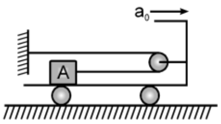
Self Practice Paper (SPP)

1. The upper portion of an inclined plane of inclination α is smooth and the lower portion is rough. A particle slides down from rest from the top and just comes to rest at the foot. If the ratio of the smooth length to rough length is m : n, the coefficient of friction is :

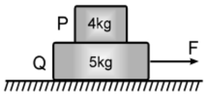
(1) $\left[\frac{m+n}{n}\right]\tan\alpha$ (2) $\left(\frac{m+n}{n}\right)\cot\alpha$ (3) $\left(\frac{m-n}{n}\right)\cot\alpha$ (4) $\frac{1}{2}$

2. Starting from rest. A flat car is given a constant acceleration a_0 = 2 m/s^2. A cable is connected to a crate A of mass 50 kg as shown. Neglect the friction between floor and car wheels and mass of pulley. Calculate corresponding tension in the cable. The coefficient of friction between crate & floor of the car is μ = 0.3. The tension in cable is -



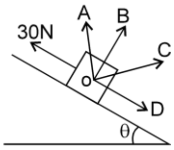
(1) 700 N (2) 350 N (3) 175 N (4) 0

3. The coefficient of friction between 4kg and 5 kg blocks is 0.2 and between 5 kg block and ground is 0.1 respectively. Choose the correct statements



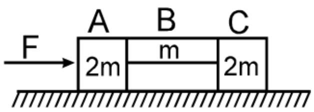
(1) Minimum force needed to cause system to move is 17 N
(2) When force is 4N static friction at all surfaces is 4N to keep system at rest
(3) Maximum acceleration of 4kg block is 2m/s^2
(4) Slipping between 4kg and 5 kg blocks start when F is > 17N

4. A body of mass 10 kg lies on a rough inclined plane of inclination $\theta = \sin^{-1}\frac{3}{5}$ with the horizontal. When a force of 30 N is applied on the block parallel to & upward the plane, the total reaction by the plane on the block is nearly along:



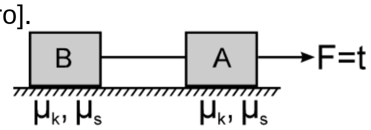
(1) OA (2) OB (3) OC (4) OD

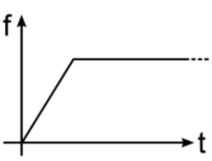
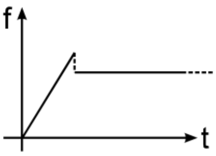
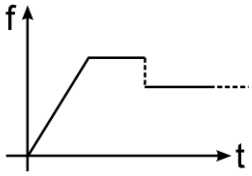
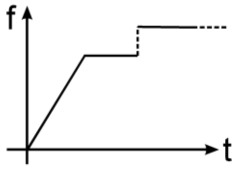
5. The system is pushed by a force F as shown in figure. All surfaces are smooth except between B and C. Friction coefficient between B and C is μ. Minimum value of F to prevent block B from downward slipping is



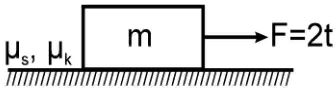
(1) $\left(\frac{3}{2\mu}\right)mg$ (2) $\left(\frac{5}{2\mu}\right)mg$ (3) $\left(\frac{5}{2}\right)\mu mg$ (4) $\left(\frac{3}{2}\right)\mu mg$

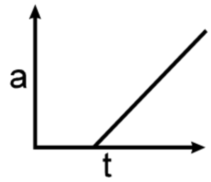
6. A force F = t is applied to a block A as shown in figure, where t is time in seconds. The force is applied at t = 0 seconds when the system was at rest. Which of the following graph correctly gives the frictional force between A and horizontal surface as a function of time t.[Assume that at t = 0, tension in the string connecting the two blocks is zero].

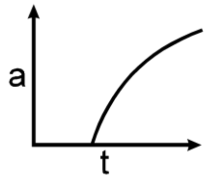


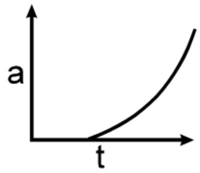
(1)  (2)  (3)  (4) 

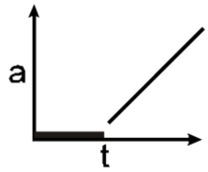
7. A force F = 2t (where t is time in seconds) is applied at t = 0 sec. to the block of mass m placed on a rough horizontal surface. The coefficient of static and kinetic friction between the block and surface are μ_s and μ_k respectively. Which of the following graphs best represents the acceleration vs time of the block. ($\mu_s > \mu_K$)



(1) 

(2) 

(3) 

(4) 

8. A block lying on a long horizontal conveyor belt moving at a constant velocity receives a velocity v_0 = 5 m/s relative to the ground in the direction opposite to the direction of motion of the conveyor. After t = 4 s, the velocity of the block becomes equal to the velocity of the belt. The coefficient of friction between the block and the belt is μ = 0.2. The magnitude of velocity of the conveyor belt is (Use g = 10 m/s^2) :

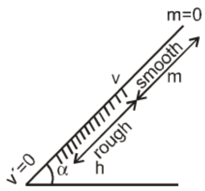
(1) 3 m/s (2) 5 m/s (3) 4 m/s (4) 7 m/s

SPP Answers

1.	(1)	**2.**	(2)	3.	(3)	4.	(1)	**5.**	(2)	**6.**	(3)	**7.**	(4)
8.	(1)												

SPP Solutions

1.



On smooth surface $a_1 = g \sin \alpha$

$\therefore v^2 = u^2 + 2a_1s_1$

$= 0 + 2 g \sin \alpha .m$

On rough surface

$a_2 = g \sin \alpha - \mu g \cos \alpha$

$\therefore v'^2 = v^2 + 2a_2s_2$

$O = 2mg \sin \alpha + 2g (\sin \alpha - \mu \cos \alpha)n$

$\Rightarrow \quad \mu = \left[\dfrac{m+n}{n}\right] \tan \alpha$

2. If acceleration of the car is a_0, acceleration of the block $2a_0 = 2 \times 2 = 4$ m/s^2 (→)

$F = \mu N = 0.3 \times 50 \times 10 = 150$

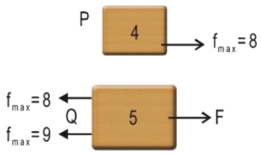
$T - F = ma$

$\Rightarrow \quad T - 150 = 50 \times 4$

$\Rightarrow \quad T = 350$ N.

3. So block 'Q' is moving due to force while block 'P' due to friction.

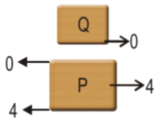
Friction direction on both P + Q blocks as shown.



First block 'Q' will move and P will move with 'Q' so by FBD taking 'P' and 'Q' as system

$F - 9 = 0 \qquad \Rightarrow F = 9$ N

When applied force is 4 N then FBD



4 kg block is moving due to friction and maximum friction force is 8 N.

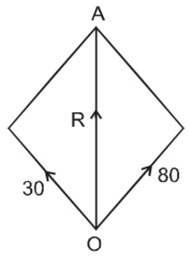
So acceleration = $\dfrac{8}{4} = 2$ m/s^2 = a_{max}.

Slipping will start when Q has +ve acceleration equal to maximum acceleration of P i.e. 2 m/s^2.

$F - 17 = 5 \times 2 \quad \Rightarrow F = 27$ N.

4. Frictional force along the upward

direction = $10 g \sin\theta - 30 = 30$ Nt



N = 10 g cosθ = 80 Nt
Direction of R is along OA.

5. The acceleration of system is

$$a = \frac{F}{5m}$$

Hence the normal reaction B exerts on C is

$$N = 2ma = \frac{2}{5} F$$

Thus frictional force on 'B' is

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

For B not to fall down. ,

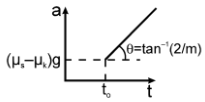
$$\mu \frac{2}{5} F = mg \quad \text{or } \mu = \frac{5\ mg}{2\mu}$$

6. Let m_A and m_B be the mass of blocks A and B respectively.
As the force F increases from 0 to μ_s m_Ag, the frictional force f on block A is such that f = F. When F = $\mu_s m_A$g, the frictional force f attains maximum value f = $\mu_s$mg.
As F is further increased to $\mu_s(m_A+m_B)$g, the block A does not move. In this duration frictional force on block A remains constant at μ_s m_A g.
Hence C is correct choice.

7. Let t_o be the time when friction force is maximum

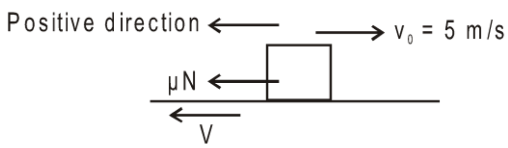
$$F = 2t_o = \mu_s\ mg$$

The block just starts moving immediately after this instant, with acceleration
For t > t_o the acceleration of the block is



$$a = \frac{2t_o - \mu_k\ mg}{m}$$

8.



using v = u + at for the block.
v = (–5 m/s) + (2 m/s2) (4s)
v = 3 m/s