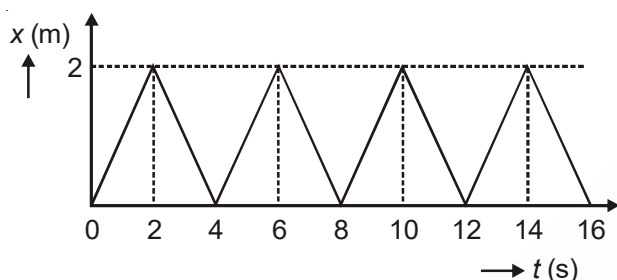


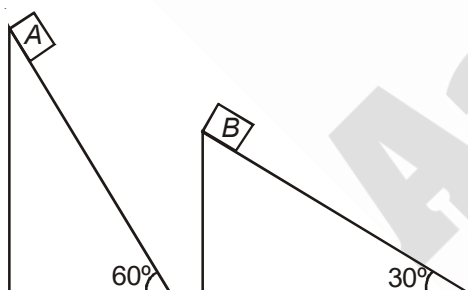
Chapter 3

Laws of Motion

1. The figure shows the position–time (x - t) graph of one-dimensional motion of a body of mass 0.4 kg. The magnitude of each impulse is [AIEEE-2010]



- (1) 0.2 Ns (2) 0.4 Ns
(3) 0.8 Ns (4) 1.6 Ns
2. Two fixed frictionless inclined planes making an angle 30° and 60° with the vertical are shown in the figure. Two blocks A and B are placed on the two planes. What is the relative vertical acceleration of A with respect to B? [AIEEE-2010]



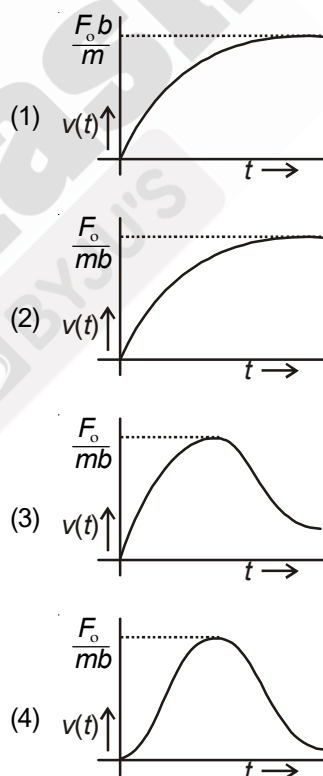
- (1) 4.9 ms^{-2} in vertical direction
(2) 4.9 ms^{-2} in horizontal direction
(3) 9.8 ms^{-2} in vertical direction
(4) Zero
3. The minimum force required to start pushing a body up a rough (frictional coefficient μ) inclined plane is F_1 while the minimum force needed to prevent it from sliding down is F_2 . If the inclined plane makes an angle θ from the horizontal such that $\tan\theta = 2\mu$, then the ratio $\frac{F_1}{F_2}$ is [AIEEE-2011]

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

4. If a spring of stiffness k is cut into two parts 'A' and 'B' of length $l_A : l_B = 2 : 3$, then the stiffness of spring 'A' is given by [AIEEE-2011]

- (1) k (2) $\frac{5}{2}k$
(3) $\frac{3k}{5}$ (4) $\frac{2k}{5}$

5. A particle of mass m is at rest at the origin at time $t = 0$. It is subjected to a force $F(t) = F_0 e^{-bt}$ in the x direction. Its speed $v(t)$ is depicted by which of the following curves? [AIEEE-2012]

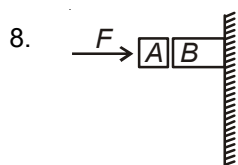


6. Two cars of masses m_1 and m_2 are moving in circles of radii r_1 and r_2 , respectively. Their speeds are such that they make complete circles in the same time t . The ratio of their centripetal acceleration is [AIEEE-2012]

- (1) $m_1 : m_2$ (2) $r_1 : r_2$
(3) $1 : 1$ (4) $m_1 r_1 : m_2 r_2$

7. A block of mass m is placed on a surface with a vertical cross-section given by $y = \frac{x^3}{6}$. If the coefficient of friction is 0.5, the maximum height above the ground at which the block can be placed without slipping is **[JEE (Main)-2014]**

- (1) $\frac{1}{6} m$ (2) $\frac{2}{3} m$
 (3) $\frac{1}{3} m$ (4) $\frac{1}{2} m$

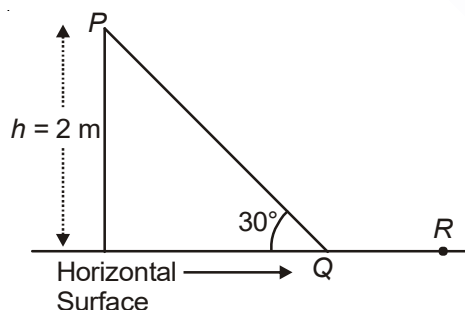


Given in the figure are two blocks A and B of weight 20 N and 100 N, respectively. These are being pressed against a wall by a force F as shown. If the coefficient of friction between the blocks is 0.1 and between block B and the wall is 0.15, the frictional force applied by the wall on block B is **[JEE (Main)-2015]**

- (1) 100 N (2) 80 N
 (3) 120 N (4) 150 N

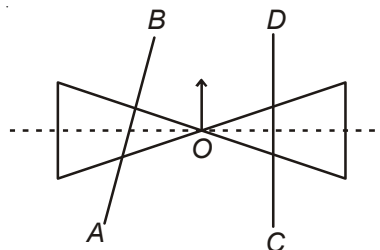
9. A point particle of mass m , moves along the uniformly rough track PQR as shown in the figure. The coefficient of friction, between the particle and the rough track equals μ . The particle is released, from rest from the point P and it comes to rest at a point R . The energies, lost by the ball, over the parts, PQ and QR , of the track, are equal to each other, and no energy is lost when particle changes direction from PQ to QR .

The values of the coefficient of friction μ and the distance $x (= QR)$, are, respectively close to **[JEE (Main)-2016]**



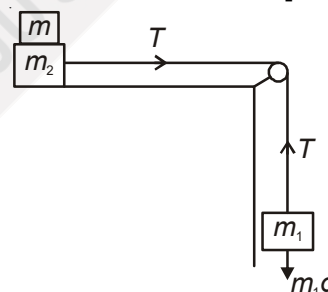
- (1) 0.2 and 3.5 m
 (2) 0.29 and 3.5 m
 (3) 0.29 and 6.5 m
 (4) 0.2 and 6.5 m

10. A roller is made by joining together two cones at their vertices O . It is kept on two rails AB and CD which are placed asymmetrically (see figure), with its axis perpendicular to CD and its centre O at the centre of line joining AB and CD (see figure). It is given a light push so that it starts rolling with its centre O moving parallel to CD in the direction shown. As it moves, the roller will tend to **[JEE (Main)-2016]**



- (1) Turn right
 (2) Go straight
 (3) Turn left and right alternately
 (4) Turn left

11. Two masses $m_1 = 5$ kg and $m_2 = 10$ kg, connected by an inextensible string over a frictionless pulley, are moving as shown in the figure. The coefficient of friction of horizontal surface is 0.15. The minimum weight m that should be put on top of m_2 to stop the motion is **[JEE (Main)-2018]**



- (1) 18.3 kg (2) 27.3 kg
 (3) 43.3 kg (4) 10.3 kg

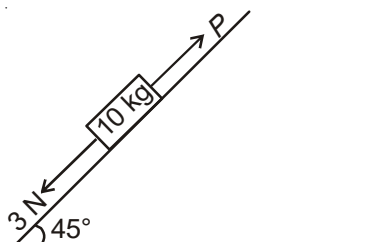
12. A particle is moving with a uniform speed in a circular orbit of radius R in a central force inversely proportional to the n^{th} power of R . If the period of rotation of the particle is T , then **[JEE (Main)-2018]**

- (1) $T \propto R^{3/2}$ for any n
 (2) $T \propto R^{\frac{n}{2}+1}$
 (3) $T \propto R^{(n+1)/2}$
 (4) $T \propto R^{n/2}$

13. A block of mass 10 kg is kept on a rough inclined plane as shown in the figure. A force of 3 N is applied on the block. The coefficient of static friction between the plane and the block is 0.6. What should be the minimum value of force P , such that the block does not move downward?

(take $g = 10 \text{ ms}^{-2}$)

[JEE (Main)-2019]



- (1) 25 N (2) 32 N
(3) 18 N (4) 23 N
14. A mass of 10 kg is suspended vertically by a rope from the roof. When a horizontal force is applied on the roof at some point, the rope deviated at an angle of 45° at the roof point. If the suspended mass is at equilibrium, the magnitude of the force applied is ($g = 10 \text{ ms}^{-2}$)

[JEE (Main)-2019]

- (1) 100 N (2) 200 N
(3) 70 N (4) 140 N

15. To mop-clean a floor, a cleaning machine presses a circular mop of radius R vertically down with a total force F and rotates it with a constant angular speed about its axis. If the force F is distributed uniformly over the mop and if coefficient of friction between the mop and the floor is μ , the torque, applied by the machine on the mop is

[JEE (Main)-2019]

- (1) $\frac{\mu FR}{2}$ (2) $\frac{\mu FR}{3}$
(3) $\frac{\mu FR}{6}$ (4) $\frac{2}{3} \mu FR$

16. A body is projected at $t = 0$ with a velocity 10 ms^{-1} at an angle of 60° with the horizontal. The radius of curvature of its trajectory at $t = 1 \text{ s}$ is R . Neglecting air resistance and taking acceleration due to gravity $g = 10 \text{ ms}^{-2}$, the value of R is

[JEE (Main)-2019]

- (1) 5.1 m (2) 2.5 m
(3) 2.8 m (4) 10.3 m

17. A particle of mass m is moving in a straight line with momentum p . Starting at time $t = 0$, a force $F = kt$ acts in the same direction on the moving particle during time interval T so that its momentum changes from p to $3p$. Here k is a constant. The value of T is

[JEE (Main)-2019]

- (1) $\sqrt{\frac{2k}{p}}$ (2) $2\sqrt{\frac{p}{k}}$
(3) $\sqrt{\frac{2p}{k}}$ (4) $2\sqrt{\frac{k}{p}}$

18. A particle moves from the point $(2.0\hat{i} + 4.0\hat{j}) \text{ m}$, at $t = 0$, with an initial velocity $(5.0\hat{i} + 4.0\hat{j}) \text{ ms}^{-1}$. It is acted upon by a constant force which produces a constant acceleration $(4.0\hat{i} + 4.0\hat{j}) \text{ ms}^{-2}$. What is the distance of the particle from the origin at time 2 s?

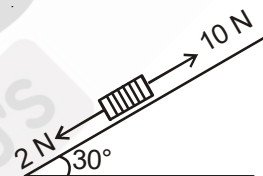
[JEE (Main)-2019]

- (1) $20\sqrt{2} \text{ m}$ (2) 15 m
(3) $10\sqrt{2} \text{ m}$ (4) 5 m

19. A block kept on a rough inclined plane, as shown in the figure, remains at rest upto a maximum force 2 N down the inclined plane. The maximum external force up the inclined plane that does not move the block is 10 N. The coefficient of static friction between the block and the plane is

[Take $g = 10 \text{ m/s}^2$]

[JEE (Main)-2019]



- (1) $\frac{1}{2}$ (2) $\frac{\sqrt{3}}{2}$
(3) $\frac{\sqrt{3}}{4}$ (4) $\frac{2}{3}$

20. A ball is thrown upward with an initial velocity V_0 from the surface of the earth. The motion of the ball is affected by a drag force equal to $m\gamma v^2$ (where m is mass of the ball, v is its instantaneous velocity and γ is a constant). Time taken by the ball to rise to its zenith is :

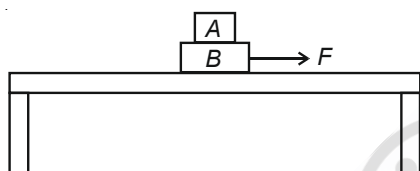
[JEE (Main)-2019]

- (1) $\frac{1}{\sqrt{\gamma g}} \sin^{-1} \left(\sqrt{\frac{\gamma}{g}} V_0 \right)$
(2) $\frac{1}{\sqrt{\gamma g}} \ln \left(1 + \sqrt{\frac{\gamma}{g}} V_0 \right)$
(3) $\frac{1}{\sqrt{\gamma g}} \tan^{-1} \left(\sqrt{\frac{\gamma}{g}} V_0 \right)$
(4) $\frac{1}{\sqrt{2\gamma g}} \tan^{-1} \left(\sqrt{\frac{2\gamma}{g}} V_0 \right)$

21. A bullet of mass 20 g has an initial speed of 1 ms^{-1} , just before it starts penetrating a mud wall of thickness 20 cm. If the wall offers a mean resistance of $2.5 \times 10^{-2} \text{ N}$, the speed of the bullet after emerging from the other side of the wall is close to :
[JEE (Main)-2019]

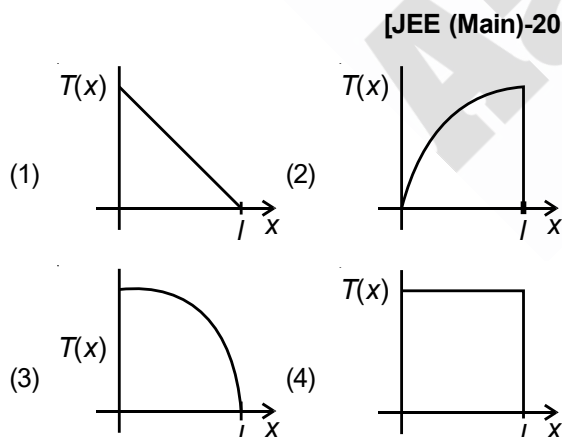
- (1) 0.4 ms^{-1} (2) 0.7 ms^{-1}
(3) 0.3 ms^{-1} (4) 0.1 ms^{-1}

22. Two blocks A and B of masses $m_A = 1 \text{ kg}$ and $m_B = 3 \text{ kg}$ are kept on the table as shown in figure. The coefficient of friction between A and B is 0.2 and between B and the surface of the table is also 0.2. The maximum force F that can be applied on B horizontally, so that the block A does not slide over the block B is:
[Take $g = 10 \text{ m/s}^2$]
[JEE (Main)-2019]

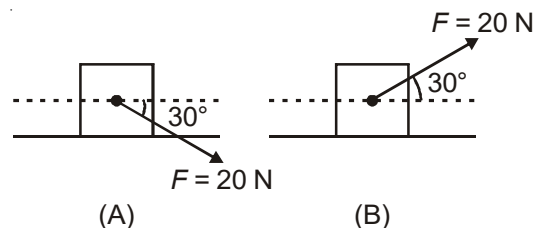


- (1) 40 N (2) 12 N
(3) 16 N (4) 8 N

23. A uniform rod of length l is being rotated in a horizontal plane with a constant angular speed about an axis passing through one of its ends. If the tension generated in the rod due to rotation is $T(x)$ at a distance x from the axis, then which of the following graphs depicts it most closely?
[JEE (Main)-2019]



24. A block of mass 5 kg is (i) pushed in case (A) and (ii) pulled in case (B), by a force $F = 20 \text{ N}$, making an angle of 30° with the horizontal, as shown in the figures. The coefficient of friction between the block and floor is $\mu = 0.2$. The difference between the accelerations of the block, in case (B) and case (A) will be :
($g = 10 \text{ ms}^{-2}$)
[JEE (Main)-2019]

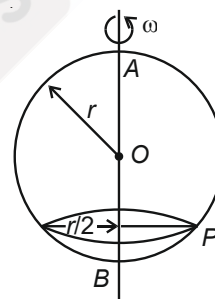


- (1) 0.4 ms^{-2} (2) 3.2 ms^{-2}
(3) 0 ms^{-2} (4) 0.8 ms^{-2}

25. A spring whose unstretched length is l has a force constant k . The spring is cut into two pieces of unstretched lengths l_1 and l_2 where, $l_1 = nl_2$ and n is an integer. The ratio k_1/k_2 of the corresponding force constants, k_1 and k_2 will be
[JEE (Main)-2019]

- (1) n^2 (2) $\frac{1}{n^2}$
(3) n (4) $\frac{1}{n}$

26. A smooth wire of length $2\pi r$ is bent into a circle and kept in a vertical plane. A bead can slide smoothly on the wire. When the circle is rotating with angular speed ω about the vertical diameter AB, as shown in figure, the bead is at rest with respect to the circular ring at position P as shown. Then the value of ω^2 is equal to
[JEE (Main)-2019]



- (1) $\frac{(g\sqrt{3})}{r}$ (2) $\frac{2g}{r}$
(3) $\frac{2g}{(r\sqrt{3})}$ (4) $\frac{\sqrt{3}g}{2r}$

27. A mass of 10 kg is suspended by a rope of length 4 m, from the ceiling. A force F is applied horizontally at the mid-point of the rope such that the top half of the rope makes an angle of 45° with the vertical. Then F equals (Take $g = 10 \text{ ms}^{-2}$ and the rope to be massless)
[JEE (Main)-2020]

- (1) 75 N (2) 70 N
(3) 90 N (4) 100 N

28. A particle of mass m is fixed to one end of a light spring having force constant k and unstretched length l . The other end is fixed. The system is given an angular speed ω about the fixed end of the spring such that it rotates in a circle in gravity free space. Then the stretch in the spring is

[JEE (Main)-2020]

- (1) $\frac{ml\omega^2}{k - m\omega^2}$ (2) $\frac{ml\omega^2}{k + m\omega^2}$
(3) $\frac{ml\omega^2}{k + m\omega}$ (4) $\frac{ml\omega^2}{k - m\omega^2}$

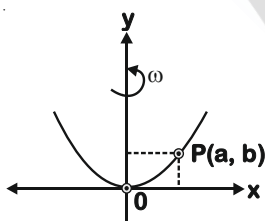
29. A spring mass system (mass m , spring constant k and natural length l) rests in equilibrium on a horizontal disc. The free end of the spring is fixed at the centre of the disc. If the disc together with spring mass system, rotates about its axis with an angular velocity ω , ($k \gg m\omega^2$) the relative change in the length of the spring is best given by the option

[JEE (Main)-2020]

- (1) $\sqrt{\frac{2}{3}} \left(\frac{m\omega^2}{k} \right)$ (2) $\frac{m\omega^2}{k}$
(3) $\frac{m\omega^2}{3k}$ (4) $\frac{2m\omega^2}{k}$

30. A bead of mass m stays at point $P(a, b)$ on a wire bent in the shape of a parabola $y = 4Cx^2$ and rotating with angular speed ω (see figure). The value of ω is (neglect friction)

[JEE (Main)-2020]



- (1) $2\sqrt{2gC}$
(2) $2\sqrt{gC}$
(3) $\sqrt{\frac{2g}{C}}$
(4) $\sqrt{\frac{2gC}{ab}}$

31. A small ball of mass m is thrown upward with velocity u from the ground. The ball experiences a resistive force mkv^2 , where v is its speed. The maximum height attained by the ball is

[JEE (Main)-2020]

- (1) $\frac{1}{2k} \tan^{-1} \frac{ku^2}{g}$
(2) $\frac{1}{k} \ln \left(1 + \frac{ku^2}{2g} \right)$
(3) $\frac{1}{2k} \ln \left(1 + \frac{ku^2}{g} \right)$
(4) $\frac{1}{k} \tan^{-1} \frac{ku^2}{2g}$

32. An insect is at the bottom of a hemispherical ditch of radius 1 m. It crawls up the ditch but starts slipping after it is at height h from the bottom. If the coefficient of friction between the ground and the insect is 0.75, then h is ($g = 10 \text{ ms}^{-2}$)

[JEE (Main)-2020]

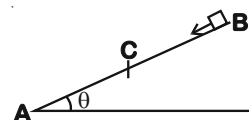
- (1) 0.45 m (2) 0.80 m
(3) 0.20 m (4) 0.60 m

33. A particle moving in the xy plane experiences a velocity dependent force $\vec{F} = k(v_y \hat{i} + v_x \hat{j})$, where v_x and v_y are the x and y components of its velocity $\vec{v}$. If $\vec{a}$ is the acceleration of the particle, then which of the following statements is true for the particle?

[JEE (Main)-2020]

- (1) Quantity $\vec{v} \cdot \vec{a}$ is constant in time
(2) Kinetic energy of particle is constant in time
(3) Quantity $\vec{v} \times \vec{a}$ is constant in time
(4) $\vec{F}$ arises due to a magnetic field

34. A small block starts slipping down from a point B on an inclined plane AB , which is making an



angle θ with the horizontal section BC is smooth and the remaining section CA is rough with a coefficient of friction μ . It is found that the block comes to rest as it reaches the bottom (point A) of the inclined plane. If $BC = 2AC$, the coefficient of friction is given by $\mu = k \tan \theta$. The value of k is _____.

[JEE (Main)-2020]

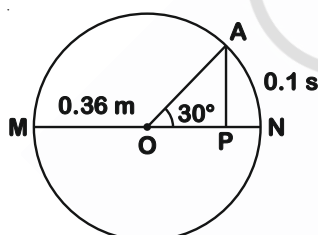
35. An inclined plane is bent in such a way that the vertical cross-section is given by $y = \frac{x^2}{4}$ where y is in vertical and x in horizontal direction. If the upper surface of this curved plane is rough with coefficient of friction $\mu = 0.5$, the maximum height in cm at which a stationary block will not slip downward is _____ cm. [JEE (Main)-2021]

36. 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. [$g = 10 \text{ ms}^{-2}$]

[JEE (Main)-2021]

37. The point A moves with a uniform speed along the circumference of a circle of radius 0.36 m and covers 30° in 0.1 s. The perpendicular projection 'P' from 'A' on the diameter MN represents the simple harmonic motion of 'P'. The restoration force per unit mass when P touches M will be

[JEE (Main)-2021]



- (1) 9.87 N
(2) 50 N
(3) 100 N
(4) 0.49 N

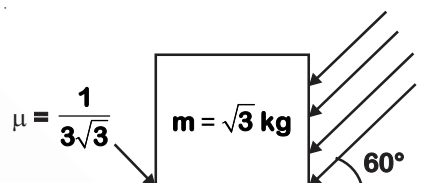
38. A particle is moving with uniform speed along the circumference of a circle of radius R under the action of a central fictitious force F which is inversely proportional to R^3 . Its time period of revolution will be given by : [JEE (Main)-2021]

- (1) $T \propto R^{\frac{4}{3}}$
(2) $T \propto R^{\frac{3}{2}}$
(3) $T \propto R^2$
(4) $T \propto R^{\frac{5}{2}}$

39. 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 _____.

$$[g = 10 \text{ m/s}^2; \sin 60^\circ = \frac{\sqrt{3}}{2}; \cos 60^\circ = \frac{1}{2}]$$

[JEE (Main)-2021]



40. 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. [$g = 10 \text{ m/s}^2$] [JEE (Main)-2021]

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

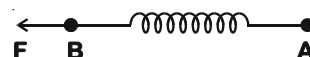
[JEE (Main)-2021]

42. The length of metallic wire is l_1 when tension in it is T_1 . It is l_2 when the tension is T_2 . The original length of the wire will be [JEE (Main)-2021]

- (1) $\frac{T_1 l_1 - T_2 l_2}{T_2 - T_1}$ (2) $\frac{l_1 + l_2}{2}$
(3) $\frac{T_2 l_1 + T_1 l_2}{T_1 + T_2}$ (4) $\frac{T_2 l_1 - T_1 l_2}{T_2 - T_1}$

43. 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 will be

[JEE (Main)-2021]



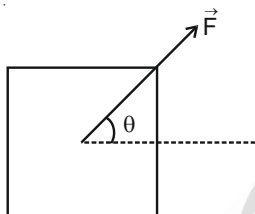
- (1) $\frac{Ma - F}{M}$ (2) $\frac{MF}{F + Ma}$
(3) $\frac{F - Ma}{M}$ (4) $\frac{F + Ma}{M}$

44. A block of 200 g mass moves with a uniform speed in a horizontal circular groove, with vertical side walls of radius 20 cm. If the block takes 40 s to complete one round, the normal force by the side walls of the groove is: [JEE (Main)-2021]

(1) 9.859×10^{-2} N
 (2) 9.859×10^{-4} N
 (3) 6.28×10^{-3} N
 (4) 0.0314 N

45. 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)

[JEE (Main)-2021]



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

46. **Statement I :** A cyclist is moving on an unbanked road with a speed of 7 kmh^{-1} and takes a sharp circular turn along a path of radius of 2 m without reducing the speed. The static friction coefficient is 0.2. The cyclist will not slip and pass the curve. ($g = 9.8 \text{ m/s}^2$)

Statement II : If the road is banked at an angle of 45° , cyclist can cross the curve of 2 m radius with the speed of 18.5 kmh^{-1} without slipping.

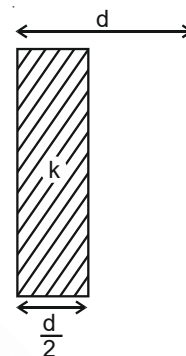
In the light of the above statements, choose the correct answer from the options given below.

[JEE (Main)-2021]

- (1) Statement I is correct and statement II is incorrect
 (2) Statement I is incorrect and statement II is correct
 (3) Both statement I and statement II are true
 (4) Both statement I and statement II are false

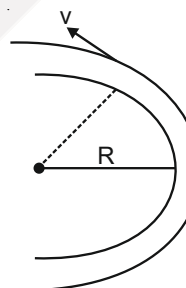
47. In a parallel plate capacitor set up, the plate area of capacitor is 2 m^2 and the plates are separated by 1 m. If the space between the plates are filled with a dielectric material of thickness 0.5 m and area 2 m^2 (see fig) the capacitance of the set-up will be _____ ϵ_0 . (Dielectric constant of the material = 3.2) (Round off to the Nearest Integer)

[JEE (Main)-2021]



48. A modern grand-prix racing car of mass m is travelling on a flat track in a circular arc of radius R with a speed v . If the coefficient of static friction between the tyres and the track is μ_s , then the magnitude of negative lift F_L acting downwards on the car is: (Assume forces on the four tyres are identical and g = acceleration due to gravity)

[JEE (Main)-2021]



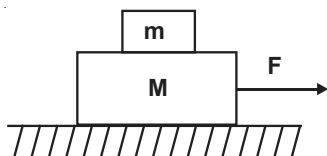
(1) $m \left(\frac{v^2}{\mu_s R} + g \right)$

(2) $m \left(\frac{v^2}{\mu_s R} - g \right)$

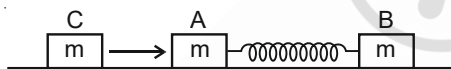
(3) $-m \left(g + \frac{v^2}{\mu_s R} \right)$

(4) $m \left(g - \frac{v^2}{\mu_s R} \right)$

49. Two block ($m = 0.5 \text{ kg}$ and $M = 4.5 \text{ kg}$) 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}] **[JEE (Main)-2021]**



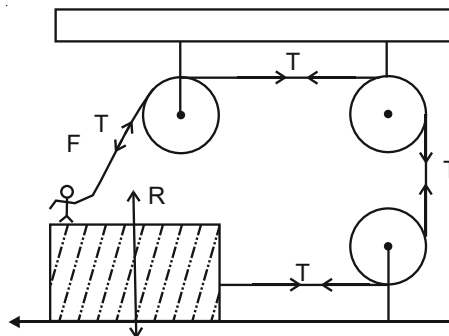
50. Two identical blocks A and B each of mass m resting on the smooth horizontal floor are connected by a light spring of natural length L and spring constant K . A third block C of mass m moving with a speed v along the line joining A and B collides with A. The maximum compression in the spring is **[JEE (Main)-2021]**



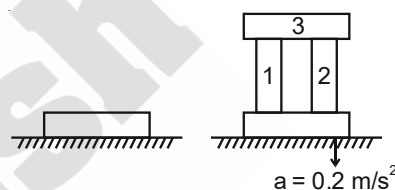
- (1) $\sqrt{\frac{mv}{2K}}$ (2) $\sqrt{\frac{mv}{K}}$
(3) $v\sqrt{\frac{m}{2K}}$ (4) $\sqrt{\frac{m}{2K}}$

51. 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 $F \text{ N}$. The value of F will be _____. (Round off to the Nearest Integer)
[Take $g = 10 \text{ ms}^{-2}$] **[JEE (Main)-2021]**

52. A boy of mass 4 kg is standing on a piece of wood having mass 5 kg . 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 $g = 10 \text{ ms}^{-2}$] **[JEE (Main)-2021]**

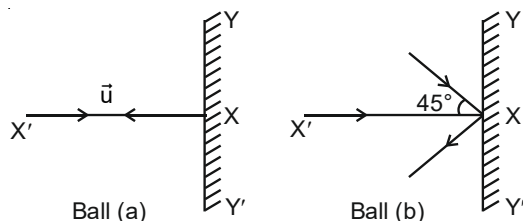


53. A steel block of 10 kg rests on a horizontal floor as shown. When three iron cylinders are placed on it as shown, the block and cylinders go down with an acceleration 0.2 m/s^2 . The normal reaction R' by the floor if mass of the iron cylinders are equal and of 20 kg each, is _____ N.
[Take $g = 10 \text{ m/s}^2$ and $\mu_s = 0.2$] **[JEE (Main)-2021]**



- (1) 714 (2) 716 (3) 684 (4) 686
54. The normal reaction ' N ' for a vehicle of 800 kg mass, negotiating a turn on a 30° banked road at maximum possible speed without skidding is $\text{_____} \times 10^3 \text{ kg m/s}^2$. **[JEE (Main)-2021]**
[Given $\cos 30^\circ = 0.87$, $\mu_s = 0.2$]
(1) 6.96 (2) 12.4 (3) 7.2 (4) 10.2
55. 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 _____. **[JEE (Main)-2021]**

56. Two billiard balls of equal mass 30 g strike a rigid wall with same speed of 108 kmph (as shown) but at different angles. If the balls get reflected with the same speed then the ratio of the magnitude of impulses imparted to ball 'a' and ball 'b' by the wall along 'X' direction is: **[JEE (Main)-2021]**



- (1) $\sqrt{2} : 1$ (2) $1 : \sqrt{2}$
(3) $2 : 1$ (4) $1 : 1$

57. A force $\vec{F} = (40\hat{i} + 10\hat{j})$ N acts on a body of mass 5 kg. If the body start from rest, its position vector $\vec{r}$ at time $t = 10$ s, will be **[JEE (Main)-2021]**

- (1) $(400\hat{i} + 400\hat{j})$ m (2) $(400\hat{i} + 100\hat{j})$ m
(3) $(100\hat{i} + 400\hat{j})$ m (4) $(100\hat{i} + 100\hat{j})$ m

58. 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 : **[JEE (Main)-2021]**

- (1) $\frac{F_0 T}{3M}$ (2) $\frac{F_0 T}{2M}$
(3) $\frac{2F_0 T}{M}$ (4) $\frac{4F_0 T}{3M}$

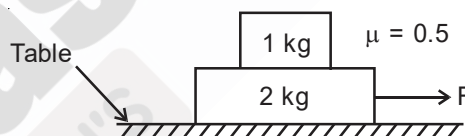
59. The initial mass of a rocket is 1000 kg. Calculate at what rate the fuel should be burnt so that the rocket is given an acceleration of 20 ms^{-2} . The gases come out at a relative speed of 500 ms^{-1} with respect to the rocket: (Use $g = 10 \text{ m/s}^2$) **[JEE (Main)-2021]**

- (1) 60 kg s^{-1} (2) 10 kg s^{-1}
(3) $6.0 \times 10^2 \text{ kg s}^{-1}$ (4) 500 kg s^{-1}

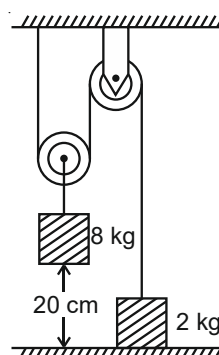
60. A particle of mass m is suspended from a ceiling through a string of length L . The particle moves in a horizontal circle of radius r such that $r = \frac{L}{\sqrt{2}}$. The speed of particle will be: **[JEE (Main)-2021]**

- (1) $2\sqrt{rg}$
(2) $\sqrt{rg}$
(3) $\sqrt{2rg}$
(4) $\sqrt{\frac{rg}{2}}$

61. 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 $g = 10 \text{ ms}^{-2}$) **[JEE (Main)-2021]**



62. 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 from rest. (use $g = 10 \text{ m/s}^2$): **[JEE (Main)-2021]**

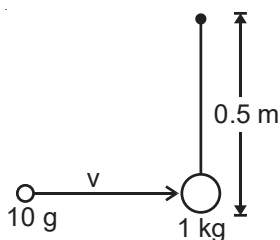


- (1) 0.4 s
(2) 0.25 s
(3) 0.34 s
(4) 0.2 s

63. A bullet of 10 g, moving with velocity v , collides head-on with the stationary bob of a pendulum and recoils with velocity 100 m/s. The length of the pendulum is 0.5 m and mass of the bob is 1 kg. The minimum value of $v =$ _____ m/s so that the pendulum describes a circle.

(Assume the string to be inextensible and $g = 10 \text{ m/s}^2$)

[JEE (Main)-2021]



64. A block moving horizontally on a smooth surface with a speed of 40 ms^{-1} splits into two equal parts. If one of the parts moves at 60 ms^{-1} in the same direction, then the fractional change in the kinetic energy will be $x : 4$ where $x =$ _____.

[JEE (Main)-2021]

65. 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 $g = 10 \text{ ms}^{-2}$)

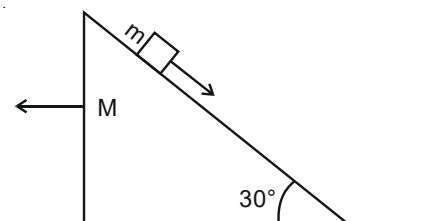
[JEE (Main)-2021]

66. 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 $m = 8 \text{ kg}$, $M = 16 \text{ kg}$

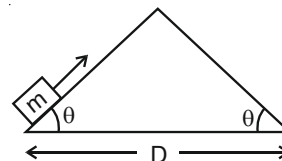
Assume all the surfaces shown in the figure to be frictionless.

[JEE (Main)-2021]

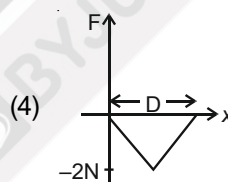
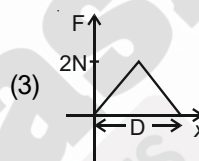
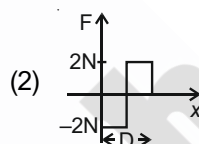
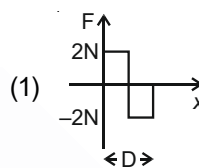


- (1) $\frac{2}{3}g$ (2) $\frac{4}{3}g$
(3) $\frac{6}{5}g$ (4) $\frac{3}{5}g$

67. 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. [JEE (Main)-2021]



The correct applied force vs distance graph will be:



68. 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 $x =$ _____. [JEE (Main)-2021]

69. A body of mass 2 kg moves under a force of $(2\hat{i} + 3\hat{j} + 5\hat{k})\text{N}$. It starts from rest and was at the origin initially. After 4 s, its new coordinates are (8, b, 20). The value of b is _____. (Round off to the nearest integer) [JEE (Main)-2021]

70. A block of mass 10 kg starts sliding on a surface with an initial velocity of 9.8 ms^{-1} . The coefficient of friction between the surface and block is 0.5. The distance covered by the block before coming to rest is

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

[JEE (Main)-2022]

- (1) 4.9 m
- (2) 9.8 m
- (3) 12.5 m
- (4) 19.6 m

71. A boy ties a stone of mass 100 g to the end of a 2 m long string and whirls it around in a horizontal plane. The string can withstand the maximum tension of 80 N. If the maximum speed with which the stone

can revolve is $\frac{K}{\pi} \text{ rev./min}$. The value of K is (Assume the string is massless and unstretchable)

[JEE (Main)-2022]

- (1) 400
- (2) 300
- (3) 600
- (4) 800

72. A uniform chain of 6 m length is placed on a table such that a part of its length is hanging over the edge of the table. The system is at rest. The co-efficient of static friction between the chain and the surface of the table is 0.5, the maximum length of the chain hanging from the table is ____ m.

[JEE (Main)-2022]

73. A force on an object of mass 100 g is $(10\hat{i} + 5\hat{j}) \text{ N}$.

The position of that object at $t = 2 \text{ s}$ is $(a\hat{i} + b\hat{j}) \text{ m}$

after starting from rest. The value of $\frac{a}{b}$ will be

[JEE (Main)-2022]

74. A disc and a flat small bottom beaker placed on it at a distance R from its center is revolving about an axis passing through the center and perpendicular to its plane with an angular velocity ω . The coefficient of static friction between the bottom of the beaker and the surface of the disc is μ . The beaker will revolve with the disc if :

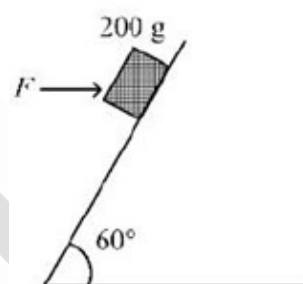
[JEE (Main)-2022]

- (1) $R \leq \frac{\mu g}{2\omega^2}$
- (2) $R \leq \frac{\mu g}{\omega^2}$
- (3) $R \geq \frac{\mu g}{2\omega^2}$
- (4) $R \geq \frac{\mu g}{\omega^2}$

75. A curved in a level road has a radius 75 m. The maximum speed of a car turning this curved road can be 30 m/s without skidding. If radius of curved road is changed to 48 m and the coefficient of friction between the tyres and the road remains same, then maximum allowed speed would be ____ m/s.

[JEE (Main)-2022]

76. A block of mass 200 g is kept stationary on a smooth inclined plane by applying a minimum horizontal force $F = \sqrt{x} \text{ N}$ as shown in figure.

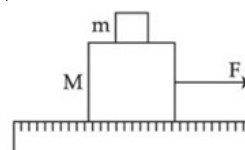


The value of $x =$ _____. [JEE (Main)-2022]

77. A person is standing in an elevator. In which situation, he experiences weight loss? [JEE (Main)-2022]

- (1) When the elevator moves upward with constant acceleration
- (2) When the elevator moves downward with constant acceleration
- (3) When the elevator moves upward with uniform velocity
- (4) When the elevator moves downward with uniform velocity

78. A system of two blocks of masses $m = 2 \text{ kg}$ and $M = 8 \text{ kg}$ is placed on a smooth table as shown in figure. The coefficient of static friction between two blocks is 0.5. The maximum horizontal force F that can be applied to the block of mass M so that the blocks move together will be [JEE (Main)-2022]



- (1) 9.8 N
- (2) 39.2 N
- (3) 49 N
- (4) 78.4 N

79. One end of a massless spring of spring constant k and natural length l_0 is fixed while the other end is connected to a small object of mass m lying on a frictionless table. The spring remains horizontal on the table. If the object is made to rotate at an angular velocity ω about an axis passing through fixed end, then the elongation of the spring will be :

[JEE (Main)-2022]

- (1) $\frac{k - m\omega^2 l_0}{m\omega^2}$ (2) $\frac{m\omega^2 l_0}{k + m\omega^2}$
 (3) $\frac{m\omega^2 l_0}{k - m\omega^2}$ (4) $\frac{k + m\omega^2 l_0}{m\omega^2}$

80. A mass of 10 kg is suspended vertically by a rope of length 5 m from the roof. A force of 30 N is applied at the middle point of rope in horizontal direction. The angle made by upper half of the rope with vertical is $\theta = \tan^{-1}(x \times 10^{-1})$. The value of x is _____

(Given, $g = 10 \text{ m/s}^2$)

[JEE (Main)-2022]

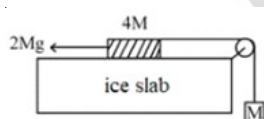
81. A hanging mass M is connected to a four times bigger mass by using a string-pulley arrangement, as shown in the figure. The bigger mass is placed on a horizontal ice-slab and being pulled by $2Mg$ force.

In this situation, tension in the string is $\frac{x}{5} Mg$ for

$x = \underline{\hspace{2cm}}$. Neglect mass of the string and friction of the block (bigger mass) with ice slab.

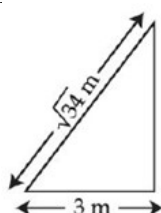
(Given $g =$ acceleration due to gravity)

[JEE (Main)-2022]



82. A $\sqrt{34} \text{ m}$ long ladder weighing 10 kg leans on a frictionless wall. Its feet rest on the floor 3 m away from the wall as shown in the figure. If F_r and F_w are the reaction forces of the floor and the wall, then ratio of F_w/F_r will be:

[JEE (Main)-2022]

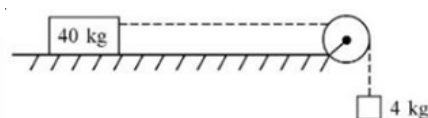
(Use $g = 10 \text{ m/s}^2$)

- (1) $\frac{6}{\sqrt{110}}$ (2) $\frac{3}{\sqrt{113}}$
 (3) $\frac{3}{\sqrt{109}}$ (4) $\frac{2}{\sqrt{109}}$

83. A block of mass 40 kg slides over a surface, when a mass of 4 kg is suspended through an inextensible massless string passing over frictionless pulley as shown below.

[JEE (Main)-2022]

The coefficient of kinetic friction between the surface and block is 0.02. The acceleration of block is (Given $g = 10 \text{ ms}^{-2}$.)



- (1) 1 ms^{-2}
 (2) $1/5 \text{ ms}^{-2}$
 (3) $4/5 \text{ ms}^{-2}$
 (4) $8/11 \text{ ms}^{-2}$

84. A block of mass M placed inside a box descends vertically with acceleration ' a '. The block exerts a force equal to one-fourth of its weight on the floor of the box.

[JEE (Main)-2022]

The value of ' a ' will be

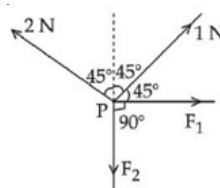
- (1) $\frac{g}{4}$ (2) $\frac{g}{2}$
 (3) $\frac{3g}{4}$ (4) g

85. A car is moving with speed of 150 km/h and after applying the break it will move 27 m before it stops. If the same car is moving with a speed of one third the reported speed then it will stop after travelling _____ m distance.

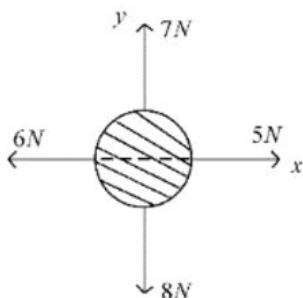
[JEE (Main)-2022]

86. For forces are acting at a point P in equilibrium as shown in figure. The ratio of force F_1 to F_2 is 1 : x where $x = \underline{\hspace{2cm}}$.

[JEE (Main)-2022]



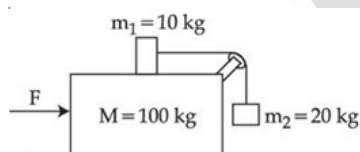
87. For a free body diagram shown in the figure, the four forces are applied in the 'x' and 'y' directions. What additional force must be applied and at what angle with positive x-axis so that net acceleration of body is zero? **[JEE (Main)-2022]**



- (1) $\sqrt{2}\text{ N}, 45^\circ$ (2) $\sqrt{2}\text{ N}, 135^\circ$
 (3) $\frac{2}{\sqrt{3}}\text{ N}, 30^\circ$ (4) $2\text{ N}, 45^\circ$
88. Three masses $M = 100\text{ kg}$, $m_1 = 10\text{ kg}$ and $m_2 = 20\text{ kg}$ are arranged in a system as shown in figure. All the surfaces are frictionless and strings are inextensible and weightless. The pulleys are also weightless and frictionless. A force F is applied on the system so that the mass m_2 moves upward with an acceleration of 2 ms^{-2} . The value of F is

(Take $g = 10\text{ ms}^{-2}$)

[JEE (Main)-2022]



- (1) 3360 N
 (2) 3380 N
 (3) 3120 N
 (4) 3240 N
89. A monkey of mass 50 kg climbs on a rope which can withstand the tension (T) of 350 N . If monkey initially climbs down with an acceleration of 4 m/s^2 and then climbs up with an acceleration of 5 m/s^2 . Choose the correct option ($g = 10\text{ m/s}^2$). **[JEE (Main)-2022]**

- (1) $T = 700\text{ N}$ while climbing upward
 (2) $T = 350\text{ N}$ while going downward
 (3) Rope will break while climbing upward
 (4) Rope will break while going downward

90. A ball of mass 0.15 kg hits the wall with its initial speed of 12 ms^{-1} and bounces back without changing its initial speed. If the force applied by the wall on the ball during the contact is 100 N , calculate the time duration of the contact of ball with the wall.

[JEE (Main)-2022]

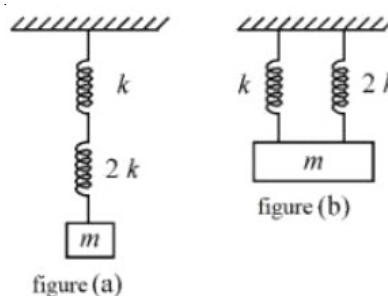
- (1) 0.018 s
 (2) 0.036 s
 (3) 0.009 s
 (4) 0.072 s

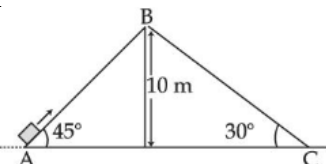
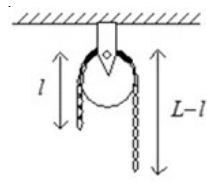
91. A body of mass 8 kg and another of mass 2 kg are moving with equal kinetic energy. The ratio of their respective momenta will be **[JEE (Main)-2022]**

- (1) 1:1
 (2) 2:1
 (3) 1:4
 (4) 4:1

92. As per given figures, two springs of spring constants k and $2k$ are connected to mass m . If the period of oscillation in figure (a) is 3 s , then the period of oscillation in figure (b) will be $\sqrt{x}\text{ s}$. The value of x is

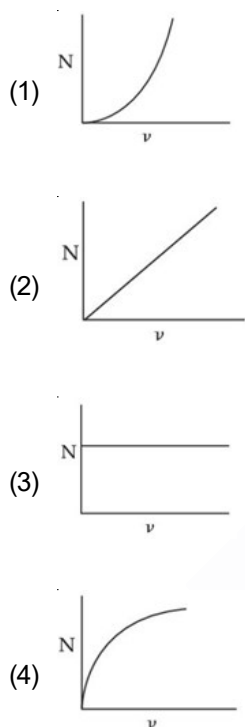
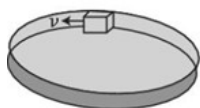
[JEE (Main)-2022]



93. A bag is gently dropped on a conveyor belt moving at a speed of 2 m/s. The coefficient of friction between the conveyor belt and bag is 0.4. Initially the bag slips on the belt before it stops due to friction. The distance travelled by the bag on the belt during slipping motion, is **[JEE (Main)-2022]**
[Take $g = 10 \text{ m/s}^2$]
(1) 2 m
(2) 0.5 m
(3) 3.2 m
(4) 0.8 ms
94. A block of mass M slides down on a rough inclined plane with constant velocity. The angle made by the incline plane with horizontal is θ . The magnitude of the contact force will be **[JEE (Main)-2022]**
(1) Mg
(2) $Mg \cos \theta$
(3) $\sqrt{Mg \sin \theta + Mg \cos \theta}$
(4) $Mg \sin \theta \sqrt{1 + \mu}$
95. A block 'A' takes 2 s to slide down a frictionless incline of 30° and length ' l ', kept inside a lift going up with uniform velocity ' v '. If the incline is changed to 45° , the time taken by the block, to slide down the incline, will be approximately **[JEE (Main)-2022]**
(1) 2.66 s
(2) 0.83 s
(3) 1.68 s
(4) 0.70 s
96. Two inclined planes are placed as shown in figure. A block is projected from the point A of inclined plane AB along its surface with a velocity just sufficient to carry it to the top point B at a height 10 m. After reaching the point B the block slides down on inclined plane BC. Time it takes to reach to the point C from point A is $t(\sqrt{2} + 1)\text{ s}$. The value of t is _____. (Use $g = 10 \text{ m/s}^2$) **[JEE (Main)-2022]**
- 
97. A balloon has mass of 10 g in air. The air escapes from the balloon at a uniform rate with velocity 4.5 cm/s. If the balloon shrinks in 5 s completely. Then, the average force acting on that balloon will be (in dyne). **[JEE (Main)-2022]**
(1) 3
(2) 9
(3) 12
(4) 18
98. A pressure-pump has a horizontal tube of cross sectional area 10 cm^2 for the outflow of water at a speed of 20 m/s. The force exerted on the vertical wall just in front of the tube which stops water horizontally flowing out of the tube, is
[given: density of water = 1000 kg/m^3]
[JEE (Main)-2022]
(1) 300 N
(2) 500 N
(3) 250 N
(4) 400 N
99. A uniform metal chain of mass m and length ' L ' passes over a massless and frictionless pulley. It is released from rest with a part of its length ' l ' is hanging on one side and rest of its length ' $L - l$ ' is hanging on the other side of the pulley. At a certain point of time, when $l = \frac{L}{x}$, the acceleration of the chain is $\frac{g}{2}$. The value of x is _____. **[JEE (Main)-2022]**
- 

- (1) 6
(2) 2
(3) 1.5
(4) 4

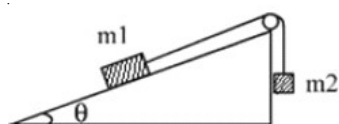
100. A smooth circular groove has a smooth vertical wall as shown in figure. A block of mass m moves against the wall with a speed v . Which of the following curve represents the correct relation between the normal reaction on the block by the wall (N) and speed of the block (v)? [JEE (Main)-2022]



101. Two bodies of masses $m_1 = 5$ kg and $m_2 = 3$ kg are connected by a light string going over a smooth light pulley on a smooth inclined plane as shown in the figure. The system is at rest. The force exerted by the inclined plane on the body of mass m_1 will be

[Take $g = 10 \text{ ms}^{-2}$]

[JEE (Main)-2022]

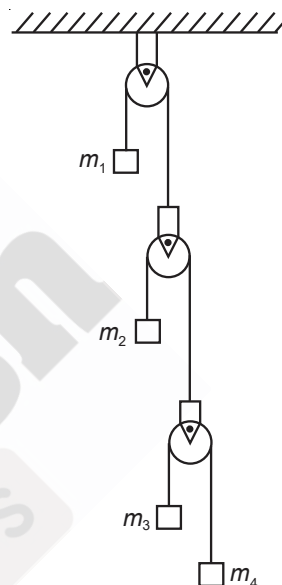


- (1) 30 N
(2) 40 N
(3) 50 N
(4) 60 N

102. If momentum of a body is increased by 20%, then its kinetic energy increases by [JEE (Main)-2022]

- (1) 36%
(2) 40%
(3) 44%
(4) 48%

103. In the arrangement shown in figure a_1 , a_2 , a_3 and a_4 are the accelerations of masses m_1 , m_2 , m_3 and m_4 respectively. Which of the following relation is true for this arrangement? [JEE (Main)-2022]



- (1) $4a_1 + 2a_2 + a_3 + a_4 = 0$
(2) $a_1 + 4a_2 + 3a_3 + a_4 = 0$
(3) $a_1 + 4a_2 + 3a_3 + 2a_4 = 0$
(4) $2a_1 + 2a_2 + 3a_3 + a_4 = 0$

104. For a particle in uniform circular motion, the acceleration $\vec{a}$ at any point $P(R, \theta)$ on the circular path of radius R is (when θ is measured from the positive x-axis and v is uniform speed):

[JEE (Main)-2022]

- (1) $-\frac{v^2}{R} \sin \theta \hat{i} + \frac{v^2}{R} \cos \theta \hat{j}$
(2) $-\frac{v^2}{R} \cos \theta \hat{i} + \frac{v^2}{R} \sin \theta \hat{j}$
(3) $-\frac{v^2}{R} \cos \theta \hat{i} - \frac{v^2}{R} \sin \theta \hat{j}$
(4) $-\frac{v^2}{R} \hat{i} + \frac{v^2}{R} \hat{j}$

105. A body of mass 10 kg is projected at an angle of 45° with the horizontal. The trajectory of the body is observed to pass through a point (20, 10). If T is the time of flight, then its momentum vector, at time $t = \frac{T}{\sqrt{2}}$, is _____. [Take $g = 10 \text{ m/s}^2$]

[JEE (Main)-2022]

- (1) $100\hat{i} + (100\sqrt{2} - 200)\hat{j}$
 (2) $100\sqrt{2}\hat{i} + (100 - 200\sqrt{2})\hat{j}$
 (3) $100\hat{i} + (100 - 200\sqrt{2})\hat{j}$
 (4) $100\sqrt{2}\hat{i} + (100\sqrt{2} - 200)\hat{j}$

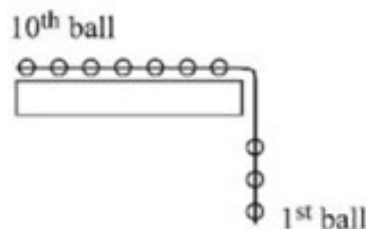
106. An object of mass 5 kg is thrown vertically upwards from the ground. The air resistance produces a constant retarding force of 10 N throughout the motion. The ratio of time of ascent to the time of descent will be equal to [Use $g = 10 \text{ ms}^{-2}$].

[JEE (Main)-2022]

- (1) 1 : 1
 (2) $\sqrt{2} : \sqrt{3}$
 (3) $\sqrt{3} : \sqrt{2}$
 (4) 2 : 3

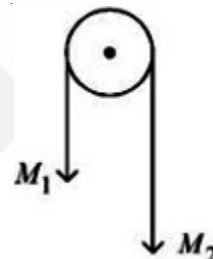
107. A batsman hits back a ball of mass 0.4 kg straight in the direction of the bowler without changing its initial speed of 15 ms^{-1} . The impulse imparted to the ball is _____ Ns. [JEE (Main)-2022]

108. A system of 10 balls each of mass 2 kg are connected via massless and unstretchable string. The system is allowed to slip over the edge of a smooth table as shown in figure. Tension on the string between the 7th and 8th ball is _____ N when 6th ball just leaves the table [JEE (Main)-2022]



109. Two masses M_1 and M_2 are tied together at the two ends of a light inextensible string that passes over a frictionless pulley. When the mass M_2 is twice that of M_1 , the acceleration of the system is a_1 . When the mass M_2 is thrice that of M_1 , the acceleration of the system is a_2 . The ratio $\frac{a_1}{a_2}$ will be

[JEE (Main)-2022]



- (1) $\frac{1}{3}$ (2) $\frac{2}{3}$
 (3) $\frac{3}{2}$ (4) $\frac{1}{2}$



Chapter 3

Laws of Motion

1. Answer (3)

$$I = \Delta p = m|\Delta v| = 0.4 \times (1 + 1) = 0.8 \text{ Ns}$$

2. Answer (1)

$$a_{A(\text{along vertical})} = g \sin^2 60^\circ$$

$$a_{B(\text{along vertical})} = g \sin^2 30^\circ$$

$$\Rightarrow a_{(A/B) \text{ along vertical}} = g \left(\frac{3}{4} - \frac{1}{4} \right) = \frac{g}{2} = 4.9 \text{ m/s}^2$$

3. Answer (1)

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

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

$$\frac{F_1}{F_2} = \frac{2\sin\theta + \tan\theta\cos\theta}{2\sin\theta - \tan\theta\cos\theta}$$

$$= 3$$

4. Answer (2)

$$k \propto \frac{1}{l}$$

$$k_1 l_1 = k l$$

$$k_1 = \frac{k l}{l_1}$$

$$\Rightarrow k_1 = k \frac{5l}{2l} = \frac{5k}{2}$$

5. Answer (2)

6. Answer (2)

7. Answer (1)

$$\tan\theta = \frac{dy}{dx} = \frac{x^2}{2}$$

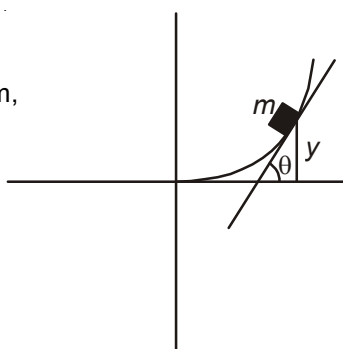
At limiting equilibrium,

$$\mu = \tan\theta$$

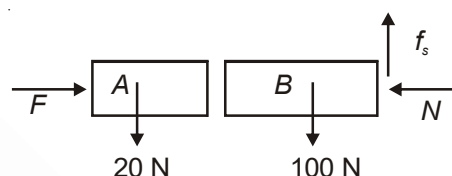
$$0.5 = \frac{x^2}{2}$$

$$\Rightarrow x = \pm 1$$

$$\text{Now, } y = \frac{1}{6}$$



8. Answer (3)



Clearly $f_s = 120 \text{ N}$ (for vertical equilibrium of the system)

9. Answer (2)

Work done by friction along PQ

= work done by friction along QR

$$\mu mg \cos\theta \frac{h}{\sin 30^\circ} = \mu mg x$$

$$\Rightarrow x = 3.5 \text{ m}$$

Now, according to work energy theorem

$$mgh = w_f(PQ) + w_f(QOR)$$

$$\text{Since, } w_f(PQ) = w_f(QR)$$

$$mg(2) = 2 \times \mu mg \cos 30^\circ \frac{h}{\sin 30^\circ}$$

$$\Rightarrow \mu = 0.29$$

10. Answer (4)

The roller will turn left as a force of friction will develop on rail AB in the backward direction.

11. Answer (2)

To stop the moving block m_2 , acceleration of m_2 should be opposite to velocity of m_2

$$m_1 g < \mu(m + m_2)g$$

$$\Rightarrow 5 < 0.15(10 + m_2)$$

$$\Rightarrow m_2 > 23.33 \text{ kg}$$

$\therefore$ Minimum mass = 27.3 kg (according to given options)

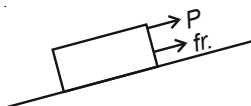
12. Answer (3)

$$m\omega^2 R = k R^{-n} = \frac{k}{R^n}$$

$$\Rightarrow \frac{1}{T^2} \propto \frac{1}{R^{n+1}}$$

$$\Rightarrow T \propto R^{\left(\frac{n+1}{2}\right)}$$

13. Answer (2)



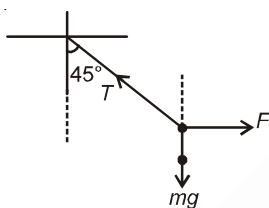
Friction force should be acting upward along the plane. So for state of impending motion.

$$3 + 10 \times 10 \frac{1}{\sqrt{2}} = P + 10 \times 10 \frac{1}{\sqrt{2}} \times \frac{6}{10}$$

$$\Rightarrow 73.71 - 42.42 = P$$

$$\Rightarrow P = 31.28 \approx 32 \text{ N}$$

14. Answer (1)



$$T \cos 45^\circ = mg$$

$$T \sin 45^\circ = F$$

$$\Rightarrow F = mg$$

$$= 10 \times 10 = 100 \text{ N}$$

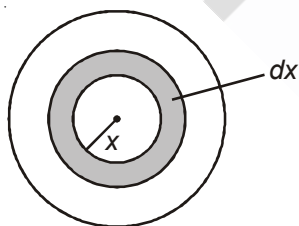
15. Answer (4)

$$P = \frac{F}{\pi R^2}$$

$$\tau = \frac{\mu F}{\pi R^2} \int_0^R 2\pi x^2 dx$$

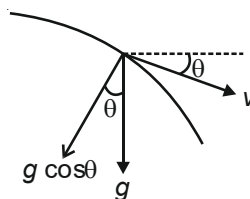
$$= \frac{\mu f \times 2\pi R^3}{3\pi R^2}$$

$$= \frac{2}{3} \mu FR$$



16. Answer (3)

$$T = \frac{2u \sin \theta}{g}$$



$$= \frac{2 \times 10}{10} \times \frac{\sqrt{3}}{2}$$

$$T = \sqrt{3} \text{ s}$$

$$V_y = 5\sqrt{3} - 10 = -1.34 \text{ ms}^{-1}$$

$$V_x = 10 \times \frac{1}{2} = 5 \text{ ms}^{-1}$$

$$|\tan \theta| = \left| \left(-\frac{1.34}{5} \right) \right|$$

$$\theta = 15^\circ$$

$$R = \frac{V^2}{g \cos \theta} = \frac{26.79}{10 \times 0.97} = 2.77 \text{ m}$$

$$\approx 2.8 \text{ m}$$

17. Answer (2)

$$F = kt$$

$$\frac{dp}{dt} = kt$$

$$\int_p^{3p} dp = k \int_0^t t dt$$

$$2p = \frac{kt^2}{2}$$

$$t = 2\sqrt{\frac{p}{k}}$$

18. Answer (1)

$$\vec{r} = \vec{r}_0 + \vec{u}t + \frac{1}{2} \vec{a}t^2$$

$$= (2\hat{i} + 4\hat{j}) + (5\hat{i} + 4\hat{j}) \times 2 + \frac{1}{2} [4\hat{i} + 4\hat{j}] \times 2^2$$

$$= (20\hat{i} + 20\hat{j}) \text{ m}$$

$$|\vec{r}| = 20\sqrt{2} \text{ m}$$

19. Answer (2)

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

$$\frac{mg}{2} + \mu mg \frac{\sqrt{3}}{2} = 10 \quad \dots(ii)$$

$$\Rightarrow 2 + mg = 10 \Rightarrow mg = 8$$

$$\text{From eq (i), } 6 = \mu \times 8 \times \frac{\sqrt{3}}{2}$$

$$\therefore \mu = \frac{2 \times 6}{8\sqrt{3}}$$

$$\Rightarrow \mu = \frac{\sqrt{3}}{2}$$

20. Answer (3)

Retardation of the particle

$$a = -(g + \gamma v^2)$$

$$\int_{v_0}^0 \frac{-dv}{g + \gamma v^2} = \int_0^t dt \quad [\text{for } H_{\max} \quad v = 0]$$

$$\frac{1}{\sqrt{\gamma g}} \tan^{-1} \left(\frac{\sqrt{\gamma} v_0}{\sqrt{g}} \right) = t$$

21. Answer (2)

$$v^2 = u^2 - 2aS$$

$$v^2 = (1)^2 - (2) \left[\frac{2.5 \times 10^{-2}}{20 \times 10^{-3}} \right] \frac{20}{100}$$

$$v^2 = 1 - \frac{1}{2}$$

$$\Rightarrow v = \frac{1}{\sqrt{2}} \text{ m/s} = 0.7 \text{ m/s}$$

22. Answer (3)

$$a_c = \left(\frac{F - f}{M + m} \right)$$

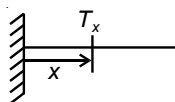
$$a = \frac{F - (0.2)4 \times 10}{4} = \left(\frac{F - 8}{4} \right)$$

$$\text{We have, } \frac{F - 8}{4} \leq (0.2)10$$

$$\Rightarrow F - 8 \leq 8$$

$$\Rightarrow F \leq 16$$

23. Answer (3)



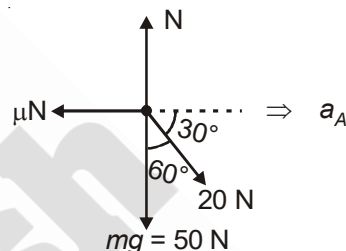
$$T_x = \frac{M}{L} (L - x) \left\{ x + \frac{L - x}{2} \right\} \omega^2 = \frac{M \omega^2}{2L} (L^2 - x^2)$$

24. Answer (4)

$$N = 60 \text{ N}$$

$$F = 0.2 \times 60 = 12 \text{ N}$$

$$a_A = \frac{\left(\frac{20\sqrt{3}}{2} - 12 \right)}{5} = \frac{5.3}{5} = 1.06 \text{ m/s}^2$$



$$\text{For B } N = 40 \text{ N}$$

$$F = 8 \text{ N} \Rightarrow \frac{20\sqrt{3}}{2} - 8 = 5a_B$$

$$a_B = \frac{17.3 - 8}{5} = \frac{9.3}{5} = 1.86 \text{ m/s}^2$$

$$a_B - a_A = 0.8 \text{ m/s}^2$$

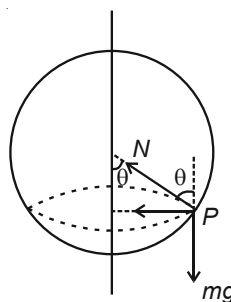
25. Answer (4)

$$l_1 = n l_2$$

$$\therefore k \propto \frac{1}{l}$$

$$\therefore \frac{k_1}{k_2} = \frac{l_2}{l_1} = \frac{1}{n}$$

26. Answer (3)



$$\theta = \sin^{-1} \frac{1}{2} = 30^\circ$$

$$N \cos \theta = mg \quad \dots(i)$$

$$N \sin \theta = \frac{m\omega^2 r}{2} \quad \dots(ii)$$

$$\tan \theta = \frac{\omega^2 r}{2g}$$

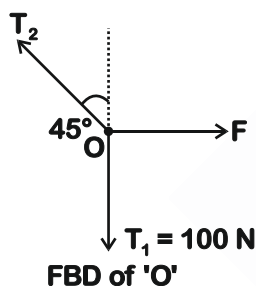
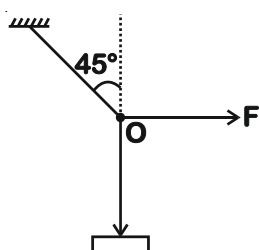
$$\Rightarrow \omega^2 = \frac{2g \tan \theta}{r} = \frac{2g}{r\sqrt{3}}$$

27. Answer (4)

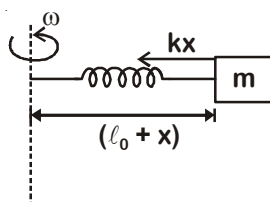
$$T_2 \cos 45^\circ = 100 \text{ N} \quad \dots(i)$$

$$T_2 \sin 45^\circ = F \quad \dots(ii)$$

$$\Rightarrow F = 100 \text{ N}$$



28. Answer (4)



At elongated position (x),

$$F_{\text{radial}} = m\omega^2$$

$$\therefore kx = m(\ell_0 + x)\omega^2$$

$$\therefore x = \frac{m\ell_0\omega^2}{k - m\omega^2}$$

29. Answer (2)

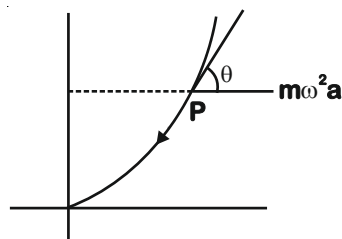
$$m\omega^2(\ell_0 + x) = kx$$

$$x = \frac{m\ell_0\omega^2}{k - m\omega^2}$$

For $k \gg m\omega^2$

$$\frac{x}{\ell_0} = \frac{m\omega^2}{K}$$

30. Answer (1)



$$y = 4Cx^2$$

$$\Rightarrow \frac{dy}{dx} = \tan \theta = 8Cx$$

At P, $\tan \theta = 8Ca$

For steady circular motion

$$mg \sin \theta = m\omega^2 a \cos \theta$$

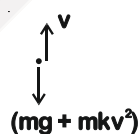
$$\Rightarrow \tan \theta = \frac{\omega^2 a}{g}$$

$$\Rightarrow 8Ca \times g = \omega^2 \times a$$

$$\Rightarrow \omega = \sqrt{8gC}$$

$$\Rightarrow \omega = 2\sqrt{2gC}$$

31. Answer (3)



$$|a| = g + kv^2$$

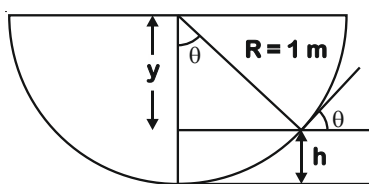
$$\Rightarrow -\frac{v dv}{dh} = g + kv^2$$

$$\Rightarrow \int_u^0 \frac{v dv}{g + kv^2} = \int_0^{H_{\text{max}}} -dh$$

On solving

$$H_{\text{max}} = \frac{1}{2k} \ln \left(1 + \frac{ku^2}{g} \right)$$

32. Answer (3)



$$\mu = \tan \theta$$

$$\Rightarrow \frac{3}{4} = \tan \theta$$

$$\Rightarrow \theta = 37^\circ$$

$$\therefore h = R - R \cos \theta = 1 - 1 \times \frac{4}{5} = 0.2 \text{ m}$$

33. Answer (3)

$$\frac{dv_x}{dt} = \frac{k}{m} v_y$$

$$\frac{dv_y}{dt} = \frac{k}{m} v_x$$

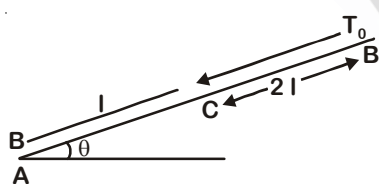
$$\Rightarrow \frac{dv_x}{dv_y} = \frac{v_y}{v_x} \Rightarrow v_x dx = v_y dy$$

$$\Rightarrow v_x^2 = v_y^2 + C$$

$$\vec{v} \times \vec{a} = (v_x^2 - v_y^2) \frac{k}{m}$$

$$\vec{v} \times \vec{a} = \frac{kC}{m}$$

34. Answer (3)



Work done by all the force/s is equal to zero.

$$\therefore 0 = mg3l \sin \theta - \mu mg l \cos \theta = 0$$

$$3 \sin \theta = \mu \cos \theta \Rightarrow \mu = 3 \tan \theta$$

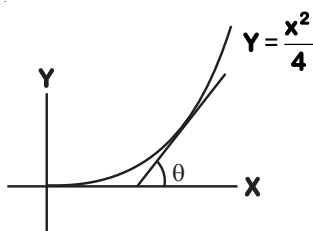
$$\therefore k = 3$$

35. Answer (25)

For no slipping

$$\tan \theta \leq \mu$$

$$\frac{x}{2} \leq 0.5$$



$$x \leq 1 \quad \tan \theta = \frac{dy}{dx} = \frac{x}{2}$$

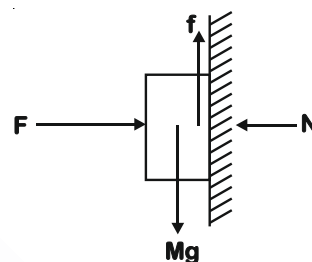
$$\sqrt{4Y} \leq 1$$

$$Y \leq \frac{1}{4} \text{ m}$$

$$Y_{\max} = 25 \text{ cm}$$

36. Answer (25)

For equilibrium of the block



$$N = F$$

$$f = Mg$$

$$\text{and } Mg \leq f_{\ell}$$

$$\Rightarrow F \geq \frac{Mg}{\mu}$$

$$F_{\max} = 25 \text{ N}$$

37. Answer (1)

$$v = \frac{\left(\frac{\pi}{6}\right) \times (0.36)}{0.1} \text{ m/s}$$

$$= \pi \times 0.6 \text{ m/s}$$

$$\therefore a_M = \frac{v^2}{r} = \frac{(\pi \times 0.6)^2}{0.36} = \pi^2 = 9.87 \text{ N/kg}$$

38. Answer (3)

$$F = \frac{K}{R^3}$$

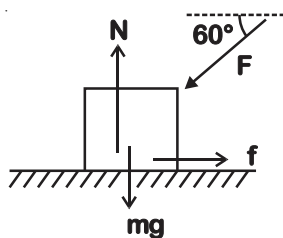
$$\Rightarrow \frac{mv^2}{R} = \frac{K}{R^3}$$

$$\Rightarrow v \propto \frac{1}{R}$$

$$\therefore T = \frac{2\pi R}{v}$$

$$\Rightarrow T \propto R^2$$

39. Answer (3.33)



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

For no movement of the block —

$$F \cos 60^\circ \leq f_l$$

$$F \cos 60^\circ \leq \mu (mg + F \sin 60^\circ)$$

$$F \leq \frac{\mu mg}{\cos 60^\circ - \mu \sin 60^\circ}$$

$$F_{\text{critical}} = 10 \text{ N}$$

40. Answer (492)

$$M = 60 \text{ kg}$$

$$N = M(g - a)$$

$$= 60(10 - 1.8)$$

$$= 492 \text{ N}$$

41. Answer (500)

$$\vec{a} = \frac{\vec{F}}{m} = 10\hat{i} + 5\hat{j}$$

$$x = \frac{1}{2} a_x t^2 = \frac{1}{2} \cdot 10 \cdot 100$$

$$= 500 \text{ m}$$

42. Answer (4)

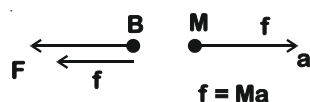
$$T_1 = K(l_1 - l_0) \quad \dots(1)$$

$$T_2 = K(l_2 - l_0) \quad \dots(2)$$

From (1) and (2),

$$l_0 = \frac{T_2 l_1 - T_1 l_2}{(T_2 - T_1)}$$

43. Answer (4)



$$F + f = Ma_1$$

$$\Rightarrow a_1 = \left(\frac{F + f}{M} \right) = \left(\frac{F + Ma}{M} \right)$$

44. Answer (2)

$$N = \frac{mv^2}{r}$$

$$= \frac{(200 \times 10^{-3}) \times \left(\frac{2\pi \times 0.2}{40} \right)^2}{0.2}$$

$$= 9.859 \times 10^{-4} \text{ N}$$

45. Answer (2)

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

$$N = (mg - F \sin \theta)$$

$$F \cos \theta - \mu mg + \mu F \sin \theta = ma$$

46. Answer (3)

For statement-I

$$v \leq \sqrt{\mu rg}$$

$$\leq \sqrt{0.2 \times 2 \times 9.8}$$

$$v \leq \sqrt{3.92} \Rightarrow \text{statement-I is true}$$

For statement-II

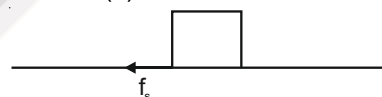
$$v_{\text{allowable}} = \sqrt{rg \frac{(\mu + \tan \theta)}{1 - \mu}} = \sqrt{\frac{3}{2} rg}$$

So, both the statements are true.

47. Answer (4)

$$C = \frac{\epsilon_0 A}{d - t + \frac{t}{k}} = \frac{\epsilon_0 \times 2}{1 - 0.5 + \frac{0.5}{3.2}} = 3.88 \epsilon_0$$

48. Answer (2)



$$f_s = \frac{mv^2}{R}$$

In limiting condition

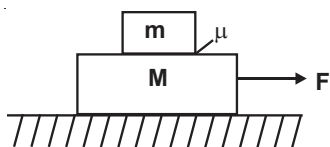
$$\mu_s N = \frac{mv^2}{R}$$

$$\Rightarrow N = \frac{mv^2}{\mu_s R}$$

$$\therefore F_L = mg - N = mg - \frac{mv^2}{\mu_s R}$$

$$-F_L = -m \left(g - \frac{v^2}{\mu_s R} \right)$$

49. Answer (21)



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

$$f = ma = m \frac{F}{m+M}$$

$$m \frac{F}{m+M} \leq \mu mg \quad \text{for no slipping}$$

$$F \leq \mu(m+M)g$$

$$F_{\max} = \frac{3}{7}(0.5 + 4.5) 9.8 \text{ N} = 21 \text{ N}$$

50. Answer (3)

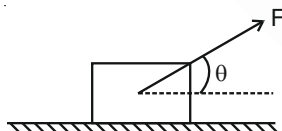
Maximum compression occurs when velocities of A and B are equal.

$$\frac{1}{2}mv_0^2 - \frac{1}{4}mv_0^2 = \frac{1}{2}Kx^2$$

$$v_0 \sqrt{\frac{m}{2K}} = x$$

51. Answer (5)

Force required to pull the block



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

$$F_{\min} = \frac{\mu Mg}{\sqrt{1+\mu^2}} = 5 \text{ N}$$

52. Answer (30)

$$T = Mg - N$$

$$R = mg + N = (\mu + m)g - T$$

For no movement of block

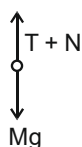
$$T \leq \mu R$$

$$T \leq \mu[(M+m)g - T]$$

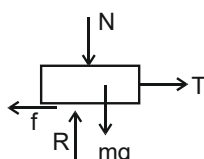
$$T \leq \frac{\mu(M+m)g}{1+\mu}$$

$$T_{\max} = 30 \text{ N}$$

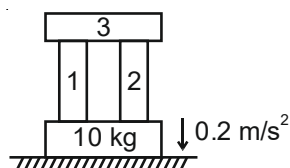
For Man:



For block:

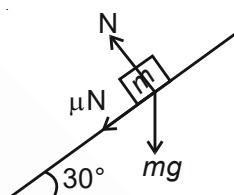


53. Answer (4)



$$\begin{aligned} R' &= (10 + 3 \times 20) \times (g - a) \\ &= 70 \times (9.8) \\ &= 686 \text{ N} \end{aligned}$$

54. Answer (4)



Along vertical

$$N \cos 30^\circ = mg + \mu N \cos 60^\circ$$

$$N \frac{\sqrt{3}}{2} = 800 \times 9.8 + 0.2N \times \frac{1}{2}$$

$$\Rightarrow N \frac{\sqrt{3}}{2} - 0.1N = 800 \times 9.8$$

$$N = \frac{800 \times 9.8}{\frac{\sqrt{3}}{2} - 0.1}$$

$$\approx 10234$$

$$\approx 10.2 \times 10^3 \text{ kg m/s}^2$$

55. Answer (3)

$$t_A = \sqrt{\frac{2\ell}{g(\sin \theta + \mu \cos \theta)}}$$

$$t_D = \sqrt{\frac{2\ell}{g(\sin \theta - \mu \cos \theta)}}$$

$$t_A = \frac{1}{2} t_D$$

$$\Rightarrow \mu = \frac{3}{5} \tan \theta = \frac{\sqrt{3}}{5}$$

56. Answer (1)

$$I_a = 2mv$$

$$I_b = 2mv \cos(45^\circ)$$

$$\text{ratio} = \sqrt{2}$$

57. Answer (2)

$$\begin{aligned}\vec{r} &= \vec{u}t + \frac{1}{2}\vec{a}t^2 \\ &= \frac{1}{2} \times (8\hat{i} + 2\hat{j}) \times 100 \\ &= (400\hat{i} + 100\hat{j}) \text{ m}\end{aligned}$$

58. Answer (4)

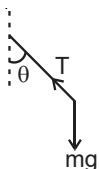
$$\begin{aligned}F &= F_0 \left[1 - \left(\frac{t-T}{T} \right)^2 \right] \\ a &= \frac{F_0}{M} \left[1 - \left(\frac{t-T}{T} \right)^2 \right] \\ \Rightarrow \int_0^v dv &= \int \frac{F_0}{M \times T^2} [T^2 - (t^2 + T^2 - 2tT)] dt \\ \Rightarrow V &= \frac{F_0}{MT^2} \times \left[2T \times \frac{t^2}{2} - \frac{t^3}{3} \right]_0^{2T} \\ &= \frac{F_0}{MT^2} \times \left[T \times 4T^2 - \frac{1}{3} \times 8T^3 \right] \\ &= \frac{F_0}{MT^2} \times \frac{4T^3}{3} = \frac{4F_0 T}{3M}\end{aligned}$$

59. Answer (1)

Here, $M = 1000 \text{ kg}$, $a = 20 \text{ m/s}^2$
 $V_{\text{rel}} = 500 \text{ m/s}$
 Using Newton's 2nd law,

$$\begin{aligned}V_{\text{rel}} \left(\frac{dm}{dt} \right) - Mg &= Ma \\ \Rightarrow 500 \times \left(\frac{dm}{dt} \right) &= 1000(10 + 20) \\ \Rightarrow \frac{dm}{dt} &= 60 \text{ kg/s}\end{aligned}$$

60. Answer (2)



$$\begin{aligned}T \cos \theta &= mg \\ T \sin \theta &= \frac{mv^2}{r} \\ \frac{v^2}{rg} &= \tan \theta \\ v &= \sqrt{rg}\end{aligned}$$

61. Answer (15)

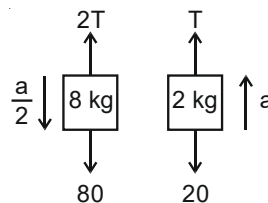
Maximum acceleration of block 1 is

$$a_{\text{max}} = 5 \text{ m/s}^2$$

$\Rightarrow$ Which is also maximum acceleration of the system without relative slipping in blocks.

$$F_{\text{max}} = 3(a_{\text{max}}) = 15 \text{ N}$$

62. Answer (1)



$$80 - 2T = 4a \quad \dots(1)$$

$$T - 20 = 2a \quad \dots(2)$$

From (1) and (2)

$$a = 5 \text{ m/s}^2$$

$$t = \sqrt{\frac{2H}{a/2}} = \sqrt{\frac{2 \times 20 \times 2}{100 \times 5}} = 0.4 \text{ s}$$

63. Answer (400)

For pendulum to describe circle

$$V_{B/\text{min}} = \sqrt{5 \times 10 \times 0.5} = 5 \text{ m/s}$$

$$p_{\text{bullet initial}} = 0.01 \times v$$

$$p_{\text{system final}} = 0.01(-100) + 1 \times 5$$

$$\Rightarrow (0.01)(-100) + 5 = \frac{v}{100}$$

$$\frac{v}{100} = 4$$

$$v = 400$$

64. Answer (1)

$$m \cdot 40 = \frac{m}{2} \cdot 60 + \frac{m}{2} V$$

$$\Rightarrow V = 20 \text{ m/s}$$

$$f = \frac{\frac{1}{2} \cdot \frac{m}{2} (60^2 + 20^2) - \frac{1}{2} m 40^2}{\frac{1}{2} m 40^2}$$

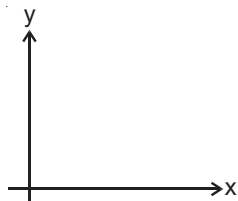
$$= \frac{1}{4}$$

65. Answer (30)

Acceleration of point of suspension

$$= 10 \cos 30^\circ \hat{i} + 10 \sin 30^\circ \hat{j}$$

$$= 5\sqrt{3}\hat{i} + 5\hat{j}$$



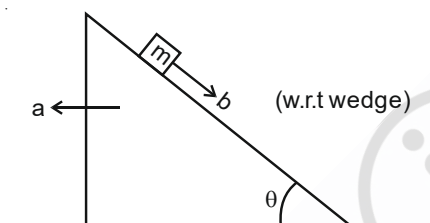
$$\begin{aligned} \vec{g}_{\text{eff}} &= -[(5\sqrt{3}\hat{i} + 5\hat{j}) + 10\hat{j}] \\ &= -(5\sqrt{3}\hat{i} + 15\hat{j}) \end{aligned}$$

$$\theta = \tan^{-1}\left(\frac{5\sqrt{3}}{15}\right) = 30^\circ$$

66. Answer (1)

$$\text{As, } \sum F_x = 0$$

$$\Rightarrow a_{\text{com}} = 0$$



$$\Rightarrow M(-a) + m(b\cos\theta - a) = 0$$

$$\Rightarrow b\cos\theta - a = \frac{M}{m}a$$

$$\Rightarrow b\cos\theta = 3a \quad \dots(i) \quad \text{As } \frac{M}{m} = 2$$

$$\text{and for block, } mg\sin\theta + ma\cos\theta = mb$$

$$b = g\sin\theta + \frac{b}{3}\cos^2\theta \Rightarrow b\left(1 - \frac{1}{3}\cos^2\theta\right) = g\sin\theta$$

$$\Rightarrow b = \frac{g \times \frac{1}{2}}{1 - \frac{1}{3} \times \frac{3}{4}} = \frac{2}{3}g$$

67. Answer (1)

In first half,

$$F = mg\sin\theta = 2 \text{ N (upwards along the incline)}$$

In 2nd half,

$$F = mg\sin\theta = 2 \text{ N (upwards along the incline)}$$

68. Answer (3)

$$\begin{aligned} \frac{T}{\alpha T} &= \sqrt{\frac{a_{\text{rough}}}{a_{\text{smooth}}}} \\ &= \sqrt{\frac{1 - \mu\sqrt{3}}{2 - \frac{2}{1/2}}} \end{aligned}$$

$$1 - \sqrt{3}\mu = \frac{1}{\alpha^2}$$

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

69. Answer (12)

$$\vec{r} = \frac{1}{2}\vec{a}t^2$$

$$\frac{1}{2} \left(\hat{i} + \frac{3}{2}\hat{j} + \frac{5}{2}\hat{k} \right) \cdot 16$$

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

$$b = 12$$

70. Answer (2)

$$\begin{aligned} S &= \frac{u^2}{2a} = \frac{u^2}{2(\mu g)} \\ &= \frac{(9.8)^2}{2 \times 0.5 \times (9.8)} \end{aligned}$$

$$= \frac{9.8}{1}$$

$$= 9.8 \text{ m}$$

71. Answer (3)

$$T = m\omega^2 r$$

$$\Rightarrow 80 = 0.1 \times \left(2\pi \times \frac{K}{\pi} \times \frac{1}{60} \right)^2 \times 2$$

$$\Rightarrow \frac{800}{2} = \frac{K^2}{900}$$

$$\Rightarrow K = 30 \times 20 = 600$$

72. Answer (2)

$$(x)g\lambda = \mu(6-x)g\lambda \text{ where } x \text{ is length of hanging part}$$

$$\Rightarrow x = 3 - 0.5x$$

$$\Rightarrow x = 2 \text{ m}$$

73. Answer (2)

$$\vec{F} = m\vec{a}$$

$$\Rightarrow \vec{a} = 100\hat{i} + 50\hat{j}$$

$$\text{So } \vec{S} = \frac{1}{2} \vec{a} t^2$$

$$\frac{1}{2} (100\hat{i} + 50\hat{j}) 2^2$$

$$= 200\hat{i} + 100\hat{j} \text{ m}$$

so $a = 200 \text{ m}$ and $b = 100 \text{ m}$

$$\text{so } \frac{a}{b} = 2$$

74. Answer (2)

To move together

$$\omega^2 R \leq \mu g$$

$$\Rightarrow R \leq \frac{\mu g}{\omega^2}$$

75. Answer (24)

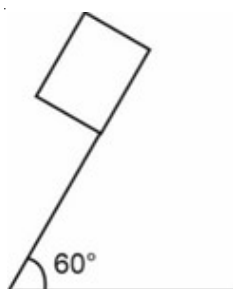
$$\therefore v = \sqrt{\mu g r}$$

$$\Rightarrow \frac{v_1}{v_2} = \sqrt{\frac{r_1}{r_2}}$$

$$\Rightarrow \frac{30}{v_2} = \sqrt{\frac{75}{48}} = \sqrt{\frac{25}{16}} = \frac{5}{4}$$

$$\Rightarrow V_2 = 24 \text{ m/s}$$

76. Answer (12)



$$F \cos 60^\circ = mg \sin 60^\circ$$

$$F \times \frac{1}{2} = 0.2 \times 10 \times \frac{\sqrt{3}}{2}$$

$$\Rightarrow F = 2\sqrt{3}$$

$$\Rightarrow F = \sqrt{12} \text{ N}$$

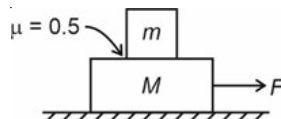
$$\therefore x = 12$$

77. Answer (2)

$$\text{Apparent weight} = m(g - a)$$

$\Rightarrow$ Weight loss in downward accelerated elevator

78. Answer (3)



$$\therefore a_{\max} = \mu g$$

$$= 0.5 \times 9.8 = 4.9 \text{ m/s}^2$$

$$\therefore F_{\max} = (8 + 2) \times 4.9 = 49 \text{ N}$$

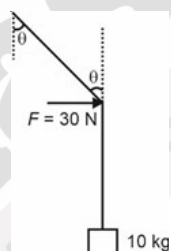
79. Answer (3)

$$m\omega^2(l_0 + x) = kx$$

$$\Rightarrow m\omega^2 l_0 = (k - m\omega^2) \times x$$

$$\Rightarrow x = \frac{m\omega^2 l_0}{(k - m\omega^2)}$$

80. Answer (3)



$$T \cos \theta = mg$$

$$T \cos \theta = 100 \text{ N} \quad \dots(i)$$

$$T \sin \theta = 30 \quad \dots(ii)$$

$$\Rightarrow \frac{T \sin \theta}{T \cos \theta} = \frac{30}{100}$$

$$\Rightarrow \tan \theta = \frac{3}{10}$$

$$\therefore x = 3$$

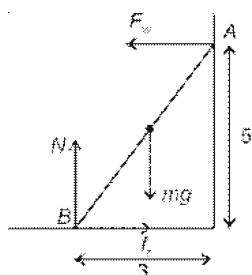
81. Answer (6)

$$a = \frac{Mg}{4M + M} = \frac{g}{5} \text{ (in upward direction)}$$

$$T = M \left(g + \frac{g}{5} \right) = \frac{6Mg}{5}$$

$$\Rightarrow x = 6$$

82. Answer (3)



Taking torque from B

$$F_w \times 5 = \frac{3}{2} mg$$

$$\Rightarrow F_w = \frac{3}{10} \times 10 \times 10$$

$$= 30 \text{ N}$$

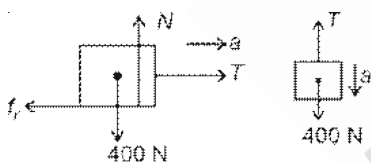
$$N = mg = 100 \text{ N}$$

$$\text{and } f_r = F_w = 30 \text{ N}$$

$$\text{so } F_f = \sqrt{N^2 + f_r^2} = \sqrt{10000 + 900} = 10\sqrt{109} \text{ N}$$

$$\text{so } \frac{F_w}{F_f} = \frac{3}{\sqrt{109}}$$

83. Answer (4)



$$f_{r_{\max}} = \mu N$$

$$= 0.02 \times 400$$

$$= 8 \text{ N}$$

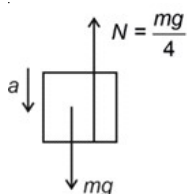
Let the acceleration is a as shown then.

$$40 - T = 4a$$

$$T - 8 = 40a$$

$$\Rightarrow a = \frac{32}{44} = \frac{8}{11} \text{ m/s}^2$$

84. Answer (3)



Using Newton's second law

$$mg - \frac{mg}{4} = ma$$

$$\Rightarrow a = \frac{3g}{4}$$

85. Answer (3)

$$F_R d = \frac{1}{2} mv^2$$

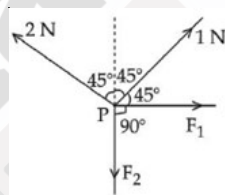
$$\frac{d_2}{d_1} = \left(\frac{v_2}{v_1} \right)^2 = \left(\frac{1}{3} \right)^2$$

$$d_2 = d_1 \times \frac{1}{9} = 3 \text{ m}$$

86. Answer (3)

$$F_1 = +2 \times \frac{1}{\sqrt{2}} - \frac{1}{\sqrt{2}} = \frac{1}{\sqrt{2}}$$

$$F_2 = 2 \times \frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}} = \frac{3}{\sqrt{2}}$$

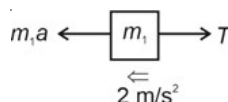


$$\frac{F_1}{F_2} = \frac{1}{3} = \frac{1}{x} \Rightarrow x = 3$$

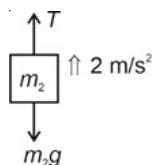
87. Answer (1)

Resultant of already applied forces $= -\hat{i} - \hat{j}$ $\Rightarrow$ Force required to balance $= \hat{i} + \hat{j}$ $\Rightarrow$ Force required $= \sqrt{2} \text{ N}$ in magnitude at angle 45° with +ve x-axis

88. Answer (3)

In frame of block of mass M moving with acceleration a 

$$m_1 a - T = 2m_1 \Rightarrow 10a - T = 20 \quad \dots(i)$$



$$T - m_2 g = m_2 a \Rightarrow T - 200 = 40 \Rightarrow T = 240 \quad \dots(ii)$$

$$\Rightarrow \text{From equation 1 and 2 } 10a = 260 \text{ or } a = 26 \text{ m/s}^2$$

for block

$$F = (M + m_2)a = 120 \times 26 \\ = 3120 \text{ N}$$

89. Answer (3)

$$T_{\text{down}} = 50 \times (10 - 4)$$

$$= 50 \times 6$$

$$= 300 \text{ N}$$

$$T_{\text{up}} = 50 \times (10 + 5)$$

$$= 50 \times 15$$

$$= 750 \text{ N}$$

$\Rightarrow$ Rope will break while climbing up.

90. Answer (2)

$$F = 100 \text{ N}$$

$$\Delta P = 2 \times 0.15 \times 12$$

$$= 3.6$$

$$\Rightarrow t = \frac{3.6}{100} = 0.036 \text{ s}$$

91. Answer (2)

$$P = \sqrt{2m KE}$$

$$\Rightarrow \frac{P_1}{P_2} = \sqrt{\frac{m_1}{m_2}}$$

$$= \sqrt{\frac{8}{2}} = \frac{2}{1}$$

92. Answer (2)

For case (a),

$$K_{eq} = \frac{2K}{3}$$

For case (b),

$$K_{eq} = 3K$$

$$\therefore T = 2\pi\sqrt{\frac{m}{K}}$$

$$\therefore \frac{T_a}{T_b} = \sqrt{\frac{K_b}{K_a}}$$

$$\frac{3}{T_b} = \sqrt{\frac{3K \times 3}{2K}} = \frac{3}{\sqrt{2}}$$

$$T_b = \sqrt{2}$$

$$x = 2$$

93. Answer (2)

$$v = 2 \text{ m/s}$$

$$\mu = 0.4$$

$$a = +(0.4)(g)$$

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

$$v^2 - u^2 = 2as$$

$$\Rightarrow (4) = 2 \times (4)(s)$$

$$s = 0.5 \text{ m}$$

94. Answer (1)

As the body is moving with constant velocity so forces acting on the body must be balanced.

$\Rightarrow$ Contact force from incline should balance weight of the body.

$$\Rightarrow |F_{\text{contact}}| = Mg$$

95. Answer (3)

$$\theta_1 = 30^\circ, \theta_2 = 45^\circ$$

$$a_1 = g \sin \theta_1 = 5 \text{ m/s}^2, a_2 = g \sin \theta_2, 5\sqrt{2} \text{ m/s}^2$$

$$\frac{t_1}{t_2} = \frac{\sqrt{\frac{2l}{a_1}}}{\sqrt{\frac{2l}{a_2}}} = \sqrt{\frac{a_2}{a_1}}$$

$$\frac{t_1}{t_2} = (2)^{\frac{1}{4}}$$

$$t_2 = (2)^{\frac{3}{4}}$$

$$\approx 1.68 \text{ s}$$

96. Answer (2)

$$AB = 10\sqrt{2} \text{ m}$$

$$v_A = \sqrt{2 \times 10 \times 10} = 10\sqrt{2} \text{ m/s}$$

$$v_C = 10\sqrt{2} \text{ m/s}$$

$$a_{BC} = g \sin(30^\circ) = 5 \text{ m/s}^2$$

$$t_{BC} = 2\sqrt{2} \text{ s} \quad \left(\frac{v_C}{a_{BC}} \right)$$

$$t_{AB} = \frac{v_A}{5\sqrt{2}} = 2 \text{ s}$$

$$t_{AB} + t_{BC} = 2(\sqrt{2} + 1)$$

$$\Rightarrow t = 2$$

97. Answer (2)

$$F_{\text{avg}} = \mu \times v_{\text{rel}}$$

$$= \frac{10}{5} \times 4.5 = 9$$

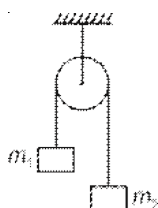
98. Answer (4)

$$F_w = \rho A v^2$$

$$= 10^3 \times 10 \times 10^{-4} \times 20 \times 20$$

$$= 400 \text{ N}$$

99. Answer (4)



$$a = \frac{m_2 - m_1}{m_1 + m} g = \frac{g}{2}$$

$$\Rightarrow m_2 = 3m_1$$

$$(L - l) = 3l$$

$$L = 4l$$

$$l = \frac{L}{4}$$

100. Answer (1)

$$N = \frac{mv^2}{r}$$

$\Rightarrow$ The graph given in option (1) suits the best for the above relation.

101. Answer (2)

$$m_2 g = m_1 g \sin \theta \quad \dots(i)$$

$$N = m_1 g \cos \theta \quad \dots(ii)$$

$$\Rightarrow \frac{N}{m_2 g} = \cot \theta$$

$$\Rightarrow N = 3 \times 10 \times \cot \theta = 3 \times 10 \times \frac{4}{3} \left(\because \sin \theta = \frac{3}{5} \right)$$

$$\Rightarrow N = 40 \text{ Newtons}$$

102. Answer (3)

$$K = \frac{p^2}{2m}$$

$$K' = \frac{(1.2p)^2}{2m}$$

$$\Rightarrow \frac{K' - K}{K} = (1.2)^2 - 1 = 0.44$$

$$\Rightarrow 44\% \text{ increase}$$

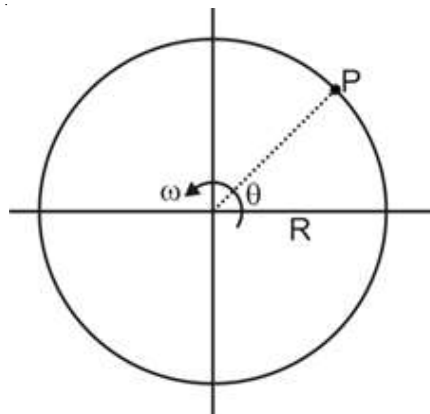
103. Answer (1)

From virtual work done method,

$$4T \times a_1 + 2T \times a_2 + T \times a_3 + T \times a_4 = 0$$

$$\Rightarrow 4a_1 + 2a_2 + a_3 + a_4 = 0$$

104. Answer (3)



As the particle in uniform circular motion experiences only centripetal acceleration of magnitude $\omega^2 R$ or

$\frac{v^2}{R}$ directed towards centre so from diagram.

$$\vec{a} = \frac{v^2}{R} \cos \theta (-\hat{i}) + \frac{v^2}{R} \sin \theta (-\hat{j})$$

105. Answer (4)

$$m = 10 \text{ kg}$$

$$\theta = 45^\circ$$

$$y = x \tan \theta \left(1 - \frac{x}{R} \right)$$

$$\Rightarrow 10 = 20 \left(1 - \frac{20}{R} \right)$$

$$\Rightarrow R = 40$$

$$40 = \frac{u^2}{10} \Rightarrow u = 20$$

$$\Rightarrow T = \frac{2 \times 20 \times \frac{1}{\sqrt{2}}}{10} = \frac{4}{\sqrt{2}} \text{ s} \Rightarrow t = 2 \text{ s}$$

$$\text{at } t = 2, \vec{v} = (10\sqrt{2}\hat{i}) + (10\sqrt{2} - 2 \times 10)\hat{j}$$

$$\Rightarrow \vec{p} = 10[10\sqrt{2}\hat{i} + (10\sqrt{2} - 20)\hat{j}]$$

$$= 100\sqrt{2}\hat{i} + (100\sqrt{2} - 200)\hat{j}$$

106. Answer (2)

Let time taken to ascent is t_1 and that to descent is t_2 . Height will be same so

$$H = \frac{1}{2} \times 12t_1^2 = \frac{1}{2} \times 8t_2^2$$

$$\Rightarrow \frac{t_1}{t_2} = \frac{\sqrt{2}}{\sqrt{3}}$$

107. Answer (12)

$$I = m\Delta v$$

$$= 0.4 \times 2 \times 15 = 12 \text{ Ns}$$

108. Answer (36)

At given instant

$$a_{\text{sys}} = \frac{6m \times g}{10m} = \frac{6g}{10}$$

$$\therefore T_{78} = (3m) \times a_{\text{sys}}$$

$$= (3m) \times \left(\frac{6g}{10} \right)$$

$$= \frac{3 \times 2 \times 6 \times 10}{10} = 36 \text{ N}$$

109. Answer (2)

$$a_1 = \frac{M_2 - M_1}{M_2 + M_1} \times g = \frac{2M_1 - M_1}{3M_1} \times g$$

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

$$\text{And, } a_2 = \frac{3M_1 - M_1}{4M_1} \times g = \frac{g}{2}$$

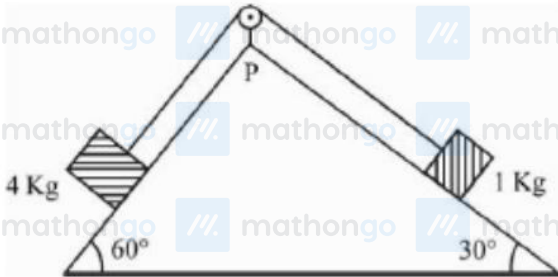
$$\therefore \frac{a_1}{a_2} = \frac{g/3}{g/2} = \frac{2}{3}$$



Q1 - 24 January - Shift 1

As per given figure, a weightless pulley P is attached on a double inclined frictionless surface.

The tension in the string (massless) will be (if $g = 10 \text{ m/s}^2$)



- (1) $(4\sqrt{3} + 1)\text{N}$ (2) $4(\sqrt{3} + 1)\text{N}$
(3) $4(\sqrt{3} - 1)\text{N}$ (4) $(4\sqrt{3} - 1)\text{N}$

Space for your notes:

Q2 - 24 January - Shift 1

Given below are two statements :

Statement-I : An elevator can go up or down with uniform speed when its weight is balanced with the tension of its cable.

Statement-II : Force exerted by the floor of an elevator on the foot of a person standing on it is more than his/her weight when the elevator goes down with increasing speed.

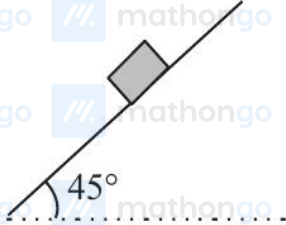
In the light of the above statements, choose the correct answer from the options given below :

- (1) Both statement I and statement II are false
(2) Statement I is true but Statement II is false
(3) Both Statement I and Statement II are true
(4) Statement I is false but Statement II is true

Space for your notes:

Q3 - 25 January - Shift 2

Consider a block kept on an inclined plane (inclined at 45°) as shown in the figure. If the force required to just push it up the incline is 2 times the force required to just prevent it from sliding down, the coefficient of friction between the block and inclined plane (μ) is equal to :



- (1) 0.33 (2) 0.60
(3) 0.25 (4) 0.50

Space for your notes:

Q4 - 29 January - Shift 1

A block of mass m slides down the plane inclined at angle 30° with an acceleration $\frac{g}{4}$. The value of coefficient of kinetic friction will be :

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

Space for your notes:

Q5 - 29 January - Shift 2

Force acts for 20 s on a body of mass 20 kg, starting from rest, after which the force ceases and then body describes 50 m in the next 10 s. The value of force will be :

- (1) 40 N (2) 5 N
(3) 20 N (4) 10 N

Space for your notes:

Q6 - 29 January - Shift 2

The time taken by an object to slide down 45° rough inclined plane is n times as it takes to slide down a perfectly smooth 45° incline plane. The coefficient of kinetic friction between the object and the incline plane is

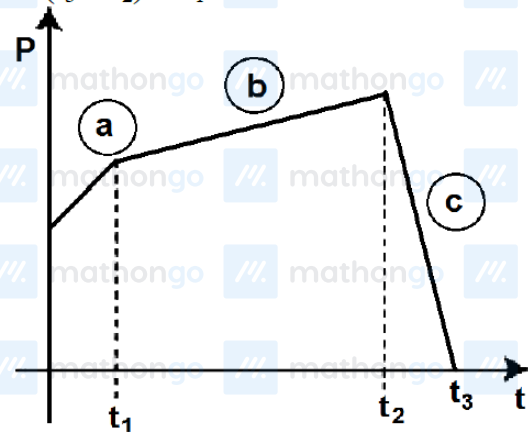
- (1) $\sqrt{\frac{1}{1-n^2}}$ (2) $\sqrt{1-\frac{1}{n^2}}$
(3) $1+\frac{1}{n^2}$ (4) $1-\frac{1}{n^2}$

Space for your notes:

Q7 - 30 January - Shift 1

The figure represents the momentum time (p-t) curve for a particle moving along an axis under the influence of the force. Identify the regions on the graph where the magnitude of the force is maximum and minimum respectively ?

If $(t_3 - t_2) < t_1$.

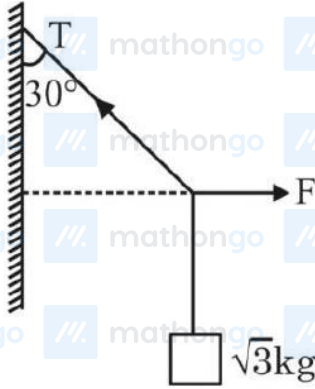


- (1) c and a (2) b and c
(3) c and b (4) a and b

Space for your notes:

Q8 - 30 January - Shift 2

A block of $\sqrt{3}$ kg is attached to a string whose other end is attached to the wall. An unknown force F is applied so that the string makes an angle of 30° with the wall. The tension T is :
(Given $g = 10 \text{ ms}^{-2}$)



- (1) 20 N (2) 25 N
(3) 10 N (4) 15 N

Space for your notes:

Q9 - 30 January - Shift 2

A stone tied to 180 cm long string at its end is making 28 revolutions in horizontal circle in every minute. The magnitude of acceleration of stone is

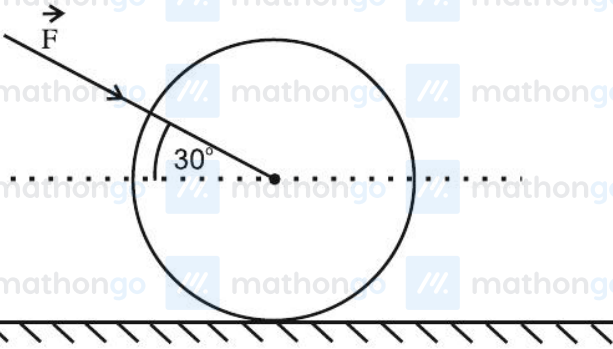
$\frac{1936}{x} \text{ ms}^{-2}$. The value of x _____.

(Take $\pi = \frac{22}{7}$)

Space for your notes:

Q10 - 31 January - Shift 1

As shown in figure, a 70 kg garden roller is pushed with a force of $\vec{F} = 200\text{ N}$ at an angle of 30° with horizontal. The normal reaction on the roller is (Given $g = 10\text{ m s}^{-2}$)



- (1) $800\sqrt{2}\text{ N}$
- (2) 600 N
- (3) 800 N
- (4) $200\sqrt{3}\text{ N}$

Q11 - 31 January - Shift 1

A lift of mass $M = 500\text{ kg}$ is descending with speed of 2 ms^{-1} . Its supporting cable begins to slip thus allowing it to fall with a constant acceleration of 2 ms^{-2} . The kinetic energy of the lift at the end of fall through to a distance of 6 m will be ____ kJ.

Q12 - 31 January - Shift 2

A stone of mass 1 kg is tied to end of a massless string of length 1 m . If the breaking tension of the string is 400 N , then maximum linear velocity, the stone can have without breaking the string, while rotating in horizontal plane, is:

- (1) 20 ms^{-1}
- (2) 40 ms^{-1}
- (3) 400 ms^{-1}
- (4) 10 ms^{-1}

Space for your notes:

Space for your notes:

Space for your notes:

Q13 - 31 January - Shift 2

A body of mass 10 kg is moving with an initial speed of 20 m/s. The body stops after 5 s due to friction between body and the floor. The value of the coefficient of friction is: (Take acceleration due to gravity $g = 10 \text{ ms}^{-2}$)

- (1) 0.2 (2) 0.3
(3) 0.5 (4) 0.4

Space for your notes:

Q14 - 01 February - Shift 1

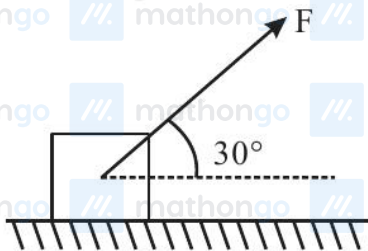
A block of mass 5 kg is placed at rest on a table of rough surface. Now, if a force of 30N is applied in the direction parallel to surface of the table, the block slides through a distance of 50 m in an interval of time 10s. Coefficient of kinetic friction is (given, $g = 10 \text{ ms}^{-2}$):

- (1) 0.60 (2) 0.75
(3) 0.50 (4) 0.25

Space for your notes:

Q15 - 01 February - Shift 2

As shown in the figure a block of mass 10 kg lying on a horizontal surface is pulled by a force F acting at an angle 30° , with horizontal. For $\mu_s = 0.25$, the block will just start to move for the value of F : [Given $g = 10 \text{ ms}^{-2}$]



- (1) 33.3 N (2) 25.2 N
(3) 20 N (4) 35.7 N

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(As per Official NTA Key released on 2 Feb)

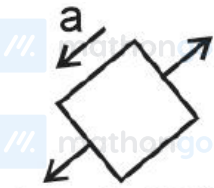
Q4 (2)

Q8 (1)

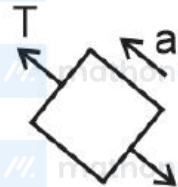
Q12 (1)

Q15 (2)

Q1 (2)



$$4g \sin 60^\circ - T = 4a \quad \dots(1)$$

 $4g \sin 60^\circ$

 $g \sin 30^\circ$

$$T - g \sin 30^\circ = a \quad \dots(2)$$

Solving (1) and (2) we get.

$$20\sqrt{3} - T = 4T - 20$$

$$T = 4(\sqrt{3} + 1)\text{N}$$

Q2 (2)

Statement-1

When elevator is moving with uniform speed $T = F_g$

**Statement-2**

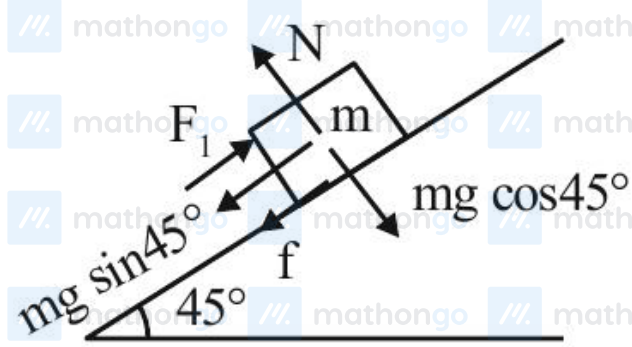
When elevator is going down with increasing speed, its acceleration is downward.

Hence

$$W - N = \frac{W}{g} \times a$$

$$N = W \left(1 - \frac{a}{g} \right) \text{ i.e. less than weight.}$$

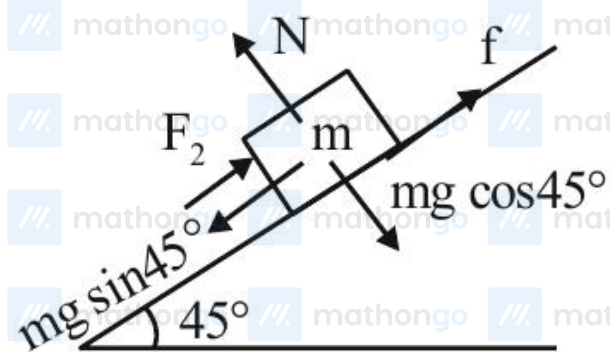
Q3 (1)



$$F_1 = mg \sin 45^\circ + f = mg \sin 45^\circ + \mu N$$

$$F_1 = \frac{mg}{\sqrt{2}} + \mu mg \cos 45^\circ$$

$$F_1 = \frac{mg}{\sqrt{2}} (1 + \mu)$$



$$F_2 = mg \sin 45^\circ - f = mg \sin 45^\circ - \mu N$$

$$= \frac{mg}{\sqrt{2}} (1 - \mu)$$

$$F_1 = 2F_2$$

$$\frac{mg}{\sqrt{2}} (1 + \mu) = 2 \frac{mg}{\sqrt{2}} (1 - \mu)$$

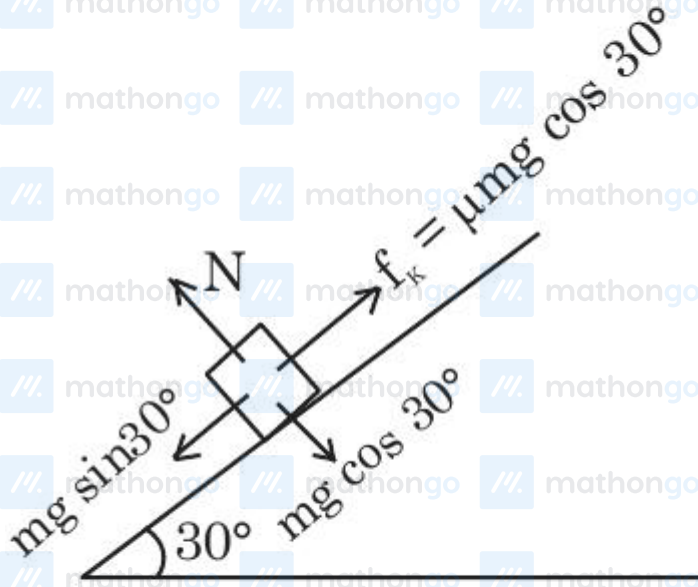
$$1 + \mu = 2 - 2\mu$$

$$\mu = 1/3 = 0.33$$

Q4 (2)

$$Mg \sin 30^\circ - \mu mg \cos 30^\circ = ma$$

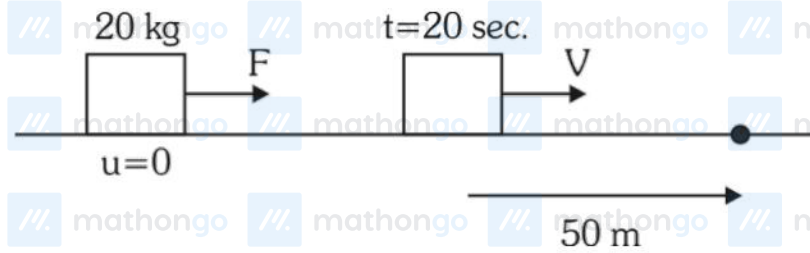
$$\frac{g}{2} - \frac{\sqrt{3}}{2} \cdot \mu g = \frac{g}{4}$$



$$\frac{\sqrt{3}}{2} \mu = \frac{1}{4}$$

$$\mu = \frac{1}{2\sqrt{3}}$$

Q5 (2)



$$50 = V \times 10$$

$$V = 5 \text{ m/s}$$

$$V = 0 + a \times 20$$

$$5 = a \times 20$$

$$a = \frac{1}{4} \text{ m/s}^2$$

$$F = ma = 20 \times \frac{1}{4} = 5 \text{ N}$$

Q6 (4)

$$a_1 = g \sin \theta = g / \sqrt{2}$$

$$a_2 = g \sin \theta - K g \cos \theta = \frac{g}{\sqrt{2}} - \frac{K g}{\sqrt{2}}$$

$$t_2 = n t_1 \quad \& \quad a_1 t_1^2 = a_2 t_2^2$$

$$\frac{g}{\sqrt{2}} t_1^2 = \left(\frac{g}{\sqrt{2}} - \frac{K g}{\sqrt{2}} \right) n^2 t_1^2$$

$$K = 1 - \frac{1}{n^2} \quad \text{Ans. 4}$$

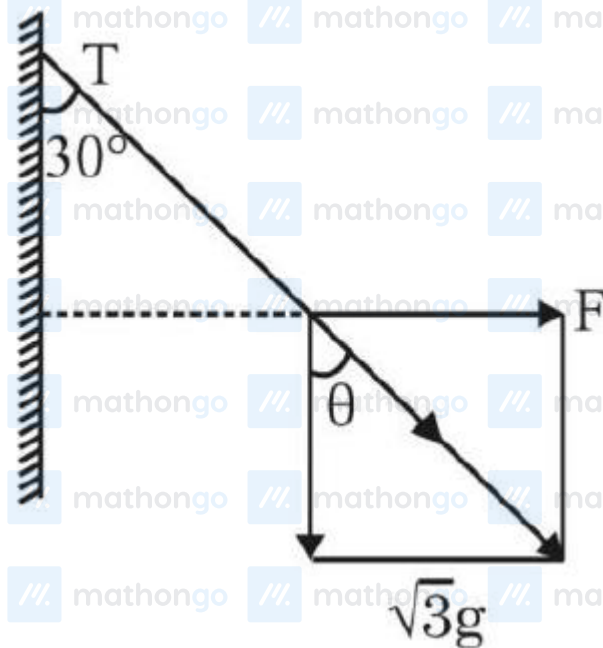
Q7 (3)

$$\left| \frac{d\vec{p}}{dt} \right| = |\vec{F}| \Rightarrow \frac{d\vec{p}}{dt} = \text{Slope of curve}$$

max slope (c)

min slope (b)

Q8 (1)



$$\theta = 30^\circ$$

$$\cos \theta = \frac{\sqrt{3}g}{T}$$

$$\Rightarrow \frac{\sqrt{3}}{2} = \frac{\sqrt{3}g}{T}$$

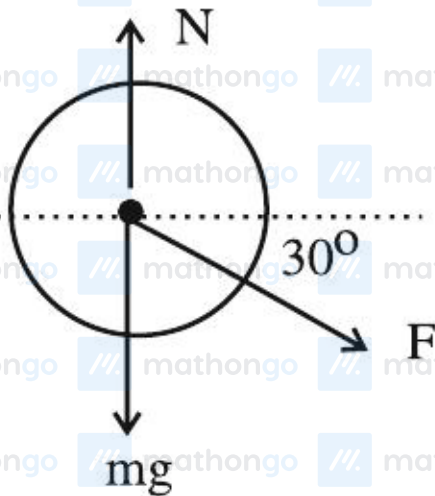
$$\Rightarrow T = 20\text{N}$$

Q9 (125)

$$\begin{aligned}
 a &= \omega^2 R = \left(\frac{28 \times 2\pi}{60} \right)^2 \times 1.8 \\
 &= \left(\frac{56}{60} \times \frac{22}{7} \right)^2 \times 1.8 \\
 &= \frac{(44)^2}{225} \times 1.8 \\
 &= \frac{1936 \times 1.8}{225} \\
 x &= 125
 \end{aligned}$$

Q10 (3)

$$\begin{aligned}
 N &= mg + F \sin 30^\circ \\
 &= 700 + 200 \times \frac{1}{2} = 800 \text{ newton.}
 \end{aligned}$$



Q11 (7)

#MathBoleTohMathonGo

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

$$= 2^2 + 2(2)(6)$$

$$= 4 + 24 = 28$$

$$KE = \frac{1}{2}mv^2$$

$$= \frac{1}{2}(500)28$$

$$= 7000 \text{ J}$$

$$= 7 \text{ kJ}$$

Ans. 7

Q12 (1)

No Solution

Q13 (4)

No Solution

Q14 (3)

#MathBoleTohMathonGo

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

$$50 = 0 + \frac{1}{2} \times a \times 100$$

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

$$F - \mu mg = ma$$

$$30 - \mu \times 50 = 5 \times 1$$

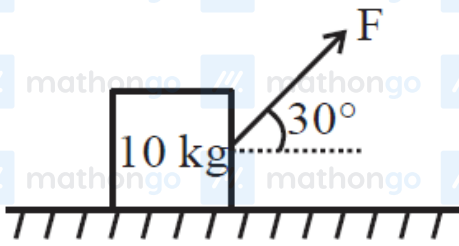
$$50\mu = 25$$

$$\mu = \frac{1}{2}$$

Q15 (2)

$$\mu = \frac{1}{2}$$

#MathBoleTohMathonGo



$$N = Mg - F \sin 30^\circ$$

$$= mg - \frac{F}{2} = 100 - \frac{F}{2} = \frac{200 - F}{2}$$

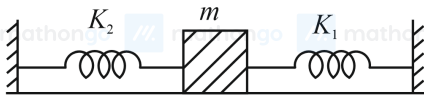
$$F \cos 30^\circ = \mu N$$

$$\sqrt{3} \frac{F}{2} = 0.25 \times \left(\frac{200 - F}{2} \right)$$

$$4\sqrt{3}F = 200 - F$$

$$F = \frac{200}{4\sqrt{3} + 1} = 25.22$$

1. A mass m is attached to two springs as shown in figure. The spring constants of two springs are K_1 and K_2 . For the frictionless surface, the time period of oscillation of mass m is



[2023 (06 Apr Shift 1)]

- (1) $2\pi\sqrt{\frac{m}{K_1+K_2}}$
 - (2) $\frac{1}{2\pi}\sqrt{\frac{K_1-K_2}{m}}$
 - (3) $2\pi\sqrt{\frac{m}{K_1-K_2}}$
 - (4) $\frac{1}{2\pi}\sqrt{\frac{K_1+K_2}{m}}$
2. A small block of mass 100 g is tied to a spring of spring constant 7.5 N m^{-1} and length 20 cm. The other end of spring is fixed at a particular point A . If the block moves in a circular path on a smooth horizontal surface with constant angular velocity 5 rad s^{-1} about point A , then tension in the spring is

[2023 (06 Apr Shift 1)]

- (1) 0.75 N
 - (2) 0.25 N
 - (3) 0.50 N
 - (4) 1.5 N
3. At any instant the velocity of a particle of mass 500 g is $(2t \hat{i} + 3t^2 \hat{j}) \text{ m s}^{-1}$. If the force acting on the particle at $t = 1 \text{ s}$ is $(\hat{i} + x \hat{j}) \text{ N}$. Then the value of x will be:

[2023 (08 Apr Shift 1)]

- (1) 3
 - (2) 4
 - (3) 2
 - (4) 6
4. Given below are two statements: one is labelled as **Assertion A** and the other is labelled as **Reason R**
Assertion A : An electric fan continues to rotate for some time after the current is switched off.
Reason R : Fan continues to rotate due to inertia of motion.
 In the light of above statements, choose the most appropriate answer from the options given below.

[2023 (10 Apr Shift 2)]

- (1) **A** is correct but **R** is not correct
 - (2) **A** is not correct but **R** is correct
 - (3) Both **A** and **R** are correct and **R** is the correct explanation of **A**
 - (4) Both **A** and **R** are correct but **R** is **NOT** the correct explanation of **A**
5. A coin placed on a rotating table just slips when it is placed at a distance of 1 cm from the centre. If the angular velocity of the table is halved, it will just slip when placed at a distance of _____ from the centre:

[2023 (11 Apr Shift 1)]

- (1) 8 cm
 - (2) 4 cm
 - (3) 1 cm
 - (4) 2 cm
6. A body of mass 500 g moves along x -axis such that its velocity varies with displacement x according to the relation $v = 10\sqrt{x} \text{ m s}^{-1}$ the force acting on the body is:

[2023 (11 Apr Shift 2)]

- (1) 125 N
- (2) 25 N
- (3) 166 N
- (4) 5 N

7. The position vector of a particle related to time t is given by $\vec{r} = (10t\hat{i} + 15t^2\hat{j} + 7t\hat{k})$ m. The direction of net force experienced by the particle is :

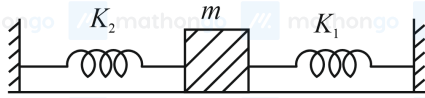
[2023 (15 Apr Shift 1)]

- (1) Positive x -axis
- (2) In $x - y$ plane
- (3) Positive y -axis
- (4) Positive z -axis

ANSWER KEYS

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

1. (1)



For the given combination, if the block is displaced towards right, elongation in one spring will be equal to the compression in other and the direction of force due to both spring will be the same and restoring in nature. Hence, both springs are effectively in parallel combination.

Therefore,

$$\Rightarrow K_{eff} = K_1 + K_2 \text{ and}$$

$$\Rightarrow T = 2\pi\sqrt{\frac{m}{K_{eff}}} = 2\pi\sqrt{\frac{m}{K_1 + K_2}}$$

2. (1)

Centripetal force will be provided by the spring force. Let the elongation in the spring be x , then we can write

$$\Rightarrow kx = m\omega^2(r + x)$$

$$\Rightarrow 7.5x = 2.5(0.2 + x)$$

$$\Rightarrow x = \frac{0.5}{5} = 0.1$$

Therefore, required tension will be $T = kx = 0.75 \text{ N}$.

3. (1)

The equation for velocity is

$$\vec{v} = (2t \hat{i} + 3t^2 \hat{j})$$

Thus, the acceleration is

$$\vec{a} = \frac{d\vec{v}}{dt} = \frac{d(2t \hat{i} + 3t^2 \hat{j})}{dt} = (2 \hat{i} + 6t \hat{j})$$

$$\text{At } t = 1 \text{ s, } \vec{a} = 2 \hat{i} + 6 \hat{j}$$

$$\text{The force is written as } \vec{F} = m\vec{a} = \frac{2\hat{i} + 6\hat{j}}{2} = \hat{i} + 3\hat{j}$$

Comparing it with the given value of force, $x = 3$.

4. (3)

When a fan is rotating, it acquires some kinetic energy. When the switch is off, because of its motion, it continues rotating for some time until it stops because of the air friction. So it is due to inertia of motion that fan continues to rotate.

Hence, both A and R are correct and R is the correct explanation of A.

5. (2)

The coin will slip when

$$\mu mg = m\omega^2 r$$

$$\Rightarrow \mu g = \omega^2 \times 1 \text{ cm} \dots (i)$$

$$\text{Now, } \omega' = \frac{\omega}{2}$$

$$\mu g = \left(\frac{\omega}{2}\right)^2 R \dots (ii)$$

Hence we can write from (i) and (ii)

$$\omega^2 \times 1 \text{ cm} = \frac{\omega'^2}{4} R$$

$$\Rightarrow R = 4 \text{ cm}$$

6. (2)

It is given that

$$v = 10\sqrt{x} \text{ m s}^{-1}$$

Force is defined by $F = m \frac{dv}{dt} \dots (i)$

Multiplying and dividing equation (i) by dx

$$F = m \frac{dv}{dt} \frac{dx}{dx}$$

$$\Rightarrow F = m \frac{dx}{dt} \frac{dv}{dx} = mv \frac{dv}{dx} \dots (ii)$$

Finding the values of the terms in equation (ii)

$$\frac{dv}{dx} = \frac{10}{2\sqrt{x}} = \frac{5}{\sqrt{x}}$$

$$v \frac{dv}{dx} = a = 10\sqrt{x} \times \frac{5}{\sqrt{x}} = 50 \text{ m s}^{-2}$$

Hence, the force is

$$F = \frac{1}{2} \times 50 = 25 \text{ N.}$$

7. (3)

Given, the position vector of the particle is

$$\vec{r} = 10t\hat{i} + 15t^2\hat{j} + 7\hat{k}$$

The velocity of the particle can be calculated as follows:

$$\begin{aligned} \vec{v} &= \frac{d\vec{r}}{dt} \\ &= \frac{d}{dt}(10t\hat{i} + 15t^2\hat{j} + 7\hat{k}) \\ &= 10\hat{i} + 30t\hat{j} \end{aligned}$$

And, the acceleration of the particle is given by

$$\begin{aligned} \vec{a} &= \frac{d\vec{v}}{dt} \\ &= \frac{d}{dt}(10\hat{i} + 30t\hat{j}) \\ &= 30\hat{j} \end{aligned}$$

Hence, the force on the particle can be written as

$$\begin{aligned} \vec{F} &= m\vec{a} \\ &= 30m\hat{j} \end{aligned}$$

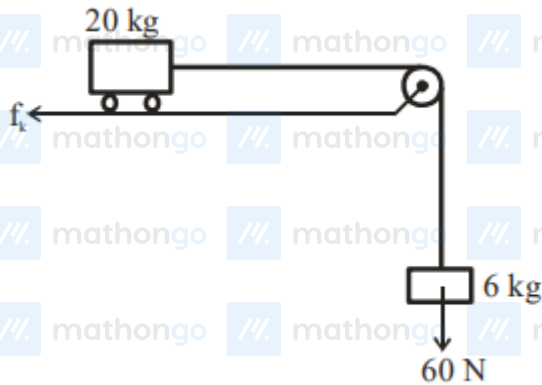
Questions with Answer Keys

MathonGo

Q1 - 2024 (01 Feb Shift 1)

Consider a block and trolley system as shown in figure. If the coefficient of kinetic friction between the trolley and the surface is 0.04, the acceleration of the system in ms^{-2} is :

(Consider that the string is massless and unstretchable and the pulley is also massless and frictionless) :



- (1) 3
- (2) 4
- (3) 2
- (4) 1.2

Q2 - 2024 (01 Feb Shift 2)

A cricket player catches a ball of mass 120 g moving with 25 m/s speed. If the catching process is completed in 0.1 s then the magnitude of force exerted by the ball on the hand of player will be (in SI unit):

- (1) 24
- (2) 12
- (3) 25
- (4) 30

Q3 - 2024 (01 Feb Shift 2)

A body of mass 4 kg experiences two forces $\vec{F}_1 = 5\hat{i} + 8\hat{j} + 7\hat{k}$ and $\vec{F}_2 = 3\hat{i} - 4\hat{j} - 3\hat{k}$. The acceleration acting on the body is :

- (1) $-2\hat{i} - \hat{j} - \hat{k}$

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Questions with Answer Keys

MathonGo

(2) $4\hat{i} + 2\hat{j} + 2\hat{k}$

(3) $2\hat{i} + \hat{j} + \hat{k}$

(4) $2\hat{i} + 3\hat{j} + 3\hat{k}$

Q4 - 2024 (27 Jan Shift 1)

A train is moving with a speed of 12 m/s on rails which are 1.5 m apart. To negotiate a curve radius 400 m, the height by which the outer rail should be raised with respect to the inner rail is (Given, $g = 10 \text{ m/s}^2$) :

(1) 6.0 cm

(2) 5.4 cm

(3) 4.8 cm

(4) 4.2 cm

Q5 - 2024 (27 Jan Shift 1)

A body of mass 1000 kg is moving horizontally with a velocity 6 m/s. If 200 kg extra mass is added, the final velocity (in m/s) is:

(1) 6

(2) 2

(3) 3

(4) 5

Q6 - 2024 (27 Jan Shift 2)

Given below are two statements:

Statement (I) : The limiting force of static friction depends on the area of contact and independent of materials.

Statement (II) : The limiting force of kinetic friction is independent of the area of contact and depends on materials.

In the light of the above statements, choose the most appropriate answer from the options given below :

(1) Statement I is correct but Statement II is incorrect

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Questions with Answer Keys

MathonGo

(2) Statement I is incorrect but Statement II is correct

(3) Both Statement I and Statement II are incorrect

(4) Both Statement I and Statement II are correct

Q7 - 2024 (27 Jan Shift 2)

A heavy iron bar of weight 12 kg is having its one end on the ground and the other on the shoulder of a man. The rod makes an angle 60° with the horizontal, the weight experienced by the man is :

(1) 6 kg

(2) 12 kg

(3) 3 kg

(4) $6\sqrt{3}$ kg

Q8 - 2024 (29 Jan Shift 2)

A stone of mass 900 g is tied to a string and moved in a vertical circle of radius 1 m making 10rpm. The tension in the string, when the stone is at the lowest point is (if $\pi^2 = 9.8$ and $g = 9.8 \text{ m/s}^2$)

(1) 97 N

(2) 9.8 N

(3) 8.82 N

(4) 17.8 N

Q9 - 2024 (30 Jan Shift 1)

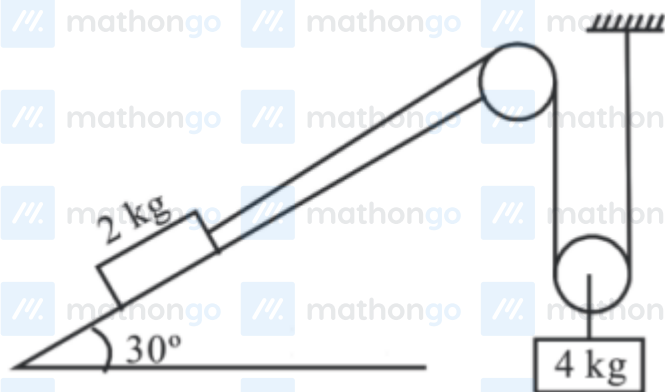
All surfaces shown in figure are assumed to be frictionless and the pulleys and the string are light. The acceleration of the block of mass 2 kg is :

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Questions with Answer Keys

MathonGo



(1) g

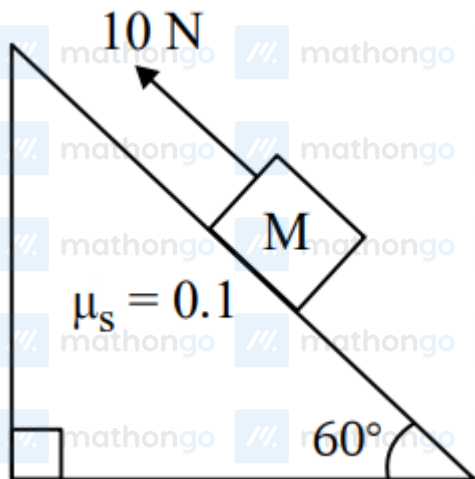
(2) $\frac{g}{3}$

(3) $\frac{g}{2}$

(4) $\frac{g}{4}$

Q10 - 2024 (30 Jan Shift 2)

A block of mass 1 kg is pushed up a surface inclined to horizontal at an angle of 60° by a force of 10 N parallel to the inclined surface as shown in figure. When the block is pushed up by 10 m along inclined surface, the work done against frictional force is : [$g = 10 \text{ m/s}^2$]



(1) $5\sqrt{3} \text{ J}$

(2) 5 J

(3) $5 \times 10^3 \text{ J}$

(4) 10 J

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Questions with Answer Keys

MathonGo

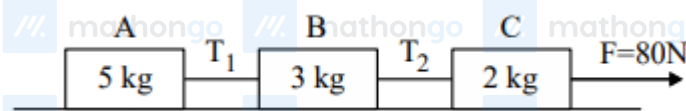
Q11 - 2024 (30 Jan Shift 2)

A block of mass m is placed on a surface having vertical cross section given by $y = x^2/4$. If coefficient of friction is 0.5, the maximum height above the ground at which block can be placed without slipping is:

- (1) $1/4$ m
- (2) $1/2$ m
- (3) $1/6$ m
- (4) $1/3$ m

Q12 - 2024 (30 Jan Shift 2)

Three blocks A, B and C are pulled on a horizontal smooth surface by a force of 80 N as shown in figure



The tensions T_1 and T_2 in the string are respectively:

- (1) 40 N, 64 N
- (2) 60 N, 80 N
- (3) 88 N, 96 N
- (4) 80 N, 100 N

Q13 - 2024 (31 Jan Shift 1)

In the given arrangement of a doubly inclined plane two blocks of masses M and m are placed. The blocks are connected by a light string passing over an ideal pulley as shown. The coefficient of friction between the surface of the plane and the blocks is 0.25. The value of m , for which $M = 10$ kg will move down with an

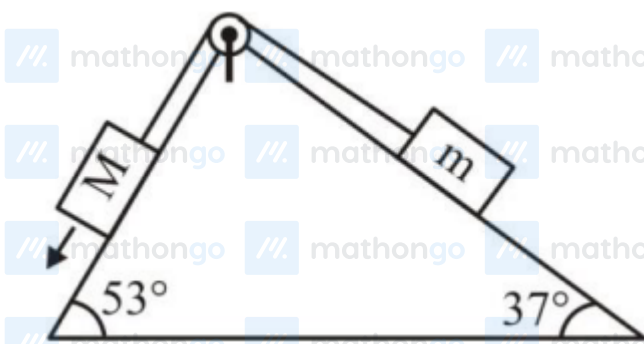
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Questions with Answer Keys

MathonGo

acceleration of 2 m/s^2 , is : (take $g = 10 \text{ m/s}^2$ and $\tan 37^\circ = 3/4$)



- (1) 9 kg
- (2) 4.5 kg
- (3) 6.5 kg
- (4) 2.25 kg

Q14 - 2024 (31 Jan Shift 1)

A coin is placed on a disc. The coefficient of friction between the coin and the disc is μ . If the distance of the coin from the center of the disc is r , the maximum angular velocity which can be given to the disc, so that the coin does not slip away, is :

- (1) $\frac{\mu g}{r}$
- (2) $\sqrt{\frac{r}{\mu g}}$
- (3) $\sqrt{\frac{\mu g}{r}}$
- (4) $\frac{\mu}{\sqrt{rg}}$

Q15 - 2024 (31 Jan Shift 2)

A light string passing over a smooth light fixed pulley connects two blocks of masses m_1 and m_2 . If the acceleration of the system is $g/8$, then the ratio of masses is

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Questions with Answer Keys

MathonGo



- (1) $\frac{9}{7}$
- (2) $\frac{8}{1}$
- (3) $\frac{4}{3}$
- (4) $\frac{5}{3}$

Q16 - 2024 (31 Jan Shift 2)

A block of mass 5 kg is placed on a rough inclined surface as shown in the figure.



If $\vec{F}_1$ is the force required to just move the block up the inclined plane and $\vec{F}_2$ is the force required to just prevent the block from sliding down, then the value of $|\vec{F}_1| - |\vec{F}_2|$ is : [Use $g = 10 \text{ m/s}^2$]

[We changed options. In official NTA paper no option was correct.]

- (1) $25\sqrt{3} \text{ N}$
- (2) $5\sqrt{3} \text{ N}$

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Questions with Answer Keys

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(3) $\frac{5\sqrt{3}}{2} \text{ N}$

(4) 10 N

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Questions with Answer Keys

MathonGo

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Answer Key

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Q5 (4) mathongo /// ma **Q6** (2) /// mathongo **Q7** (3) mathongo /// mc **Q8** (2) /// mathongo

Q9 (2) mathongo /// ma **Q10** (2) /// mathongo **Q11** (1) mathongo /// mc **Q12** (1) /// mathongo

Q13 (2) thongo /// ma **Q14** (3) /// mathongo **Q15** (1) mathongo /// mc **Q16** (2) /// mathongo

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Solutions

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Q1

$$f_k = \mu N = 0.04 \times 20 \text{ g} = 8 \text{ Newton}$$

$$a = \frac{60-8}{26} = 2 \text{ m/s}^2$$

Q2

$$F_{av} = \frac{\Delta p}{\Delta t} = \frac{0.12 \times 25}{0.1} = 30 \text{ N}$$

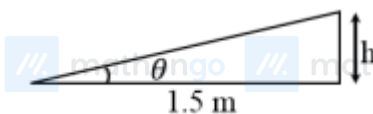
Q3

$$\text{Net force} = 8\hat{i} + 4\hat{j} + 4\hat{k}$$

$$\vec{a} = \frac{\vec{F}}{m} = 2\hat{i} + \hat{j} + \hat{k}$$

Q4

$$\tan \theta = \frac{v^2}{Rg} = \frac{12 \times 12}{10 \times 400}$$



$$\tan \theta = \frac{h}{1.5}$$

$$\Rightarrow \frac{h}{1.5} = \frac{144}{4000}$$

$$h = 5.4 \text{ cm}$$

Q5

Momentum will remain conserve

$$1000 \times 6 = 1200 \times v$$

$$v = 5 \text{ m/s}$$

Q6

Co-efficient of friction depends on surface in contact So, depends on material of object.

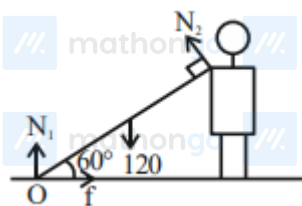
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Solutions

MathonGo

Q7



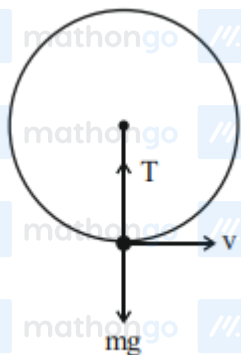
Torque about O = 0

$$120 \left(\frac{L}{2} \cos 60^\circ \right) - N_2 L = 0$$

$$N_2 = 30 \text{ N}$$

Q8

Given that



$$m = 900 \text{ gm} = \frac{900}{1000} \text{ kg} = \frac{9}{10} \text{ kg}$$

$$r = 1 \text{ m}$$

$$\omega = \frac{2\pi N}{60} = \frac{2\pi(10)}{60} = \frac{\pi}{3} \text{ rad/sec}$$

$$T - mg = mr^2$$

$$T = mg + mr\omega^2$$

$$= \frac{9}{10} \times 9.8 + \frac{9}{10} \times 1 \left(\frac{\pi}{3} \right)^2$$

$$= 8.82 + \frac{9}{10} \times \frac{\pi^2}{9}$$

$$= 8.82 + 0.98$$

$$= 9.80 \text{ N}$$

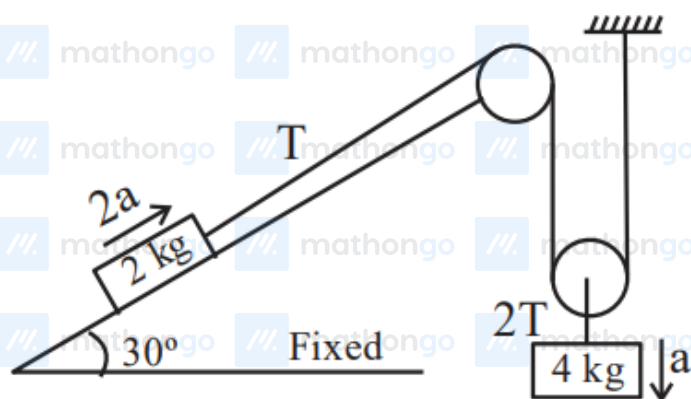
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Solutions

MathonGo

Q9



$$40 - 2T = 4a$$

$$T - 10 = 4a \Rightarrow 20 = 12a$$

$$\Rightarrow a = 5/3 \Rightarrow 2a = \frac{g}{3}$$

Q10

Work done against frictional force

$$= \mu N \times 10$$

$$= 0.1 \times 5 \times 10 = 5 \text{ J}$$

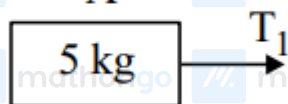
Q11

$$\frac{dy}{dx} = \tan \theta = \frac{x}{2} = \mu = \frac{1}{2}$$

$$x = 1, y = 1/4$$

Q12

$$a_A = a_B = a_C = \frac{F}{5+3+2} = \frac{80}{10} = 8 \text{ m/s}^2$$

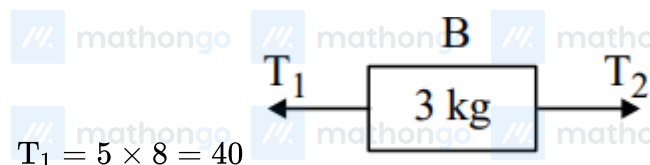


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Solutions

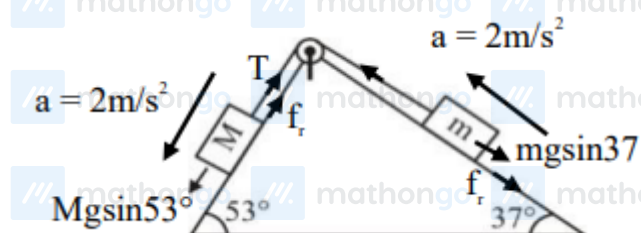
MathonGo



$$T_1 = 5 \times 8 = 40$$

$$T_2 - T_1 = 3 \times 8 \Rightarrow T_2 = 64$$

Q13

For M block

$$10 g \sin 53^\circ - \mu(10 g) \cos 53^\circ - T = 10 \times 2$$

$$T = 80 - 15 - 20$$

$$T = 45 \text{ N}$$

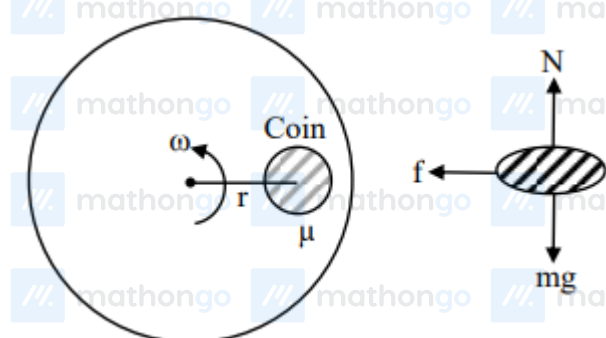
For m block

$$T - mg \sin 37^\circ - \mu mg \cos 37^\circ = m \times 2$$

$$45 = 10 m$$

$$m = 4.5 \text{ kg}$$

Q14



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Solutions

MathonGo

$$N = mg$$

$$f = m\omega^2 r$$

$$f = \mu N$$

$$\mu mg = mr\omega^2$$

$$\omega = \sqrt{\frac{\mu g}{r}}$$

Q15

$$a = \frac{(m_1 - m_2)g}{(m_1 + m_2)} = \frac{g}{8}$$

$$8m_1 - 8m_2 = m_1 + m_2$$

$$7m_1 = 9m_2$$

$$\frac{m_1}{m_2} = \frac{9}{7}$$

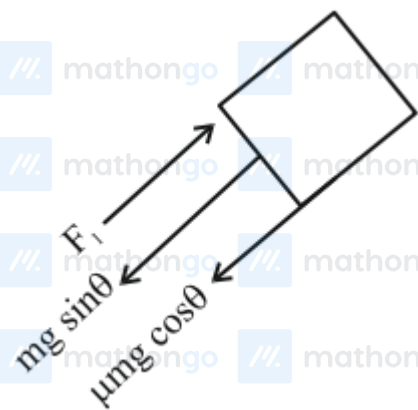
Q16

$$(5\sqrt{3}N)$$

$$f_K = \mu mg \cos \theta$$

$$= 0.1 \times \frac{50 \times \sqrt{3}}{2}$$

$$= 2.5\sqrt{3} N$$



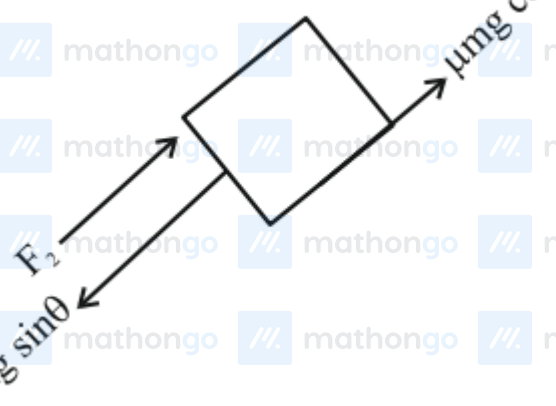
$$F_1 = mg \sin \theta + f_K$$

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Solutions

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$$= 25 + 2.5\sqrt{3}$$

$$F_2 = mg \sin \theta - f_k$$

$$= 25 - 2.5\sqrt{3}$$

$$\therefore F_1 - F_2 = 5\sqrt{3} \text{ N}$$

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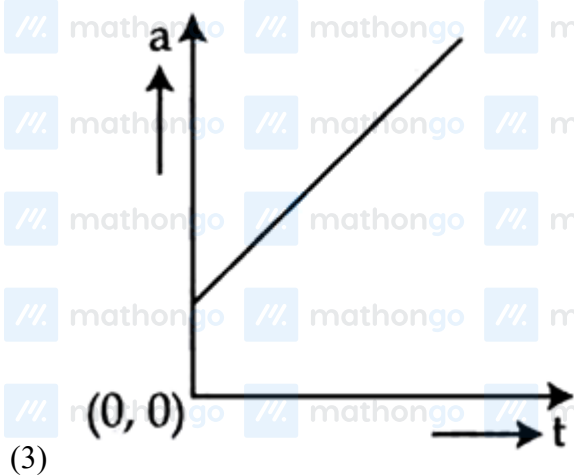
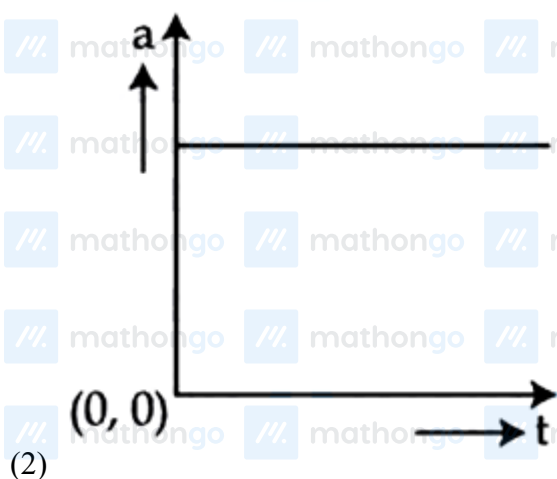
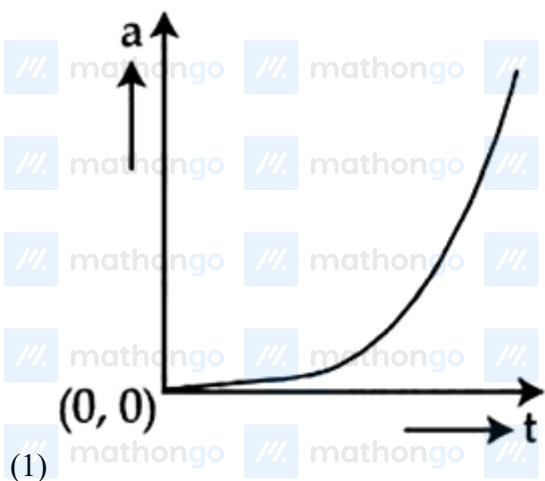
Questions

MathonGo

Q1 - 2024 (04 Apr Shift 1)

A wooden block, initially at rest on the ground, is pushed by a force which increases linearly with time t .

Which of the following curve best describes acceleration of the block with time:



Questions

MathonGo



(4)

Q2 - 2024 (04 Apr Shift 2)

A 2 kg brick begins to slide over a surface which is inclined at an angle of 45° with respect to horizontal axis. The co-efficient of static friction between their surfaces is:

(1) 1.7

(2) $\frac{1}{\sqrt{3}}$

(3) 0.5

(4) 1

Q3 - 2024 (05 Apr Shift 1)

A wooden block of mass 5 kg rests on a soft horizontal floor. When an iron cylinder of mass 25 kg is placed on the top of the block, the floor yields and the block and the cylinder together go down with an acceleration of 0.1 ms^{-2} . The action force of the system on the floor is equal to:

(1) 196 N

(2) 291 N

(3) 294 N

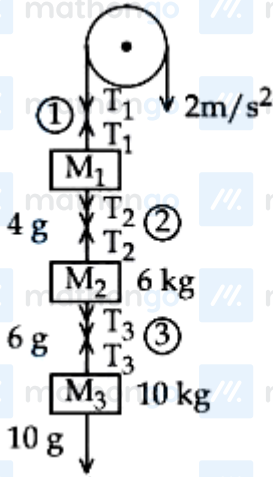
(4) 297 N

Q4 - 2024 (05 Apr Shift 1)

Questions

MathonGo

Three blocks M_1 , M_2 , M_3 having masses 4 kg, 6 kg and 10 kg respectively are hanging from a smooth pulley using rope 1, 2 and 3 as shown in figure. The tension in the rope 1, T_1 when they are moving upward with acceleration of 2 ms^{-2} is _____ N (if $g = 10 \text{ m/s}^2$).



Q5 - 2024 (05 Apr Shift 2)

A heavy box of mass 50 kg is moving on a horizontal surface. If co-efficient of kinetic friction between the box and horizontal surface is 0.3 then force of kinetic friction is :

- (1) 1.47 N
- (2) 147 N
- (3) 14.7 N
- (4) 1470 N

Q6 - 2024 (06 Apr Shift 1)

A light string passing over a smooth light pulley connects two blocks of masses m_1 and m_2 (where $m_2 > m_1$). If the acceleration of the system is $\frac{g}{\sqrt{2}}$, then the ratio of the masses $\frac{m_1}{m_2}$ is:

- (1) $\frac{1+\sqrt{5}}{\sqrt{5}-1}$
- (2) $\frac{\sqrt{2}-1}{\sqrt{2}+1}$
- (3) $\frac{1+\sqrt{5}}{\sqrt{2}-1}$
- (4) $\frac{\sqrt{3}+1}{\sqrt{2}-1}$

Questions

MathonGo

Q7 - 2024 (06 Apr Shift 2)

A body of weight 200 N is suspended from a tree branch through a chain of mass 10 kg. The branch pulls the chain by a force equal to (if $g = 10 \text{ m/s}^2$) :

- (1) 100 N
- (2) 200 N
- (3) 300 N
- (4) 150 N

Q8 - 2024 (06 Apr Shift 2)

A car of 800 kg is taking turn on a banked road of radius 300 m and angle of banking 30° . If coefficient of static friction is 0.2 then the maximum speed with which car can negotiate the turn safely:

$(g = 10 \text{ m/s}^2, \sqrt{3} = 1.73)$

- (1) 264 m/s
- (2) 51.4 m/s
- (3) 70.4 m/s
- (4) 102.8 m/s

Q9 - 2024 (08 Apr Shift 2)

A given object takes n times the time to slide down 45° rough inclined plane as it takes the time to slide down an identical perfectly smooth 45° inclined plane. The coefficient of kinetic friction between the object and the surface of inclined plane is :

- (1) $\sqrt{1 - \frac{1}{n^2}}$
- (2) $1 - n^2$
- (3) $1 - \frac{1}{n^2}$
- (4) $\sqrt{1 - n^2}$

Q10 - 2024 (09 Apr Shift 1)

Questions

MathonGo

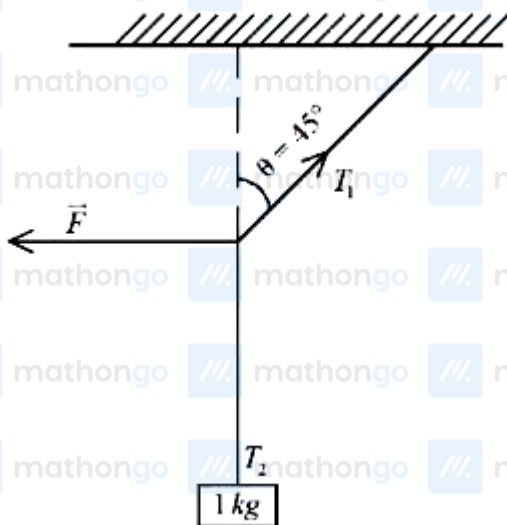
A light unstretchable string passing over a smooth light pulley connects two blocks of masses m_1 and m_2 . If the acceleration of the system is $\frac{g}{8}$, then the ratio of the masses $\frac{m_2}{m_1}$ is :

- (1) 8 : 1
- (2) 5 : 3
- (3) 4 : 3
- (4) 9 : 7

Q11 - 2024 (09 Apr Shift 2)

A 1 kg mass is suspended from the ceiling by a rope of length 4 m. A horizontal force ' F ' is applied at the mid point of the rope so that the rope makes an angle of 45° with respect to the vertical axis as shown in figure. The magnitude of F is :

(Assume that the system is in equilibrium and $g = 10 \text{ m/s}^2$)



- (1) 10 N
- (2) $\frac{10}{\sqrt{2}}$ N
- (3) 1 N
- (4) $\frac{1}{10\sqrt{2}}$ N

Questions

MathonGo

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Answer Key

mathongo mathongo mathongo mathongo mathongo mathongo

Q1 (4) mathongo Q2 (4) mathongo Q3 (2) mathongo Q4 (240) mathongo

Q5 (2) mathongo Q6 (2) mathongo Q7 (3) mathongo Q8 (2) mathongo

Q9 (3) mathongo Q10 (4) mathongo Q11 (1) mathongo mathongo

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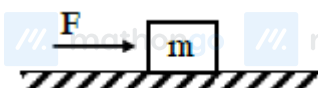
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#MathBoleTohMathonGo

Solutions

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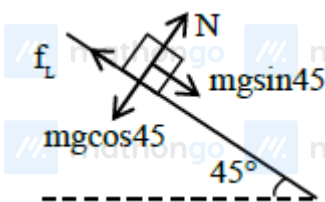
Q1



$$F = ma \Rightarrow a = \frac{F}{m} = \frac{kt}{m}$$

a vs t will be straight line passing through origin.

Q2



$$mg \sin 45 = f_L$$

$$mg \cos 45 = N$$

$$f_L = \mu_s N$$

$$\mu_s = \tan 45 = 1$$

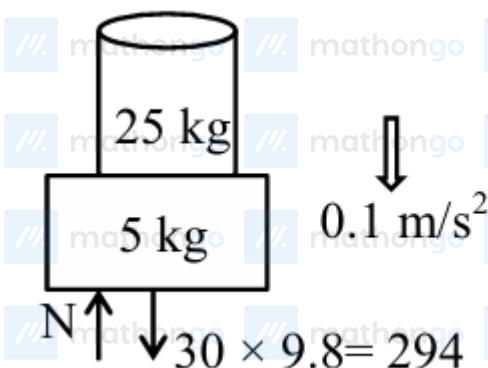
or

$\tan \theta = \mu_s$ (θ is angle of repose)

$$\tan 45 = \mu_s = 1$$

Q3

Taking $g = 9.8 \text{ m/s}^2$



$$294 - N = 30 \times 0.1$$

$$N = 291$$

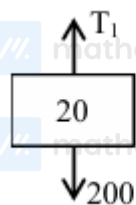
Q4

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Solutions

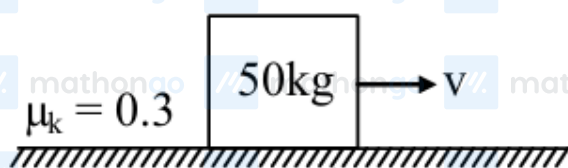
MathonGo

FBD of M_1 :
 2 m/s^2

$$T_1 - 200 = (4 + 6 + 10) \times 2$$

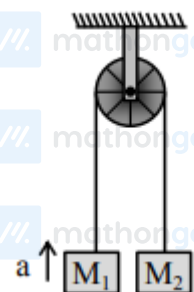
$$\therefore T_1 = 240$$

Q5



$$F_k = \mu_k N = 0.3 \times 50 \times 9.8 = 147 \text{ N}$$

Q6



$$a = \left(\frac{M_2 - M_1}{M_1 + M_2} \right) g$$

$$\frac{g}{\sqrt{2}} = \left(\frac{M_2 - M_1}{M_1 + M_2} \right) g$$

$$(M_1 + M_2) = \sqrt{2} M_2 - \sqrt{2} M_1$$

$$\frac{M_1}{M_2} = \left(\frac{\sqrt{2} - 1}{\sqrt{2} + 1} \right)$$

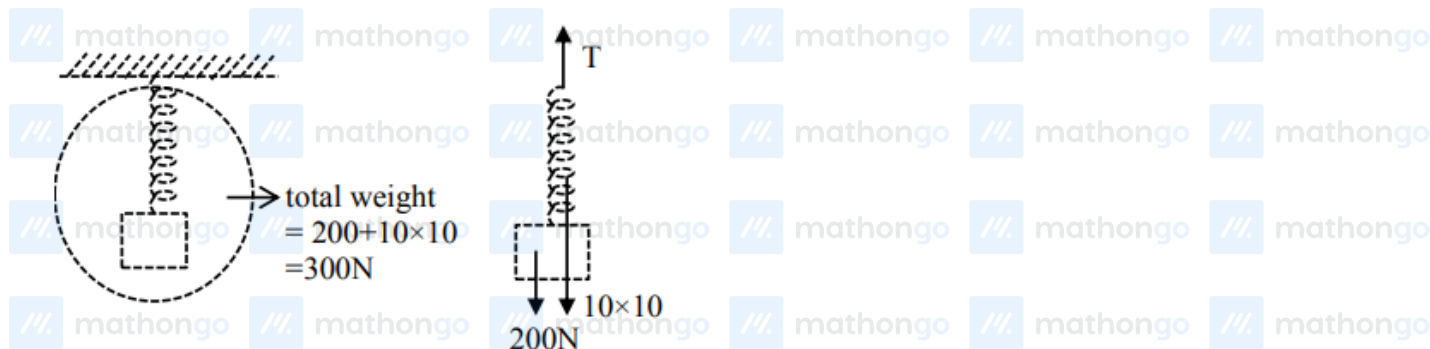
Q7

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Solutions

MathonGo



Chain block system is in equilibrium so

$$T = 200 + 100 = 300 \text{ N.}$$

Q8

$$m = 800 \text{ kg}$$

$$r = 300 \text{ m}$$

$$\theta = 30^\circ$$

$$\mu_s = 0.2$$

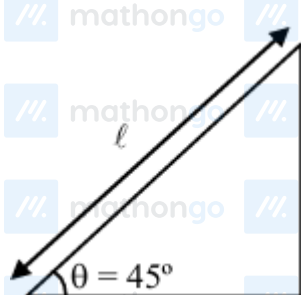
$$V_{\max} = \sqrt{Rg \left[\frac{\tan \theta + \mu}{1 - \mu \tan \theta} \right]}$$

$$= \sqrt{300 \times g \times \left[\frac{\tan 30^\circ + 0.2}{1 - 0.2 \times \tan 30^\circ} \right]}$$

$$= \sqrt{300 \times 10 \times \left[\frac{0.57 + 0.2}{1 - 0.2 \times 0.57} \right]}$$

$$V_{\max} = 51.4 \text{ m/s}$$

Q9



Case-1 : No friction

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Solutions

MathonGo

$$a = g \sin \theta$$

$$\ell = \frac{1}{2} (g \sin \theta) t_1^2$$

$$t_1 = \sqrt{\frac{2\ell}{g \sin \theta}}$$

Case-2 : With friction

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

$$\ell = \frac{1}{2} (g \sin \theta - \mu g \cos \theta) t_2^2$$

$$\sqrt{\frac{2\ell}{g \sin \theta - \mu g \cos \theta}} = n \sqrt{\frac{2\ell}{g \sin \theta}}$$

$$\mu = 1 - \frac{1}{n^2}$$

Q10

$$a_{\text{sys}} = \left(\frac{m_2 - m_1}{m_1 + m_2} \right) g = \frac{g}{8}$$

$$\Rightarrow \frac{m_2}{m_1} = \frac{9}{7}$$

Q11

$$T_1 \sin 45^\circ = F$$

$$T_1 \cos 45^\circ = T_2 = 1 \times g$$

$$\therefore \tan 45^\circ = \frac{F}{g}$$

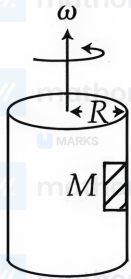
$$\therefore F = 10 \text{ N}$$

Do you want to practice these PYQs along with PYQs of JEE Main from 2002 till 2024?

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Q1. JEE Main 2026 (21 January Shift 2)

A large drum having radius R is spinning around its axis with angular velocity ω , as shown in figure. The minimum value of ω so that a body of mass M remains stuck to the inner wall of the drum, taking the coefficient of friction between the drum surface and mass M as μ , is :



(1) $\sqrt{\frac{\mu g}{R}}$

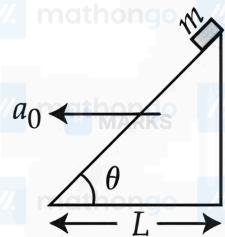
(2) $\sqrt{\frac{g}{2\mu R}}$

(3) $\sqrt{\frac{2g}{\mu R}}$

(4) $\sqrt{\frac{g}{\mu R}}$

Q2. JEE Main 2026 (28 January Shift 2)

A small block of mass m slides down from the top of a frictionless inclined surface, while the inclined plane is moving towards left with constant acceleration a_0 . The angle between the inclined plane and ground is θ and its base length is L . Assuming that initially the small block is at the top of the inclined plane, the time it takes to reach the lowest point of the inclined plane is _____.



(1) $\sqrt{\frac{2L}{g \sin \theta - a_0 \cos \theta}}$

(2) $\sqrt{\frac{4L}{g \cos^2 \theta - a_0 \sin \theta \cos \theta}}$

(3) $\sqrt{\frac{2L}{g \sin 2\theta - a_0(1 + \cos 2\theta)}}$

(4) $\sqrt{\frac{4L}{g \sin 2\theta - a_0(1 + \cos 2\theta)}}$

Q3. JEE Main 2026 (24 January Shift 2)

A flexible chain of mass m hangs between two fixed points at the same level. The inclination of the chain with the horizontal at the two points of support is 30° . Considering the equilibrium of each half of the chain, the tension of the chain at the lowest point is _____.

(1) $\frac{\sqrt{3}}{2}mg$

(2) mg

(3) $\frac{1}{2}mg$

(4) $\sqrt{3}mg$

Q4. JEE Main 2026 (23 January Shift 2)

A block is sliding down on an inclined plane of slope θ and at an instant $t = 0$ this block is given an upward momentum so that it starts moving up on the inclined surface with velocity u . The distance (S) travelled by the block before its velocity become zero, is ____.

(g = gravitational acceleration)

- (1) $\frac{2u^2}{\cos \theta}$ (2) $\frac{u^2}{2g \sin \theta}$ (3) $\frac{u^2}{2g \cos \theta}$ (4) $\frac{u^2}{\sqrt{2}g \cos \theta}$

Q5. JEE Main 2026 (21 January Shift 1)

A 4 kg mass moves under the influence of a force $\vec{F} = (4t^3\hat{i} - 3t\hat{j})$ N where t is the time in second. If mass starts from origin at $t = 0$, the velocity and position after $t = 2$ s will be:

- (1) $\vec{v} = 4\hat{i} - \frac{3}{2}\hat{j}$ $\vec{r} = \frac{6}{5}\hat{i} - \hat{j}$
 (2) $\vec{v} = 3\hat{i} + \frac{3}{2}\hat{j}$ $\vec{r} = \frac{6}{5}\hat{i} + \hat{j}$
 (3) $\vec{v} = 4\hat{i} - \frac{3}{2}\hat{j}$ $\vec{r} = \frac{8}{5}\hat{i} - \hat{j}$
 (4) $\vec{v} = 4\hat{i} + \frac{5}{2}\hat{j}$ $\vec{r} = \frac{8}{5}\hat{i} + 2\hat{j}$

Q6. JEE Main 2026 (28 January Shift 1)

A particle of mass m falls from rest through a resistive medium having resistive force, $F = -kv$, where v is the velocity of the particle and k is a constant. Which of the following graphs represents velocity (v) versus time (t)?

**Q7. JEE Main 2026 (28 January Shift 1)**

A block of mass 5 kg is moving on an inclined plane which makes an angle of 30° with the horizontal. Friction coefficient between the block and inclined plane surface is $\frac{\sqrt{3}}{2}$. The force to be applied on the block so that the block will move down without acceleration is ____ N.

($g = 10 \text{ m/s}^2$).

- (1) 25 (2) 7.5 (3) 12.5 (4) 15

Q8. JEE Main 2026 (24 January Shift 1)

A spring of force constant 15 N/m is cut into two pieces. If the ratio of their length is $1 : 3$, then the force constant of smaller piece is _____ N/m .

(1) 60

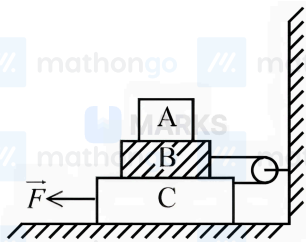
(2) 15

(3) 20

(4) 45

Q9. JEE Main 2026 (24 January Shift 1)

In the given figure the blocks A , B and C weigh 4 kg , 6 kg and 8 kg respectively. The co-efficient of sliding friction between any two surfaces is 0.5 . The force $\vec{F}$ required to slide the block C with constant speed is _____ N .

(Use $g = 10 \text{ m/s}^2$)

ANSWERS AND SOLUTIONS

1. (4) 2. (4) 3. (1) 4. (2) 5. (3) 6. (1) 7. (3) 8. (1)
9. 210

1. (4) Consider the mass M in the frame of the rotating drum. The forces acting on the mass are:

1. Weight Mg acting vertically downwards.

2. Normal reaction N from the wall acting towards the center, which provides the centripetal force: $N = M\omega^2 R$.

3. Frictional force f acting vertically upwards to balance the weight.

For the mass to remain stuck to the wall, the frictional force must balance the weight: $f = Mg$.

The maximum available static friction is $f_{max} = \mu N = \mu M\omega^2 R$.

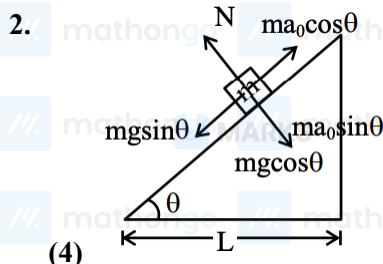
To prevent slipping, we must have $f_{max} \geq Mg$.

$$\mu M\omega^2 R \geq Mg$$

$$\omega^2 \geq \frac{g}{\mu R}$$

$$\omega \geq \sqrt{\frac{g}{\mu R}}$$

The minimum value of ω is $\sqrt{\frac{g}{\mu R}}$.



$$mg \sin \theta - ma_0 \cos \theta = ma$$

$$a = g \sin \theta - a_0 \cos \theta$$

Now using,

$$S = ut + \frac{1}{2} a_{down} t^2$$

$$\frac{L}{\cos \theta} = \frac{1}{2} (g \sin \theta - a_0 \cos \theta) t^2$$

$$t = \sqrt{\frac{2L}{g \sin \theta \cos \theta - a_0 \cos^2 \theta}}$$

$$t = \sqrt{\frac{4L}{g \sin 2\theta - a_0 (1 + \cos 2\theta)}}$$

3. (1) A chain of mass m hangs between two fixed points at the same level with inclination 30° at support points.

Consider equilibrium of one half of the chain (mass $m/2$):

$$\text{Horizontal equilibrium: } T_0 = T_1 \cos(30^\circ) = T_1 \cdot \frac{\sqrt{3}}{2}$$

$$\text{Vertical equilibrium: } T_1 \sin(30^\circ) = \frac{m}{2} g$$

From vertical equation: $T_1 \cdot \frac{1}{2} = \frac{mg}{2}$, giving $T_1 = mg$

Substituting into horizontal equation: $T_0 = mg \cdot \frac{\sqrt{3}}{2} = \frac{\sqrt{3}}{2}mg$

4. (2) $a = -g \sin \theta$

$$V^2 = U^2 + 2as$$

$$0 = u^2 - 2g \sin \theta \cdot s$$

$$s = \frac{u^2}{2g \sin \theta}$$

5. (3) Given $\vec{F} = (4t^3\hat{i} - 3t\hat{j})$ N, $m = 4$ kg

$$\vec{a} = \frac{\vec{F}}{m} = t^3\hat{i} - \frac{3t}{4}\hat{j}$$

Integrating with $\vec{v}(0) = 0$:

$$\vec{v} = \frac{t^4}{4}\hat{i} - \frac{3t^2}{8}\hat{j}$$

$$\text{At } t = 2: \vec{v} = \frac{16}{4}\hat{i} - \frac{12}{8}\hat{j} = 4\hat{i} - \frac{3}{2}\hat{j}$$

Integrating with $\vec{r}(0) = 0$:

$$\vec{r} = \frac{t^5}{20}\hat{i} - \frac{t^3}{8}\hat{j}$$

$$\text{At } t = 2: \vec{r} = \frac{32}{20}\hat{i} - \frac{8}{8}\hat{j} = \frac{8}{5}\hat{i} - \hat{j}$$

6. (1) The particle experiences downward gravitational force (mg) and upward resistive force ($-kv$).

The equation of motion is $m \frac{dv}{dt} = mg - kv$.

Initially at $t = 0$, $v = 0$ gives maximum acceleration $a_0 = g$.

As velocity increases, the resistive force increases, reducing the net acceleration.

Eventually the particle reaches terminal velocity $v_t = \frac{mg}{k}$ when acceleration becomes zero.

The velocity-time graph shows an increasing curve starting from origin with decreasing slope, asymptotically approaching the terminal velocity.

This behavior matches option (1), which displays a curve starting at (0,0) with steep initial slope that gradually flattens.

7. (3) For motion without acceleration, net force = 0.

Component of weight along incline: $mg \sin(30^\circ) = 5 \times 10 \times 0.5 = 25$ N (down).

Normal force: $N = mg \cos(30^\circ) = 50 \times \frac{\sqrt{3}}{2} = 25\sqrt{3}$ N.

Friction force opposing downward motion:

$$f = \mu N = \frac{\sqrt{3}}{2} \times 25\sqrt{3} = 37.5 \text{ N (up)}.$$

For equilibrium along the incline, applying force F down the incline:

$$mg \sin \theta + F = f, \text{ so } 25 + F = 37.5, \text{ giving } F = 12.5 \text{ N}.$$

8. (1) Spring force constant is inversely proportional to length: $k \propto \frac{1}{L}$

So $kL = \text{constant}$ for a given spring material and structure.

Original spring: $k = 15$ N/m, length = L .

Smaller piece has length $\frac{L}{4}$ (since length ratio is 1:3, smaller is $\frac{1}{4}$ of total).

For smaller piece: $k_1 \times \frac{L}{4} = 15 \times L$

$$k_1 = 15 \times 4 = 60 \text{ N/m}$$

9. (210) For the 8 kg block (C) to move with constant velocity, $F_{net} = 0$.

Friction forces acting:

- Between C and ground: $f = \mu(m_A + m_B + m_C)g = 0.5 \times (4 + 6 + 8) \times 10 = 90 \text{ N}$

- Between C and B: $f = \mu(m_A + m_B)g = 0.5 \times (4 + 6) \times 10 = 50 \text{ N}$

For the 6 kg block (B):

$$T = f_{B \text{ on ground}} + f_{A \text{ on B}}$$

$$T = \mu(m_A + m_B)g \cdot \frac{m_B}{m_A + m_B} + \mu \cdot m_A \cdot g$$

$$T = 20 + 50 = 70 \text{ N}$$

For the 8 kg block (C):

$$F = 90 + T + 50 = 90 + 70 + 50 = 210 \text{ N}$$