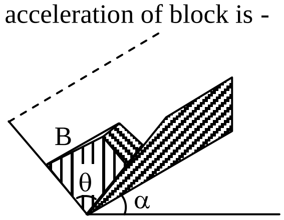
PHYSICS

Q.1 A block 'B' is just fitting between two plane inclined at an angle 'θ'. The combination of plane is inclined at angle 'α' with horizontal. If coefficient of friction between block and the plane 'μ' is insufficient to stop slipping, then acceleration of block is -



(A) g{sin α – μ cos α}

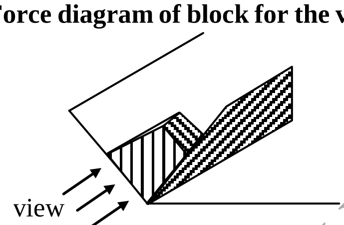
(B) $g\left\{\sin\alpha - \mu\frac{\cos\alpha}{\sin(\theta/2)}\right\}$

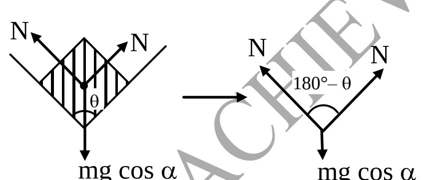
(C) g {sin α – 2 μ cos α cos θ/2}

(D) g {sin α – μ cos α. sin (θ/2)}

[B]

Sol. **Force diagram of block for the view shown**





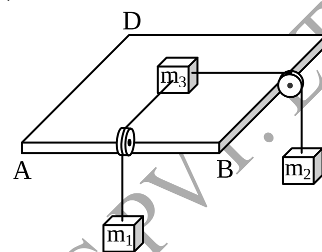
$\Rightarrow N = \frac{mg\cos\alpha}{2\sin(\theta/2)}$

∴ Net friction up the plane = 2 μN

$= \mu mg\ \frac{\cos\alpha}{\sin(\theta/2)}$

∴ a = g $\left\{\sin\alpha - \mu\frac{\cos\alpha}{\sin(\theta/2)}\right\}$

Q.2 Three blocks are arranged as shown in which ABCD is a horizontal plane. Strings are massless and both pulley stands vertical while the strings connecting blocks m_1 and m_2 are also vertical and are perpendicular to faces AB and BC which are mutually perpendicular to each other. If m_1 and m_2 are 3 kg and 4 kg respectively. Coefficient of friction between the block m_3 = 10 kg and surface is μ = 0.6 then, frictional force on m_3 is -



(A) 30 N (B) 40 N

(C) 50 N (D) 60 N

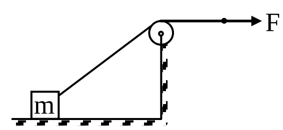
[C]

Sol. Net force on m_3 = $\sqrt{(30)^2+(40)^2}$ = 50 N

and limiting friction on m_3 = $\mu m_3 g$ = 60N

∴ System remain in equilibrium and friction on m_3 = 50 N

Q.3 The block of mass m is placed on a rough horizontal floor and it is pulled by an ideal string by a constant force F as shown. As the block moves towards right on the floor, then the frictional force on block -



(A) remains constant

(B) increases

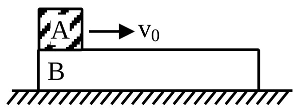
(C) decreases

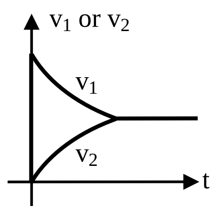
(D) can not be calculated

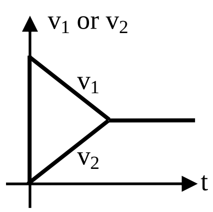
[C]

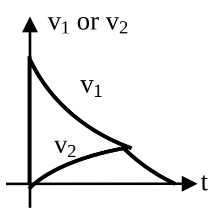
Sol. As the block moves towards right normal reaction on it decreases therefore frictional force on it decreases

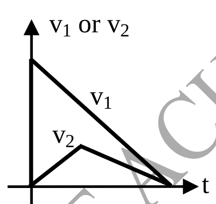
Q.4 A block A is placed over a long rough plank B of same mass as shown in figure. The plank is placed over a smooth horizontal surface. At time $t = 0$, block A is given a velocity v_0 in horizontal direction. Let v_1 and v_2 be the velocities of A and B at time t. Then choose the correct graph between $\mathbf{v_1}$ or $\mathbf{v_2}$ and $\mathbf{t}$:



(A)


(B)


(C)


(D)


[B]

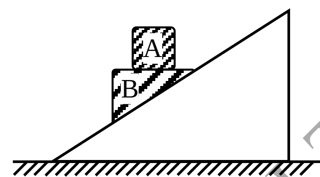
Sol. Friction force between A and B (= μmg) will accelerate B and retard A till slipping is stopped between the two and since mass of both are equal.

acceleration of B = retardation of A = μg

$\therefore v_1 = v_0 - \mu gt$ and $v_2 = \mu gt$

Hence, the correct graph is (B). After slipping is ceased the common velocity of both will become $\frac{v_0}{2}$, which can be obtained from conservation of linear momentum also.

Q.5 Block A is placed over the block B as shown in figure. Wedge is smooth and fixed. Force of friction on block A is :

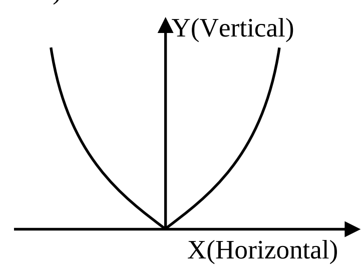


(A) towards right (B) towards left
(C) zero (D) always kinetic

[B]

Sol. Block A moves in horizontal direction only due to friction

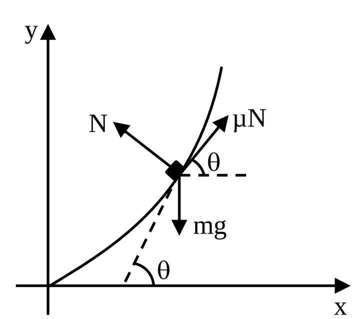
Q.6 A parabolic bowl with its bottom at origin has the shape $\mathbf{y} = x^2/20$. Here x and y are in metres. The maximum height at which a small mass **m** can be placed on the bowl without slipping (coefficient of static friction is 0.5) is :



(A) 2.5 m (B) 1.25 m
(C) 1.0 m (D) 4.0 m

[B]

Sol. $\frac{dy}{dx} = \frac{x}{10}$



or $\tan\theta = \frac{x}{10}$ … (i)

Equilibrium of mass in horizontal direction gives the equation,

$\mu N \cos\theta = N \sin\theta$

or $\tan\theta = \mu = \frac{1}{2}$ … (ii)

From Eqs. (i) and (ii)

$\frac{x}{10} = \frac{1}{2}$ or $x = 5$ m

$\therefore y = \frac{x^2}{20} = \frac{25}{20} = 1.25$ m

Q.7 A sphere is rotating between two rough inclined walls as shown in figure (a). Coefficient of friction between each wall and the sphere is 1/3. If $\mathbf{f_1}$ and $\mathbf{f_2}$ be the friction forces at P and Q. Then $\frac{f_1}{f_2}$ is –

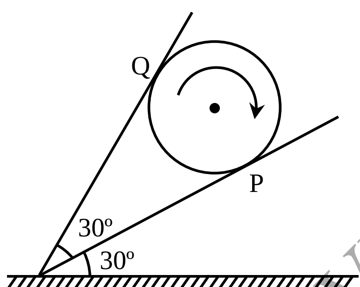


Fig. (a)

(A) $\frac{4}{\sqrt{3}} + 1$ (B) $\frac{1}{\sqrt{3}} + 2$

(C) $\frac{1}{2} + \sqrt{3}$ (D) $1 + 2\sqrt{3}$

[A]

Sol. Let μ be the friction coefficient between sphere and each wall. Free body diagram of sphere is

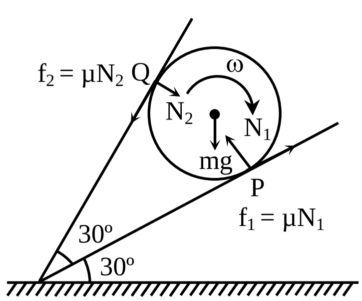


Fig.

Net force on the sphere in horizontal direction is zero.

$\therefore N_1 \cos 60^\circ + \mu N_2 \cos 60^\circ = N_2 \cos 30^\circ + \mu N_1 \cos 30^\circ$

or $N_1 + \mu N_2 = \sqrt{3}(N_2 + \mu N_1)$

or $N_1(1 - \sqrt{3}\mu) = N_2(\sqrt{3} - \mu)$

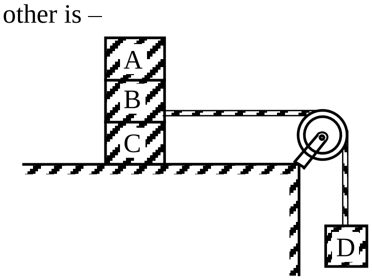
$\therefore \frac{N_1}{N_2} = \frac{\sqrt{3} - \mu}{1 - \sqrt{3}\mu}$

Substituting $\mu = \frac{1}{3}$ we get,

$$\frac{N_1}{N_2} = \frac{\sqrt{3} - \frac{1}{3}}{1 - \frac{\sqrt{3}}{3}} = \frac{3\sqrt{3} - 1}{3 - \sqrt{3}} = 1 + \frac{4}{\sqrt{3}}$$

Now $\frac{f_1}{f_2} = \frac{\mu N_1}{\mu N_2} = 1 + \frac{4}{\sqrt{3}}$

Q.8 Three blocks A, B and C of equal mass m are placed one over the other on a smooth horizontal ground as shown in figure. Coefficient of friction between any two blocks of A, B and C is ½. The maximum value of mass of block D so that the blocks A, B and C move without slipping over each other is –



(A) 6 m (B) 5 m

(C) 3 m (D) 4 m

[C]

Sol. Blocks A and C both move due to friction. But less friction is available to A as compared to C because normal reaction between A and B is less. Maximum friction between A and B can be:

$f_{max} = \mu\, m_A g = \left(\frac{1}{2}\right) mg$

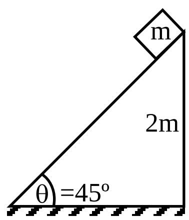
$\therefore$ Maximum acceleration of A can be:

$a_{max} = \frac{f_{max}}{m} = \frac{g}{2}$

further $a_{max} = \frac{m_D g}{3m + m_D}$

or $\frac{g}{2} = \frac{m_D g}{3m + m_D}$ or $m_D = 3m$

Q.9 A wedge of mass 2 m and a cube of mass m are shown in figure. Between cube and wedge, there is no friction. The minimum coefficient of friction between wedge and ground so that wedge does not move is –



(A) 0.10 (B) 0.20
(C) 0.25 (D) 0.50

[B]

Sol. Net horizontal force on wedge

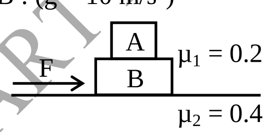
$F_H = mg \cos\theta \sin\theta$

Net normal reaction from the ground = 2 mg + mg $\cos^2\theta$

$\therefore \mu N = F_H$

$\Rightarrow \mu = 0.20$

Q.10 In the figure, $m_A = 2$ kg and $m_B = 4$ kg. For what minimum value of F, A starts slipping over B : ($g = 10$ m/s^2) –



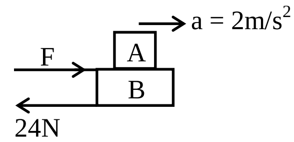
(A) 24 N (B) 36 N
(C) 12 N (D) 20 N

[B]

Sol. Maximum frictional force between A and B could be

$f_1 = \mu_1 m_A g = (0.2)(2)(10)$ N

$f_1 = 4$ N



Hence, maximum common acceleration till both the blocks move with same acceleration is

$a = \frac{f_1}{m_A} = \frac{4}{2} = 2$ m/s^2

Now, taking (A + B) as the system:

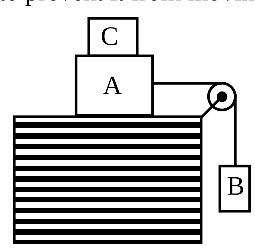
(From weight = upthrust)

$(f_2)_{max} = \mu_2(m_A + m_B)g = 24$ N

$F - 24 = (m_A + m_B)\, a = 6 \times 2 = 12$

$\therefore$ F = 36 N

Q.11 Two masses A and B of 10 kg and 5 kg respectively, are connected with a string passing over a frictionless pulley fixed at the corner of a table as shown in figure. The coefficient of friction of A with the table is 0.2. The minimum mass of C that may be placed on A to prevent it from moving is –



(A) 15 kg (B) 5 kg (C) 10 kg (D) 0 kg

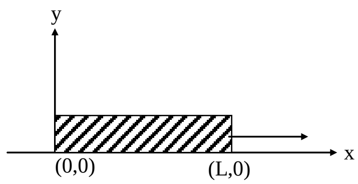
Sol. **[A]**

$5g = 0.2(10 + m)g \Rightarrow m = 15$ kg

Q.12 A uniform rod of length 'ℓ' and mass 'M' has been placed on rough horizontal surface as shown in figure. The rod is pulled by applying a horizontal force. Friction coefficient between surface and rod is 'μ' given by :

$$\mu = \begin{matrix} \mu_0 x & : & 0 \le x \le L \\ 0 & : & x > L \end{matrix}$$

Heat generated as rod moves by a distance 'L' is-



(A) $\dfrac{\mu MgL^2}{2}$ (B) μMgL^2

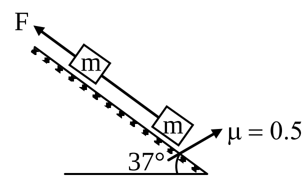
(C) $\dfrac{\mu MgL^2}{3}$ (D) $\dfrac{\mu MgL^2}{6}$

[A]

Sol. Heat generated = – (Work done by friction)

$$W_f = \int_0^L \mu\left(\frac{L-x}{L}.M\right)g = -\frac{\mu MgL^2}{2}$$

Q.13 Two identical blocks are kept on rough inclined plane (μ = 0.5). The blocks are connected with light string. If mg < F < 2mg, then -



(A) Friction force on block 'A' is in upward direction

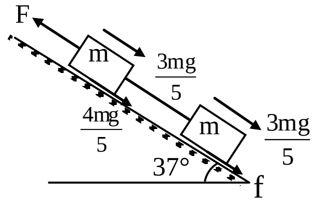
(B) Friction force on block B may be either in upward direction or downward direction

(C) Friction on block 'A' depends upon force 'F'

(D) Friction force on block 'B' may be zero

[B]

Sol. Figure shows forces acting along the string



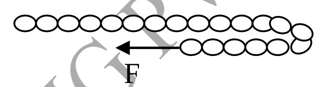
$\therefore\ f + \dfrac{3mg}{5} = F - mg$

$\Rightarrow f = F - \dfrac{8mg}{5}$

$\therefore$ If $F < \dfrac{8mg}{5} \Rightarrow f$: – ve $\Rightarrow$ Friction force on block 'B' is in upward direction.

$F > \dfrac{8mg}{5} \Rightarrow f$: + ve $\Rightarrow$ friction force on block 'B' is in downward direction.

Q.14 A chain of mass 'M' and length 'L' is put on a rough horizontal surface and is pulled by constant horizontal force 'F' as shown in figure. Velocity of chain as it turns completely: (Coefficient of friction = μ)

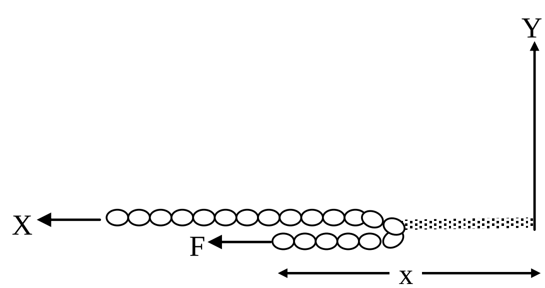


(A) $\left\{2\left(\dfrac{F}{M} - \mu g\right)L\right\}^{\frac{1}{2}}$ (B) $\left\{\left(\dfrac{2F}{M} - \mu g\right)\dfrac{L}{2}\right\}^{\frac{1}{2}}$

(C) $\left\{2\left(\dfrac{2F}{M} - \mu g\right)L\right\}^{\frac{1}{2}}$ (D) $\left\{\left(\dfrac{4F}{M} - \mu g\right)\dfrac{L}{2}\right\}^{\frac{1}{2}}$

[C]

Sol.



Let point of application of force have moved by distance 'dx'.

$\therefore$ Work done by friction

$$W_f = \int_0^{2L} -\mu\left(\frac{M}{L}.\ x\right)g\ dx$$

$\Rightarrow W_f = -Mg\ell$

$W_f = 2F\ell$

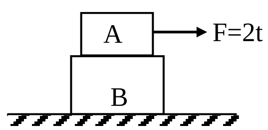
$\therefore W_{net} = 2FL - \mu MgL$

$\Rightarrow \frac{1}{2}Mv^2 = 2FL - \mu MgL$

$$\Rightarrow \mathbf{v} = \left\{2\left(\frac{2F}{M} - \mu g\right)L\right\}^{\frac{1}{2}}$$

Q.15 Two blocks A and B of mass 2 kg and 4 kg are placed one over the other. A horizontal force

F = 2t, which varies with time is applied on the upper block. If coefficient of friction between blocks A and B is 0.5 and horizontal surface is smooth. Then assuming t is in seconds, the total time upto which both blocks will move together without slipping over each other is -



(A) 5 sec (B) 7.5 sec
(C) 10 sec (D) 12.5 sec

[B]

Sol. If common maximum acceleration is a then,

$(m_A + m_B)a = f$

$(2 + 4)a = 2t$

$3a = t$ … (1)

For block B

$f_L = m_B \times a$

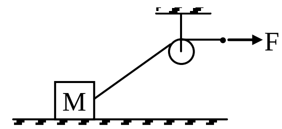
$0.5 \times 2 \times 10 = 4a$

$a = 2.5\ m/s^2$

From equation (1)

t = 7.5 sec

Q.16 The block of mass m is placed on a rough horizontal floor and it is pulled by an ideal string as shown by a constant force F. As the block moves towards right the frictional force on block-

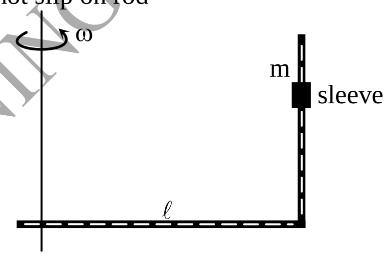


(A) remains constant (B) increases
(C) decreases (D) cannot be said

[C]

Sol. As block moves right normal reaction decreases

Q.17 A L shaped rod whose one end is horizontal and other is vertical is rotating about a vertical axis as shown with angular speed ω. The sleeve has mass m and friction coefficient between rod and sleeve is μ. The minimum angular speed ω for which sleeve cannot slip on rod –



(A) $\omega = \sqrt{\frac{g}{\mu\ell}}$ (B) $\omega = \sqrt{\frac{\mu g}{\ell}}$

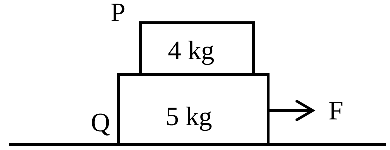
(C) $\omega = \sqrt{\frac{\ell}{\mu g}}$ (D) $\omega = \sqrt{\frac{\mu\ell}{g}}$

[A]

Sol. $N = m\ell\omega^2$ and $f_L = mg$

$\therefore\ \mu m\ell\omega^2 = mg \quad \Rightarrow \omega = \sqrt{\frac{g}{\mu\ell}}$

Q.18 If the lower block is held fixed and force is applied to P, minimum horizontal force required to slide P on Q is 12 N. Now if Q is free to move on frictionless surface and force is applied to Q, then the minimum force F required to slide P on Q is –



(A) 12 N (B) 18 N
(C) 27 N (D) 36 N

[C]

Sol. $12 = \mu 4g \quad \Rightarrow \mu = 0.3$

a_{pmax} possible $= \mu g = 3\ m/s^2$

F = (5 + 4) × 3 = 27 N

Q.19 The force of kinetic friction does not depend on–

(A) the relative velocity of the two surfaces in contact.

(B) nature of the surfaces in contact.

(C) normal reaction on the moving body

(D) all of the above **[A]**

Sol. μ_k depends upon nature of contact surfaces only

Q.20 On a rough horizontal surface, a body of mass 2 kg is given a velocity of 10 m/s. If the coefficient of friction is 0.2 and g = 10 ms^{-2}, the body will stop after covering a distance of –

(A) 10 m (B) 25 m

(C) 50 m (D) 250 m

[B]

Sol. u = 10, v = 0, a = – μg

Now $v^2 = u^2 + 2as$

Q.21 A blocks of mass 5.2 kg is placed on a rough plane inclined at an angle α to the horizontal where sin α =0.6. The coefficient of friction between the block and the plane is 0.4. The block is just prevented from sliding down the plane by a horizontal force P. Then the value P is –

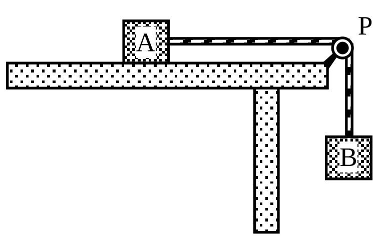
(A) 14 N (B) 15 N

(C) 13 N (D) 18 N

[A]

Sol. Mg sin α = P cos α + μ [Mg cos α + P sin α]

Q.22 The block A and B are arranged as shown in the figure. The pulley is frictionless. The mass of A is 10 kg. The coefficient of friction of A with the horizontal surface is 0.20. The minimum mass of B to start the motion will be –



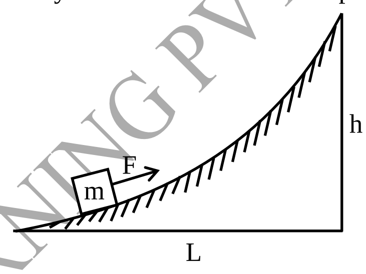
(A) 2 kg (B) 0.2 kg

(C) 5 kg (D) 10 kg

[A]

Sol. $\mu M_A g = M_B g \Rightarrow M_B = \mu M_A = .2 \times 10 = 2$ kg

Q.23 A body of mass m is hauled up the hill with constant speed v by a force such that the force at each point is directed along the tangent to the path. The length of base of hill is L and its height is h. The coefficient of friction between the body and path is μ. Then which of the following statement is incorrect when body moves from bottom to top -



(A) work done by gravity is –mgh

(B) work done by friction is – μmgL

(C) work done by gravity is path independen

(D) None of the above

[B]

Sol. Conceptual

Q.24 A bead of mass m is located on a parabolic wire with its axis vertical and vertex directed towards downward as in figure and whose equation is $x^2 = ay$. If the coefficient of friction is μ, the highest distance above the x-axis at which the particle will be in equilibrium is -

(A) μa (B) $\mu^2 a$

(C) $\frac{1}{4}\mu^2 a$ (D) $\frac{1}{2}\mu a$

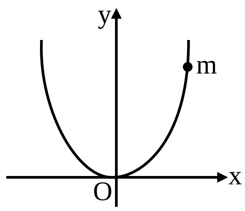
[C]

Sol. For the sliding not to occur when tan θ ≤ μ

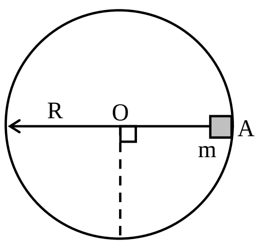
$$\tan\theta = \frac{dy}{dx} = \frac{2x}{a} = \frac{2\sqrt{ya}}{a} = 2\sqrt{\frac{y}{a}}$$

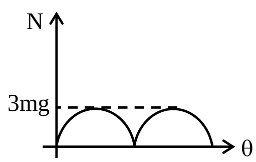
$$2\sqrt{\frac{y}{a}} \le \mu \text{ or } y \le \frac{a\mu^2}{4}$$

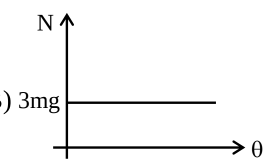
Q.25 A particle of mass m is released from point

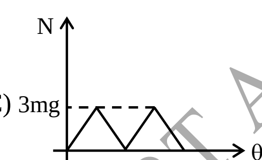


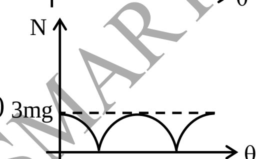
A on smooth fixed circular track as shown. If the particle is released from rest at t = 0, then variation of normal reaction N with (θ) angular displacement from initial position is -



(A)


(B)


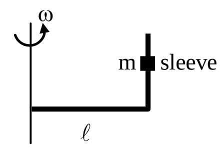
(C)


.(D)


Sol. **[A]**

$N = mg \sin\theta + \dfrac{mv^2}{r}$ and $v^2 = 2g\, r \sin\theta$

Q.26 A L shaped rod whose one rod is horizontal and other is vertical is rotating about a vertical axis as shown with angular speed ω. The sleeve shown in figure has mass m and friction coefficient between rod and sleeve is μ. The minimum angular speed ω for which sleeve cannot sleep on rod is -



(A) $\omega = \sqrt{\dfrac{g}{\mu\ell}}$ (B) $\omega = \sqrt{\dfrac{\mu g}{\ell}}$

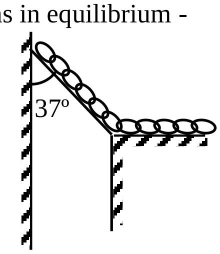
(C) $\omega = \sqrt{\dfrac{\ell}{\mu g}}$ (D) None of these

Sol. **[A]**

$N = m\ell\omega^2$ therefore $f = \mu N$

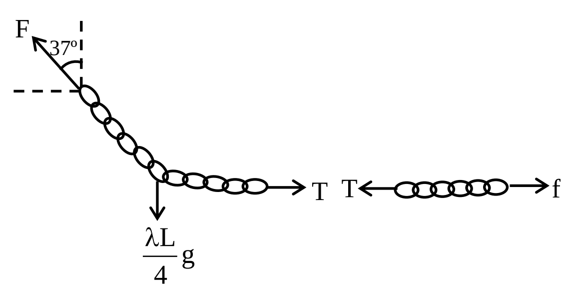
$\therefore \mu m\ell\omega^2 = mg$

Q.27 A uniform chain of length 'L' has one of its ends attached to the wall at point 'A', while $\dfrac{3L}{4}$ of the length of chain is lying on table as shown in figure. The minimum coefficient of friction between table and chain so that chain remains in equilibrium -



(A) $\dfrac{1}{3}$ (B) $\dfrac{1}{4}$ (C) $\dfrac{3}{4}$ (D) $\dfrac{1}{5}$

Sol. **[B]**



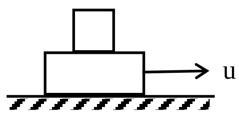
$F \cos 37^\circ = \dfrac{\lambda L}{4} g$

$F \sin 37^o = T = f$

$\therefore f = \frac{3\lambda Lg}{16} \le \mu N$

$\Rightarrow \mu \ge \frac{1}{4}$

Q.28 A block is resting on a horizontal plate in the XY plane and co-efficient of friction between block and the plate is 'μ'. The plate begins to move with velocity $u = bt^2$ in X-direction. At what time will the block starts sliding from plate -



(A) $\frac{\mu b}{g}$ (B) $\frac{\mu bg}{2}$ (C) $\frac{\mu g}{b}$ (D) $\frac{\mu g}{2b}$

Sol. **[D]**

$\mu\, mg = m.\, 2bt \Rightarrow t = \frac{\mu g}{2b}$

Q.29 The coefficient of friction between two surfaces is 0.2. The angle of friction is -

(A) $\sin^{-1}(0.2)$ (B) $\cos^{-1}(0.2)$

(C) $\tan^{-1}(0.1)$ (D) $\cot^{-1}(5)$

Sol. **[D]**

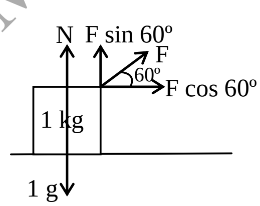
$\theta = \tan^{-1}(\mu)$

Q.30 A block of mass 1 kg is at rest on a horizontal table. The coefficient of static friction between the block and the table is 0.5. If g = 10 m s^{-2} , then the magnitude of the force acting upwards at an angle of 60º from the horizontal that will just start the block moving is -

(A) 5 N (B) 5.36 N

(C) 74.6 N (D) 10 N

Sol. **[B]**



$F \cos 60^o = f$ ...(i)

$f = \mu N = \mu\, (1\, g - F \sin 60^o)$ ...(ii)

Q.31 A block of mass 2 kg rests on a rough inclined plane making an angle of 30º with the horizontal. The coefficient of static friction between the block and the plane is 0.7. The frictional force on the block is -

(A) 9.8 N (B) $0.7 \times 9.8 \times \sqrt{3}$ N

(C) $9.8 \times \sqrt{3}$ N (D) 0.7×9.8 N

Sol. **[A]**

$f = \mu mg \cos\theta = 0.7 \times 2 \times g \times \frac{\sqrt{3}}{2} = 0.7 \times g \times \sqrt{3}$ Ext. force = mg sin θ = $2 \times g \times \frac{1}{2} = 9.8$

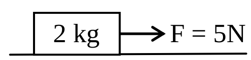
f > Ext. force. So particle will at rest

Q.32 A body of mass 2 kg is at rest on a horizontal table. The coefficient of friction between the body and the table is 0.3. A force of 5 N is applied on the body. The acceleration of the body is -

(A) 0 m s^{-2} (B) 2.5 m s^{-2}

(C) 5 m s^{-2} (D) 7.5 m s^{-2}

Sol. **[A]**



μ = 0.3

friction $f = \mu\, mg = 0.3 \times 2 \times 10 = 6$ N, acce = 0

Q.33 A car starts from rest to cover a distance x. The coefficient of friction between the road and tyres is μ. The minimum time in which the car can cover distance x is proportional to -

(A) μ (B) $\frac{1}{\sqrt{\mu}}$

(C) $\sqrt{\mu}$ (D) $\frac{1}{\mu}$

Sol. **[B]**

V = u + at

$0 = u + (-\mu g)t$

$t = \frac{u}{\mu g}$

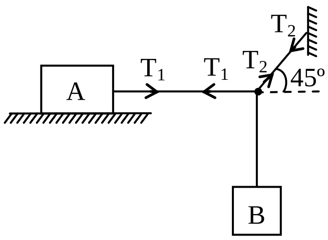
$v^2 = u^2 + 2as$

$0 = u^2 + 2(-\mu g)\, s$

$u = \sqrt{2\mu gs}$

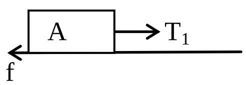
$t = \frac{\sqrt{2\mu gs}}{\mu g} \Rightarrow t \propto \frac{1}{\sqrt{\mu}}$

Q.34 The block A in Figure weighs 100 N. The coefficient of static friction between the block and the table is 0.25. The weight of the block B is maximum for the system to be in equilibrium. The value of T_1 is



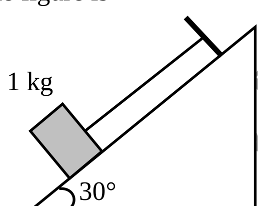
(A) 0.25 N (B) 25 N
(C) 100 N (D) 100.25 N

Sol. **[B]**



$T_1 = f = 0.25 \times 100$; $T_1 = 25$ N

Q.35 The coefficient of friction between two surfaces is $\mu = 0.8$. The tension in the string shown in the figure is -



(A) 0 N (B) 6 N
(C) 4 N (D) 8 N

Sol. **[A]**

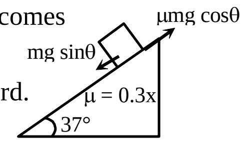
$\because \tan\theta < \mu$ $\therefore$ Body will not slide and string will be slack $\Rightarrow$ T = 0

Q.36 A body is moving down a long inclined plane of slope 37°. The coefficient of friction between the body and plane varies as $\mu = 0.3x$, where x is the distance travelled down the plane. The body will have maximum speed -

(sin 37° = $\left(\frac{3}{5}\right)$ and g = 10 m/s^2)

(A) at x = 1.16 m (B) at x = 2 m
(C) at bottom of plane (D) at x = 2.5 m

Sol. **[D]**



After some time friction becomes more than mgsinθ, then body will retard. Thus speed is maximum when, total force or acc. is zero.

$mg\sin\theta - \mu mg\cos\theta = 0$

$\Rightarrow \mu = \tan\theta \Rightarrow 0.3x = 3/4$

$\Rightarrow x = 2.5$m

Q.37 A piece of ice slides down a 45° incline in twice the time it takes to slide down a frictionless 45° incline. What is the coefficient of friction between the ice and incline ?

(A) 0.25 (B) 0.50
(C) 0.75 (D) 0.40

Sol. **[C]**

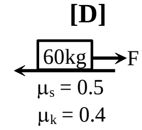
$\mu = \tan\theta\left(1 - \frac{1}{n^2}\right)$ [discussed in class room]

$= \tan 45\left(1 - \frac{1}{2^2}\right) = ¾$

Q.38 A 60 kg body is pushed with just enough force to start it moving across a floor and the same force continues to act afterwards. The coefficient of static friction and sliding friction are 0.5 and 0.4 respectively. The acceleration of the body is -

(A) 6 m/s^2 (B) 4.9 m/s^2
(C) 3.92 m/s^2 (D) 1 m/s^2

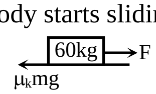
Sol. **[D]**



Force required to start the motion,

$F = \mu_s mg$

Once body starts sliding friction becomes kinetic.



$\therefore a = \frac{F - \mu_k mg}{m} = \frac{\mu_s mg - \mu_k mg}{m} = (\mu_s - \mu_k)g = 1\text{m/s}^2$

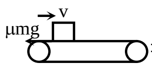
Q.39 A suitcase is gently dropped on a conveyor belt moving at 3 m/s. If the coefficient of friction between the belt and the suitcase is 0.5, find the displacement of the suitcase relative to conveyor belt before the slipping between the two is stopped : (g = 10 m/s^2)

(A) 2.7 m (B) 1.8 m

(C) 0.9 m (D) 1.2 m

Sol. **[C]**

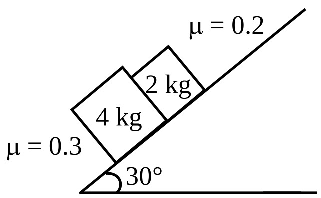
Relative to belt, $a = \frac{\mu mg}{m} = \mu g = 5 m/s^2$



$\Rightarrow 0 = u^2 - 2as \Rightarrow s =$

$\frac{u^2}{2a} = \frac{(3)^2}{2\times5} = 0.9m$

Q.40 Two blocks, 4 kg and 2 kg are sliding down an incline plane as shown in figure. The acceleration of 2 kg block is -



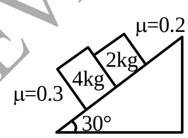
(A) 1.66 m/s^2 (B) 2.66 m/s^2

(C) 3.66 m/s^2 (D) 4.66 m/s^2

Sol. **[B]**

$m_1 g\sin\theta + m_2 g\sin\theta - \mu_1 m_1 g\cos\theta - \mu_2 m_2 g\cos\theta = (m_1 + m_2)a$

$\Rightarrow a = g\sin\theta - \left(\frac{\mu_1 m_1 + \mu_2 m_2}{m_1 + m_2}\right) g\cos\theta$



$= g\left[\frac{1}{2} - \left(\frac{0.3\times4 + 0.2\times2}{4+2}\right)\times\frac{\sqrt{3}}{2}\right] = 2.66 m/s^2$

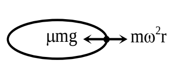
Q.41 A gramophone record is revolving with an angular velocity ω. A coin is placed at a distance R from the centre of the record. The static coefficient of friction is μ. The coin will revolve with the record if -

(A) $R > \frac{\mu g}{\omega^2}$ (B) $R = \frac{\mu g}{\omega^2}$ only

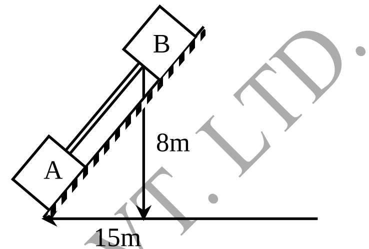
(C) $R < \frac{\mu g}{\omega^2}$ (D) $R \le \frac{\mu g}{\omega^2}$

Sol. **[D]**

$m\omega^2 r \le \mu mg \Rightarrow r \le \mu g/\omega^2$



Q.42 Blocks A and B in the figure are connected by a bar of negligible weight. If A = B = 170 kg & μ_A = 0.2 and μ_B = 0.4, where μ_A and μ_B are the coefficients of limiting friction between blocks and plane, calculate the force on the bar : (g = 10 m/s^2)



(A) 150 N (B) 75 N

(C) 200 N (D) 250 N

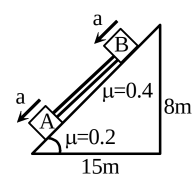
Sol. **[A]**

For (A) → $mg\sin\theta - T - \mu_A mg\cos\theta = ma$ ....(1)

For (B) → $T + mg\sin\theta - \mu_B mg\cos\theta = ma$ ....(2)

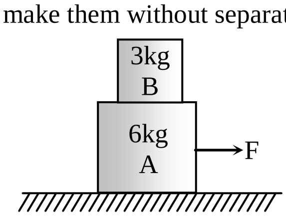
$\Rightarrow mg\sin\theta - T - \mu_A mg\cos\theta = T + mg\sin\theta - \mu_B mg\cos\theta$

$\Rightarrow T = \frac{mg\cos\theta}{2}(\mu_B - \mu_A)$



$= \frac{170\times10\times15/17}{2}(0.4 - 0.2) = 150N$

Q.43 Two blocks A and B of masses 6 kg and 3 kg rest on a smooth horizontal surface as shown in fig. If coefficient of friction between A and B is 0.4, the maximum horizontal force which can make them without separation is -



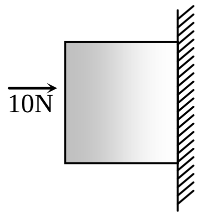
(A) 72 N (B) 40 N

(C) 36 N (D) 20 N

Sol. **[C]**

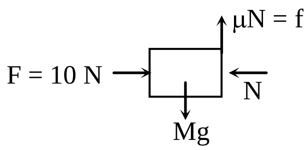
$F = \mu(m_A + m_B) g = 0.4 (3 + 6) \times 10 = 36 N$

Q.44 A horizontal force of 10 N is necessary to just hold a block stationary against a wall. The coefficient of friction between the block and the wall is 0.2 (fig.). The weight of the block is -



(A) 2N (B) 20 N (C) 50 N (D) 100 N

Sol. **[B]**



N = 10 N

f = μN = Mg = 20 N

Q.45 A car is moving along a straight horizontal road with a velocity of 72 km h^{-1}. If $\mu_s = 0.5$, then the shortest distance in which the car can be stopped is [Take g = 10 ms^{-2}].

(A) 40 m (B) 80 m (C) 100 m (D) 120 m

Sol. **[A]**

$v^2 = u^2 + 2as \Rightarrow 0 = u^2 + 2(-\mu g)s$

$$s = \frac{u^2}{2\mu g} = \frac{(20)^2}{2\times0.5\times10}.$$

Q.46 A mass m is placed on an inclined plane. If the mass is in equilibrium, the maximum inclination of the plane with the horizontal would be (where μ is the coefficient of friction between the mass and surface) -

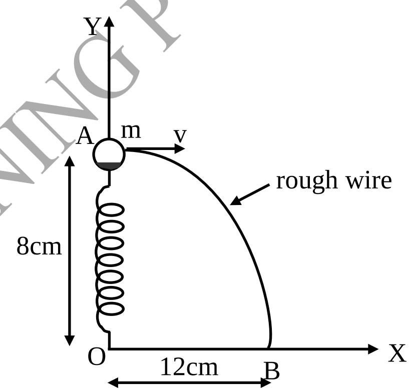
(A) $\tan^{-1}\mu$ (B) $\tan^{-1}\left(\frac{\mu}{2}\right)$

(C) $\tan^{-1}\left(\frac{\mu}{m}\right)$ (D) $\cos^{-1}\mu$

Sol. **[A]**

Repose angle = $\tan^{-1}(\mu)$ = maximum inclination of the plane with the horizontal if the mass is in equilibrium.

Q.47 A ring of mass 200 gram is attached to one end of a light spring of force constant 100 N/m and natural length 10 cm. The ring is constrained to move on a rough wire in the shape of quarter ellipse of major axis 24 cm and minor axis 16 cm with its centre at origin. The plane of ellipse is vertical and wire is fixed at points A and B as shown in figure. Initially ring is at A with other end of spring fixed at origin. Ring is given a horizontal velocity of 10 m/s towards right so that it just reaches point B, then select the correct alternative (s) ($g = 10\ m/s^2$)



(A) Work done by friction is – 10 Joule

(B) At B energy stored in spring is more than energy stored at A.

(C) Work done by friction is –10.16 Joule

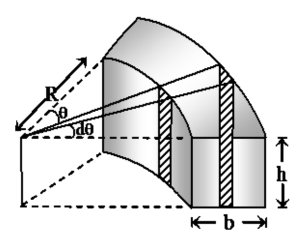
(D) Work done by spring force is positive

Sol.[C] Apply work energy theorem

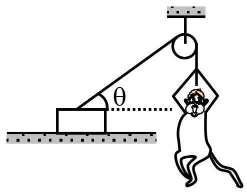
$W_g + W_N + W_{fr} + W_s = \Delta K$

$W_{fr} = -\frac{1}{2}mv^2 - mg(0.08)$

$W_{fr} = -10.16$



Q.48 A block of mass m rests on a rough horizontal surface with a rope tied to it. The co-efficient of friction between the surface and the block is μ. A monkey of the same mass climbs at the free end of the rope. The maximum acceleration with which the monkey can climb without moving the block is-

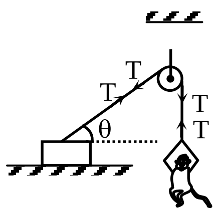


(A) $\frac{\mu g}{\mu \sin\theta + \cos\theta} - g$ (B) $\frac{\mu g}{\mu \sin\theta - \cos\theta} + g$

(C) $\frac{\mu g}{\tan\theta - \mu \cos\theta} + g$ (D)

$\frac{\mu g}{\tan\theta + \mu \sec\theta} - g$

Sol.[A]



$T - mg = ma$ ……(1)

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

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

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

Q.49 A block of mass 2 kg is placed on the floor. The coefficient of static friction is 0.4. If a force of 2.8 N is applied on the block parallel to the floor, the force of friction between the block and the floor (taking $g = 10\ ms^{-2}$) is -

(A) 2.8 N (B) 8 N

(C) 2 N (D) zero

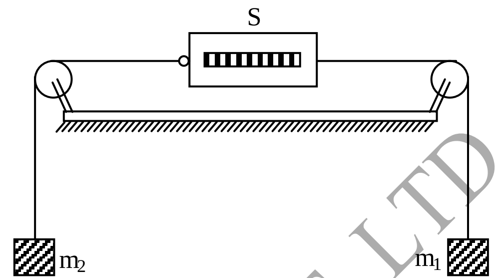
Sol. **[A]**

∵ 2.8 N is less than limiting force

∴ static friction $f_S = 2.8$ N

$f_L = (0.4)(2g) = 8$ N

Q.50 In the arrangement shown, the pulleys are fixed and ideal, the strings are light, $m_1 > m_2$, and S is a spring balance which is itself massless. The reading of S (in units of mass) is -



(A) $m_1 - m_2$ (B) $\frac{1}{2}(m_1 + m_2)$

(C) $\frac{m_1 m_2}{m_1 + m_2}$ (D) $\frac{2m_1 m_2}{m_1 + m_2}$

Sol. **[D]**

Acceleration of system = $\frac{m_1 - m_2}{m_1 + m_2} g$

Tension in string $= \frac{2m_1 m_2}{m_1 + m_2} g$

reading of spring balance is T.