NLM & FRICTION

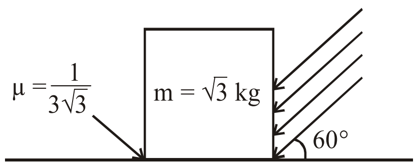
1. The coefficient of static friction between a wooden block of mass 0.5 kg and a vertical rough wall is 0.2. The magnitude of horizontal force that should be applied on the block to keep it adhere to the wall will be ______N.
[$g = 10\ ms^{-2}$]

2. An inclined plane is bent in such a way that the vertical cross-section is given by $y = \frac{x^2}{4}$ where y is in vertical and x in horizontal direction. If the upper surface of this curved plane is rough with coefficient of friction $\mu = 0.5$, the maximum height in cm at which a stationary block will not slip downward is ________ cm.

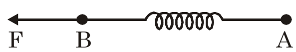
3. A person standing on a spring balance inside a stationary lift measures 60 kg. The weight of that person if the lift descends with uniform downward acceleration of 1.8 m/s^2 will be_ N.
[$g = 10\ m/s^2$]

4. A boy pushes a box of mass 2 kg with a force $\vec{F} = \left(20\hat{i} + 10\hat{j}\right)N$ on a frictionless surface. If the box was initially at rest, then ______ m is displacement along the x-axis after 10 s.

5. As shown in the figure, a block of mass $\sqrt{3}$ kg is kept on a horizontal rough surface of coefficient of friction $\frac{1}{3\sqrt{3}}$. The critical force to be applied on the vertical surface as shown at an angle 60° with horizontal such that it does not move, will be 3x. The value of x will be
[$g = 10\ m/s^2$; $\sin 60° = \frac{\sqrt{3}}{2}$; $\cos 60° = \frac{1}{2}$]



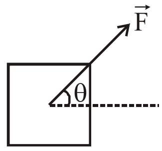
6. Two masses A and B, each of mass M are fixed together by a massless spring. A force acts on the mass B as shown in figure. If the mass A starts moving away from mass B with acceleration 'a', then the acceleration of mass B wil be :-



(1) $\frac{Ma - F}{M}$ (2) $\frac{MF}{F + Ma}$

(3) $\frac{F + Ma}{M}$ (4) $\frac{F - Ma}{M}$

7. A block of mass m slides along a floor while a force of magnitude F is applied to it at an angle θ as shown in figure. The coefficient of kinetic friction is μ_K. Then, the block's acceleration 'a' is given by : (g is acceleration due to gravity)



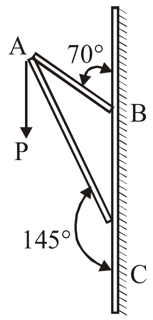
(1) $-\frac{F}{m}\cos\theta - \mu_K\left(g - \frac{F}{m}\sin\theta\right)$

(2) $\frac{F}{m}\cos\theta - \mu_K\left(g - \frac{F}{m}\sin\theta\right)$

(3) $\frac{F}{m}\cos\theta - \mu_K\left(g + \frac{F}{m}\sin\theta\right)$

(4) $\frac{F}{m}\cos\theta + \mu_K\left(g - \frac{F}{m}\sin\theta\right)$

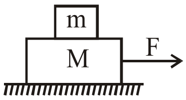
8. Consider a frame that is made up of two thin massless rods AB and AC as shown in the figure. A vertical force $\vec{P}$ of magnitude 100 N is applied at point A of the frame.



Suppose the force is $\vec{P}$ resolved parallel to the arms AB and AC of the frame. The magnitude of the resolved component along the arm AC is xN. The value of x, to the nearest integer, is ________.
[Given : $\sin(35°) = 0.573$, $\cos(35°) = 0.819$
$\sin(110°) = 0.939$, $\cos(110°) = -0.342$]

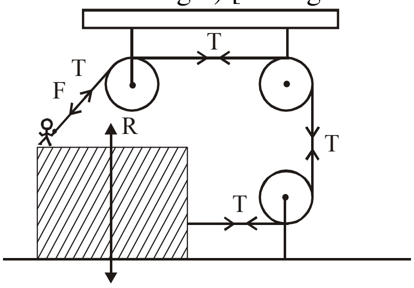
9. A body of mass 2kg moves under a force of $(2\hat{i} + 3\hat{j} + 5\hat{k})N$. It starts from rest and was at the origin initially. After 4s, its new coordinates are (8, b, 20). The value of b is __________.
(Round off to the Nearest Integer)

10. Two blocks (m = 0.5 kg and M = 4.5 kg) are arranged on a horizontal frictionless table as shown in figure. The coefficient of static friction between the two blocks is $\frac{3}{7}$. Then the maximum horizontal force that can be applied on the larger block so that the blocks move together is ______ N. (Round off to the Nearest Integer) [Take g as 9.8 ms^{-2}]



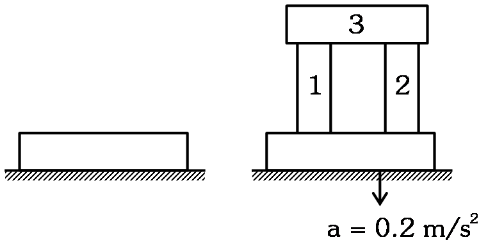
11. A body of mass 1 kg rests on a horizontal floor with which it has a coefficient of static friction $\frac{1}{\sqrt{3}}$. It is desired to make the body move by applying the minimum possible force F N. The value of F will be __________. (Round off to the Nearest Integer) [Take g = 10 ms^{-2}]

12. A boy of mass 4 kg is standing on a piece of wood having mass 5kg . If the coefficient of friction between the wood and the floor is 0.5, the maximum force that the boy can exert on the rope so that the piece of wood does not move from its place is ________N.(Round off to the Nearest Integer) [Take g = 10 ms^{-2}]



13. A bullet of mass 0.1 kg is fired on a wooden block to pierce through it, but it stops after moving a distance of 50 cm into it. If the velocity of bullet before hitting the wood is 10 m/s and it slows down with uniform deceleration, then the magnitude of effective retarding force on the bullet is 'x' N. The value of 'x' to the nearest integer is ______ .

14. A steel block of 10 kg rests on a horizontal floor as shown. When three iron cylinders are placed on it as shown, the block and cylinders go down with an acceleration 0.2 m/s^2. The normal reaction R' by the floor if mass of the iron cylinders are equal and of 20 kg each, is ______ N. [Take g = 10 m/s^2 and $\mu_s = 0.2$]



(1) 716 (2) 686 (3) 714 (4) 684

15. A particle of mass M originally at rest is subjected to a force whose direction is constant but magnitude varies with time according to the relation

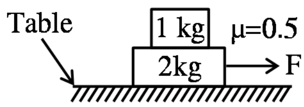
$$F = F_0\left[1-\left(\frac{t-T}{T}\right)^2\right]$$

Where F_0 and T are constants. The force acts only for the time interval 2T. The velocity v of the particle after time 2T is :

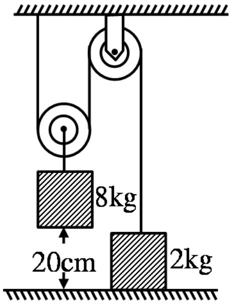
(1) $2F_0T / M$ (2) $F_0T / 2M$
(3) $4F_0T / 3M$ (4) $F_0T / 3M$

16. A body of mass '*m*' is launched up on a rough inclined plane making an angle of 30° with the horizontal. The coefficient of friction between the body and plane is $\frac{\sqrt{x}}{5}$ if the time of ascent is half of the time of descent. The value of x is _____.

17. The coefficient of static friction between two blocks is 0.5 and the table is smooth. The maximum horizontal force that can be applied to move the blocks together is ....N.(Take: g = 10 ms^{-2})



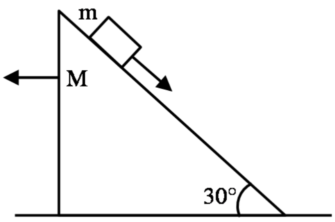
18. The boxes of masses 2 kg and 8 kg are connected by a massless string passing over smooth pulleys. Calculate the time taken by box of mass 8 kg to strike the ground starting from rest. (use g = 10 m/s^2)



(1) 0.34 s (2) 0.2 s
(3) 0.25 s (4) 0.4 s

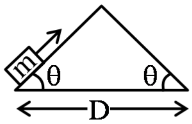
19. A car is moving on a plane inclined at 30° to the horizontal with an acceleration of 10 ms^{-2} parallel to the plane upward. A bob is suspended by a string from the roof of the car. The angle in degrees which the string makes with the vertical is______. (Take g = 10 ms^{-2})

20. A block of mass m slides on the wooden wedge, which in turn slides backward on the horizontal surface. The acceleration of the block with respect to the wedge is : Given m = 8 kg, M = 16 kg. Assume all the surfaces shown in the figure to be frictionless.

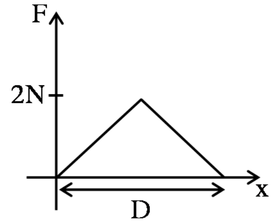


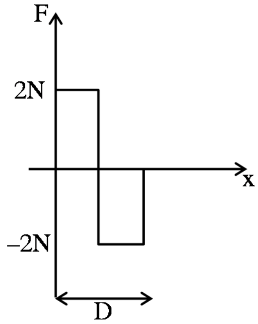
(1) $\frac{4}{3}g$ (2) $\frac{6}{5}g$ (3) $\frac{3}{5}g$ (4) $\frac{2}{3}g$

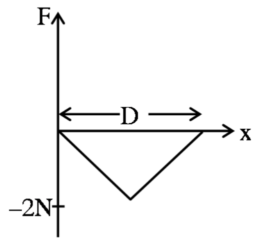
21. An object of mass 'm' is being moved with a constant velocity under the action of an applied force of 2N along a frictionless surface with following surface profile.

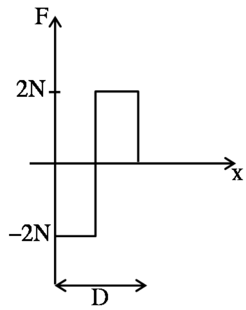


The correct applied force vs distance graph will be:

(1)


(2)


(3)


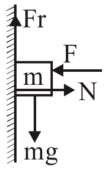
(4)


22. When a body slides down from rest along a smooth inclined plane making an angle of 30° with the horizontal, it takes time T. When the same body slides down from the rest along a rough inclined plane making the same angle and through the same distance, it takes time αT, where α is a constant greater than 1. The co-efficient of friction between the body and the rough plane is $\frac{1}{\sqrt{x}}\left(\frac{\alpha^2-1}{\alpha^2}\right)$ where x = ...

SOLUTION

1. Official Ans. by NTA (25)

Sol. F.B.D. of the block is shown in the diagram



Since block is at rest therefore

fr – mg = 0 …(1)

F – N = 0 …(2)

fr ≤ μN

In limiting case

fr = μN = μF …(3)

Using eq. (1) and (3)

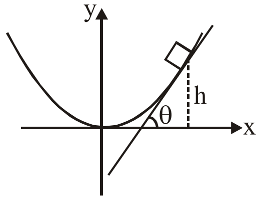
∴ μF = mg

$\Rightarrow F = \dfrac{0.5\times10}{0.2} = 25$ N

Ans. 25.00

2. Official Ans. by NTA (25)

Sol.



At maximum ht. block will experience maximum friction force. Therefore if at this height slope of the tangent is tan θ, then θ = Angle of repose.

$\therefore \tan\theta = \dfrac{dy}{dx} = \dfrac{2x}{4} = \dfrac{x}{2} = 0.5$

$\Rightarrow x = 1$ and therefore $y = \dfrac{x^2}{4} = 0.25$ m

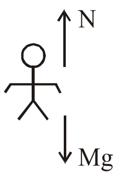
= 25 cm

∴ Answer is 25 cm

(Assuming that x & y in the equation are given in meter)

3. Official Ans. by NTA (492)

Sol.



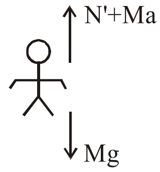
When lift is at rest

N = mg

⇒ 60 × 10 = 600 N

When lift moves with downward acceleration.

In frame of lift pseudo force will be in upward direction.



N' = M (g – a)

⇒ 60 (10 – 1.8)

N' ⇒ 492 N

4. Official Ans. by NTA (500)

Sol. $\vec{F} = 20\hat{i} + 10\hat{j}$

$\vec{a} = \dfrac{\vec{F}}{m} = \dfrac{20\hat{i}+10\hat{j}}{2} \Rightarrow 10\hat{i} + 5\hat{j}$

$\therefore \vec{s} = \dfrac{1}{2}\vec{a}t^2 = \dfrac{1}{2}\left(10\hat{i}+5\hat{j}\right)\times(10)^2$

$\Rightarrow 50\left(10\hat{i}+5\hat{j}\right)$m

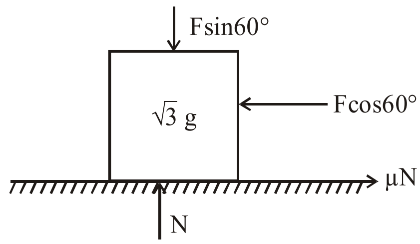
∴ Displacement along x-axis

⇒ 50 × 10 ⇒ 500 m

∴ Ans. 500

5. Official Ans. by NTA (3)

Sol.



$F\cos 60° = \mu N$ or $\dfrac{F}{2} = \dfrac{1}{3\sqrt{3}}N$ ... (1)

& $N = \sin 60° + \sqrt{3}g$ ... (2)

From equation (1) & (2)

$\dfrac{F}{2} = \dfrac{1}{3\sqrt{3}}\left(\dfrac{F\sqrt{3}}{2} + \sqrt{3}g\right)$

⇒ F = g = 10 Newton = 3x

So $x = \dfrac{10}{3} = 3.33$

6. Official Ans. by NTA (4)

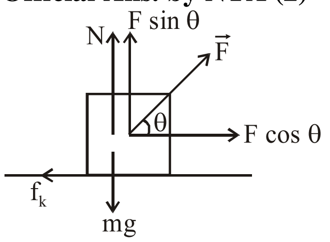
Sol. $a_{cm} = \dfrac{m_1a_1 + m_2a_2}{m_1 + m_2}$

$\dfrac{F}{2M} = \dfrac{Ma + Ma_B}{2M}$

$a_B = \dfrac{F - Ma}{M}$

7. Official Ans. by NTA (2)

Sol.



$N = mg - f\sin\theta$

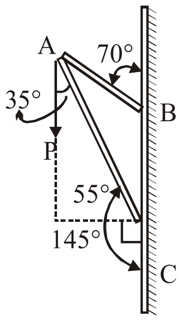
$F\cos\theta - \mu_k N = ma$

$F\cos\theta - \mu_k\,(mg - F\sin\theta) = ma$

$a = \dfrac{F}{m}\cos\theta - \mu_K\left(g - \dfrac{F}{m}\sin\theta\right)$

8. Official Ans. by NTA (82)

Sol.



Component along AC

$= 100\cos 35°\text{N}$

$= 100 \times 0.819$ N

$= 81.9$ N

$\approx$ 82 N

9. Official Ans. by NTA (12)

Sol. Ans. (12)

$\vec{a} = \dfrac{\vec{F}}{m} = \dfrac{2\hat{i} + 3\hat{j} + 5\hat{k}}{2}$

$= \hat{i} + 1.5\hat{j} + 2.5\hat{k}$

$\vec{\tau} = \vec{u}t + \dfrac{1}{2}\vec{a}t^2$

$= 0 + \dfrac{1}{2}(\hat{i} + 1.5\hat{j} + 2.5\hat{k})\ (16)$

$= 8\hat{i} + 12\hat{j} + 20\hat{k}$

$b = 12$

10. Official Ans. by NTA (21)

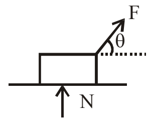
Sol. $a_{max} = \mu g = \dfrac{3}{7} \times 9.8$

$F = (M + m)\,a_{max} = 5\,a_{max}$

$= 21$ Newton

11. Official Ans. by NTA (5)

Sol.



$F\cos\theta = \mu N$

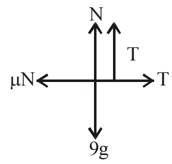
$F\sin\theta + N = mg$

$\Rightarrow F = \dfrac{\mu mg}{\cos\theta + \mu\sin\theta}$

$F_{min} = \dfrac{\mu mg}{\sqrt{1 + \mu^2}} = \dfrac{\dfrac{1}{\sqrt{3}} \times 10}{\dfrac{2}{\sqrt{3}}} = 5$

12. Official Ans. by NTA (30)

Sol.



$N + T = 90$

$T = \mu N = 0.5\,(90 - T)$

$1.5\,T = 45$

$T = 30$

13. Official Ans. by NTA (10)

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

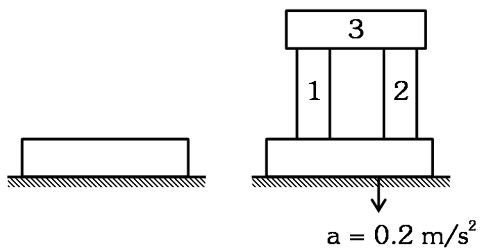
$0 = (10)^2 + 2\,(-a)\left(\dfrac{1}{2}\right)$

$a = 100\ \text{m/s}^2$

$F = ma = (0.1)\,(100) = 10$ N

14. Official Ans. by NTA (2)

Sol.



Writing force equation in vertical direction

$Mg - N = Ma$

$\Rightarrow 70g - N = 70 \times 0.2$

$\Rightarrow N = 70\,[g - 0.2] = 70 \times 9.8$

$\therefore N = 686$ Newton

Note : Since there is no compressive normal from the sides, hence friction will not act.

Hence option 2.

15. Official Ans. by NTA (3)

Sol. t = 0, u = 0

$$a = \frac{F_o}{M} - \frac{F_o}{MT^2}(t-T)^2 = \frac{dv}{dt}$$

$$\int_0^v dv = \int_{t=0}^{2T}\left(\frac{F_o}{M} - \frac{F_o}{MT^2}(t-T)^2\right)dt$$

$$V = \left[\frac{F_o}{M}t\right]_o^{2T} - \frac{F_o}{MT^2}\left[\frac{t^3}{3} - t^2T + T^2t\right]_0^{2T}$$

$$V = \frac{4F_oT}{3M}$$

16. Official Ans. by NTA (3)

Sol. $t_a = \frac{1}{2}t_d$

$$\sqrt{\frac{2s}{a_a}} = \frac{1}{2}\sqrt{\frac{2s}{a_d}} \quad \text{....(i)}$$

$$a_a = g\sin\theta + \mu g\cos\theta$$

$$= \frac{g}{2} + \frac{\sqrt{3}}{2}\mu g$$

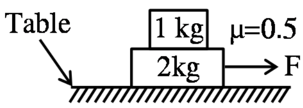
$$a_d = g\sin\theta - \mu g\cos\theta$$

$$= \frac{g}{2} - \frac{\sqrt{3}}{2}\mu g$$

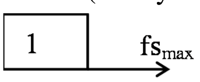
using the above values of a_a and a_d and putting in eqution (i) we will gate $\mu = \frac{\sqrt{3}}{5}$

17. Official Ans. by NTA (15)

Sol.



F = 3a (For system) ....(i)

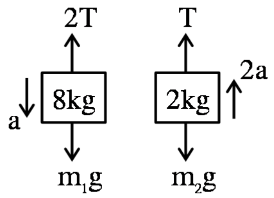


$fs_{max} = 1a$ (for 1kg block) ....(ii)

$\mu \times 1 \times g = a \Rightarrow 5 = a$ F = 15N

18. Official Ans. by NTA (4)

Sol.



$(m_1g - 2T) = m_1a$ – (1)

$T - m_2g = m_2(2a)$

$2T - 2m_2g = 4m_2 a$ – (2)

$m_1g - 2m_2g = (m_1 + 4m_2)\,a$

$$a = \frac{(8-4)g}{(8+8)} = \frac{4}{16}g = \frac{g}{4}$$

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

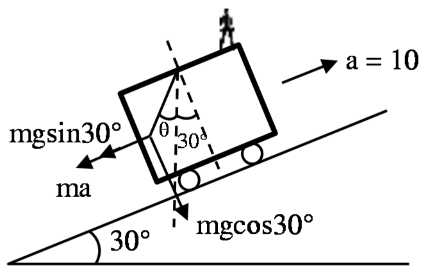
$$S = \frac{1}{2}at^2$$

$$\frac{0.2\times2\times4}{10} = t^2$$

t = 0.4 sec

19. Official Ans. by NTA (30)

Sol.



$$\tan(30+\theta) = \frac{mg\sin30° + ma}{mg\cos30°}$$

$$\tan(30+\theta) = \frac{5+10}{5\sqrt{3}} = \frac{1+2}{\sqrt{3}}$$

$$\frac{\tan\theta + \frac{1}{\sqrt{3}}}{1 - \frac{1}{\sqrt{3}}\tan\theta} = \sqrt{3}$$

$$\sqrt{3}\tan\theta + 1 = 3 - \sqrt{3}\tan\theta$$

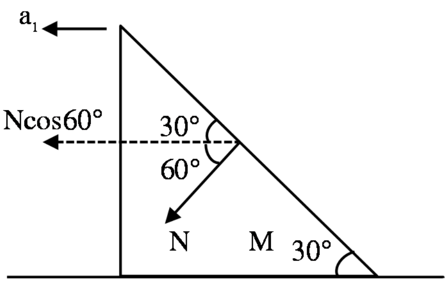
$$2\sqrt{3}\tan\theta = 2$$

$$\tan\theta = \frac{1}{\sqrt{3}}$$

θ = 30°

20. Official Ans. by NTA (4)

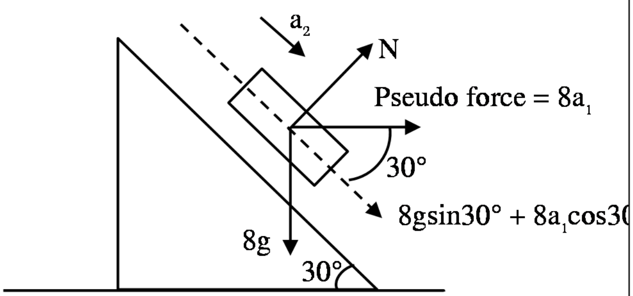
Sol. Let acceleration of wedge is a_1 and acceleration of block w.r.t. wedge is a_2



$N\cos 60° = Ma_1 = 16a_1$

$\Rightarrow N = 32a_1$

F.B.D. of block w.r.t wedge



$\perp$ to incline

$N = 8g\cos 30° - 8a_1 \sin 30° \Rightarrow 32a_1 = 4\sqrt{3}g - 4a_1$

$\Rightarrow a_1 = \frac{\sqrt{3}}{9}g$

Along incline

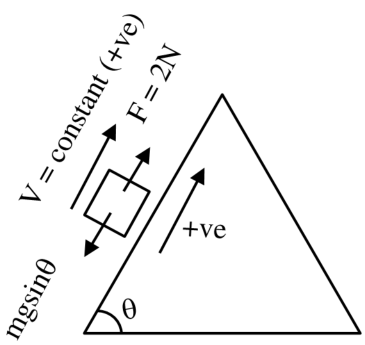
$8g\sin 30° + 8a_1\cos 30° = ma_2 = 8a_2$

$a_2 = g \times \frac{1}{2} + \frac{\sqrt{3}}{9}g.\frac{\sqrt{3}}{2} = \frac{2g}{3}$

Option (4)

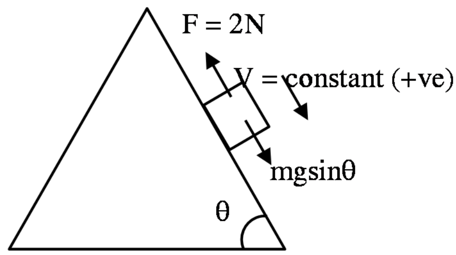
21. Official Ans. by NTA (2)

Sol. During upward motion



F = 2N = (+ve) constant

During downward motion

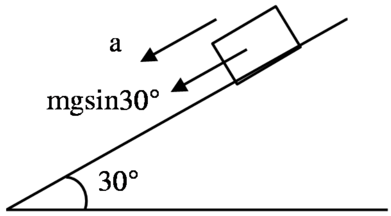


$\Rightarrow$ F = 2N = (–ve) constant

$\Rightarrow$ Best possible answer is option (2)

22. Official Ans. by NTA (3)

Sol.

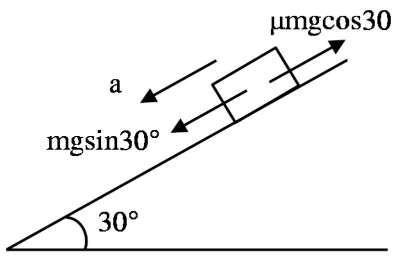


On smooth incline

$a = g\sin 30°$

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

$S = \frac{1}{2}\frac{g}{2}T^2 = \frac{g}{4}T^2$ ....(i)



On rough incline

$a = g\sin 30° - \mu g\cos 30°$

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

$S = \frac{1}{4}g\left(1-\sqrt{3}\mu\right)\left(\alpha T\right)^2$ ...(ii)

By (i) and (ii)

$\frac{1}{4}gT^2 = \frac{1}{4}g\left(1-\sqrt{3}\mu\right)\alpha^2T^2$

$\Rightarrow 1-\sqrt{3}g = \frac{1}{\alpha^2} \Rightarrow g = \left(\frac{\alpha^2-1}{\alpha^2}\right).\frac{1}{\sqrt{3}}$

$\Rightarrow x = 3.00$