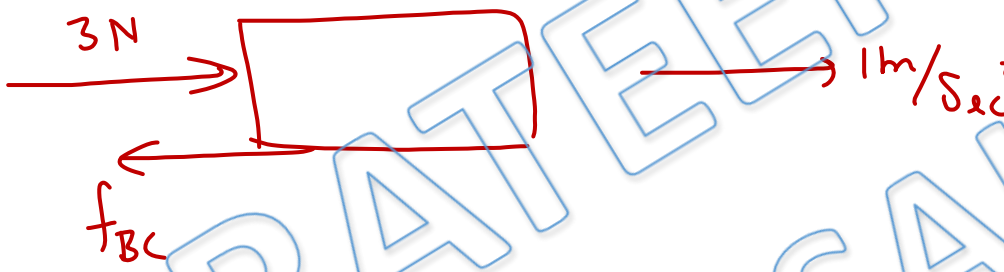
ANS (C)

Solution.12

Since $F < 12N$

$\Rightarrow$ all three blocks will move together with $a = \frac{3}{3} = 1 m/sec^2$

F B D of C



$3 - f_{BC} = 1 \times 1$

$f_{BC} = 2N$

Ans(a)

Solution.13

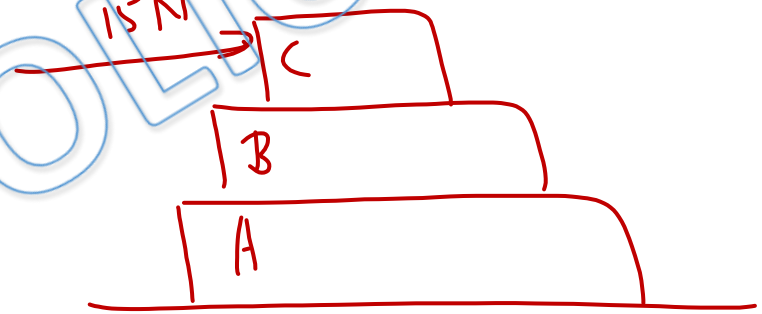
Since $F > 12N$, There will be sliding b/w B & C but A & B will move together

acceleration of (A+B)

$= \frac{8}{2} = 4 m/Sec^2$

F B D of A

$f_{AB} = 1 \times 4 = 4N$



Ans(b)

Solution.14

from $t = 0$ to $t = 1$

both move with same velocity

$\Rightarrow$ friction = 0

$\Rightarrow$ both move with Constant velocity

20m/Sec.

Ans (a)

Solution.16

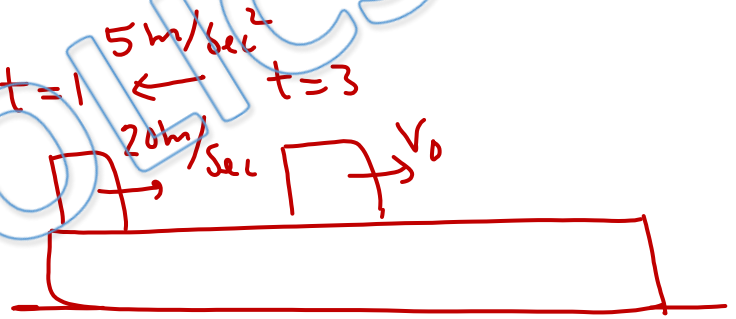
Velocity of block at $t=3$

$V_0 = 20 - 5 \times 2 = 10\ m/Sec$

for $t>3$ (until they move with same velocity)

acceleration of block $= \frac{\mu mg}{m} = 5\ m/Sec^2$

" " plank $= \frac{\mu mg}{m} = 5\ m/Sec^2$



for $t>3$ Sec

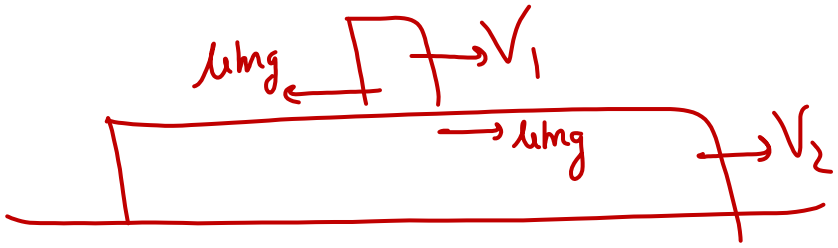
Let their final Common velocity is V &
they take t_0 Sec more after $t=3$ to achieve it

$V = 10 - 5t_0 = 0 + 5t_0$

$\Rightarrow 10t_0 = 10$

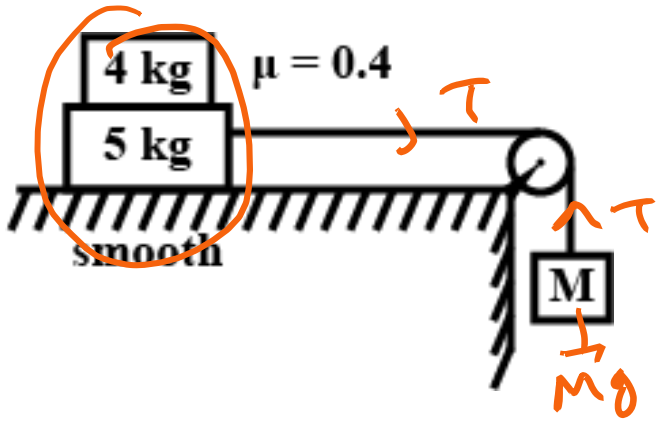
$t_0 = 1$

$\Rightarrow V = 5\ m/Sec$



ANS(b)

Solution:17



If 4 kg does not slip

then $(a)_{5kg} = (a)_{4kg} = a$

$T = 5a$ — (i)

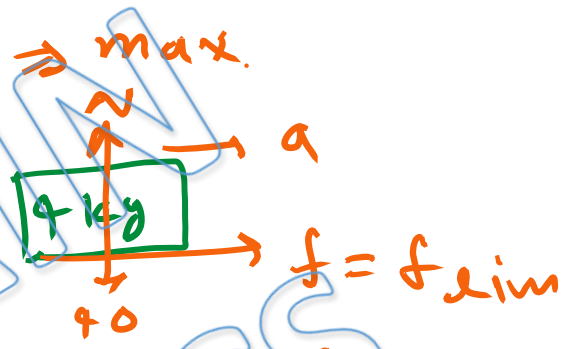
$Mg - T = Ma$ — (ii)

(i) + (ii) ⇒ $Mg = 5a + Ma$ — (iii)

$M = \frac{5a}{g-a} = \frac{5}{\left(\frac{g}{a}-1\right)}$ — (iv)

& for max value of M

a ⇒ max.



$f_{lim} = ma$

$0.4 \times 40 = 4a$

$a = 4\ m/s^2$

Put 'a' in eq^n (iv)

max: $M = \frac{5}{\left(\frac{10}{4}-1\right)} = \frac{36}{6}$

$M = 6\ kg$ Ans.

Ans.d

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