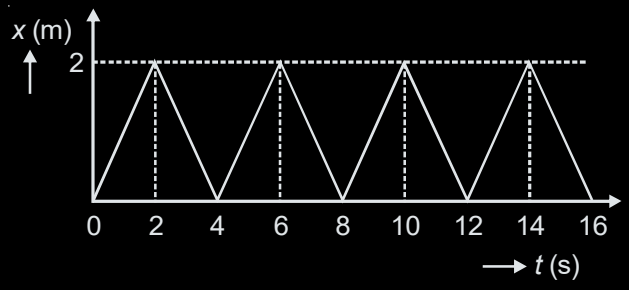
Chapter 3

Laws of Motion

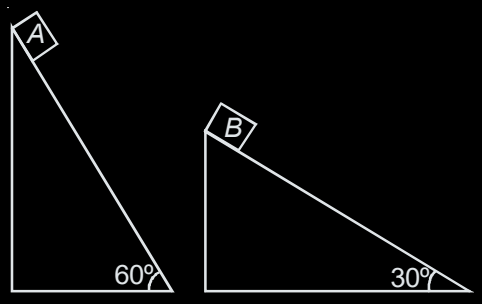
1. The figure shows the position–time (x-t) graph of one-dimensional motion of a body of mass 0.4 kg. The magnitude of each impulse is **[AIEEE-2010]**



(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

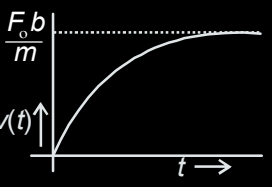
(3) 1 (4) 2

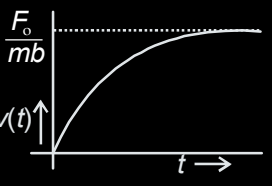
4. If a spring of stiffness k is cut into two parts 'A' and 'B' of length $l_A : l_B = 2 : 3$, then the stiffness of spring 'A' is given by **[AIEEE-2011]**

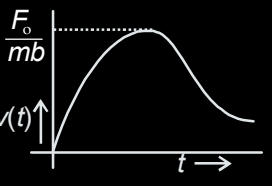
(1) k (2) $\frac{5}{2}k$

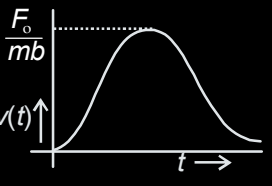
(3) $\frac{3k}{5}$ (4) $\frac{2k}{5}$

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

(1) 

(2) 

(3) 

(4) 

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]**

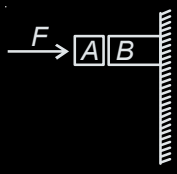
(1) $m_1 : m_2$ (2) $r_1 : r_2$

(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

8. 

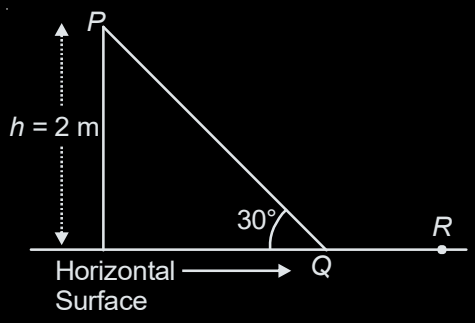
Given in the figure are two blocks A and B of weight 20 N and 100 N, respectively. These are being pressed against a wall by a force F as shown. If the coefficient of friction between the blocks is 0.1 and between block B and the wall is 0.15, the frictional force applied by the wall on block B is **[JEE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



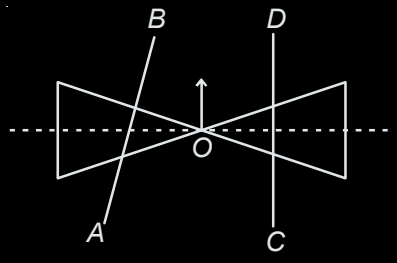
(1) 0.2 and 3.5 m

(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]**



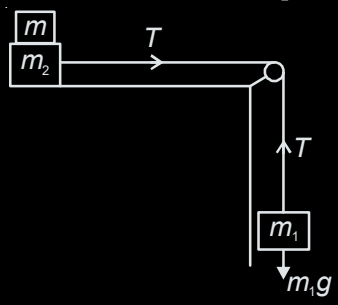
(1) Turn right

(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

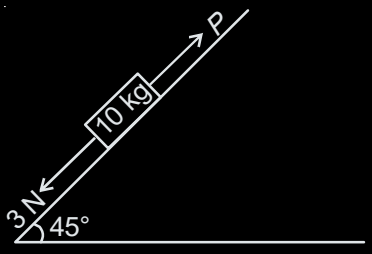
(2) $T \propto R^{\frac{n}{2}+1}$

(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 doesnot move downward?

(take g = 10 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 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 s is R. Neglecting air resistance and taking acceleration due to gravity g = 10 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) $2\sqrt{\frac{k}{p}}$

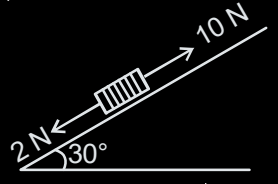
18. A particle moves from the point $\left(2.0\hat{i}+4.0\hat{j}\right)$ m, at t = 0, with an initial velocity $\left(5.0\hat{i}+4.0\hat{j}\right)$ ms^{-1}. It is acted upon by a constant force which produces a constant acceleration $\left(4.0\hat{i}+4.0\hat{j}\right)$ ms^{-2}. What is the distance of the particle from the origin at time 2 s? **[JEE (Main)-2019]**

(1) $20\sqrt{2}$ m (2) 15 m

(3) $10\sqrt{2}$ 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 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) $\frac{1}{\sqrt{2\gamma g}}\tan^{-1}\left(\sqrt{\frac{2\gamma}{g}}V_0\right)$

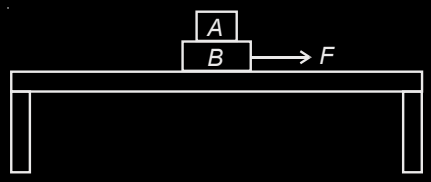
21. A bullet of mass 20 g has an initial speed of 1 ms^{-1}, just before it starts penetrating a mud wall of thickness 20 cm. If the wall offers a mean resistance of 2.5×10^{-2} N, the speed of the bullet after emerging from the other side of the wall is close to : **[JEE (Main)-2019]**

(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 kg and m_B = 3 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 m/s^2] **[JEE (Main)-2019]**

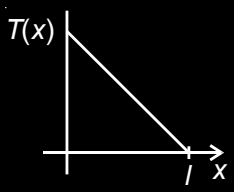


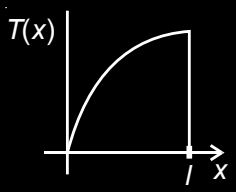
(1) 40 N (2) 12 N

(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]

(1)


(2)


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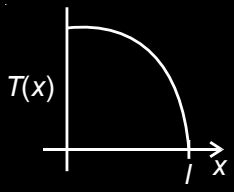

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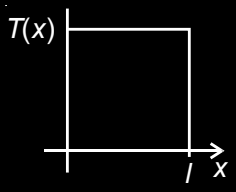
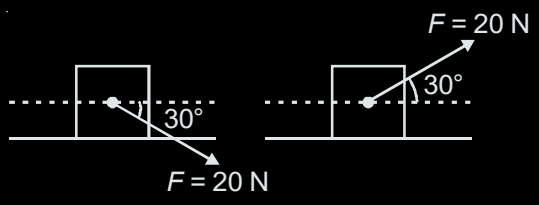


24. A block of mass 5 kg is (i) pushed in case (A) and (ii) pulled in case (B), by a force F = 20 N, making an angle of 30° with the horizontal, as shown in the figures. The coefficient of friction between the block and floor is μ = 0.2. The difference between the accelerations of the block, in case (B) and case (A) will be :

(g = 10 ms^{-2}) **[JEE (Main)-2019]**



(A) (B)

(1) 0.4 ms^{-2} (2) 3.2 ms^{-2}

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

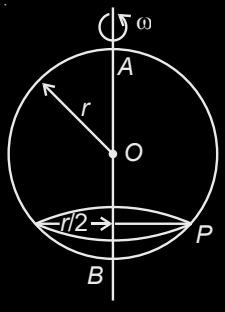
25. A spring whose unstretched length is *l* has a force constant *k*. The spring is cut into two pieces of unstretched lengths l_1 and l_2 where, $l_1 = nl_2$ and *n* is an integer. The ratio k_1/k_2 of the corresponding force constants, k_1 and k_2 will be

[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) $\frac{\left(g\sqrt{3}\right)}{r}$ (2) $\frac{2g}{r}$

(3) $\frac{2g}{\left(r\sqrt{3}\right)}$ (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 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) $\frac{ml\omega^2}{k-\omega m}$ (2) $\frac{ml\omega^2}{k+m\omega^2}$

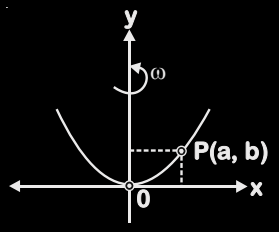
(3) $\frac{ml\omega^2}{k+m\omega}$ (4) $\frac{ml\omega^2}{k-m\omega^2}$

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 it's axis with an angular velocity ω, ($k >> m\omega^2$) 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 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 $\vec{F} = k\left(v_y\hat{i} + v_x\hat{j}\right)$, 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]**

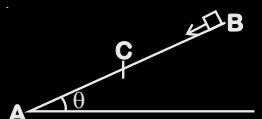
(1) Quantity $\vec{v}\cdot\vec{a}$ is constant in time

(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]**

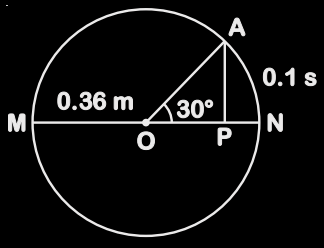
35. An inclined plane is bent in such a way that the vertical cross-section is given by $y = \frac{x^2}{4}$ where y is in vertical and x in horizontal direction. If the upper surface of this curved plane is rough with coefficient of friction $\mu = 0.5$, the maximum height in cm at which a stationary 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 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) $T \propto R^{\frac{3}{2}}$

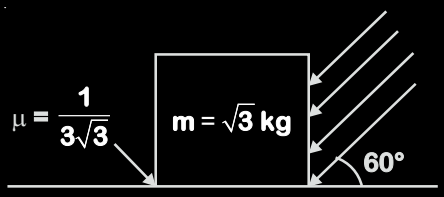
(3) $T \propto R^2$

(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 m/s^2; $\sin 60° = \frac{\sqrt{3}}{2}$; $\cos 60° = \frac{1}{2}$]

[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 m/s^2] **[JEE (Main)-2021]**

41. A boy pushes a box of mass 2 kg with a force $\vec{F} = (20\hat{i} + 10\hat{j})\ N$ 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

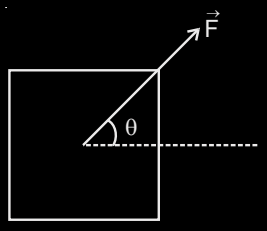
(2) 9.859×10^{-4} N

(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. ($g = 9.8\ m/s^2$)

Statement II : If the road is banked at an angle of 45º, 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

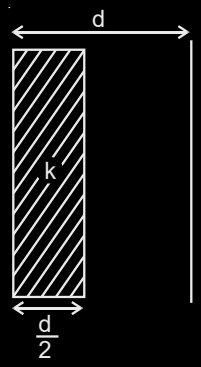
(2) Statement I is incorrect and statement II is correct

(3) Both statement I and statement II are true

(4) Both statement I and statement II are false

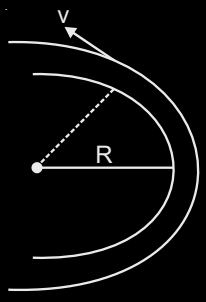
47. In a parallel plate capacitor set up, the plate area of capacitor is 2 m^2 and the plates are separated by 1 m. If the space between the plates are filled with a dielectric material of thickness 0.5 m and area 2 m^2 (see fig) the capacitance of the set-up will be _____ ε_0. (Dielectric constant of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



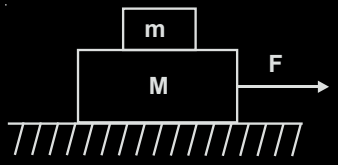
(1) $m\left(\frac{v^2}{\mu_s R} + g\right)$

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

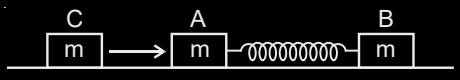
(3) $-m\left(g + \frac{v^2}{\mu_s R}\right)$

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

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

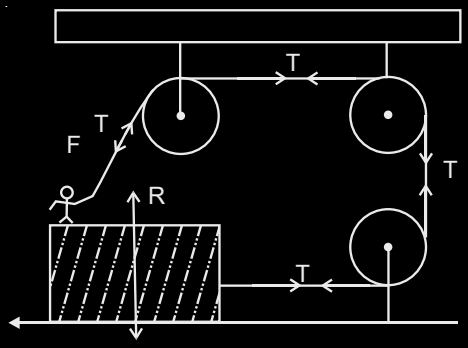
51. A body of mass 1 kg rests on a horizontal floor with which it has a coefficient of static friction $\frac{1}{\sqrt{3}}$.

It is desired to make the body move by applying the minimum possible force F N. The value of F will be_____. (Round off to the Nearest Integer)

[Take g = 10 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)

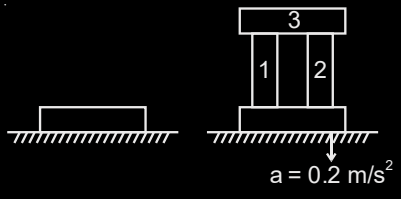
[Take g = 10 ms^{-2}] **[JEE (Main)-2021]**



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 m/s^2 and μ_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_____× 10^3 kg m/s^2. **[JEE (Main)-2021]**

[Given cos30° = 0.87, μ_s = 0.2]

(1) 6.96

(2) 12.4

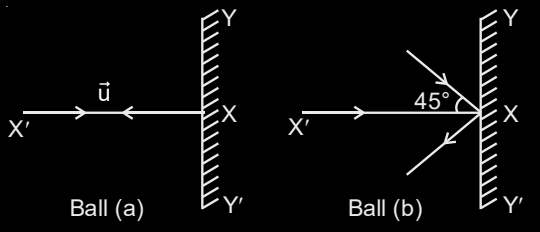
(3) 7.2

(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) $\frac{F_0T}{3M}$ (2) $\frac{F_0T}{2M}$

(3) $\frac{2F_0T}{M}$ (4) $\frac{4F_0T}{3M}$

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 m/s^2)

[JEE (Main)-2021]

(1) 60 kg s^{-1} (2) 10 kg s^{-1}

(3) 6.0 $\times 10^2$ 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) $2\sqrt{rg}$

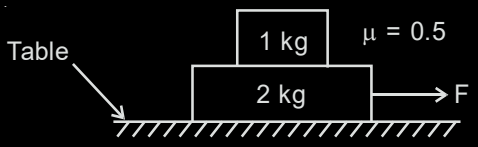
(2) $\sqrt{rg}$

(3) $\sqrt{2rg}$

(4) $\sqrt{\frac{rg}{2}}$

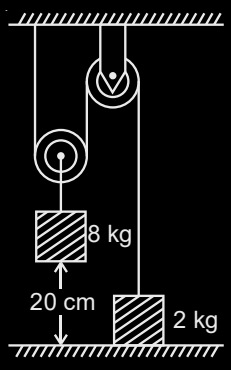
61. The coefficient of static friction between two blocks is 0.5 and the table is smooth. The maximum horizontal force that can be applied to move the blocks together is ___ N. (take g = 10 ms^{-2})

[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 m/s^2):

[JEE (Main)-2021]



(1) 0.4 s

(2) 0.25 s

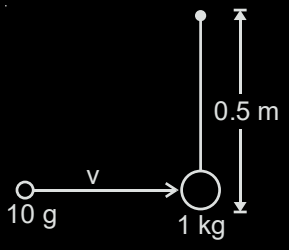
(3) 0.34 s

(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 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]

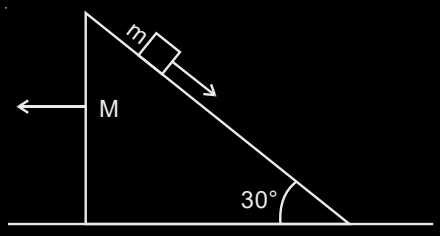
65. A car is moving on a plane inclined at 30° to the horizontal with an acceleration of 10 ms^{-2} parallel to the plane upward. A bob is suspended by a string from the roof of the car. The angle in degrees which the string makes with the vertical is _____. (Take g = 10 ms^{-2})

[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 kg, M = 16 kg

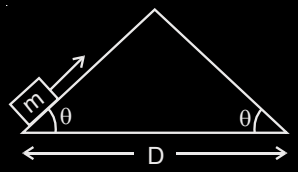
Assume all the surfaces shown in the figure to be frictionless. **[JEE (Main)-2021]**



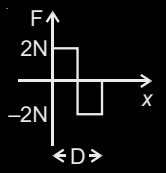
(1) $\frac{2}{3}$ g (2) $\frac{4}{3}$ g

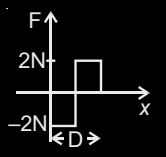
(3) $\frac{6}{5}$ g (4) $\frac{3}{5}$ g

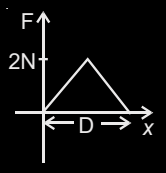
67. An object of mass 'm' is being moved with a constant velocity under the action of an applied force of 2N along a frictionless surface with following surface profile. **[JEE (Main)-2021]**

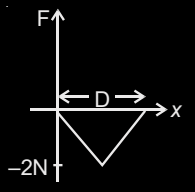


The correct applied force vs distance graph will be:

(1)


(2)


(3)


(4)


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 $\left(2\hat{i}+3\hat{j}+5\hat{k}\right)$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 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 $\frac{K}{\pi}$ 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]

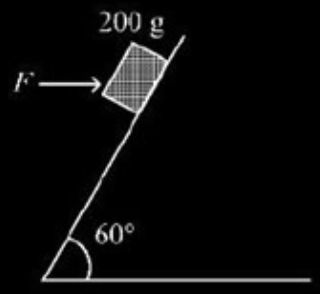
73. A force on an object of mass 100 g is $\left(10\hat{i}+5\hat{j}\right)$N. The position of that object at t = 2 s is $\left(a\,\hat{i}+b\,\hat{j}\right)$ m after starting from rest. The value of $\frac{a}{b}$ will be _____.
[JEE (Main)-2022]

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) $R \le \frac{\mu g}{2\omega^2}$ (2) $R \le \frac{\mu g}{\omega^2}$
(3) $R \ge \frac{\mu g}{2\omega^2}$ (4) $R \ge \frac{\mu g}{\omega^2}$

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 $F = \sqrt{x}$ N as shown in figure.

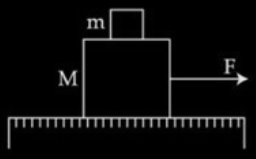


The value of x = _____. **[JEE (Main)-2022]**

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 kg and M = 8 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 _____

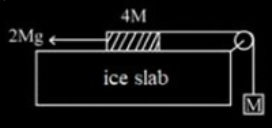
(Given, g = 10 m/s^2) **[JEE (Main)-2022]**

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 2 Mg force.

In this situation, tension in the string is $\frac{x}{5}$ Mg for x =_____. Neglect mass of the string and friction of the block (bigger mass) with ice slab.

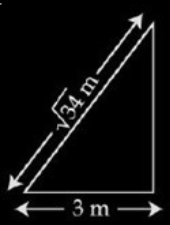
(Given g = acceleration due to gravity)

[JEE (Main)-2022]



82. A $\sqrt{34}$ 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_f and F_w are the reaction forces of the floor and the wall, then ratio of F_w/F_f will be: **[JEE (Main)-2022]**

(Use g = 10 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 ms^{-2}.)

(1) 1 ms^{-2}

(2) 1/5 ms^{-2}

(3) 4/5 ms^{-2}

(4) 8/11 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]**

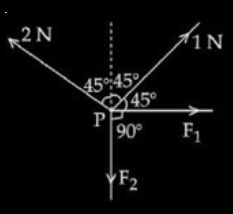
The value of 'a' will be

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

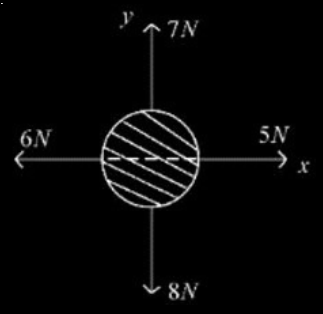
(3) $\frac{3g}{4}$ (4) g

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 =___. **[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) $\sqrt{2}$ N, 45°

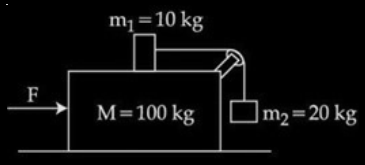
(2) $\sqrt{2}$ N, 135°

(3) $\frac{2}{\sqrt{3}}$ N, 30°

(4) 2 N, 45°

88. Three masses M = 100 kg, m_1 = 10 kg and m_2 = 20 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 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 m/s^2). **[JEE (Main)-2022]**

(1) T = 700 N while climbing upward

(2) T = 350 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]**

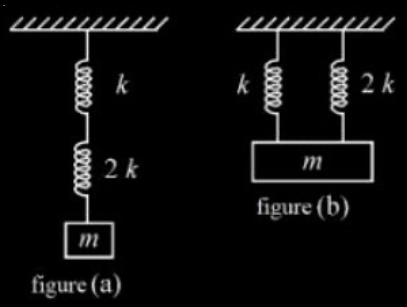
(1) 1:1

(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 $\sqrt{x}$ 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 $g = 10\ m/s^2$]

(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]**

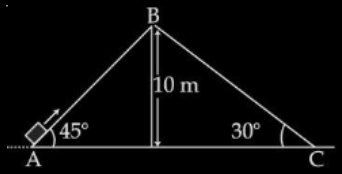
(1) 2.66 s

(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 $t\left(\sqrt{2}+1\right)$S . The value of *t* is _____. (Use $g = 10\ m/s^2$) **[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

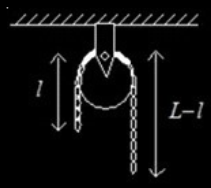
(2) 500 N

(3) 250 N

(4) 400 N

99. A uniform metal chain of mass *m* and length '*L*' passes over a massless and frictionless pully. 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 pully. 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 _____.

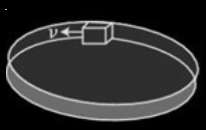
[JEE (Main)-2022]

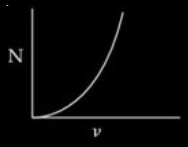


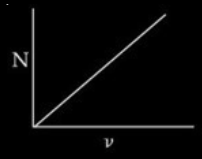
(1) 6 (2) 2

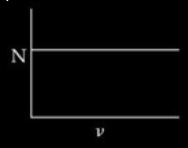
(3) 1.5 (4) 4

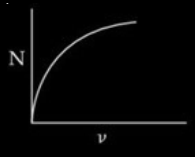
100. A smooth circular groove has a smooth vertical wall as shown in figure. A block of mass m moves against the wall with a speed v. Which of the following curve represents the correct relation between the normal reaction on the block by the wall (N) and speed of the block (v)? **[JEE (Main)-2022]**



(1) 

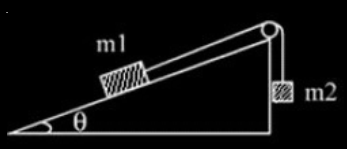
(2) 

(3) 

(4) 

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 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]**

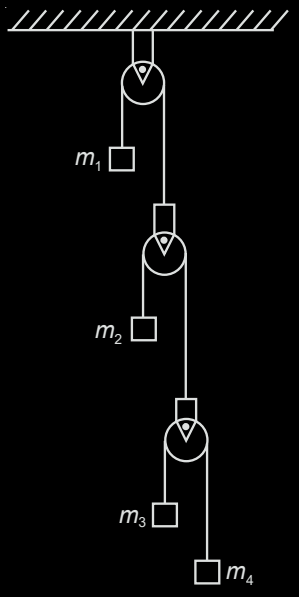
(1) 36%

(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 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 ms^{-2}].

[JEE (Main)-2022]

(1) 1 : 1

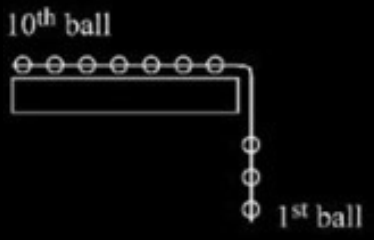
(2) $\sqrt{2}:\sqrt{3}$

(3) $\sqrt{3}:\sqrt{2}$

(4) 2 : 3

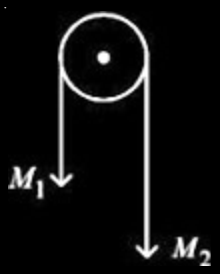
107. A batsman hits back a ball of mass 0.4 kg straight in the direction of the bowler without changing its initial speed of 15 ms^{-1}. The impulse imparted to the ball is _____ Ns. **[JEE (Main)-2022]**

108. A system to 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)

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

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

$k_1 l_1 = kl$

$k_1 = \frac{kl}{l_1}$

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

5. Answer (2)

6. Answer (2)

7. Answer (1)

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

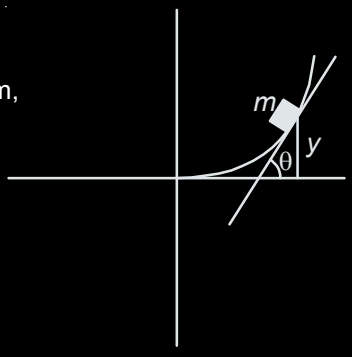
At limiting equilibrium,

$\mu = \tan\theta$

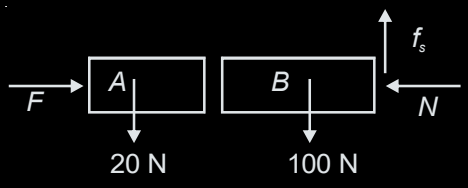
$0.5 = \frac{x^2}{2}$

$\Rightarrow\ x = \pm 1$

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



8. Answer (3)



Clearly f_s = 120 N (for vertical equilibrium of the system)

9. Answer (2)

Work done by friction along PQ

= work done by friction along QR

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

$\Rightarrow\ x = 3.5$ m

Now, according to work energy theorem

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

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

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

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

$\Rightarrow\ m_2 > 23.33$ kg

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

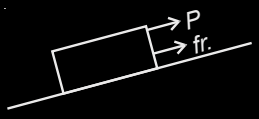
12. Answer (3)

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

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

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

13. Answer (2)



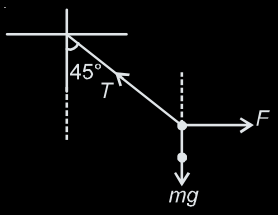
Friction force should be acting upward along the plane. So for state of impending motion.

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

$\Rightarrow$ 73.71 – 42.42 = P

$\Rightarrow$ P = 31.28 $\approx$ 32 N

14. Answer (1)



$T\cos 45° = mg$

$T\sin 45° = F$

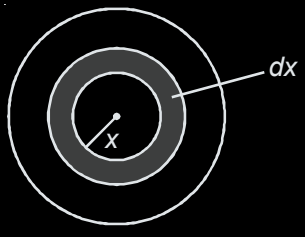
$\Rightarrow \quad F = mg$

$= 10 \times 10 = 100$ N

15. Answer (4)

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

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

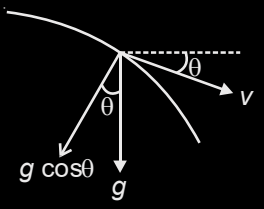


$= \frac{\mu f \times 2\pi R^3}{3\pi R^2}$

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

16. Answer (3)

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



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

$T = \sqrt{3}$ s

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

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

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

θ = 15°

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

$\simeq 2.8$ 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)

$\vec{r} = \vec{r_0} + \vec{u}t + \frac{1}{2}\vec{a}t^2$

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

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

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

19. Answer (2)

$$2 + mg\,\frac{1}{2} = \mu mg\,\frac{\sqrt{3}}{2} \qquad \text{...(i)}$$

$$\frac{mg}{2} + \mu mg\,\frac{\sqrt{3}}{2} = 10 \qquad \text{...(ii)}$$

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

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

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

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

20. Answer (3)

Retardation of the particle

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

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

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

21. Answer (2)

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

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

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

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

22. Answer (3)

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

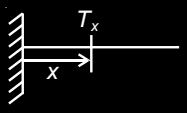
$$a = \frac{F - (0.2)4 \times 10}{4} = \left(\frac{F - 8}{4}\right)$$

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

$\Rightarrow$ $F - 8 \le 8$

$\Rightarrow$ $F \le 16$

23. Answer (3)



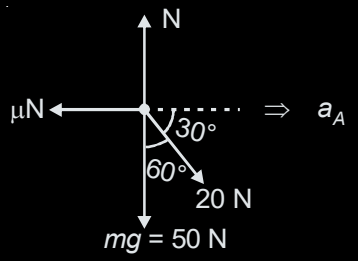
$$T_x = \frac{M}{L}(L - x)\left\{x + \frac{L - x}{2}\right\}\omega^2 = \frac{M\omega^2}{2L}(L^2 - x^2)$$

24. Answer (4)

$N = 60$ N

$F = 0.2 \times 60 = 12$ N

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



For B $N = 40$ N

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

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

$a_B - a_A = 0.8$ m/s^2

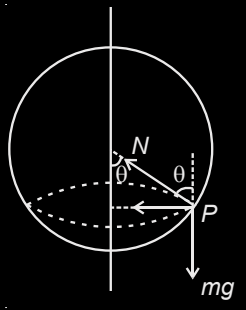
25. Answer (4)

$l_1 = nl_2$

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

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

26. Answer (3)



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

$N\cos\theta = mg$ …(i)

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

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

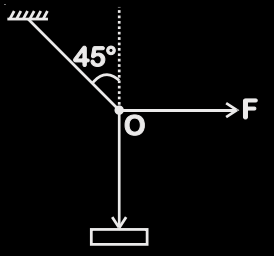
$\Rightarrow \quad \omega^2 = \frac{2g\tan\theta}{r} = \frac{2g}{r\sqrt{3}}$

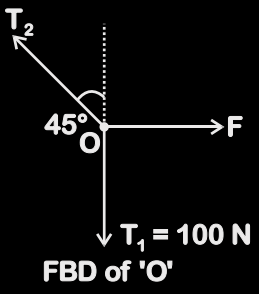
27. Answer (4)

$T_2\cos45° = 100$ N ...(i)

$T_2\sin45° = F$ ...(ii)

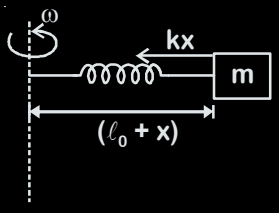
$\Rightarrow$ F = 100 N





FBD of 'O'

28. Answer (4)



At elongated position (x),

$F_{radial} = mr\omega^2$

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

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

29. Answer (2)

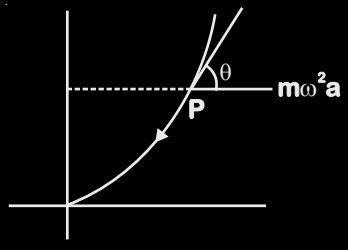
$m\omega^2(l_0 + x) = kx$

$x = \frac{ml_0\omega^2}{k - m\omega^2}$

For $k >> m\omega^2$

$\frac{x}{l_0} = \frac{m\omega^2}{K}$

30. Answer (1)



$y = 4Cx^2$

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

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

For steady circular motion

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

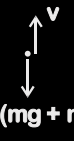
$\Rightarrow \quad \tan\theta = \frac{\omega^2 a}{g}$

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

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

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

31. Answer (3)



$|a| = g + kv^2$

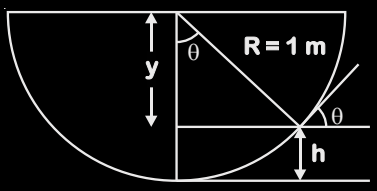
$\Rightarrow \quad -\frac{vdv}{dh} = g + kv^2$

$\Rightarrow \quad \int_u^0 \frac{vdv}{g + kv^2} = \int_0^{H_{max}} -dh$

On solving

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

32. Answer (3)



$\mu = \tan\theta$

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

$\Rightarrow \quad \theta = 37°$

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

33. Answer (3)

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

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

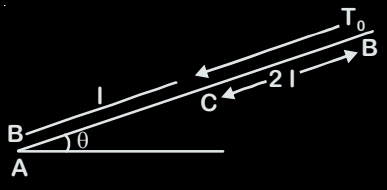
$\Rightarrow \quad \frac{dv_x}{dv_y} = \frac{v_y}{v_x} \Rightarrow v_x dx = v_y dy$

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

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

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

34. Answer (3)



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

$\therefore \quad 0 = mg3l\sin\theta - \mu mgl\cos\theta = 0$

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

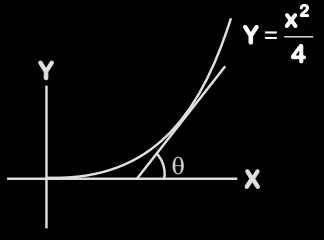
$\therefore \quad k = 3$

35. Answer (25)

For no slipping

$\tan\theta \le \mu$

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



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

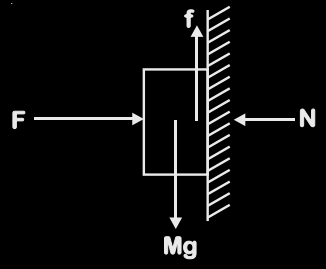
$\sqrt{4Y} \le 1$

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

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

36. Answer (25)

For equilibrium of the block



$N = F$

$f = Mg$

and $Mg \le f_\ell$

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

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

37. Answer (1)

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

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

$\therefore \quad a_M = \frac{v^2}{r} = \frac{(\pi\times0.6)^2}{0.36} = \pi^2 = 9.87 \text{ N/kg}$

38. Answer (3)

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

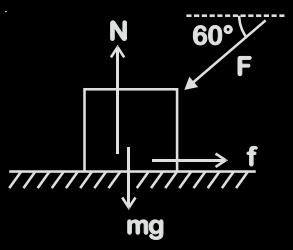
$\Rightarrow \quad \frac{mv^2}{R} = \frac{K}{R^3}$

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

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

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

39. Answer (3.33)



$N = mg + F\sin60°$

For no movement of the block —

$F\cos60° \le f_l$

$F\cos60° \le \mu\,(mg + F\sin60°)$

$$F \le \frac{\mu mg}{\cos60° - \mu\sin60°}$$

$F_{critical} = 10$ N

40. Answer (492)

$M = 60$ kg

$N = M(g - a)$

$= 60(10 - 1.8)$

$= 492$ N

41. Answer (500)

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

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

$= 500$ m

42. Answer (4)

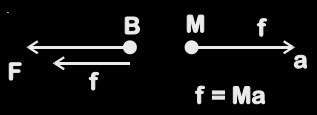
$T_1 = K(l_1 - l_0)$ ...(1)

$T_2 = K(l_2 - l_0)$ ...(2)

From (1) and (2),

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

43. Answer (4)



$F + f = Ma_1$

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

44. Answer (2)

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

$$= \frac{(200\times10^{-3})\times\left(\frac{2\pi\times0.2}{40}\right)^2}{0.2}$$

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

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

$\le \sqrt{0.2\times2\times9.8}$

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

For statement-II

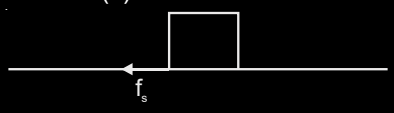
$$v_{allowable} = \sqrt{rg\frac{(\mu+\tan\theta)}{1-\mu}} = \sqrt{\frac{3}{2}rg}$$

So, both the statements are true.

47. Answer (4)

$$C = \frac{\varepsilon_0 A}{d - t + \frac{t}{k}} = \frac{\varepsilon_0\times2}{1-0.5+\frac{0.5}{3.2}} = 3.88\ \varepsilon_0$$

48. Answer (2)



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

In limiting condition

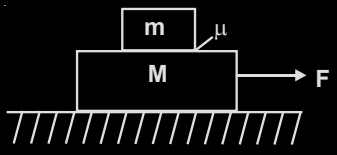
$$\mu_s N = \frac{mv^2}{R}$$

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

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

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

49. Answer (21)



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

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

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

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

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

50. Answer (3)

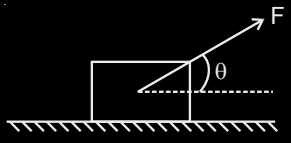
Maximum compression occurs when velocities of A and B are equal.

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

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

51. Answer (5)

Force required to pull the block



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

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

52. Answer (30)

$T = Mg - N$

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

For no movement of block

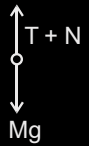
$T \le \mu R$

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

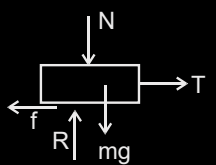
$$T \le \frac{\mu(M+m)g}{1+\mu}$$

T_{max} = 30 N

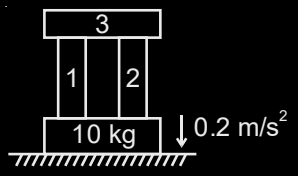
For Man:



For block:



53. Answer (4)

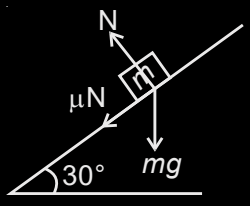


$R' = (10 + 3 \times 20) \times (g - a)$

$= 70 \times (9.8)$

$= 686$ N

54. Answer (4)



Along vertical

$N\cos30° = mg + \mu N\cos60°$

$$N\frac{\sqrt{3}}{2} = 800\times9.8 + 0.2N\times\frac{1}{2}$$

$$\Rightarrow\ N\frac{\sqrt{3}}{2} - 0.1N = 800\times9.8$$

$$N = \frac{800\times9.8}{\frac{\sqrt{3}}{2} - 0.1}$$

≈ 10234

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

55. Answer (3)

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

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

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

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

56. Answer (1)

$I_a = 2mv$

$I_b = 2mv\cos(45°)$

ratio $= \sqrt{2}$

57. Answer (2)

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

$$= \frac{1}{2}\times(8\hat{i} + 2\hat{j})\times 100$$

$$= (400\hat{i} + 100\hat{j})\ \text{m}$$

58. Answer (4)

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

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

$$\Rightarrow \int_0^v dv = \int \frac{F_0}{M\times T^2}\left[T^2 - \left(t^2 + T^2 - 2tT\right)\right]dt$$

$$\Rightarrow V = \frac{F_0}{MT^2}\times\left[2T\times\frac{t^2}{2} - \frac{t^3}{3}\right]_0^{2T}$$

$$= \frac{F_0}{MT^2}\times\left[T\times 4T^2 - \frac{1}{3}\times 8T^3\right]$$

$$= \frac{F_0}{MT^2}\times\frac{4T^3}{3} = \frac{4F_0T}{3M}$$

59. Answer (1)

Here, M = 1000 kg, a = 20 m/s^2

V_{rel} = 500 m/s

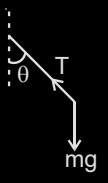
Using Newton's 2nd law,

$$V_{rel}\left(\frac{dm}{dt}\right) - Mg = Ma$$

$$\Rightarrow 500\times\left(\frac{dm}{dt}\right) = 1000(10 + 20)$$

$$\Rightarrow \frac{dm}{dt} = 60\ \text{kg/s}$$

60. Answer (2)



$T\cos\theta = mg$

$$T\sin\theta = \frac{mv^2}{r}$$

$$\frac{v^2}{rg} = \tan\theta$$

$$v = \sqrt{rg}$$

61. Answer (15)

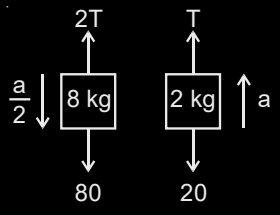
Maximum acceleration of block 1 is

a_{max} = 5 m/s^2

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

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

62. Answer (1)



80 – 2T = 4a ...(1)

T – 20 = 2a ...(2)

From (1) and (2)

a = 5 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

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

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

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

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

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

v = 400

64. Answer (1)

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

$\Rightarrow$ V = 20 m/s

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

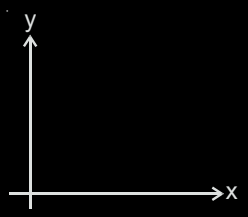
$$= \frac{1}{4}$$

65. Answer (30)

Acceleration of point of suspension

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

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



$g_{eff} = -\left[\left(5\sqrt{3}\hat{i}+5\hat{j}\right)+10\hat{j}\right]$

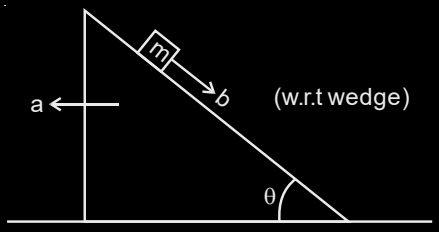
$= -\left(5\sqrt{3}\hat{i}+15\hat{j}\right)$

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

66. Answer (1)

As, $\sum F_x = 0$

$\Rightarrow$ a_{com} = 0



$\Rightarrow$ M(–a) + m(bcosθ – a) = 0

$\Rightarrow$ bcosθ – a = $\frac{M}{m}$a

$\Rightarrow$ bcosθ = 3a ...(i) As $\frac{M}{m} = 2$

and for block,

mgsinθ + macosθ = 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 = mgsinθ = 2 N (upwards along the incline)

In 2nd half,

F = mgsinθ = 2 N (upwards along the incline)

68. Answer (3)

$\frac{T}{\alpha T} = \sqrt{\frac{a_{rough}}{a_{smooth}}}$

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

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

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

69. Answer (12)

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

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

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

b = 12

70. Answer (2)

$S = \frac{u^2}{2a} = \frac{u^2}{2(\mu g)}$

$= \frac{(9.8)^2}{2\times0.5\times(9.8)}$

$= \frac{9.8}{1}$

= 9.8 m

71. Answer (3)

$T = m\omega^2 r$

$\Rightarrow 80 = 0.1\times\left(2\pi\times\frac{K}{\pi}\times\frac{1}{60}\right)^2\times2$

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

$\Rightarrow K = 30\times20 = 600$

72. Answer (2)

(x)gλ = μ(6 – x) gλ where x is length of hanging part

$\Rightarrow x = 3 - 0.5x$

$\Rightarrow x$ = 2 m

73. Answer (2)

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

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

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

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

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

so a = 200 m and b = 100 m

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

74. Answer (2)

To move together

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

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

75. Answer (24)

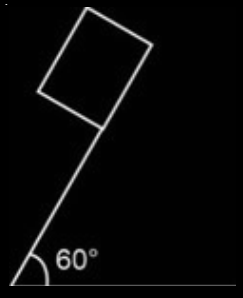
$\because \quad v = \sqrt{\mu g r}$

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

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

$\Rightarrow \quad V_2 = 24$ m/s

76. Answer (12)



$F\cos60° = mg\sin60°$

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

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

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

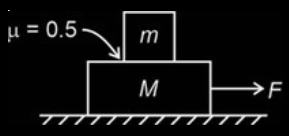
$\therefore \quad x = 12$

77. Answer (2)

Apparent weight = $m(g - a)$

$\Rightarrow$ Weight loss in downward accelerated elevator

78. Answer (3)



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

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

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

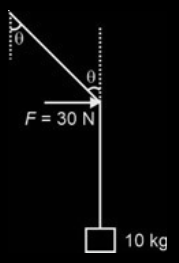
79. Answer (3)

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

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

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

80. Answer (3)



$T\cos\theta = mg$

$T\cos\theta = 100$ N …(i)

$T\sin\theta = 30$ …(ii)

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

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

$\therefore \quad x = 3$

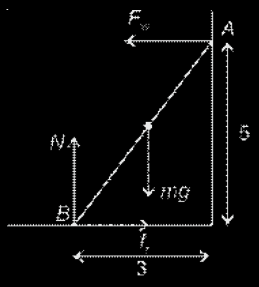
81. Answer (6)

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

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

$\Rightarrow \quad x = 6$

82. Answer (3)



Taking torque from *B*

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

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

$= 30$ N

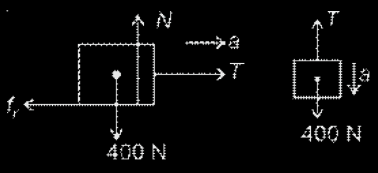
$N = mg = 100$ N

and $f_r = F_w = 30$ N

so $F_f = \sqrt{N^2 + f_r^2} = \sqrt{10900} = 10\sqrt{109}$ N

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

83. Answer (4)



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

$= 0.02 \times 400$

$= 8$ N

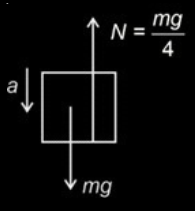
Let the acceleration is a as shown then.

$40 - T = 4a$

$T - 8 = 40a$

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

84. Answer (3)



Using Newton's second law

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

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

85. Answer (3)

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

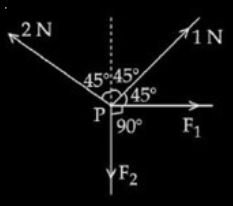
$$\frac{d_2}{d_1} = \left(\frac{v_2}{v_1}\right)^2 = \left(\frac{1}{3}\right)^2$$

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

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)

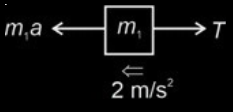
Resultant of already applied forces $= -\hat{i} - \hat{j}$

$\Rightarrow$ Force required to balance $= \hat{i} + \hat{j}$

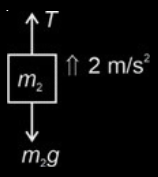
$\Rightarrow$ Force required $= \sqrt{2}$ N in magnitude at angle 45° with +ve *x*-axis

88. Answer (3)

In frame of block of mass *M* moving with acceleration *a*



$m_1a - T = 2m_1 \Rightarrow 10a - T = 20$ …(i)



$T - m_2g = m_22 \Rightarrow T - 200 = 40 \Rightarrow T = 240$ …(ii)

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

for block

$F = (M + m_2)a = 120 \times 26$

$= 3120$ N

89. Answer (3)

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

$= 50 \times 6$

$= 300$ N

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

$= 50 \times 15$

$= 750$ N

$\Rightarrow$ Rope will break while climbing up.

90. Answer (2)

$F = 100$ N

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

$= 3.6$

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

91. Answer (2)

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

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

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

92. Answer (2)

For case (a),

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

For case (b),

$K_{eq} = 3K$

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

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

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

$T_b = \sqrt{2}$

$x = 2$

93. Answer (2)

$v = 2$ m/s

$\mu = 0.4$

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

$= +\,4$ m/s^2

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

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

$s = 0.5$ 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.

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

95. Answer (3)

$\theta_1 = 30°$, $\theta_2 = 45°$

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

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

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

$t_2 = (2)^{3/4}$

≈ 1.68 s

96. Answer (2)

$AB = 10\sqrt{2}$ m

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

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

$a_{BC} = g\sin(30°) = 5$ m/s^2

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

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

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

$\Rightarrow$ $t = 2$

97. Answer (2)

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

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

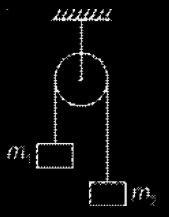
98. Answer (4)

$F_w = \rho A v^2$

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

$= 400$ 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)

$m_2 g = m_1 g\sin\theta$ …(i)

$N = m_1 g\cos\theta$ …(ii)

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

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

$\Rightarrow$ $N = 40$ 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% increase

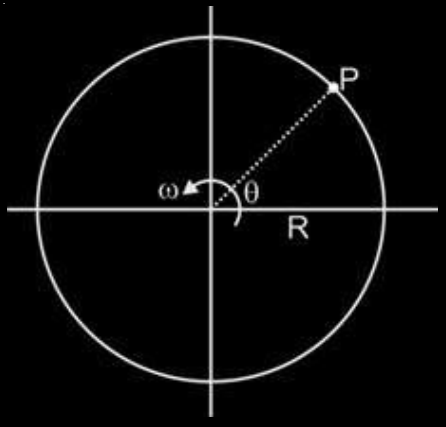
103. Answer (1)

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.

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

105. Answer (4)

m = 10 kg

$\theta = 45°$

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

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

$$\Rightarrow \quad R = 40$$

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

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

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

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

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

106. Answer (2)

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

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

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

107. Answer (12)

$I = m\Delta v$

= 0.4 × 2 × 15 = 12 Ns

108. Answer (36)

At given instant

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

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

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

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

109. Answer (2)

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

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

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

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

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