PHYSICS

BOOKS - CP SINGH PHYSICS (HINGLISH)

ROTATIONAL MOTION

Example

1. Three particles A,B and C of masses m,$2m$ and $3m$ are placed on a straight line of length

$2L$ as shown. Find the $M.I.$ about an axis passing through B and perpendicular to the line AC.

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2. Two particles of masses m and $2m$ are placed at separation L. Find the $M.I.$ about an axis passing through the center of mass and perpendicular to the line joining the point masses.

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3. Three particles each of mass m are placed on the vertices of an equilateral triangle of length L. Find the $M.I.$

(a) about an axis passing through

(i) one particle and perpendicular to the plane

(ii) mid-point of the side of triangle and $\perp^{ar}$ to the plane

(iii) center of triangle and $\perp^{ar}$ to the plane

(b) (i) an axis coinciding with side of triangle

(ii) about median of triangle

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4. Three thin, uniform, indentical rods each or mass M and length L are joined as shown. Find the $M.I.$ about an axis passing through O and perpendicular to the plane.

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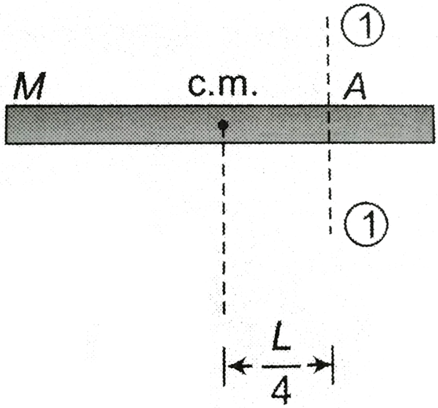
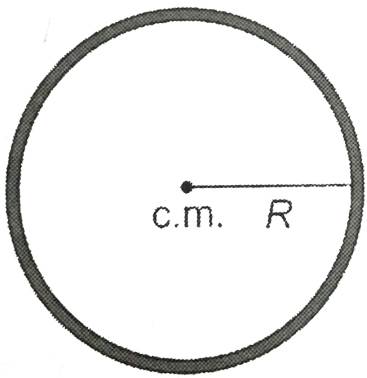
5. Find the $M.I.$

(a) An axis passing through A and $\perp^{ar}$ to the length.

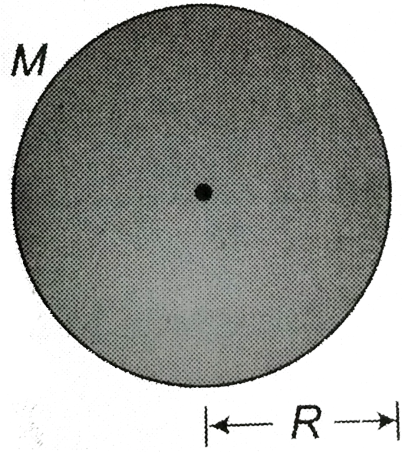


(b) (i)An axis passing through the perimeter of ring and $\perp^{ar}$ to the plane.



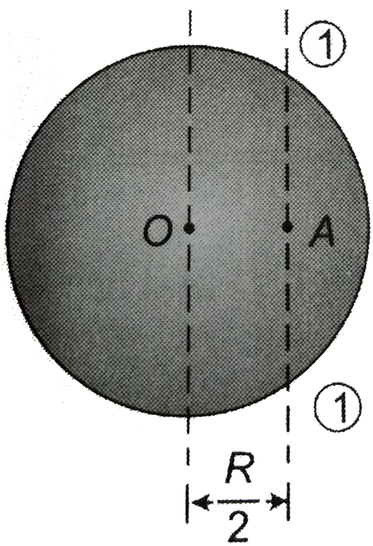
(ii) An axis touching the perimeter and lying in the same the plane.

(c) Solid sphere



An axis touching the sphere (tangential axes)

(d) An uniform disc



An axis passing through A, parallel to the diameter and lying in the same plane.

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6. Four identical spheres each of mass M and radius R are placed on the vertices of a square of edge L. Find the $M.I.$ about an axis

(a) coinciding with the side of a square and

(b) coinciding with the diagonal of a square.

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7. Three identical roads each of mass M and L are joined to form an equilateral triangle. Find the $M. I.$ about an axis perpendicular to the plane of triangle and passing through

(a) center of triangle

(b) mid-point of a rod and

(c) one vertex of triangle.

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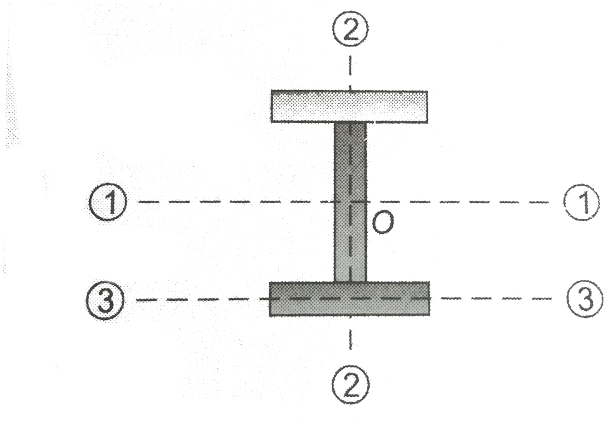
8. The three rods of the previous problem are connected symmetrically as shown. Find the

$M.I.$ about $(1)-(1), (2)-(2)$ and $(3)-(3)$



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9. Three thin unifrom circular discs each of mass M and radius R are placed touching each other on a horizontal surface such that an equilateral triangle is formed, when the center of three discs are joined. Find the $M.I.$ about an axis passing through the center of mass system of discs and perpendicular to the plane.

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10. From a thin uniform disc of radius $2R$. Another disc of diameter $2R$ is removed. The mass of the remaining portion is m. Find the $M.I.$ of the shaded portion about an axis passing through O and pependicular to the plane.

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11. From a disc of radius r_1, a concentric disc of radius r_2 is removed . The mass of the remaining portion is m. Find the $M.I.$ of the remaining about an axis passing through the center of mass and perpendicular to the plane.

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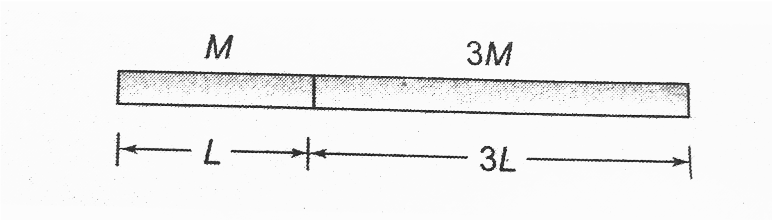
12. Two thin uniform rods A $(M. L)$ and B $(3M, 3L)$ are joined as shown. Find the $M. I.$ about an axis passing through the center of mass of system of rods and perpendicular to the length.



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13. Two thin uniform rings made of same material and of radii R and $4R$ are joined as shown. The mass of smaller ring is m. Find the $M.I.$ about an axis passing through the center of mass of system of rings and perpendicular to the plane.

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14. Find the momentof inertia of a uniform square plate of mass m and edge a about one of its diagonals.

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15. Four identical rods each of mass m and length L are joined to form a square. Find the $M.I.$ about

(a) the x-axis,

(b) the y-axis,

(c) the z-axis,

(d) about $1-1$,

(e) an axis passing through one corner and perpendicular to the plane.

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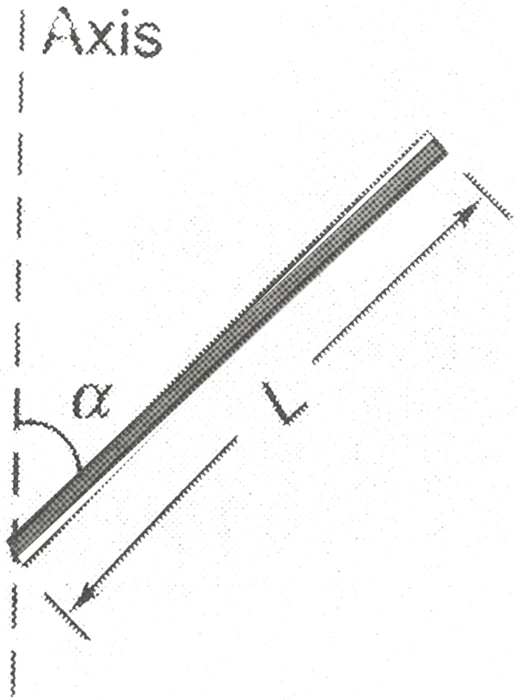
16. Find the $M.I.$ of thin uniform rod of mass M and length L about the axis as shown.



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17. The linear mass density (i.e. Mass per unit length) of a rod of length L is given by $\rho = \rho_0 \frac{x}{L}$, where ρ_0 is constant and x is the

distance from one end A. Find the $M.I.$ about an axis passing through A and perpendicular to length of rod. Express your answer in terms of mass of rod M and length L.

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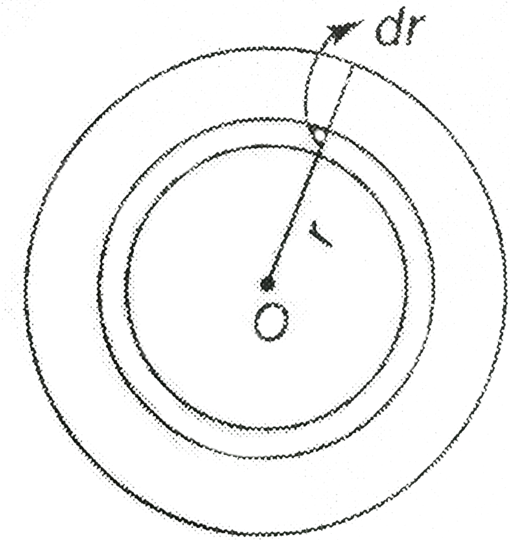
18. Find the $M. I.$



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19. The radius of gyration of an uniform rod of length l about an axis passing through one of its ends and perpendicular to its length is.

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20. Find the radius of gyration of a system of particles about an axis passing through the center of mass and perpendicular to the line joining the particles. The system consists of two particles of masses m_1 and m_2 placed at separation at r

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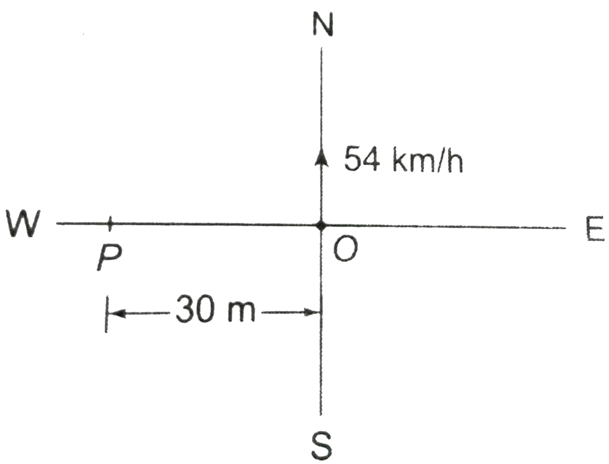
21. A verticle is moving due north with an absolute velocity $54 km / h$. An observer at P is at distance $30 m$ to the west of the line of travel. What is the angular velocity of vehicle relative to the observer at $t = 0$ and $t = 2s$.



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22. As shown, there is rotating spotlight at a perpendicular distance h from a horizontal floor. The light revolves at $N rev / \min$ about a horizontal axis perpendicular to the paper. Find the velocity of light spot traveling along the floor.

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23. A flywheel rotates with a uniform angular acceleration. Its angular speed increases from

$2\pi rad/s$ to $10\pi rad/s$ in $4s$. Find the number of revolutions in this period.

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24. When a fan is switched on, it makes 10 rotations in the first $2s$. How many rotations will it make in the next $2s$, assuming uniform angular acceleration?

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25. A wheel rotates under constant angular acceleration starting from rest. Find the ratio of angle rotated in $n \sec ond$ and $n^{th} \sec ond$.

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26. A wheel starting from rest is uniformely accelerated at $2rad/s^2$ for $5s$. It is allowed to rotated uniformly for the next $10s$ and is finally brought to rest in the next $5s$. Find the total angle rotated by the wheel.

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27. A wheel of radius $15cm$ is rotating about its axis at angluar speed of $20rad/s$. Find the linear speed and total acceleration of a point on the rim.

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28. A disc rotates about its axis with a constant angular accelertion of $2rad/s^2$. Find the radial and tangential accelerations of a

particle at a distance of $10cm$ from the axis at the end of the fourth second after the disc starts rotating.

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29. A uniform rod of length L is rotating about its one end in the horizontal plane under constant aceeleration α starting from rest. Find the linear velocity of its mid-point after time t_0. Also, find the normal and tangential components of acceleration of the mid-point of the rod at this instant.

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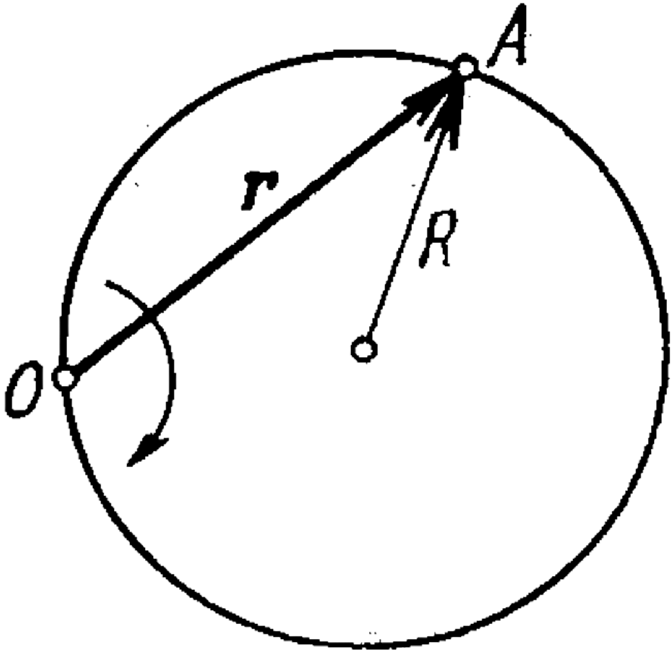
30. A particle A moves along a circle of radius $R = 50cm$ so that its radius vector r relative to the point O(figure) rotates with the constant angular velocity $\omega = 0.40 rad / s$. Find the modulus of the velocity of the particle, and the modulus and direction of its total acceleration.



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31. The angular position of a swinging door is described by $\theta = 5 + 10t + 20t^2$. Determine the angular position, angular speed and angular acceleration at $t = 2s$.

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32. The angular position of a point on the rim of a rotating wheel is given by $\theta = 4t^3 - 2t^2 + 5t + 3$ rad. Find

(a) the angular velocity at $t = 1s$,

(b) the angular acceleration at $t = 2s$.

(c) the average angular velocity in time interval $t = 0$ to $t = 2s$ and

(d) the average angular acceleration in time interval $t = 1$ to $t = 3s$.

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33. A solid body rotates about a stationary axis so that the rotation angle θ varies with time as $\theta = 6t - 2t^3$ radian. Find

(a) the angular acceleration at the moment when the body stops and

(b) the average value of angular velocity and angular acceleration averaged over the time interval between $t = 0$ and the complete stop.

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34. A solid body rotates with angular velocity $\overrightarrow{\omega} = 3t\hat{i} + 2t^2\hat{j} rad/s$. Find

(a) the magnitude of angular velocity and angular acceleration at time $t = 1s$ and

(b) the angle between the vectors of the angular velocity and the angular acceleration at that moment.

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35. A roller in a printing press turns through an angle $\theta = 3t^2 - t^3 rad.$

(a) Calculate the angular velocity and angular acceleration as a function of time t.

(b) What is the maximum positive angular velocity and at what time t does it occur?

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36. A particle describes circular motion with its angular displacement θ at anytime t is given by $\theta = 5t - 3$ radian. If the radius of circular path is $2m$, find the total acceleration of particle.

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37. A wheel rotates around a stationary axis so that the rotation angle θ varies with time as $\theta = 2t^2$ radian. Find the total acceleration of the point A at the rim at the moment $t = 0.5s$ If the radius of wheel is $1m$.

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38. A solid body starts rotating about a stationary axis with an angular acceleration $\alpha = kt$, where k is a constant. How soon after the beginning of motion will the total acceleration vector of an arbitrary point of the body form an angle 60° with its velocity vector?

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39. A solid body rotates about a stationary axis so that its angular velocity depends on the rotation angle φ as $\omega = \omega_0 - a\varphi$, where ω_0 and a are positive constants. At the moment $t = 0$ the angle $\varphi = 0$. Find the time dependence of

(a) the rotation angle,

(b) the angular velocity.

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40. A solid body starts rotating about a stationary axis with an angular acceleration $\alpha = \alpha_0 \cos\theta$, where α_0 is a constant and θ is an angle of rotation from the initial position. Find the angular velocity of the body as a function of θ.

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41. A solid body rotates with deceleration about a stationary axis with an angular deceleration $\beta \propto \sqrt{\omega}$, where ω is its angular velocity. Find the mean angular velocity of the body averaged over the whole time of rotation if at the initial moment of time its angular velocity was equal to ω_0.

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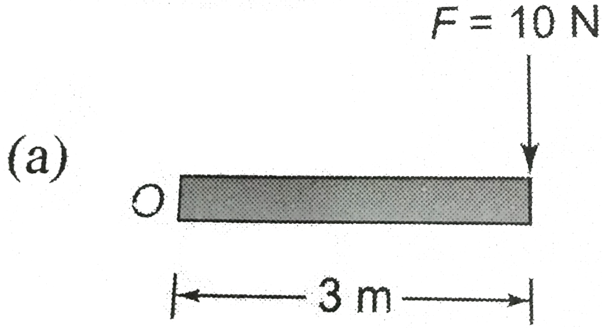
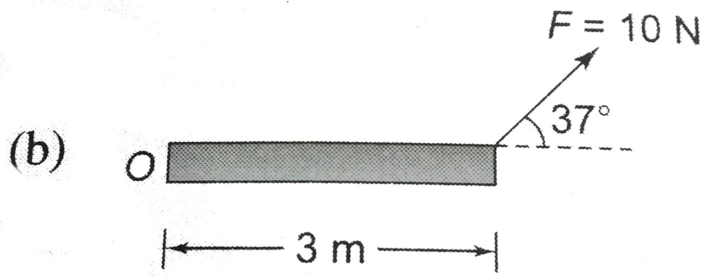
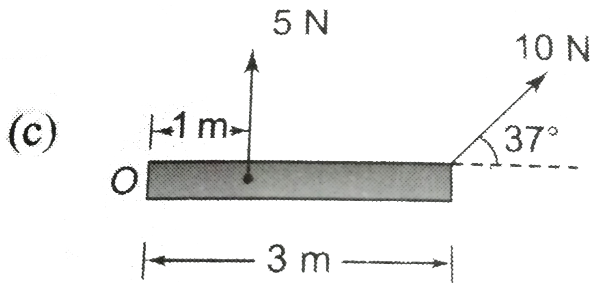
42. Calculate the torque (magnitude and direction) about point O due to the forces as shown. In each case, forces and rod lie in the plane of the paper.



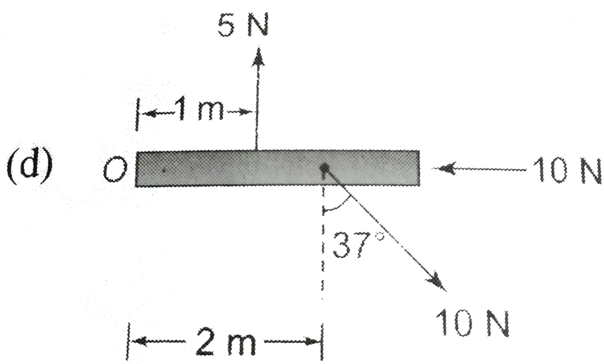
(a)



(b)



(c)



(d)

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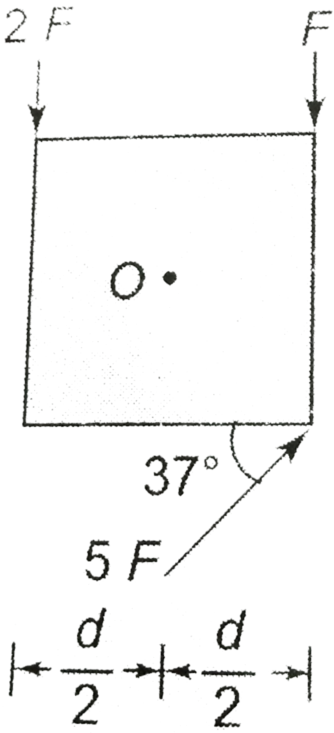
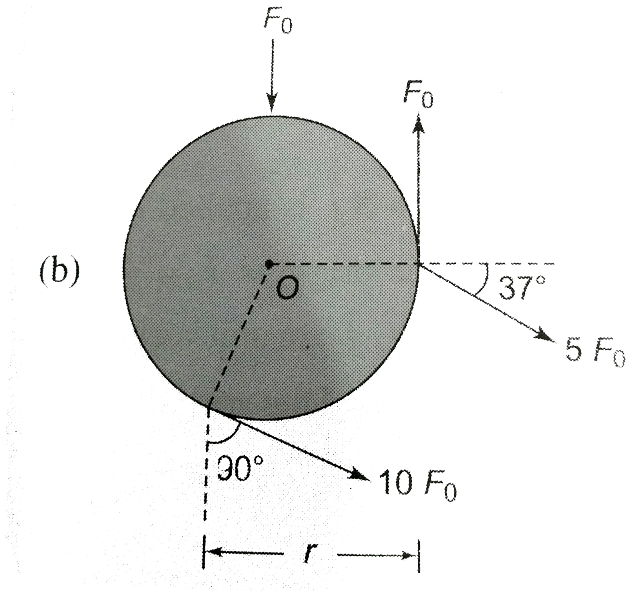
43. Find the torque of forces about O

(a)



(a)



(b)

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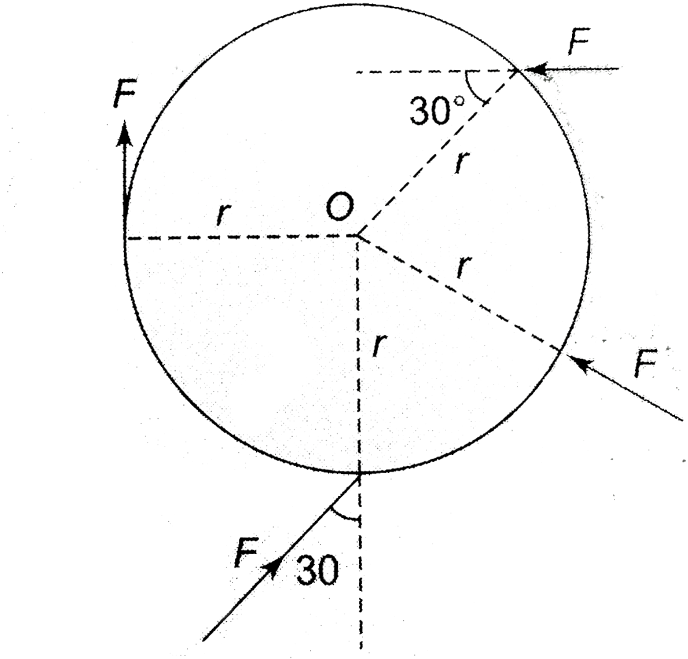
44. Find the total torque acting on the body shown in the figure about the point O.



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45. A particle of mass m is projected with a speed v_0 at an angle of projection θ with horizontal. Find the torque of the weight of

the particle about the point of projection after time $\dfrac{v_0 \sin \theta}{g}$

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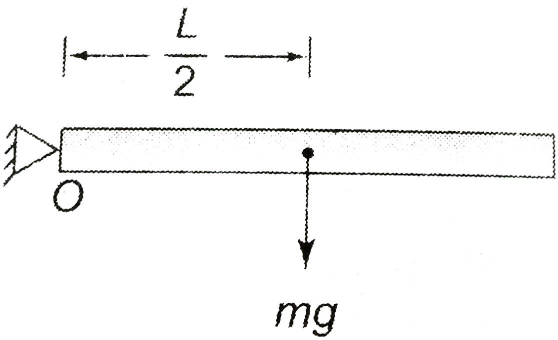
46. A uniform rod of length L and mass M is free to rotate about a frictionless pivot at one end. The rod is released from rest in the horizontal position. What are the initial angular acceleration of the rod and the initial linear acceleration of the right end of the Rod

?



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47. Find the torque of a force $\overrightarrow{F} = 3\hat{i} + 4\hat{j} + 5\hat{k}N$ about a point O, whose position vector is $\overrightarrow{r} = \hat{i} + \hat{j} + \hat{k}m$.

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48. A force $\overrightarrow{F} = A\hat{i} + B\hat{j}$ is applied to a point whose radius vector relative to the origin is $\overrightarrow{r} = a\hat{i} + b\hat{j}$, where a, b, A,B are constants and $\hat{i}$, $\hat{j}$ are unit vectors along the X and Y axes. Find the torque $\overrightarrow{\tau}$ and the arm l of the force $\overrightarrow{F}$ relative to the point O.

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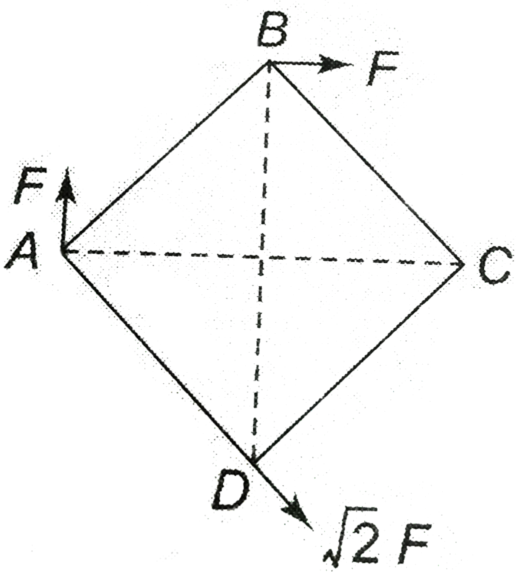
49. Three force are applied to a square plate as shown in the figure. Find the magnitude,

direction and point of application of the resultant force if this point is taken on the side BC.



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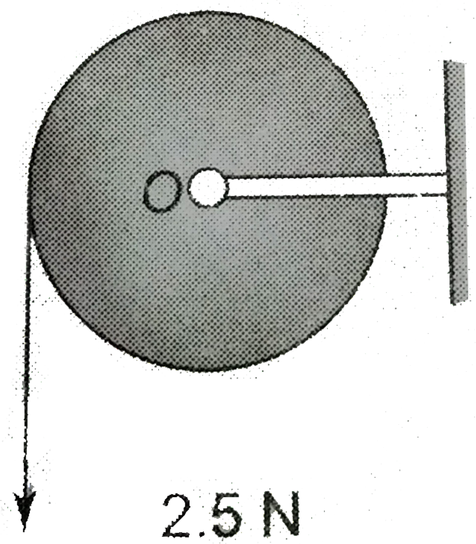
50. A pulley has the shape of a uniform solid disc of mass $2kg$ and radius $0.5m$. A string is wrapped over its rim and is pulled by a force of $2.5N$. The pulley is free to rotate about its axis. Initially, the pulley is at rest. Find the angular velocity and angle rotated by pulley in

$10s$.



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51. A wheel rotating at a speed of 120 rpm about its axis is brought to rest by applying a constant torque for $4s$. Find the number of revolutions completed by the wheel before stop.

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52. A pulley in the form of solid disc of mass $5kg$ and radius $1m$ is rotating at an angular speed of 120 rpm when the motor is turned off, Neglecting the friction at the axle, calculate the force that must by applied tangentially to the pulley to bring it to rest in 4 revolutions.

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53. A rod of mass M and length L lying horizontally is free to rotate about a vertical axis through its end. A horizontal force F on the rod at the other end, the force always remains perpendicular to the rod. Find the angular velocity of the rod when it has turned an angle $\pi / 2$.

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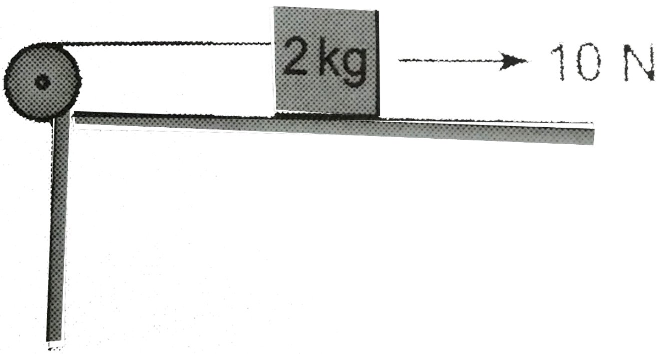
54. Consider the situation as shown in the figure. The moment of inertia of wheel is $2kgm^2$ and its radius is $0.25m$. Find the angular acceleration of the wheel, assuming no slipping.



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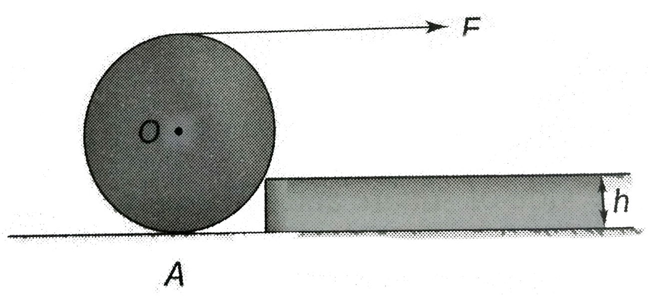
55. A cylinder of weight W and raidus R is to be raised onto a horizontal step of height $h = R/3$ as shown. A rope is wrapped around the cylinder and pulled horizontally. Assuming no slipping, find the minimum value of F to raise the cylinder.



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56. Two men support a uniform rod of mass M and length L at its two ends. If one of them suddenly withdraws, find the force excerted by the rod on the other man

(a) immediately after withdrawl and

(b) when the rod makes angle θ with vertical.

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57. A thin horizontal uniform rod AB of mass m and length l can rotate freely about a vertical axis passing through its end A. At a certain moment, the end B starts experiencing constant force F which is always perpendicular to the original position of the stationary rod and directed in a horizontal plane. Find the angular velocity of the rod as a function of its rotation angle ϕ counted relative to the initial position.

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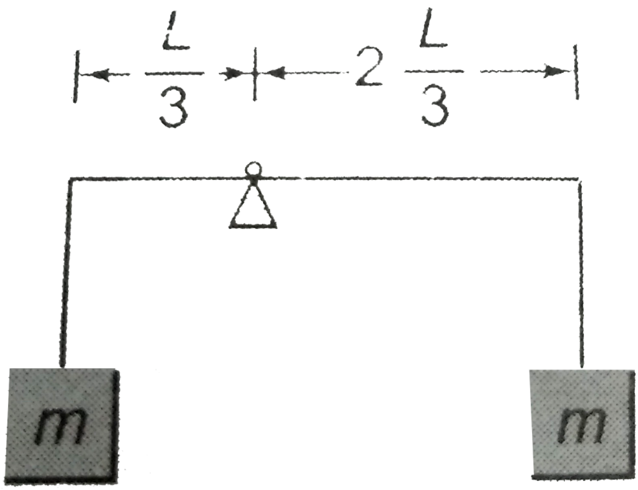
58. As shown in the figure, two blocks, each of mass m, suspended from the ends of a rigid light rod of length L. The rod is held horizontally on the fulcrum and then released.

(a) Find the initial angular acceleration of the rod.

(b) If the mass of rod is also m uniformly distributed. find the tension in the strings attached to blocks.



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59. Two masses $2m$ and m are attached to the ends of the card which passes over a pulley of mass m and radius R. Calculate the tension in the wire on both sides of the pulley. Assume no slipping.

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60. A uniform rod of mass m and length L is suspended through two vertical strings of equal lengths fixed at ends. A small object of mass $2m$ is placed at distance $L/4$ from the left end. Find the tensions in the two strings.

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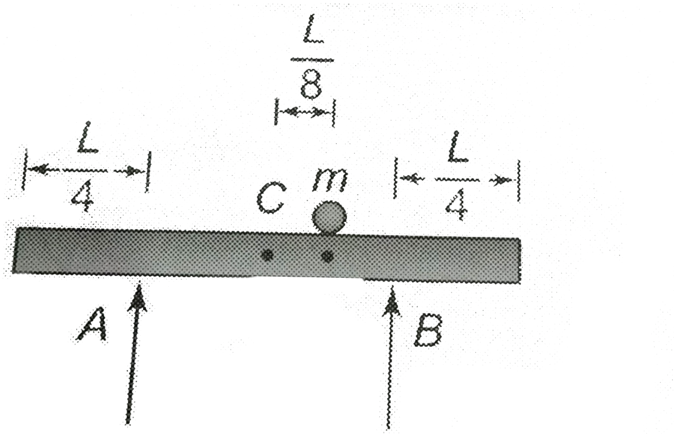
61. A uniform rod of mass M and length L rests on two supports. A ball of mass $m = M/3$ is placed at distance $L/8$ from the center as shown. Find reactions at supports.



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62. A uniform ladder of weight W and length L is resting between rough floor and smooth vertical wall. The ladder makes an angle 53° with horizontal. A man of weight $3W$ climbs the ladder and stays at distance $L/3$ as shown.

(a) Find the normal and friction force on the ladder at its base.

(b) Find the minimum coefficient of the static friction needed to prevent slipping at the base.

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63. A uniform rod is made to lean between a rough vertical wall and the ground. The coefficient of friction between the rod and the ground is μ_1 and between the rod and the wall is μ_2. Find the angle at which the rod can be leaned without slipping.

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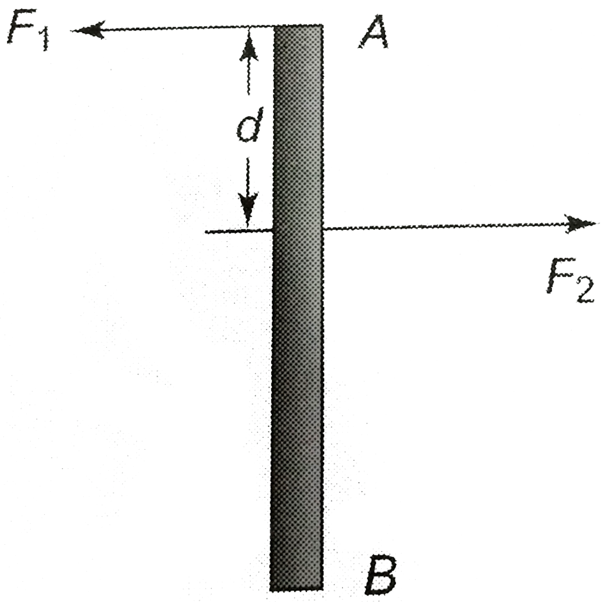
64. A Thin uniform rod AB of mass $m = 1.0kg$ moves translationally with acceleration $a = 2.0m/s^2$ due to two antiparallel forces F_1 and F_2. The distance between the points at which these forces are applied is equal to $d = 20cm$. Besides, it is known that $F_2 = 5.0N$. Find the length of the rod.



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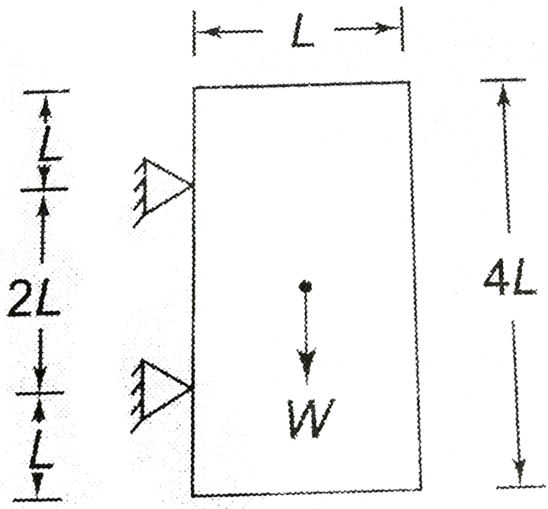
65. Consider the door of a room of wieght W

hinged at two points as shown in the diagram.

If the magnitude of forces by the hings on the door are equal, find the magnitude of force.



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66. A cubical box rests on a rough, horizontal, rectangular plank of friction coefficient $\frac{1}{\sqrt{3}}$.

Now the plank is slowly raised so that it makes some angle with horizontal. Find whether the box will slide first or topple.

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67. In the previous problem, if the coefficient of friction is μ, find whether the box will slide first or topple.

(a) If the box is of height h having square base measuring $a \times a$.

(b) If the box is hollow cylinder of radius r and height h.

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68. A cubical block of side a and of mass m rests on a rough horizontal surface. A horizontal force F is applied to normal to one of the faces at height h above the base $h > a/2$. What is the minimum value of F for which the cube begins to tip about an edge?

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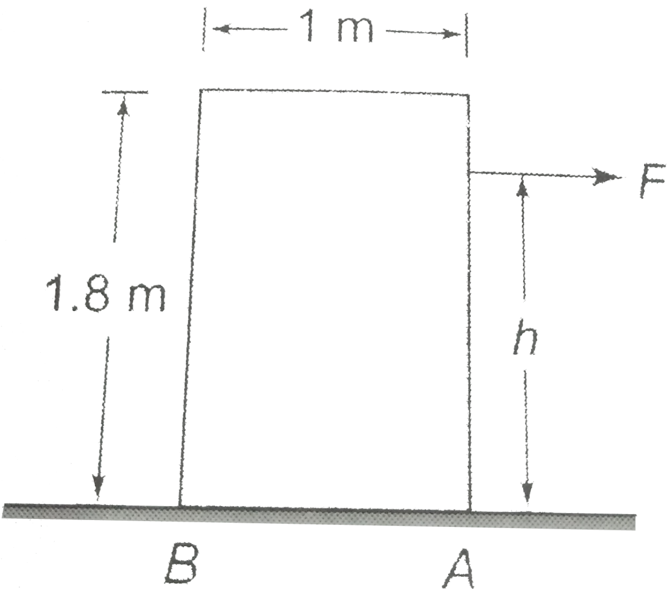
69. A rectangular block of square base ($1m \times 1m$) and height $1.8m$ is moving with constant speed on a rough horizontal surface ($\mu_k = 0.5$) due to horizontal force F as shown. If the mass of block is $40kg$, find

(a) the value of F_1

(b) the value of h at which the block just starts to tip

(c) If force F is applied at $h/2$, find the perpendicular distance of normal reaction from O (center of mass).



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70. Consider a vehicle taking turn on the horizontal curve with speed v. If the distance

between wheels is $2m$, height of center of mass above road is $1m$ and radius of circle is $57.6m$, find the maximum value of v for no overturning.

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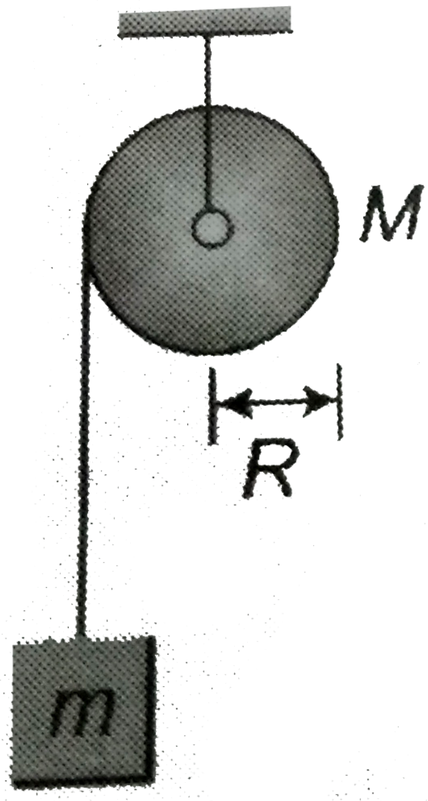
71. A frictionless pulley has the shape of a uniform solid disc of mass M and radius R. A stone of mass m is attached to a light wire that is wrapped around the rim of the pulley and a system is released from rest. If a stone falls by a distance h, what is the angular speed of pulley at that moment?



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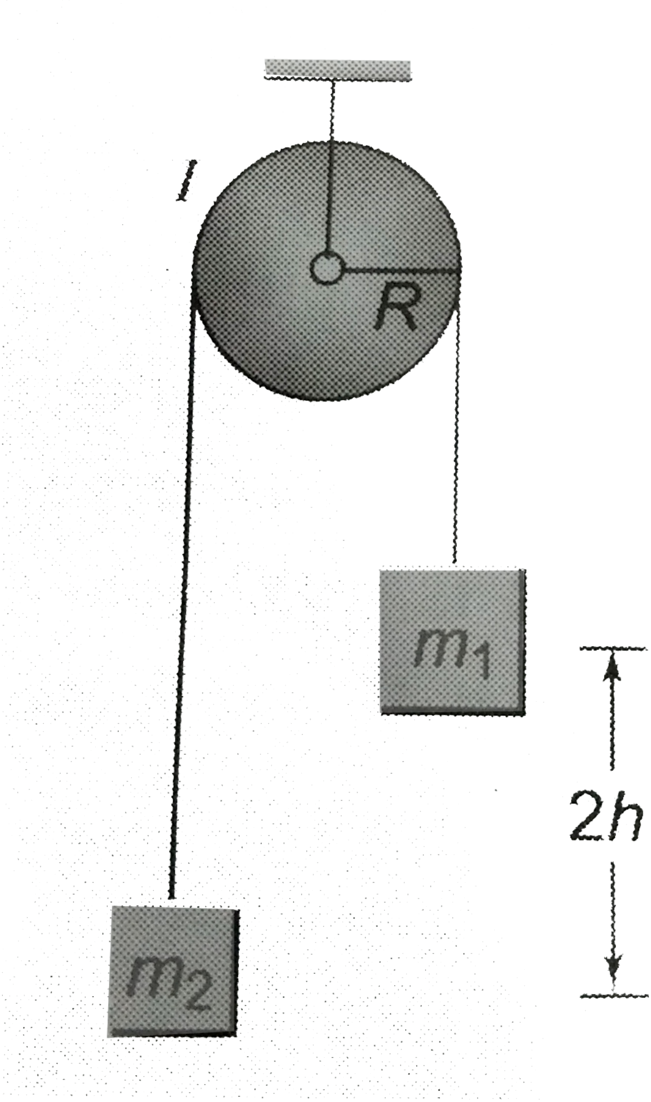
72. Consider the situation as shown in the figure. If $m_1 > m_2$, I is the moment of intertia about its axis of rotation, R is the radius of pulley. The objects are released from rest separated by a vertical distance $2h$. Find the translational speed of the objects as they pass each other. Assume no slipping.



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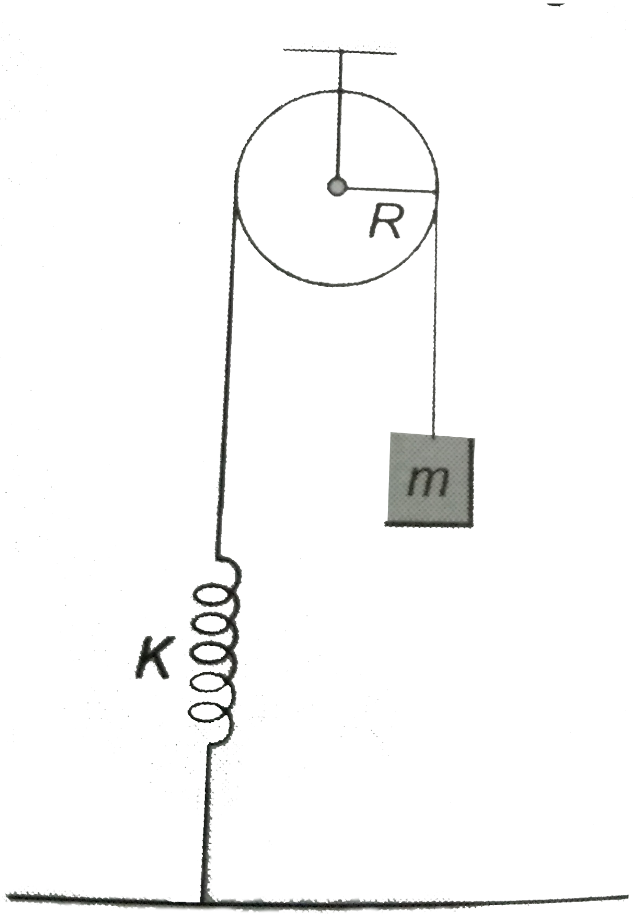
73. Consider the situation as shown in the diagram. The pulley has radius R and moment of inertia I. The block is release when the spring (spring constant k) is unstretched. Find the speed of block when the vlock has fallen a distance h. Assume no slipping.



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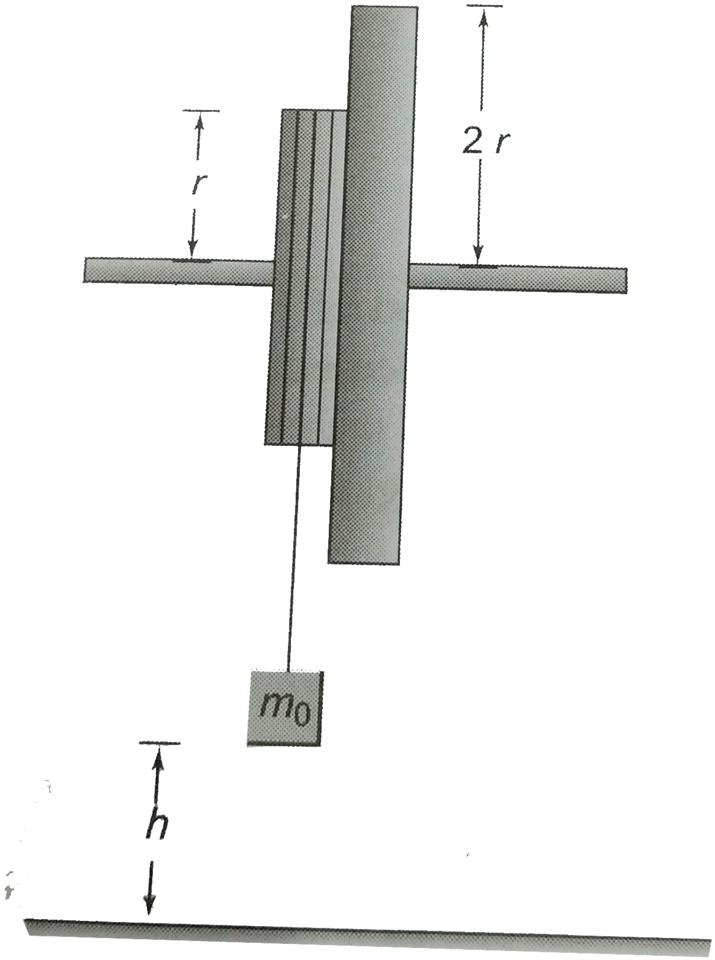
74. Two metal discs, one with radius r and mass m and the other with radius $2r$ and mass $2m$, are welded together and mounted on a frictionless axis through their common center.

(a) What is the total moment of inertia of the two discs?

(b) A light string is wrapped around the edge of the smaller disc and a block of mass m_0 is suspended from the free end of the string. If the block is released from rest at a distance h, what is its speed just before it strikes the floor?



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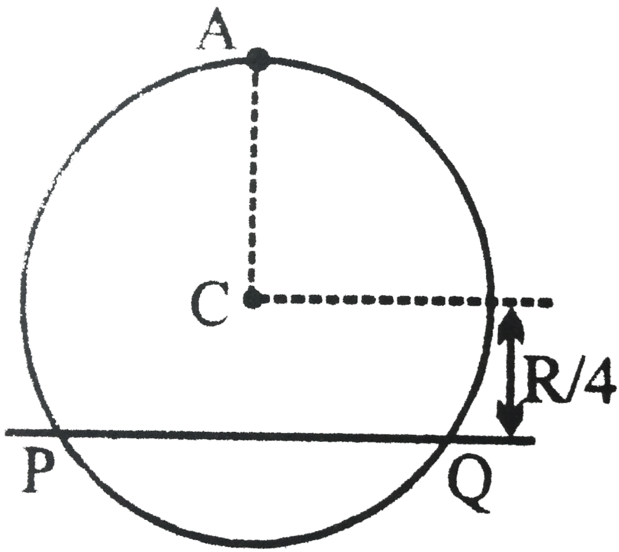
75. A uniform circular disc has radius R and mass m. A particle also of mass m is fixed at a point A on the wedge of the disc as in fig. The disc can rotate freely about a fixed horizontal chord PQ that is at a distance $R/4$ from the centre C of the disc. The line AC is perpendicular to PQ. Initially the disc is held vertical with the point A at its highest position. It is then allowed to fall so that it tarts rotating about PQ. Find the linear speed of the particle at it reaches its lowest position.



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76. Consider a uniform rod of mass M and length L is hinged at one end as shown.

Initially the rod is vertical, it is slightly pushed and released. Find the angular velocity of rod and liner velocity of its one end when the rod becomes horizontal. Also calculate angular velocity of rod when it has rotated by an angle $\theta(\theta < 90^\circ)$.

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77. A uniform rod of mass M and length L is hinged at its end. The rod is released from its vertical position by slightly pushing it. What is the reaction at the hinge when the rod becomes horizontal, again vertical.

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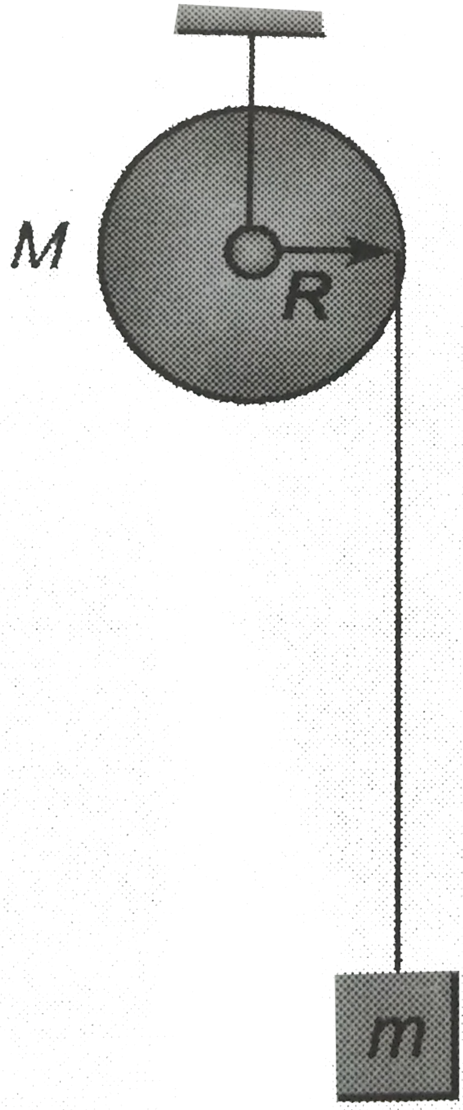
78. A light thread with a body of mass m tied to its end is wound on a uniform solid cylinder of mass M and radius R. At a moment $t = 0$ the system is set in motion. Assuming the friction in the axle of the cylinder to be negligible, find the time dependence of

(a) the angular velocity of the cylinder and

(b) the kinetic energy of the whole system ($M = 2m$).



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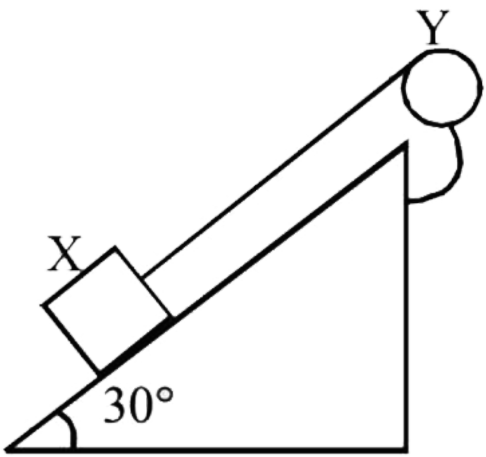
79. A block X of mass 0.5 kg is held by a long massless string on a frictionless inclined plane of inclination 30° to the horizontal. The string is wound on a uniform solid cylindrical drum Y of mass 2kg and of radius 0.2 and of radius 0.2 m as shown in Fingure. The drum is given an initial angular velocity such that the block X starts moving up the plane.

(i) Find the tension in the string during the motion.

(ii) At a certain instant of time the magnitude of the angular velocity of Y s $10 rad s^{-1}$ calculate the distance travelled by X from that instant of time until it comes to rest



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80. A playground merry-go-round has radius $2m$ and moment of inertia $2000kgm^2$ about a vertical axle through its center.

(a) A boy applies $50N$ force tangentially to the edge of the merry-go-round for $20s$. If the merry-go-round is initially at rest, what is its angular speed after $20s$?

(b) How much work did the boy do on the merry-go-round?

(c) What is the average power supplied by the child?

(d) What is the instantaneous power supplied by the child at $t = 20s$?

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81. A flywheel of moment of inertia $10kgm^2$ is rotating at $50rad/s$. It must be brought to stop in $10s$.

(a) How much work must be done to stop it?

(b) What is the required average power?

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82. The engine delivers $150kW$ at an angular speed of $600 rev / \min$.

(a) How much torque does the engine provide? How much work does the engine do in two revolutions?

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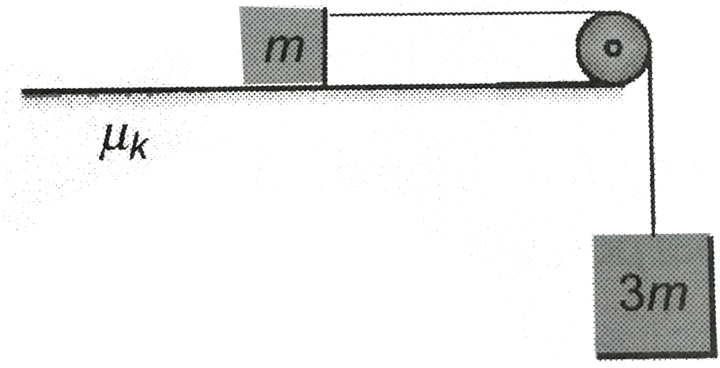
83. Consider the situation as shown in the figure. The pulley has moment of inertia I and radius r. The table is rough and the coefficient of kinetic friction is μ_k. The system is released from the rest. Calculated speed of block of mass $3m$ as a function of the distance h it has descended. Assume no slipping.



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84. Find the angular momentum of the particle about O in the following situations.

(a) A particle of mass m moving with velocity v parallel to the x-axis at distance d from it.

(b) A particle of mass m moving with velocity v on a line $y = x + 3$.

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85. A particle of mass m is thrown with speed v_0 at angle 30° with horizontal. Find the angular momentum about the point of projection when the particle is at the highest point of its trajectory.

86. Two balls of masses m and $2m$ are attached to the ends of a light rod of length L. The rod rotates with an angular speed ω about an axis passing through the center of mass of system and perpendicular to the plane. Find the angular momentum of the system about the axis of rotation.

87. Find the angular momentum about the axis of rotation and kinetic energy.

(a) A uniform circular disc of mass m and radius R rotating about its diameter with an angular speed ω.

(b) A uniform square plate of mass m and edge L rotating about its diagonal with an angular speed ω.

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88. Find the angular momentum of the earth

(a) about the sun due to its orbital motion and

(b) about its axis due to its spinning motion.

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89. A particle of mass m is projected at $t = 0$ from the point P on the ground with speed v_0 at an angle of θ to the horizontal. Find the magnitude and direction of the angular momentum of the particle at time $t = \dfrac{v_0 \sin\theta}{2g}$.

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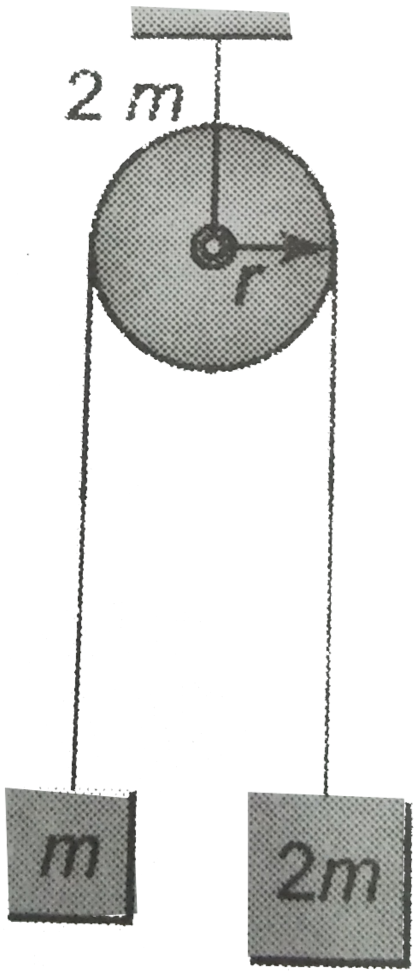
90. Two blocks of masses $2m$ and m are connected by a light string going over a pulley of mass $2m$ and radius R as shown in the figure. The system is released from rest. Find the angular momentum of system when the mass $2m$ has descended through a height h.

Assume no slipping.



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91. If radius of the earth is doubled without change in its mass, what will be the length of the day?

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92. A thin uniform circular disc of mass M and radius R is rotating in a horizontal plane about an axis passing through its center and perpendicular to its plane with an angular velocity ω. Now two particles each of mass m

are placed on its perimeter along a diameter along a diameter. Find the new angular velocity. If $m = M/2$, find the percentage change in the angular velocity.

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93. A child stands at the turn table center of a turnable with his two arms outstretched. The turnable is set rotating with an angular speed of $10 rad/s$. If the child folds his hands back so that the moment of inertia reduces to $3/5$

times the initial value, find the new angular speed. Why does the kinetic energy of child increase?

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94. Two discs of moments of inertia I_1 and I_2 about their respective axes (normal to the disc and passing through the centre) and rotating with angular speeds ω_1 and ω_2 are brought into contact face to face with their axes of rotation coincident.

(a) Does the law of conservation of angular momentum apply to the situation ? Why ?

(b) Find the angular speed of the two-disc system.

(c) Calculate the loss in kinetic energy of the system in the process.

(d) Account for this loss.

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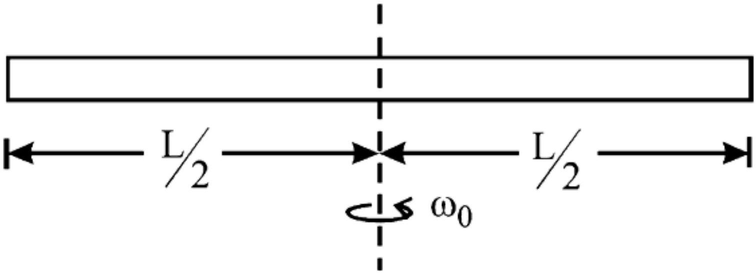
95. A smooth uniform rod of length L and mass M has two identical beads of negligible

size each of mass m which can slide freely along the rod. Initially the two beads are at the centre of the rod and the system is rotating with an angular velocity ω_0 about an axis perpendicular to the rod and passing through the midpoint of the rod. There are no external forces. When the beads reach the ends of the rod, the angular velocity of the system is ......



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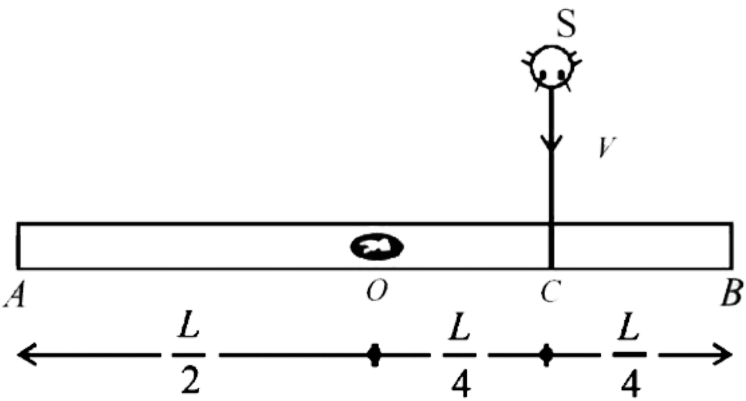
96. A homogeneous rod AB of length L = 1.8 m and mass M is pivoted at the center O in such a way that it can rotate it can rotate freely position. An insect S of the same mass M falls vertically with speed V on the point C, midway between the points O and B. Immediately after falling, the insect moves towards the end B such that the rod rotates with a constant angular velocity omega.

(a) Determine the angular velocity ω in terms of V and L.

(b) If the insect reaches the end B when the rod has turned through an angle of 90°, determine V.



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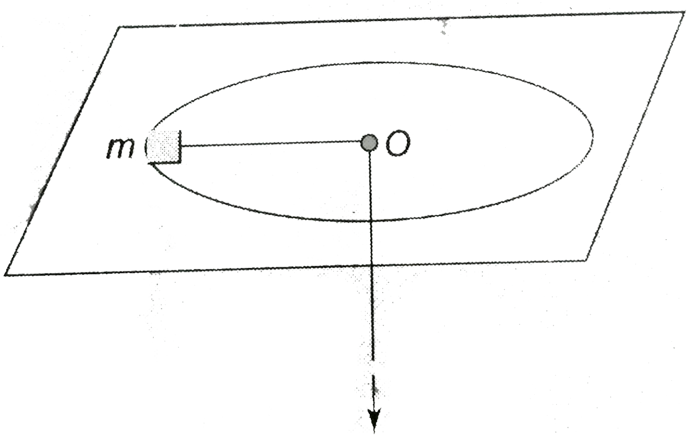
97. A small block of mass m on a horizontal smooth table is attached to a light string passing through a hole as shown in the figure. Initially, the block moves in a circle of radius r

with speed v and the string is held by a person. The person pulls the strin slowly to decrease the radius of circle to $r/2$. (a) Find the tension in the string when the block moves in a circle of radius $r/2$. (b) Calculate the change in the kinetic energy of the block.



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98. A stone of mass m tied to the end of a string, is whirled around in a horizontal circle. (Neglect the force due to gravity). The length of the string is reduced gradually keeping the angular momentum of the stone about the centre of the circle constant. Then, the tension in the string is given by $T = Ar^n$ where A is a constant, r is the instantaneous radius of the circle and n=....

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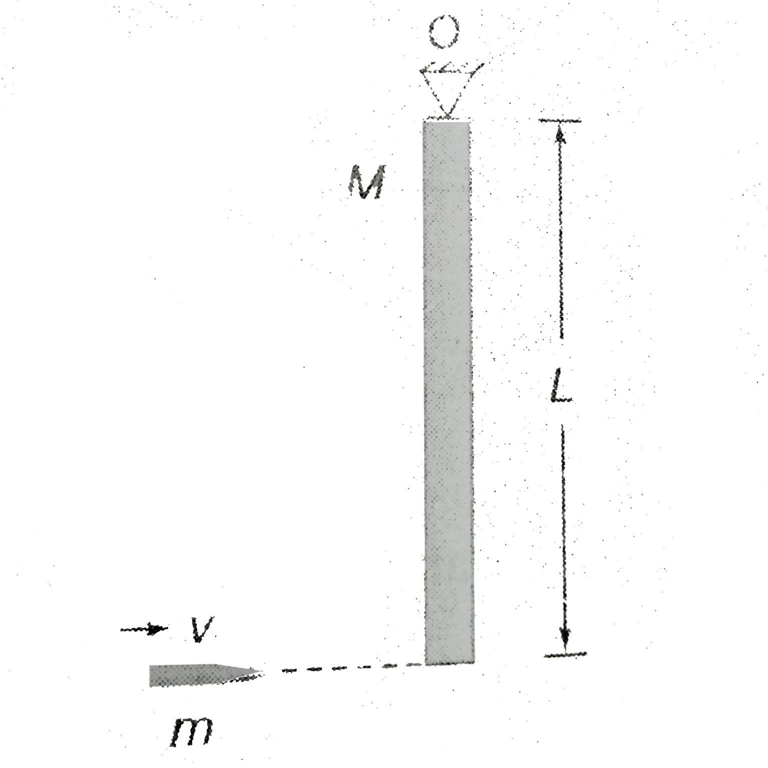
99. A bird of mass m is flying horizontally with speed v_0 suddenly strikes a vertical rod of mass $3m$ and length L hinged at its base at distance $L/3$ from the top of the rod. After collision the bird drops to the ground (but soon recovers to fly happly away). What is the angular velocity of the rod

(a) just after it is hit by the bird and

(b) just as it reaches the ground?

100. A wooden log of mass M and length L is hinged by a frictionless nail at O. A bullet of mass m strikes with velocity v and sticks to it. Find the angular velocity of the system, immediately after the collision about O. Also, calculate the minimum value of v so that log becomes horizontal after collision.



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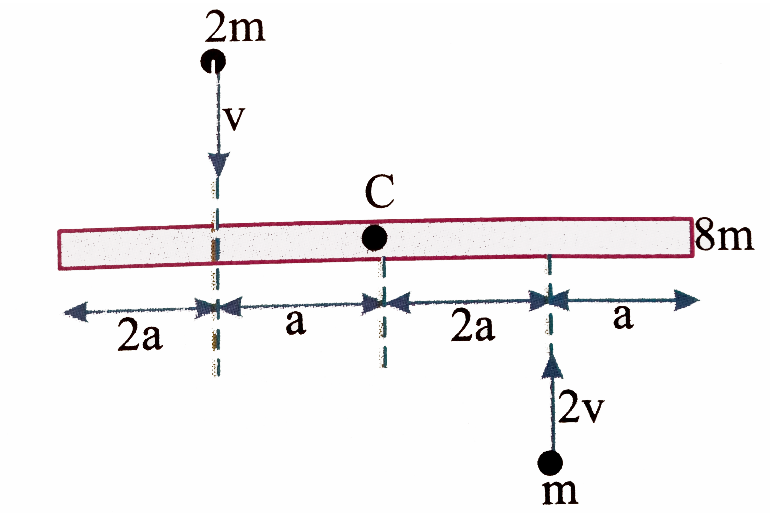
101. A uniform bar of length $6a$ and mass $8m$ lies on a smooth horizontal table. Two point masses m and $2m$ moving in the same horizontal plane with speeds $2v$ and v respectively, strike the bar (as shown in figure) and stick to the bar after collision. Calculate (a) velocity of the centre of mass (b) angular velocity about centre of mass and (c) total kinetic energy, just after collision.



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102. A heavy circular disc of mass M is revolving in a horizontal plane with angular speed ω_0 about its center which is fixed. An insect of mass m walks from the center to the edge and then files away. Find the final angular speed of disc.

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103. In the previous problem, initially the insect is at the edge and the disc is rotating with angular speed ω_0 in clockwise direction. Now the insect starts walking along the rim with speed v relative to the disc also in clockwise direction. Find new angular speed of platfrom.

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104. A uniform circular board of mass M and radius R is fixed on a horizontal plane and free to rotate along a vertical axis through its center. A man of mass m walks round the edge of the board without slipping, when he has walked completely round the board to his starting point, find the angle turned by the board.

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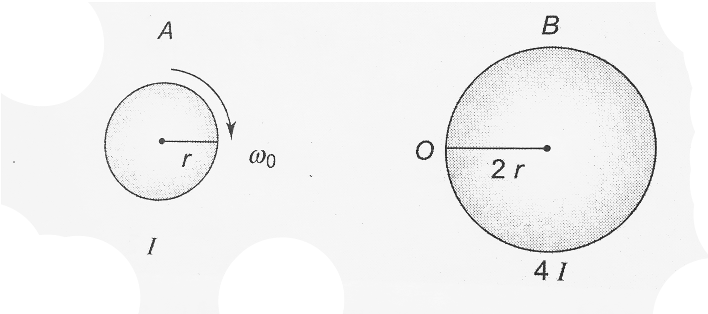
105. Two horizontal discs A and B of radii r and $2r$ having moments of inertia I and $4I$ about their axes. Initially, disc A is rotating with ω_0 and disc B is at rest. Their rims are now brought in contact. The discs first slip over each other at the contact but slipping finally ceases due to the fricition between them. Find the angular speeds of the discs after the slipping ceases. Also, find the loss in kinetic energy.



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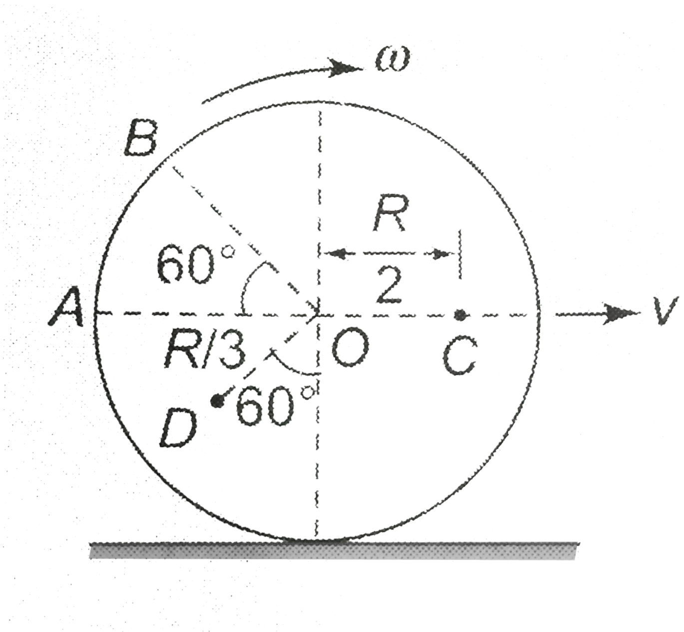
106. A disc rolls without slipping on a horizontal surface such that its velocity of center of the mass is v. Find the velocity of points A,B,C and D.



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107. A solid sphere of mass m and radius R rolls without slipping on the horizontal surface such that its velocity of center of mass is v_0. Find its translational kinetic energy, rotational kinetic energy, total kinetic energy, gravitational potential energy taking surface as reference level and mechanical energy.

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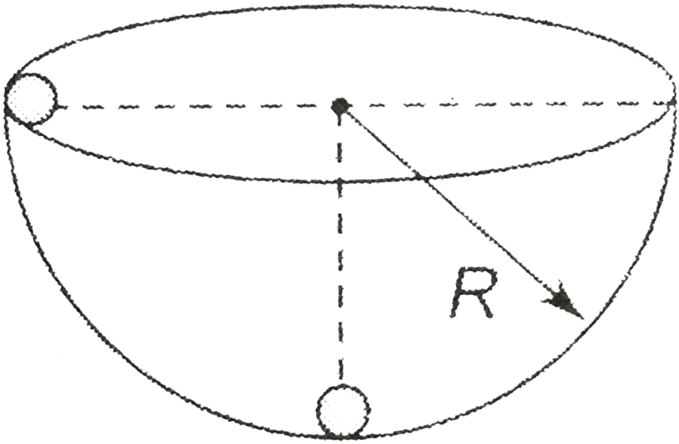
108. Consider the situation as shown in the figure. A solid sphere of mass m is released from rest from the rim of a hemispherical cup so that it rolls along the surface. Find the normal contact force between the solid sphere and the cup at the bottom most point.



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109. A uniform ball of radius r rolls without slipping down from the top of a sphere of radius R Find the angular velocity of the ball at the moment it breaks off the sphere. The initial velocity of the ball is negligible.

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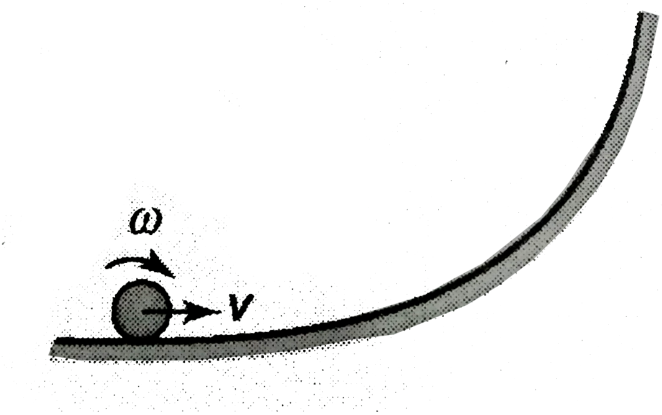
110. A hollow sphere rolls without slipping the on the horizontal surface such that its translational velocity is v. Find that the maximum height attained by it on an inclined surface.



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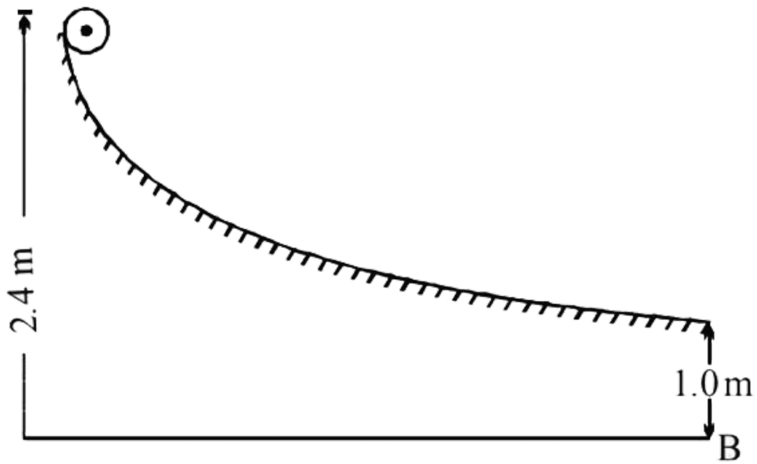
111. A small sphere rolls down without slipping from the top of a track in a vertical plane. The track has an elevated section and a horizontal part, The horizontal part, is 1.0 metre above the ground lenvel and the top of the track is 2.4 meters above the ground. Find the distance on the ground with respect to the point B (which is vertically below the end of the track as shown i fig.) where the sphere lands. During its flight as a projectlie, does the sphere continue to rotate about its centre of mass? Explain.



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112. A carpet of mass M is rolled along its length so as to from a cylinder of radius R and is kept on a rough floor. When a negligibly small push is given to the cylindrical carpet, it stars unrolling itself without sliding on the floor. Calculate horizontal velocity of cylindrical part of the carpet when its radius reduces to $R/2$.

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113. A wheel of radius R rolls without slipping on the horizontal surface with speed v_0. When the contact point is P on the road, a small patch of mud separates from the wheel at its highest point strikes the road at point Q. Find distance PQ.

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114. A hollow sphere of mass M lies on a rough horizontal plane when a particle of mass m traveling with speed v collides and sticks with it. If line of motion of the particle is at height h above the center of sphere, find h if the body rolls without slipping after collision $(m < < M)$.

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115. A sphere of mass m and radius r rolls without slipping on the horizontal surface with speed v. During its motion it encounters a fixed rectangular block of height $h = \frac{r}{4}$ as shown. The collision is inelastic. Find the angular speed of sphere immediately after collision. The body rolls without slipping.

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116. A solid sphere of mass m and radius R is hit by a cue at height h above the center of sphere. The cue applies a force F and the contact period is small time t. Find

(a) the velocity of center of mass,

(b) the angular speed of sphere about the center of mass and

(c) the value of h so that the sphere rolls without slipping after removal of force.

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117. A point A is located on the rim of a wheel of radius $R = 0.50m$ which rolls without slipping along a horizontal surface with velocity $v = 1.00m/s$. Find:

(a) the modulus and the direction of the acceleration vector of the point A,

(b) the total distance s traveresed by the point

A between the two successive moments at which it touches the surface.

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118. A thin uniform rod of mass M and length L is lying on a smooth horizontal floor. It is struck by a force F normally at one end. The contact lasts for a very small time t_0. Find the distance traveled by the rod in the time in which it is turned by $\pi / 2$.

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119. A rod AB of mass M and length L is lying on a horizontal frictionless surface. A particle of mass m traveling along the surface hits the end A of the rod with a velocity v_0 in a direction perpendicular to AB. The collision is completely elastic. After the collision the particle comes to rest. Find the ration m/M.

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120. A uniform rod of mass M and length L lies on a smooth horizontal plane. A particle of mass m moving at a speed v perpendicular to the length of the rod strikes it at a distance $L/6$ from the center and stops after the collision. Find

(a) the velocity of center of mass of rod and

(b) the angular velocity of the rod about its center just after collision.

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121. In the previous problem, particle strikes and sticks to rod. Repeat the problem (given $m < < M$).

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122. A uniform rod of mass M and length L lies on a frictionless horizontal plane. A particle of same mass M moving with speed v_0 perpendicular to the length of the rod strikes the end of the rod and sticks to it. Find the velocity of the center of mass and the angular velocity about the center of mass of (rod + particle) system.

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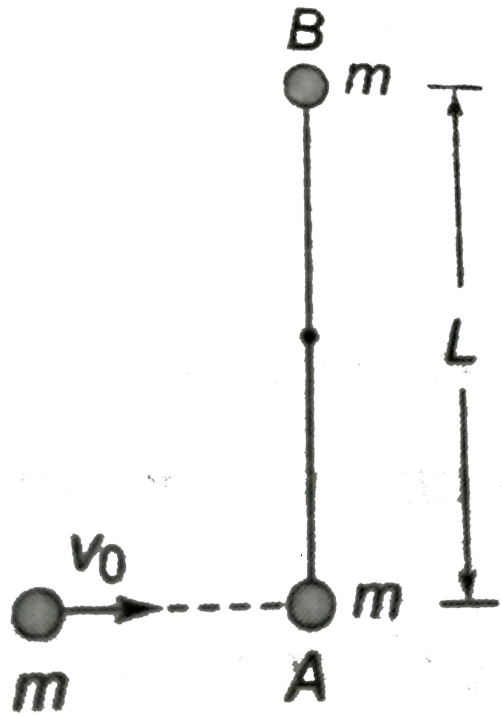
123. Two particles A and B, each of mass m, are connected by a light rod of length L lying on a smooth horizontal surface. A particle of mass m moving with speed v_0 strikes to the end of rod and sticks to A as shown . Find

(a) the velocity of the center of mass,

(b) the angular velocity about the center of mass of system ($A+B+$ particle) and

(c) the linear speeds of A and B immediately after collision.



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124. A solid sphere of radius R lies on a smooth horizontal surface. It is pulled by a horizontal force acting tangentially from the highest point. Find the distance traveled by the sphere during the times it makes one rotation.

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125. A solid cylinder has a thin string wrapped several times around its circumference. The string is fixed at one end and the cylinder is released. Find the downward acceleration of cylinder and tension in the string.

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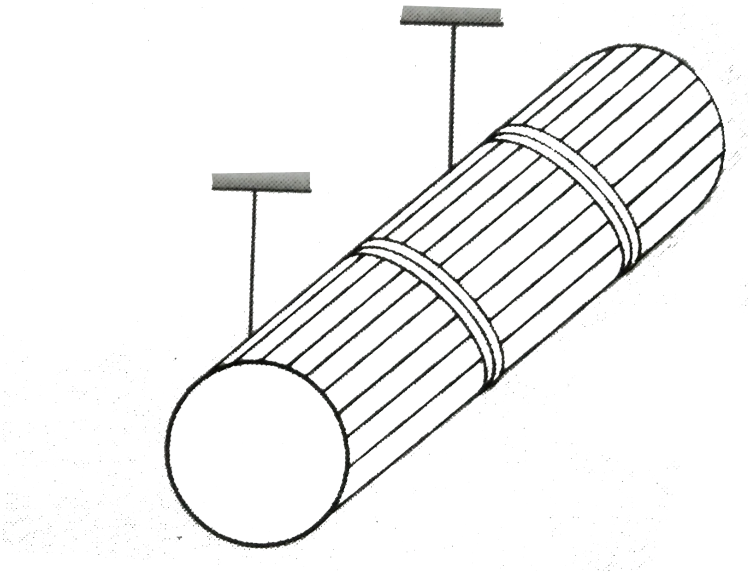
126. A uniform cylinder of mass m and radius R starts descending at a moment $t = 0$ due to gravity, Neglecting the mass of the thread, find

(a) the tension of each thread and the angular acceleration of the cylinder,

(b) the time dependence of the instantaneous power developed by the gravitational force.



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127. A force F acts tangentially at the highest point of a solid cylinder of mass m kept on a rough horizontal plane. If the cylinder rolls

without slipping, find the acceleration of the center of cylinder.

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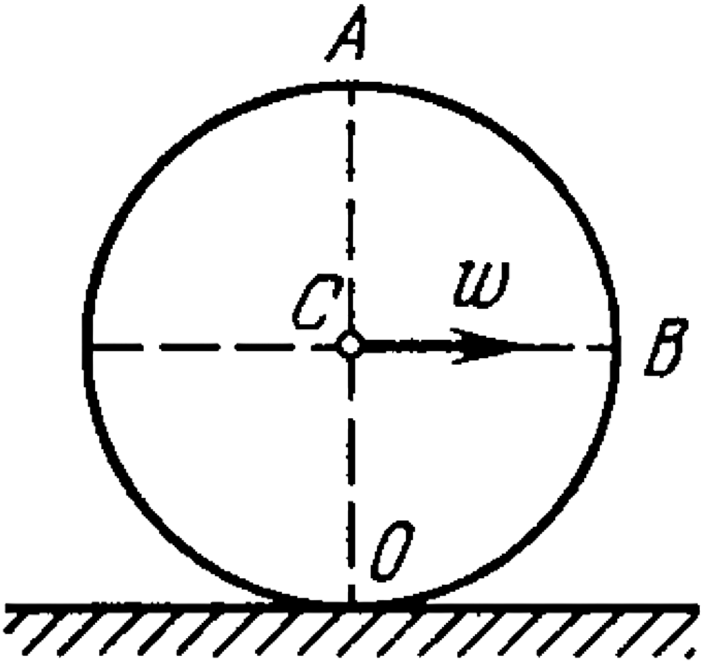
128. A ball of radius $R = 10.0cm$ rolls without slipping down an inclined plane so that its centre moves with constant acceleration $w = 2.50cm/s^2$, $t = 2.00s$ after the beginning of motion its position corresponds to that shown in figure. Find:

(a) the velocities of the points A, B, and O,

(b) the accelerations of these points.



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129. A hollow sphere is released from the top of an inclined plane of inclination θ and length L. If a hollow sphere rolls without slipping, what will be its speed when it reaches the bottom?

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130. A cylinder of mass m rolls without slipping on an inclined plane of inclination θ. Find the liner acceleration of the sphere and friction acting on it. What should be the minimum coefficient of static friction to support pure rolling?

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131. (a) A rigid body of radius of gyration k and radius R rolls without slipping down a plane inclined at an angle θ with the horizontal. Calculate its acceleration and the frictional force acting on it.

(b) If the body be in the form of a disc and

$\theta = 30^\circ$, what will be the acceleration and the frictional force acting on it.

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132. A uniform sphere of mass m and radius R rolls without slipping down an inclined plane set at an angle θ to the horizontal. Find

(a) the friction coefficient at which slipping is absent,

(b) the kinetic energy of the sphere t seconds after the beginning of motion.

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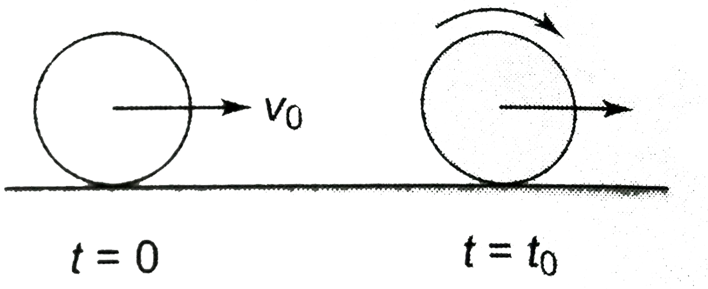
133. A uniform disc of mass m and radius R is projected horizontally with velocity v_0 on a rough horizontal floor so that it starts off with a purely sliding motion at $t = 0$. After t_0 seconds, it acquires pure rolling motion as shown in the figure.

(a) Calculate the velocity of the center of mass of the disc at t_0.

Assuming that the coefficent of friction to be

μ, calculate t_0.



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134. A uniform solid cylinder of mass m and radius R is set in rotation about its axis with an angular velocity ω_0, then lowered with its lateral surface onto a horizontal plane and released. The coefficient of friction between the cylinder and the plane is equal to μ. Find

(a) how long the cylinder will move with sliding,

(b) the total work performed by the sliding friction force acting on the cylinder.

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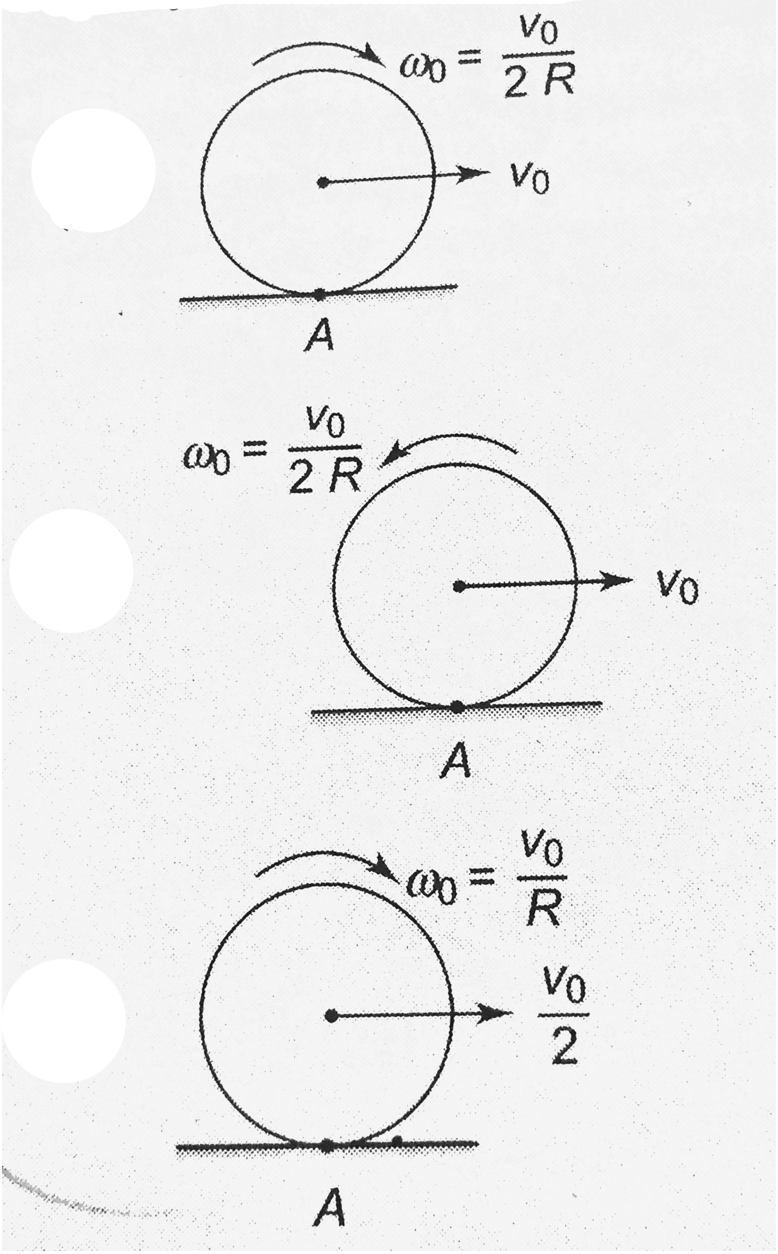
135. Consider a hollow sphere rolling with slipping with velocities as shown. Find the translational velocity after the hollow sphere starts pure rolling.

(a) 
$\omega_0 = \frac{v_0}{2R}$
v_0
A
$\omega_0 = \frac{v_0}{2R}$
v_0
A
$\omega_0 = \frac{v_0}{R}$
$\frac{v_0}{2}$
A

(b)

(c)

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136. A horizontal force F is applied at a height h above the center of a solid cylinder of mass m and radius R. Determine friction, if cylinder rolls without slipping. For what value of h, friction is zero.

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137. A cylinder of mass M and radius R is resting on a horizontal platform (which is parallel to the x-y plane) with its axis fixed along the y-axis and free to rotate about its axis. The platform is given a motion in the x-direction given by $x = A\cos(\omega t)$. There is no slipping between the cylinder and platform. The maximum torque acting on the cylinder during its motion is ....

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138. A ring, a solid cylinder and a solid sphere, all having same mass and radius, are placed at the top of an incline and released. The friction coefficents between the objects and the incline are same and not sufficient to allow pure rolling.

(a) Which body will reach the bottom first?

(b) Which body will have the minimum kinetic energy at the bottom?

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Exercise

1. Three point masses, each of mass m, are placed at the corners of an equilateral triangle of side L. The moment of inertia of this system about an axis along one side of the triangle is

A. mL^2

B. $\frac{3mL^2}{4}$

C. $3mL^2$

D. $\frac{3mL^2}{2}$

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2. The moment of inertia of a disc of mass M and radius R about an axis. Which is tangential to sircumference of disc and parallel to its diameter is.

A. $\frac{5Mr^2}{4}$

B. $\frac{5Mr^2}{2}$

C. $\frac{3Mr^2}{4}$

D. $\frac{Mr^2}{2}$

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3. Let I_A and I_B be moments of inertia of a body about two axes A and B respectively. The axis A passes through the centre of mass of the body but B does not. Then

A. $I_A < I_B$

B. If the axes are parallel, $I_A < I_B$

C. If the axes are parallel, $I_A = I_B$

D. If the axes are not parallel, $I_A > I_B$

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4. A closed cylindrica tube containing some water (not filling the entire tube) lies in a horizontal plane. If the tueb is rotated about a perpendicular bisector, the moment of inertia of water about the axis

A. increases

B. decreases

C. remains constant

D. increases if the rotation is clockwise.

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5. A uniform cylinder has radius R and length L. If the moment of inertia of this cylinder about an axis passing through its centre and normal to its circular face is $\frac{mR^2}{2}$ is equal to moment of inertia of the same cylinder about an axis passing through its centre and normal to its length, then

A. $L = R$

B. $L = \sqrt{3}R$

C. $L = \frac{R}{\sqrt{3}}$

D. $L = \sqrt{\frac{3}{2}}R$

Answer: B

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6. A solid sphere of mass M, radius R and having moment of inertia about as axis passing through the centre of mass as I, is recast into a disc of thickness t, whose moment of inertia about an axis passing through its edge and perpendicular to its plance remains I. Then, radius of the disc will be.

A. $\frac{2R}{\sqrt{15}}$

B. $R\sqrt{\frac{2}{15}}$

C. $\frac{4R}{\sqrt{15}}$

D. $\frac{R}{4}$

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7. Two circular discs are of same thickness. The diameter of A is twice that of B. The moment of inertia of A as compared to that of B is

A. twice as large

B. four times as large

C. 8 times as large

D. 16 times as large

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8. The moment of inertia of a circular disc of mass M and radius R about an axis passing thrugh the center of mass is I_0. The moment of inertia of another circular disc of same mass and thickness but half the density about the same axis is

A. $\frac{I_0}{8}$

B. $\frac{I_0}{4}$

C. $8I_0$

D. $2I_0$

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9. From a uniform wire, two circular loops are made (i) P of radius r and (ii) Q of radius nr. If the moment of inertia of Q about an axis passing through its center and perpendicular to tis plane is 8 times that of P about a similar axis, the value of n is (diameter of the wire is very much smaller than r or nr)

A. 8

B. 6

C. 4

D. 2

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10. The moment of inertia of a uniform rod about a perpendicular axis passing through one end is I_1. The same rod is bent into a ring and its moment of inertia about a diameter is I_2. Then I_1 / I_2 is

A. $\frac{\pi^2}{3}$

B. $\frac{2\pi^2}{3}$

C. $\frac{4\pi^2}{3}$

D. $\frac{8\pi^2}{3}$

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11. The density of a rod AB increases linearly from A to B its midpoint is O and its centre of mass is at C. four axes pass through A, B, O and C, all perpendicular to the length of the rod. The moment of inertial of the rod about these axes are I_A, I_B, I_O and I_C respectively.

A. (i),(ii)

B. (ii),(iii)

C. (ii),(iv)

D. (i),(iii)

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12. The $M.\,I.$ of a rod about an axis through its center and perpendicular to it is I_0. The rod is bent in the middle so that the two halves make an angle θ. The moment of inertia of the bent rod about the same axis would be

A. $I_0 \sin^2 \theta$

B. $I_0 \cos^2 \theta$

C. I_0

D. $\frac{I_0}{2}$

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13. The moment of inertia of a thin uniform rod of mass M and length L about an axis passing through its mid-point and perpendicular to its length isI_0. Its moment of inertia about an axis passing through one of its ends perpendicular to its length is.

A. $I_0 + ML^2$

B. $I_0 + \frac{ML^2}{2}$

C. $I_0 + \frac{ML^2}{4}$

D. $I_0 + 2ML^2$

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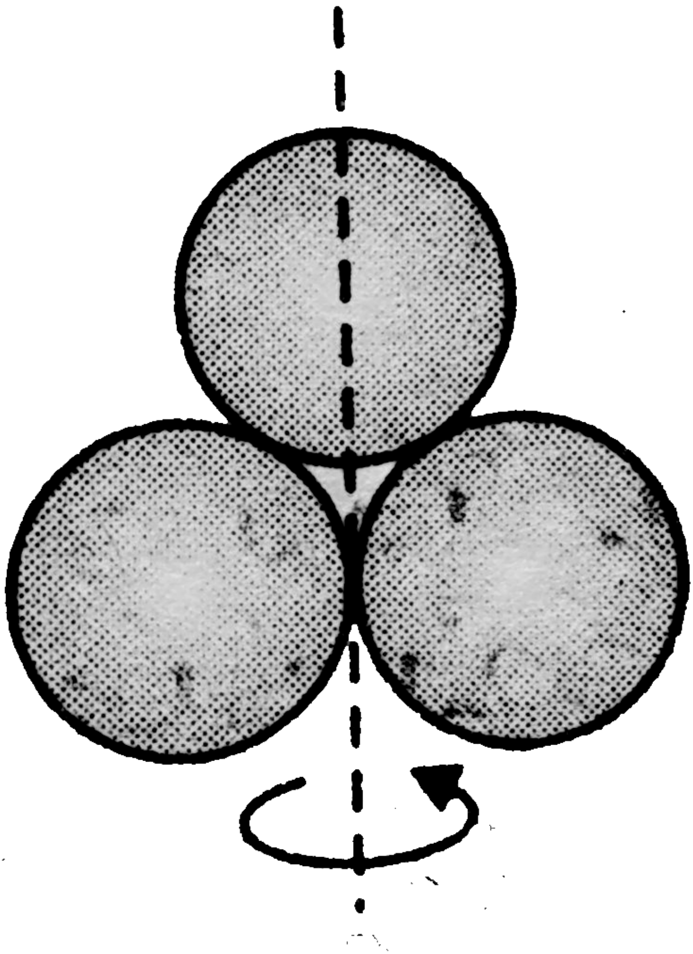
14. Three rings, each of mass m and radius r, are so placed that they touch each other. Find the moment of inertia about the axis as shown in Fig.



A. $3MR^2$

B. $\frac{3}{2}MR^2$

C. $5MR^2$

D. $\frac{7}{2}MR^2$

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15. Two rings A $(2m, R)$ and B (m, R) are placed such that these are perpendicular but common center. The $M.I.$ of the system about an axis passing through the common center and perpendicular to the plane of B is

A. $\frac{1}{2}mR^2$

B. mR^2

C. $\frac{3}{2}mR^2$

D. $2mR^2$

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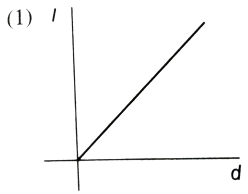
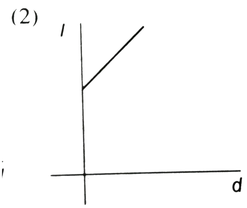
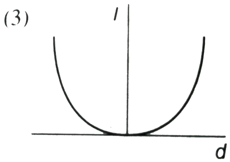
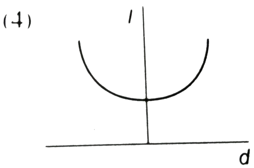
16. If I_0 is the moment of inertia body about an axis passing through its center of mass. The moment about a parallel axis and at distance d is $I = I_0 + Md^2$. The variation of I with d is

A. 

B. 

C. 

D. 

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17. A rod of length L is made of a uniform length $L/2$ of mass M_1 and a uniform length $L/2$ of mass M_2,

The $M.I$ of rod about an axis passing through the geometrical center and $\perp^{ar}$ to length

A. $\frac{1}{3}(M_1+M_2)L^2$

B. $\frac{1}{12}(M_1+M_2)L^2$

C. $\frac{1}{6}(M_1+M_2)L^2$

D. $\frac{1}{4}(M_1 + M_2)L^2$

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18. Four spheres each of mass M and diameter $2r$, are placed with their centers on the four corners of a square of side $a(\,>2r)$. The moment of inertia of the system about one side of the square is

A. $\frac{2M(5r^2 + 4a^2)}{5}$

B. $\dfrac{2M(5r^2 + 2a^2)}{5}$

C. $\dfrac{2M(2r^2 + 5a^2)}{5}$

D. $\dfrac{2M(4r^2 + 5a^2)}{5}$

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19. The ratio of the radii of gyration of a circular disc about a tangential axis in the plane of the disc and a circular ring of the same radius about a tengential axis in the plane of the ring is

A. $2:3$

B. $2:1$

C. $\sqrt{5}:\sqrt{6}$

D. $1:\sqrt{2}$

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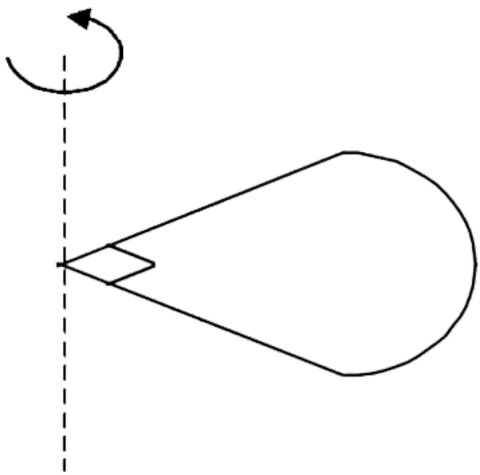
20. One quarter sector is cut from a uniform circular disc of radius R. This sector has mass M. it is made to rotate about a line perpendicular to its plane and passing through the center of the original disc. Its moment of inertia about the axis of rotation is



A. $\frac{1}{2}MR^2$

B. $\frac{1}{4}MR^2$

C. $\frac{1}{8}MR^2$

D. $\sqrt{2}MR^2$

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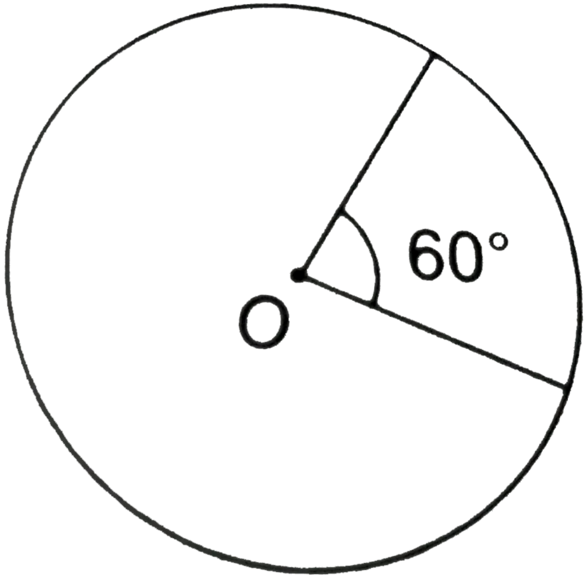
21. From a circular disc of mass M and radius R, a part of 60° is removed. The $M.I.$ of the remaining portion of disc about an axis passing through the center and perpendicular to plane of disc is



A. $\frac{5}{6} MR^2$

B. $\frac{5}{3} MR^2$

C. $\frac{5}{12} MR^2$

D. $\frac{5}{24} MR^2$

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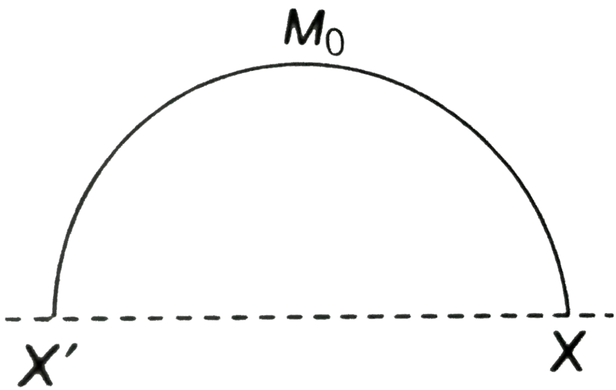
22. A rod of length$L$ and mass M_0 is bent to form a semicircular ring as shown. The $M.I.$ about $X'X$ is



A. $\dfrac{M_0 L^2}{2\pi^2}$

B. $\dfrac{M_0L^2}{\pi^2}$

C. $\dfrac{M_0L^2}{4\pi^2}$

D. $\dfrac{2M_0L^2}{\pi^2}$

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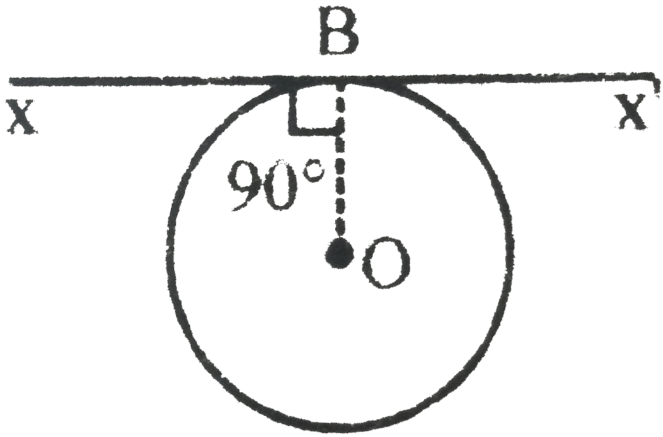
23. A thin wire of length L and uniform linear mass density ρ is bent into a circular loop with centre at O as shown. The moment of inertia of the loop about the axis XX' is :



A. $\dfrac{\rho L^3}{8\pi^2}$

B. $\dfrac{\rho L^3}{16\pi^2}$

C. $\dfrac{5\rho L^3}{16\pi^2}$

D. $\dfrac{3\rho L^3}{8\pi^2}$

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24. A circular disc is to be made by using iron and aluminium, so that it acquires maximum moment of inertia about its geometrical axis. It is possible with

A. Iron and aluminium layers in alternate order

B. Aluminium at interior and iron surrounding it

C. Iron at interior and aluminium surrounding it

D. Either (1) or (3)

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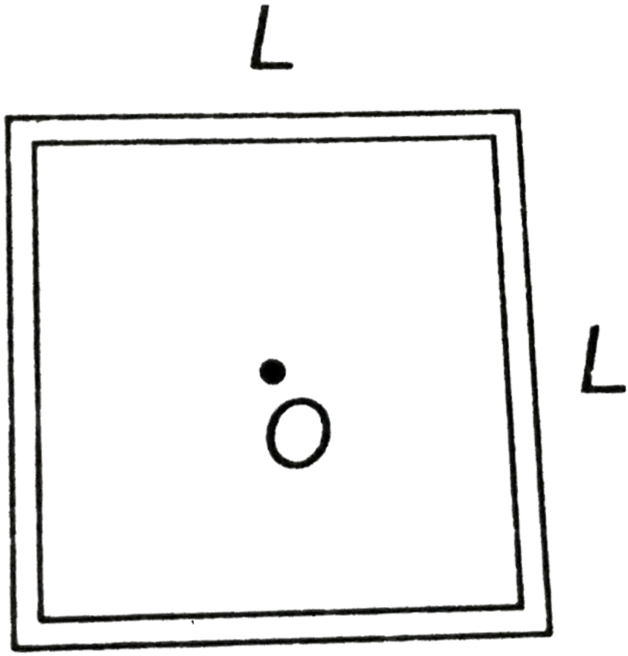
25. Four thin rods of same mass m and same length L form a square as shown in the figure. $M.I.$ of this system about an axis through center O and perpendicular to its plane is



A. $\frac{4mL^2}{3}$

B. $\frac{mL^2}{3}$

C. $\frac{mL^2}{6}$

D. $\frac{4mL^2}{3}$

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26. Four identical rods each of mass m and length l are joined to form a rigid square frame. The frame lies in the xy plane, with its centre at the origin and the sides parallel to the x and y axes. Its moment of inertial about

A. (i),(ii)

B. (ii),(iii)

C. (ii),(iv)

D. (i),(ii),(iii)

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27. Let I be the moment of interia of a uniform square plate about an axis AB that passses through its centre and is parallel to two its sides. CD is a line in the plane of the plate that passes through the centre of the plate and makes an angle θ with AB. The moment of inertia of the plate about the axis CD is then equal to-

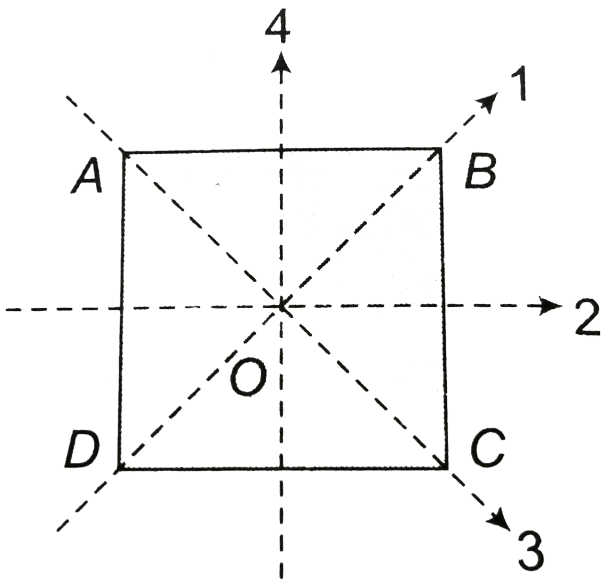
A. I

B. $I\sin^2\theta$

C. $I\cos^2\theta$

D. $I\cos^2\left(\frac{\theta}{2}\right)$

28. The moment of inertia of thin square plate $ABCD$ of uniform thickness about an axis passing through the center O and perpendicular to the plane of the plate is



(*i*) $I_1 + I_2$

(*ii*) $I_2 + I_4$

(*iii*) $I_1 + I_3$

(iv) $I_1 + I_2 + I_3 + I_4$

where I_1, I_2, I_3 and I_4 are repectively moments of inertia about axes 1, 2, 3 and 4 which are in the plane of the plane

A. (i),(ii)

B. (i), (ii), (iii)

C. (ii), (iii)

D. (i), (iii)

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29. Consider a uniform square plate of of side and mass m. The moment of inertia of this plate about an axis perpendicular to its plane and passing through one of its corners is -

A. $\frac{1}{12}ma^2$

B. $\frac{7}{12}ma^2$

C. $\frac{2}{3}ma^2$

D. $\frac{5}{6}ma^2$

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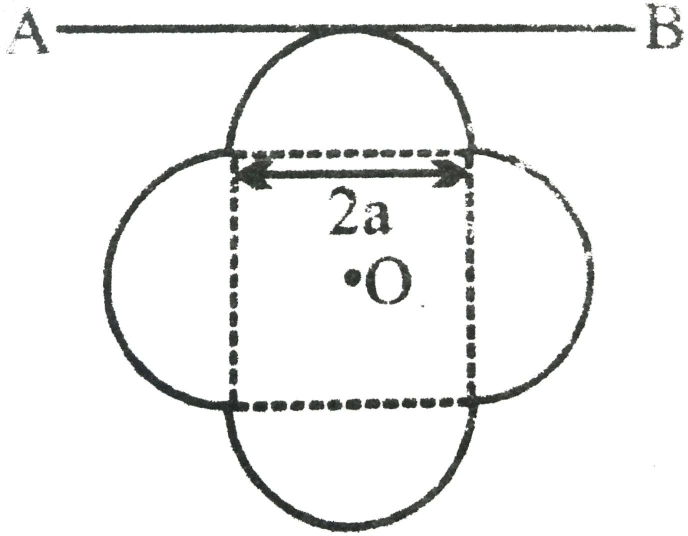
30. A symmetric lamina of mass M consists of a square shape with a semicircular section over each of the edge of the square as in fig. The side of the square is $2a$.

The moment of inertia of the lamina about an axis through its centre of mass and perpendicular to the plane is $1.6Ma^2$. The moment of inertia of the lamina about the tangent AB in the plane of lamina is.



A. $4.8Ma^2$

B. $2.6Ma^2$

C. $1.8Ma^2$

D. $7.2Ma^2$

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31. For the same total mass which of the following will have the largest moment of inertia about an axis passing through its centre of mass and perpendicular to the plane of the body.

A. Disc of radius a

B. Ring of radius a

C. Square lamina of side $2a$

D. Four rods of length $2a$ making a square

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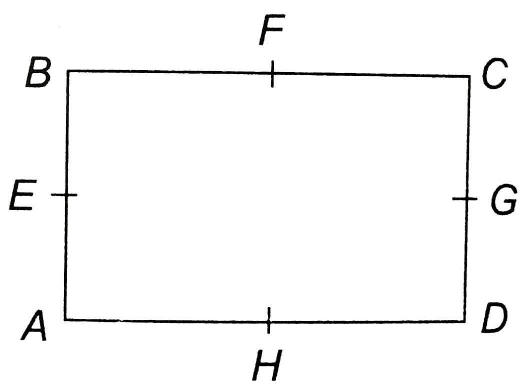
32. In a rectangle $ABCD$ $(BC = 2AB)$. The moment of inertia along which the axis will be minimum



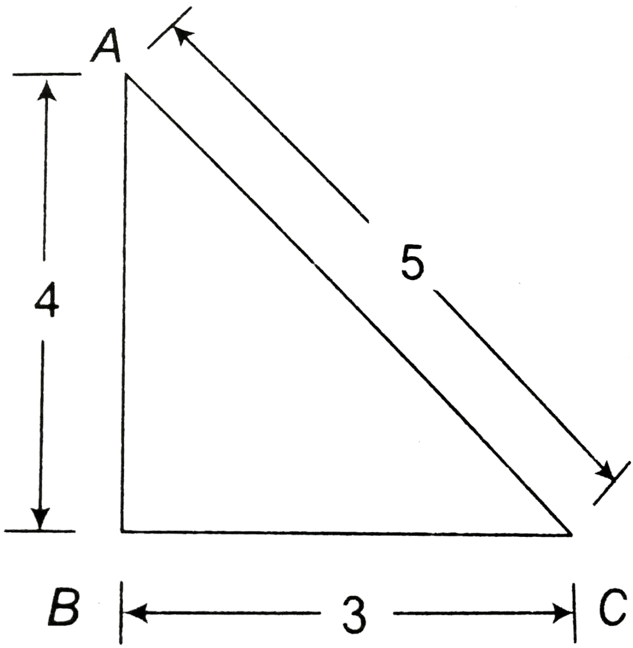
A. BC

B. BD

C. HF

D. EG

33. ABC is a traiangular plate of uniform thickness. The sides are in the ratio shown in the figure. I_{AB}, I_{BC} and I_{CA} are the moments of inertia of the plate about AB, BC and CA repectively. Which one of the following relations is correct?



A. I_{CA} is maximum

B. $I_{AB} > I_{BC}$

C. $I_{BC} > I_{AB}$

D. $I_{AB} + I_{BC} = I_{CA}$

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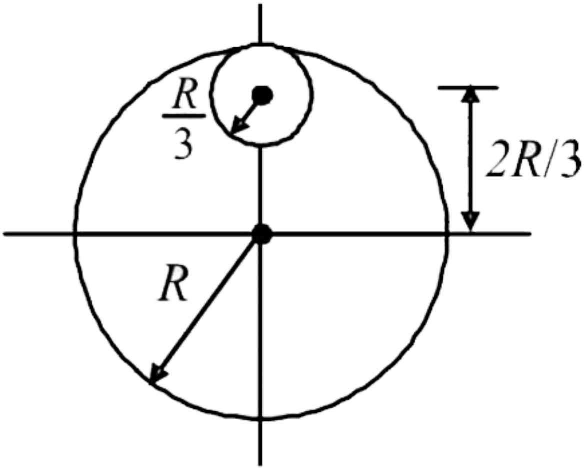
34. From a circular disc of radius R and mass 9 M , a small disc of radius R/3 is removed from the disc. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through O is



A. $4MR^2$

B. $\frac{40}{9}MR^2$

C. $10MR^2$

D. $\frac{37}{9}MR^2$

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35. A disc of mass m and radius R has a concentric hole of radius r. Its moment of inertia about an axis through its center and perpendicular to its plane is

A. $\frac{1}{2}m(R-r)^2$

B. $\frac{1}{2}m\left(R^2-r^2\right)$

C. $\frac{1}{2}m(R+r)^2$

D. $\frac{1}{2}m\left(R^2+r^2\right)$

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36. Three identical rods, each of length L, are joined to form a rigid equilateral triangle. Its radius of gyration about an axis passing thorugh a corner and perpendicular to plane of triangle is

A. $\frac{L}{2}$

B. $\sqrt{\frac{3}{2}L}$

C. $\frac{L}{\sqrt{2}}$

D. $\frac{L}{\sqrt{3}}$

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37. A ody is in pure rotation. The linear speed v of a particle, the distance r of the particle from the axis and the angular velocity ω of the body are related as $\omega = \frac{v}{r}$. Thus

A. $\omega \propto 1/r$

B. $\omega \propto r$

C. $\omega = 0$

D. ω is independent r

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38. A flywheel rotates with a uniform angular acceleration. Its angular speed increases from $2\pi rad/s$ to $10\pi rad/s$ in $4s$. Find the number of revolutions in this period.

A. 80

B. 100

C. 120

D. 150

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39. A fan is making 600 revolutions per minute. If after some time it makes 1200 revolutions per minute, then the increase in its angular velocity is

A. $10\pi rad/s$

B. $20\pi rad / s$

C. $40\pi rad / s$

D. $60\pi rad / s$

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40. A wheel is subjected to uniform angular acceleration about its axis. Initially, its angular velocity is zero. In the first $2\sec$, it rotates through an angle θ_1, in the next $2\sec$, it rotates through an angle θ_2. The ratio of θ_2 / θ_1 is

A. 1

B. 2

C. 3

D. 5

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41. When a celling fan is switched off, its angular velocity falls to half while it makes 36 rotations. How many more rotations will it make before coming to rest ?

A. 18

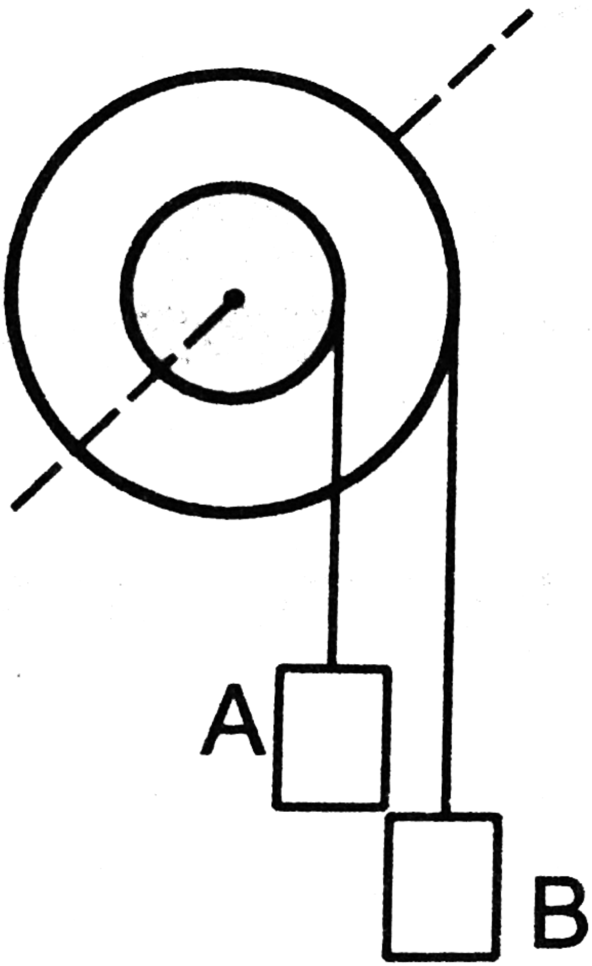
B. 12

C. 36

D. 48

42. Figure shows a small wheel fixed coaxially on a bigger one of double the radius. The system rotates about the comon axis. The strings supporting A and B do not slip on the wheels. If x and y be thedistances travelled by

A and B in the same time interval, then



A. $x = 2y$

B. $x = y$

C. $y = 2x$

D. None of these

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43. The angle turned by a body undergoing circular motion depends on time as $\theta = \theta_0 + \theta_1 t + \theta_2 r^2$. Then the angular acceleration of the body is

A. θ_1

B. θ_2

C. $2\theta_1$

D. $2\theta_2$

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44. If the equation for the displacement of a particle moving in a circular path is given by $(\theta) = 2t^3 + 0.5$, where θ is in radians and t in seconds, then the angular velocity of particle after $2s$ from its start is

A. $8rad/s$

B. $12rad/s$

C. $24rad/s$

D. $36rad/s$

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45. A flywheel rotates about an axis. Due to friction at the axis, it experiences an angular retardation proportional to its angular velocity. If its angular velocity falls to half while it makes n rotations, how many more rotations will it make before coming to rest?

A. $2n$

B. n

C. $\frac{n}{2}$

D. $\frac{n}{3}$

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46. A wheel rotates about an axis passing through the center and perpendicular to the plane with slowly increasing angular speed. Then it has

A. radial velocity and acceleration

B. tangential velocity and radial acceleration

C. tangential velocity and tangential acceleration

D. tangential velocity but acceleration having both components

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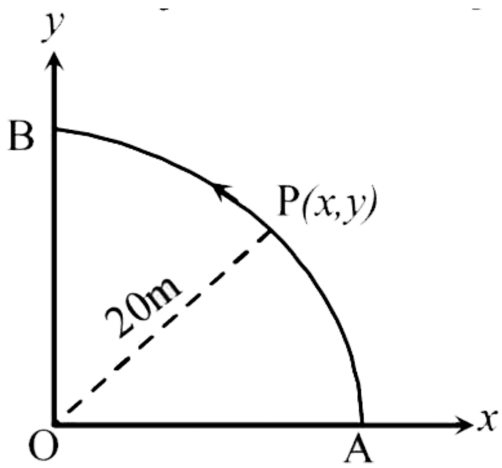
47. A point p moves in counter - clockwise direction on a circular path as shown in the figure . The movement of 'p' is such that it sweeps out in the figure . The movement of 'p' is such that it sweeps out a length $s = t^3 + 5$, where s is in metres and t is in seconds . The radius of the path is $20m$. The acceleration of 'P' when $t = 2s$ is nearly .



A. $14m / s^2$

B. $13m / s^2$

C. $12m/s^2$

D. $7.2m/s^2$

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48. Find the torque of a force $\overrightarrow{F} = -3\hat{i} + \hat{j} + 5\hat{k}$ acting at the point $\overrightarrow{r} = 7\hat{i} + 3\hat{j} + \hat{k}$

A. $14\hat{i} - 38\hat{j} + 16\hat{k}$

B. $4\hat{i} + 4\hat{j} + 6\hat{k}$

C. $21\hat{i} + 4\hat{j} + 4\hat{k}$

D. $-14\hat{i} + 34\hat{j} + 16\hat{k}$

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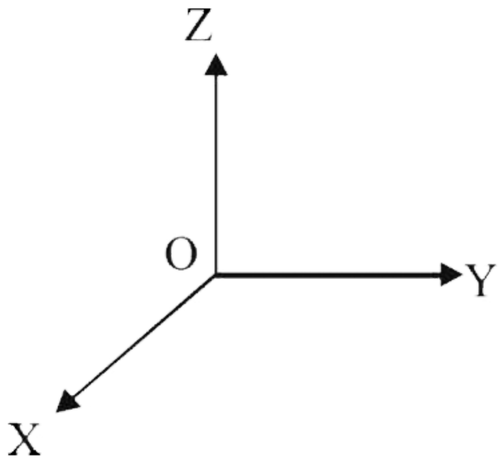
49. A force of $-F\hat{k}$ acts on O, the origin of the coodinate system. The torque about the point

(1,-1) is



A. $-F(\hat{i}+\hat{j})$

B. $F(\hat{i}+\hat{j})$

C. $-F(\hat{i}-\hat{j})$

D. $F(\hat{i}-\hat{j})$

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50. A couple produces.

A. purely linear motion

B. purely rotational motion

C. linear and rotational motion

D. no motion

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51. Let $\overrightarrow{F}$ be a force acting on a particle having positon vector $\overrightarrow{r}. Let \overrightarrow{r}$ be the torque of this force about the origin then

A. $\overrightarrow{r} \times \overrightarrow{\tau} = 0$ and $\overrightarrow{F} \times \overrightarrow{\tau} = 0$

B. $\overrightarrow{r} \times \overrightarrow{\tau} = 0$ and $\overrightarrow{F} \times \overrightarrow{\tau} \neq 0$

C. $\overrightarrow{r} \times \overrightarrow{\tau} \neq 0$ and $\overrightarrow{F} \times \overrightarrow{\tau} = 0$

D. $\overrightarrow{r} \times \overrightarrow{\tau} \neq 0$ and $\overrightarrow{F} \times \overrightarrow{\tau} \neq 0$

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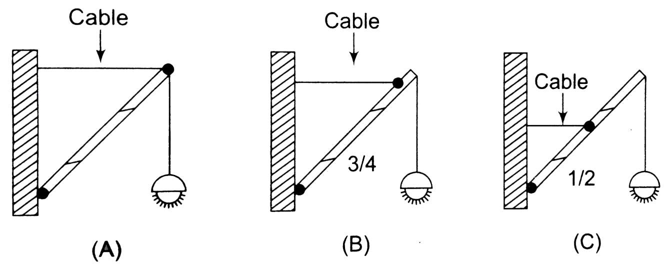
52. If a street light of mass M is suspended from the end of a uniform rod of length L in different possible patterns as shown in figure, then:



A. pattern (A) is sturdier

B. pattern (B) is sturdier

C. pattern (C) is sturdier

D. all will have same sturdiness

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53. The instantaneous angular position of a point on a rotating wheel is given by the equation

$\theta(t) = 2t^3 - 6t^2$

The torque on the wheel becomes zero at

A. $t = 2s$

B. $t = 1s$

C. $t = 0.2s$

D. $t = 0.25s$

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54. A constant torque of $31.4N - m$ id exterted on a pivoted wheel. If the angular acceleration of the wheel is $4\pi rad/s^2$, then the moment of inertia will be.

A. $2.5kg - m^2$

B. $3.5kg - m^2$

C. $4.5kg - m^2$

D. $5.5kg - m^2$

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55. A string is wound round the rim of a mounted flywheel of mass $20kg$ and radius $20cm$. A steady pull of $25N$ is applied on the cord. Neglecting friction and mass of the string, the angular acceleration of the wheel in rad/s^2 is

A. 50

B. 25

C. 12.5

D. 6.25

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56. A wheel having moment of inertia $2kgm^2$ about its vertical axis, rotates at the rate of $60r \pm$ about this axis. The torque which can stop the wheel's rotation in one minute would be

A. $\frac{2\pi}{15} N - m$

B. $\frac{\pi}{12} N - m$

C. $\frac{\pi}{15} N - m$

D. $\frac{\pi}{18} N - m$

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57. A flywheel of moment of inertia I is rotating with uniform angular speed ω. If a torque τ retards the wheel, then the time in which the wheel comes to rest is

A. $\frac{I\omega}{\tau}$

B. $\frac{2I\omega}{\tau}$

C. $\frac{I\omega}{2\tau}$

D. $\frac{I\omega}{4\tau}$

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58. The moment of inertia of a body about a given axis is $1.2kgm^2$. Initially, the body is at rest. In order to produce a rotational KE of $1500J$, for how much duration, an acceleration of $25rads^{-2}$ must be applied about that axis ?

A. $4s$

B. $2s$

C. $8s$

D. $10s$

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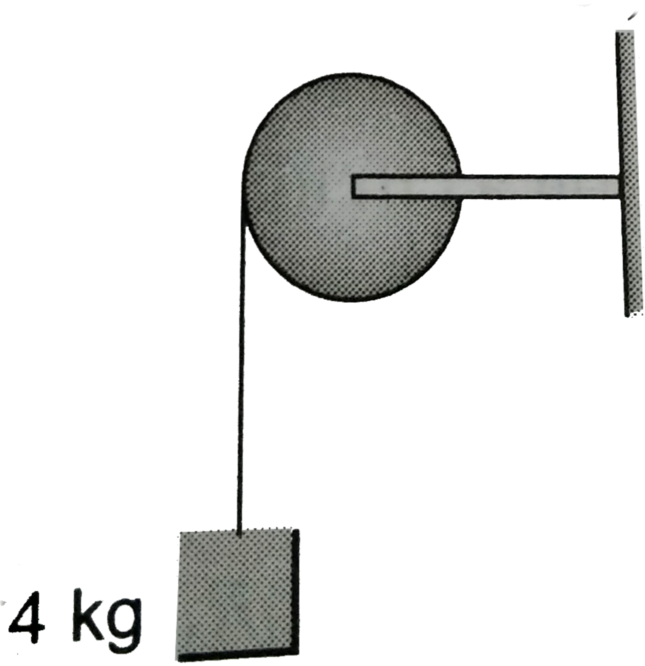
59. A wheel of radius $0.4m$ can rotate freely about its axis as shown in the figure. A string is wrapped over its rim and a mass of $4kg$ is hung. An angular acceleration of $8rad/s^2$ is produced in it due to the torque. Then, the moment of inertia of the wheel is (

$g = 10m/s^2$)



A. $2kg - m^2$

B. $1.36kg - m^2$

C. $4kg - m^2$

D. $8kg - m^2$

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60. A mas m hangs with help of a string wraped around a pulley on a frictionless bearling. The pulley has mass m and radius R. Assuming pulley to be a perfect uniform circular disc, the acceleration of the mass m, if the string does not slip on the pulley, is:

A. $\frac{3}{2}g$

B. g

C. $\frac{2}{3}g$

D. $\frac{g}{3}$

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61. In the previous problem, the tension in the string is

A. $\frac{mg}{4}$

B. $\frac{mg}{3}$

C. $\frac{mg}{2}$

D. $\frac{2mg}{3}$

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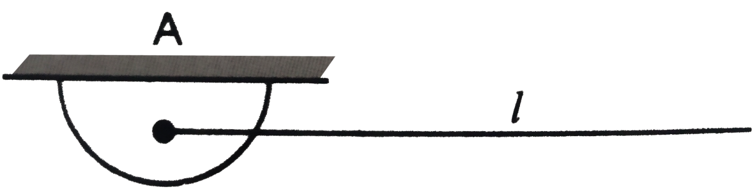
62. A uniform rod of length l and mass m is free to rotate in a vertical plane about A as shown in Fig. The rod initially in horizontal position is released. The initial angular acceleration of the rod is



A. $\frac{2g}{3L}$

B. $\frac{3g}{2L}$

C. $\frac{2g}{5L}$

D. $\frac{3g}{4L}$

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63. Two men support a uniform horizontal beam at its two ends, if one of them suddenly lets go, the force exerted by the beam on the other man will

A. remain unaffected

B. increase

C. decrease

D. become unequal to the force exerted by him on the beam

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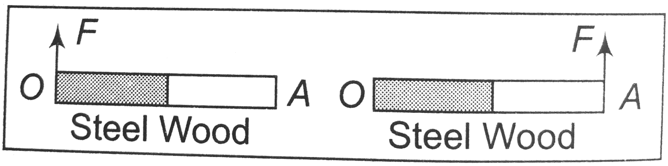
64. In first figure a meter stick, half of which is wood and the other half steel is pivoted at the wooden end at A and a force is applied at the steel and at O. On second figure the stick is pivoted at the steel end at O and the same force is applied at the wooden end at A. The angular acceleration.



A. More acceleration will be produced in (i)

B. More acceleration will be produced in $(ii$

)

C. Same acceleration will be produced in both conditions.

D. Information is incomplete

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65. The density of as rod graduallly decreases from one end to the other. It is pivoted at an

end so that ilt can move about a vertical axius through the pivot. A horizontal force F is applied on the free end n a direction perpendicular to the rod. The quantities, that do not depend on which end of the rod is pivoted are

A. angular acceleration

B. angular velocity when the rod completes one rotation

C. angular momentum when the rod completes one rotation

D. torque of the applied force

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66. A circular disc A of radius r is made from an iron plate of thickness t and another circular disc B of radius $4r$ is made from an iron plate of thickness $t/4$. Equal torques act on the discs A and B, initially both being at rest. At a later instant, the linear speeds of a point on the rim of A and another point on the rim of B are v_A and v_B, respectively. We have

A. $v_A > v_B$

B. $v_A = v_B$

C. $v_A < v_B$

D. The relation depends on the actual magnitude of the torques.

67. A pulley os radius 2m is rotated about its axis by a force $F = \left(20t - 5t^2\right)$ newton (where t is measured in seconds) applied tangentially. If the moment of inertia of the pulley about its axis of rotation is $10 kgm^2$ the number of rotaitons made by the pulley before its direction of motion is reversed, is:

A. less than 3

B. more than 3 but less than 6

C. more than 6 but less than 9

D. more than 9

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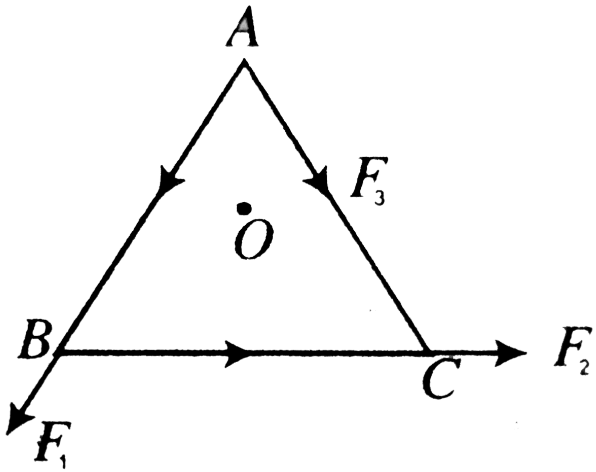
68. O is the centre of an equilateral triangle ABC. F_1, F_2 and F_3 are the three forces acting along the sides AB, BC and AC respectively. What should be the value of F_3

so that the total torque about O is zero?



A. $F_1 + F_2$

B. $F_1 - F_2$

C. $\frac{F_1 + F_2}{2}$

D. $2(F_1 + F_2)$

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69. For a system to be in equilibrium, the torques acting on it must balance. This is true only if the torques are taken about

A. the center of the system

B. the center of mass of the system

C. any point on the system

D. any point on the system or outside it.

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70. Two men A and B are carrying a uniform bar of length L on their shoulders. The bar is held horizontally such that A gets one-fourth load. If A is at one end of the bar, the distance of B from that end is

A. $\frac{L}{3}$

B. $\frac{2L}{3}$

C. $\frac{3L}{4}$

D. L

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71. A uniform horizontal meter scale of mass m is suspended by two vertical strings attached to its two ends. A block of mass $3m$ is placed on the $60cm$ mark. The tensions in the two strings are in the ratio

A. $17:19$

B. $19:21$

C. $17 : 23$

D. $19 : 23$

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72. The line of action of the resultant of two like parallel forces shifts by one-third of the distance between the forces when the two forces are interchanged. The ratio of the two forces is

A. $1:2$

B. $2:3$

C. $3:4$

D. $3:5$

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73. If a ladder weighting $250N$ is placed against a smooth vertical wall having coefficient of friction between it and floor 0.3, then what is the maximum force of friction available at the point of contact between the ladder and the floor?

A. $75N$

B. $50N$

C. $35N$

D. $25N$

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74. A ladder rests against a frictionless vertical wall, with its upper end $6m$ above the ground and the lower end $4m$ away from the wall. The weight of the ladder is $500N$ and its CG at $1/3^{rd}$ distance from the lower end. Wall's reaction will be (in newton)

A. 111

B. 333

C. 222

D. 129

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75. A cyckist moves along a curved road with a velocity v. The road is banked for speed v. The angle of banking is θ. Which of the following statement is not true?

A. The cyclist will lean away from the vertical an angle θ.

B. The normal reaction of the road will pass through the center of gravity of the "cycle plus cyclist" system.

C. There will be on force of friction between the tyres and the road.

D. The cyclist is in equilibrium with respect to the ground.

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76. A cyclist moves around a circular path of radius $40\sqrt{3}m$ with a speed of $20m/s$. He must lean inwards at an angle θ with the vertical such that $\tan\theta$ is equal to

A. 1

B. $\sqrt{3}$

C. $1/\sqrt{3}$

D. 2

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77. A car is moving on a circular path and takes a turn. If R_1 and R_2 be the reactions on the inner and outer wheels, respectively, then

A. $R_1 = R_2$

B. $R_1 < R_2$

C. $R_1 > R_2$

D. $R_1 \geq R_2$

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78. A car sometimes overturns while taking a turn. When it overturns, it is

A. the inner wheel which leaves the ground first

B. the outer wheel which leaves the ground first

C. both the wheels leave the ground simultanously

D. either wheel leaves the ground first

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79. A rectangular block has a square base measuring $a \times a$ and its height is h. It moves on a horizontal surface in a direction perpendicular to one of the edges. The coefficient of friction is μ. It will topple if

A. $\mu > \frac{h}{a}$

B. $\mu > \frac{a}{h}$

C. $\mu > \frac{2a}{h}$

D. $\mu > \frac{a}{2h}$

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80. A block of base $10cm \times 10cm$ and height 15cm is kept on an inclined plane. The coefficient of friction between them is $\sqrt{3}$. The inclination θ of this inclined plane from the horizontal plane is gradually increased from 0° Then

A. At $\theta = 30^\circ$, the block will start sliding down the plane

B. The block will remian at rest on the plane up to certain θ and then it will topple

C. At $\theta = 60^\circ$, the block will start sliding down the plane and continue to do so at higher angles

D. At $\theta = 60^\circ$, the block will start sliding down the plane and on further increasing θ, it will topple at certain θ

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81. A rod of length L, hinged at the bottom is held vertically and then allowed to fall, the linear velocity of its top when it hits the floor is

A. $\sqrt{2gL}$

B. $\sqrt{\frac{2g}{L}}$

C. $\sqrt{3gL}$

D. $\sqrt{\frac{3g}{L}}$

Answer: C

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82. A uniform rod of length L is placed with one end in contact with the horizontal and is then inclined at an angle α to the horizontal and allowed to fall without slipping at contact point. When it becomes horizontal, its angular velocity will be

A. $\omega = \sqrt{\frac{3g\sin\alpha}{L}}$

B. $\omega = \sqrt{\frac{2L}{3g \sin \alpha}}$

C. $\omega = \sqrt{\frac{6g \sin \alpha}{L}}$

D. $\omega = \sqrt{\frac{L}{g \sin \alpha}}$

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83. A cord is wound round the circumference of wheel of radius r. The axis of the wheel is horizontal and fixed and moment of inertia about it is I. A weight mg is attached to the end of the cord and falls from rest. After falling through a distance h, the angular velocity of the wheel will be.

A. $\sqrt{\frac{2gh}{I+mr}}$

B. $\left[\frac{2mgh}{I+mr^2}\right]^{1/2}$

C. $\left[\frac{2mgh}{I+2mr^2}\right]^{1/2}$

D. sqrt(2gh)

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84. A uniform rod is kept vertically on a horizontally smooth surface at a point O. IF it is rotated slightly and released, it falls down on the horizontal surface. The lower end will remain

A. at O

B. at a distance less than $L/2$ from O

C. at a distance $L/2$ from O

D. at a distance larger than $L/2$ from O

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85. An automobile engine develops 100 kilo $-$ watt, when rotating at a speed of $1800 rev/\min$. Find the torque developed by it.

A. $350N-m$

B. $440N-m$

C. $531N-m$

D. $628N-m$

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86. A flywheel is in the form of a uniform circular disc of radius $1m$ and mass $2kg$. The work which must be done on it to increase its frequency of rotation from 5 to $10 rev/s$ is approximately

A. $1.5 \times 10^2 J$

B. $3.0 \times 10^2 J$

C. $1.5 \times 10^3 J$

D. $3.0 \times 10^3 J$

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87. Two point masses of 0.3 kg and 0.7kg are fixed at the ends of a rod of length 1.4 m and of negligible mass. The rod is set rotating about an axis perpendicular to its length with a uniform angular speed. The point on the rod through which the axis should pass in order that the work required for rotation of the rod is minimum, is located at a distance of

A. $0.4m$ from mass of $0.3kg$

B. $0.98m$ from mass of $0.3kg$

C. $0.70m$ from mass of $0.7kg$

D. $0.98m$ from mass of $0.7kg$

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88. One end of a uniform rod of mas m and length l is clamped. The rod lies on a smooth horizontal surface and rotates on it about the clamped end at a unifrom angular velocity ω. Theforce exerted by the clamp on the rod has a horizontal component

A. $m\omega^2 L$

B. zero

C. mg

D. $\frac{m\omega^2 L}{2}$

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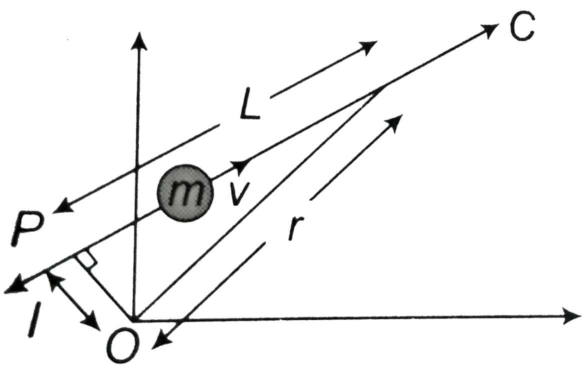
89. A particle of mass m moves along line PC with velocity v as shown. What is the angular momentum of the particle about O?



A. mvL

B. mvl

C. mvr

D. $zero$

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90. In an orbital motion, the angular momentum vector is :

A. along the radius vector

B. parallel to the linear momentum

C. in the orbital plane

D. perpendicular to the orbital plane

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91. The position of a particle is given by $\overrightarrow{r} = \left(\hat{i} + 2\hat{j} - \hat{k}\right)$ and momentum $\overrightarrow{p} = \left(3\hat{i} + 4\hat{j} - 2\hat{k}\right)$. The angular momentum is perpendicular to the

A. x-axis

B. y-axis

C. z-axis

D. line at equal angles to all the three axes

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92. A unit mass at position vector $\overrightarrow{r} = \left(3\hat{i} + \hat{j}\right)$ is moving with velocity $\overrightarrow{v} = \left(5\hat{i} - 6\hat{j}\right)$. What is the angular momentum of the body about the origin?

A. 2 units along the z-axis

B. 38 units along the x-axis

C. 38 units along the y-axis

D. 38 units along the z-axis

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93. A mass M moving with a constant velocity parlale to the X-axis. Its angular momentum with respect to the origin

A. zero

B. remains constant

C. goes on increasing

D. goes on decreasing

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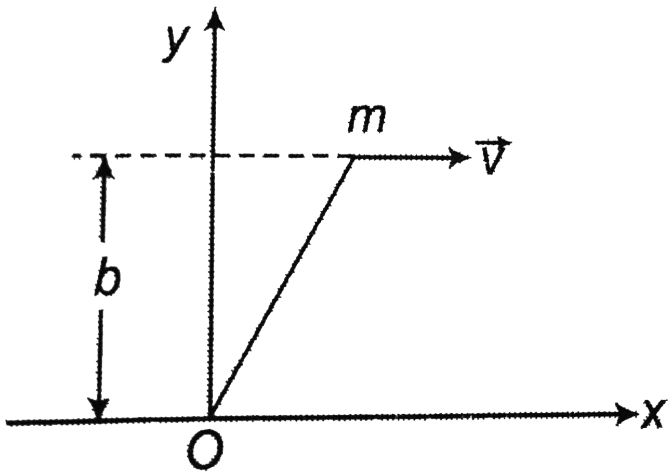
94. If the particle of mass m is moving with constant velocity v parallel to x-axis in x-y plane as shown in (figure), Find its angular momentum with respect to origin at any time

t.



A. $mvb\hat{k}$

B. $-mvb\hat{k}$

C. $mvb\hat{i}$

D. $mv\hat{i}$

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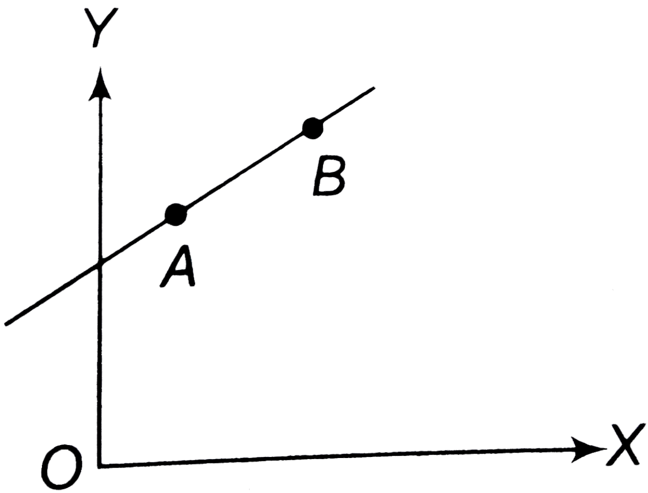
95. A particle of mass m moves in the XY plane with a velocity v along the straight line AB. If the angular momentum of the particle with respect to origin O is L_A when it is at A and L_B when it is at B, then



A. $L_A > L_B$

B. $L_A = L_B$

C. The relationship between L_A and L_B depends upon the slop of the line AB

D. $L_A < L_B$

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96. A particle of mass $5g$ is moving with a uniform speed of $3\sqrt{2}cm/s$ in the $x-y$ plane along the line $y=x+4$. The magnitude of its angular momentum about the origin in gcm^2/s is

A. zero

B. 30

C. $3\sqrt{2}$

D. 60

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97. A particle of mass m is projected with a velocity v making an angle of 45° with the horizontal. The magnitude of the angular momentum of the projectile abut the point of projection when the particle is at its maximum height h is.

A. (i),(ii)

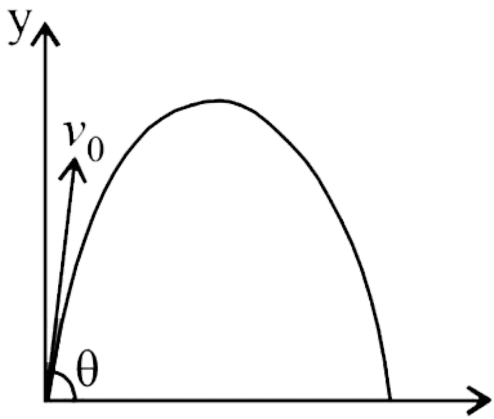
B. (ii),(iii)

C. (ii),(iv)

D. (iii),(iv)

98. A small particle of mass m is projected at an angle θ with the x- axis with an initial velocity v_0 in the $x-y$plane as shown in the figure . At a time $t<\frac{v_0 \sin \theta}{g}$, the angular momentum of the particle is

where $\hat{i}, \hat{j}$ and $\hat{k}$ are unit vectors along x, y and z - axis respectively.



A. $\frac{1}{2}mgv_0t^2\cos\theta\hat{i}$

B. $-mgv_0t^2\cos\theta\hat{j}$

C. $mgv_0t^2\cos\theta\hat{k}$

D. $-\frac{1}{2}mgv_0t^2\cos\theta\hat{k}$

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99. A particle performing uniform circular motion gas angular momentum L. If its angular frequency is double and its kinetic energy halved, then the new angular momentum is :

A. $2L$

B. $4L$

C. $L/2$

D. $L/4$

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100. Two bodies have their moments of inertia I and $2I$ respectively about their axis of rotation. If their kinetic energies of rotation are equal, their angular momenta will be in the ratio.

A. $1:2$

B. $\sqrt{2}:1$

C. $2:1$

D. $1:\sqrt{2}$

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101. If the angular momentum of any rotating body increases by 200%, then the increase in its kinetic energy

A. 400%

B. 800%

C. 200%

D. 100%

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102. A particle of mass m is moving in a plane along a circular path of radius r. Its angular momentum about the axis of rotation is L. The centripetal force acting on the particle is.

A. L^2 / mr

B. $L^2 m / r$

C. $L^2 / m^2 r^2$

D. L^2 / mr^3

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103. The angular momentum of a system of particles is conserved

A. when no external force acts upon the system

B. when no external torque acts on the system

C. when no external impulse acts upon the system

D. when axis of rotation remains same

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104. Angular momentum of the particle rotating with a central force is constant due to

A. constant forces

B. constant linear momentum

C. zero torque

D. constant torque

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105. A thin circular ring of mass M and radius r is rotating about its axis with a constant angular velocity ω, Two objects, each of mass m, are attached gently to the opposite ends of a diameter of the ring. The wheel now rotates with an angular velocity $\omega =$

A. $\dfrac{\omega M}{M-m}$

B. $\dfrac{\omega(M-2m)}{M-2m}$

C. $\dfrac{M\omega}{M+2m}$

D. $\dfrac{\omega(M+2m)}{M}$

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106. A solid sphere is rotating about a diameter at an angular velocity ω. If it cools so that its radius reduces to I/n of its original value, its angular velocity becomes

A. $\frac{\omega}{n}$

B. $\frac{\omega}{n^2}$

C. ωn

D. $n^2\omega$

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107. If radius of the earth contracts to half of its present value without change in its mass, what will be the new duration of the day?

A. $6h$

B. $12h$

C. $48h$

D. $96h$

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108. A solid sphere is rotating in free space. If the radius of the sphere is increased keeping mass same which one of the following will not be affected?

A. Moment of inertia

B. Angular momentum

C. Angular velocity

D. Rotational kinetic energy

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109. If the polar ice caps melt suddenly

A. the length of the day will be more than $24h$

B. the length of the day will be less than $24h$

C. the length of the day will remain same as $24h$

D. the length of the day will become more than $24h$ initially and then becomes equal to $24h$

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110. A uniform horizontal circular platform of mass $200kg$ is rotating at 10 rpm about a vertical axis passing through its center. A boy of mass $50kg$ is standing at its edge. If the boy moves to the center of the platform, the frequency of rotation would become

A. 7.5 rpm

B. 12.5 rpm

C. 15 rpm

D. 20 rpm

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111. A thin uniform circular disc of mass M and radius R is rotating in a horizontal plane about an axis passing through its centre and perpendicular to its plane with an angular velocity ω. another disc of the same dimensions but of mass M/4 is placed gently on the first disc coaxially. The angular velocity of the system now is $2\omega / \sqrt{5}$.

A. $\frac{5}{4}\omega$

B. $\frac{2}{3}\omega$

C. $\frac{4}{5}\omega$

D. $\frac{3}{2}\omega$

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112. A round disc of moment of inertia I_2 about its axis perpendicular to its plane and passing through its centre is placed over another disc of moment of inertia I_1 rotating with an angular velocity ω about the same axis. The final angular velocity of the combination of discs is.

A. $\dfrac{I_2\omega}{I_1 + I_2}$

B. ω

C. $\dfrac{I_1\omega}{I_1 + I_2}$

D. $\frac{(I_1 + I_2)\omega}{I_1}$

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113. Two discs of moment of inertia I_1 and I_2 and angular speeds ω_1 and ω_2 are rotating along the collinear axes passing through their center of mass and perpendicular to their plane. If the two are made to rotate combindly along the same axis the rotational $K.E.$ of system will be

A. $\dfrac{I_1\omega_1 + I_2\omega_2}{2(I_1 + I_2)}$

B. $\dfrac{(I_1 + I_2)(\omega_1 + \omega_2)^2}{2}$

C. $\dfrac{(I_1\omega_1 + I_2\omega_2)^2}{2(I_1 + I_2)}$

D. None of these

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114. A circular disc of moment of inertia I_t is rotating in a horizontal plane about its symmetry axis with a constant angular velocity

ω_i. Another disc of moment of inertia I_b is dropped co-axially onto the rotating disc. Initially, the second disc has zero angular speed. Eventually, both the discs rotate with a constant angular speed ω_f. Calculate the energy lost by the initially rotating disc due to friction.

A. $\frac{1}{2}\frac{I_b I_t}{I_t + I_b}\omega_1^2$

B. $\frac{1}{2}\frac{I_b^2}{I_t + I_b}\omega_1^2$

C. $\frac{1}{2}\frac{I_t^2}{I_t + I_b}\omega_1^2$

D. $\frac{I_b - I_t}{(I_t + I_b)}\omega_1^2$

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115. A child is standing with folded hands at the center of a platform rotating about its central axis. The kinetic energy of the system is K. The child now stretches his arms so that the moment of inertia of the system doubles. The kinetic energy of the system now is

A. $2K$

B. $K/2$

C. $K/4$

D. $4K$

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116. A cockroach is moving with velocity v in anticlockwise direction on the rim of a disc of radius R of mass m. The moment of inertia of the disc about the axis is I and it is rotating in clockwise direction with an angular velocity ω.

If the cockroach stops, the angular velocity of the disc will be

A. $\dfrac{I\omega}{I+mR^2}$

B. $\dfrac{I\omega+mvR}{I+mR^2}$

C. $\dfrac{I\omega-mvR}{I+mR^2}$

D. $\dfrac{I\omega-mvR}{I}$

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117. A thin horizontal circular disc is roating about a vertical axis passing through its centre. An insect is at rest at a point near the rim of the disc. The insect now moves along a diameter of the disc to reach its other end. During the journey of the insect, the angular speed of the disc.

A. remains unchanged

B. continuously decreases

C. continuously increases

D. first increases and then decreases

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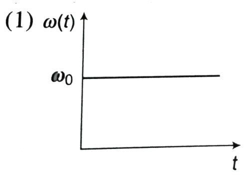
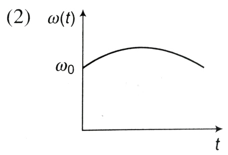
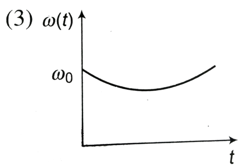
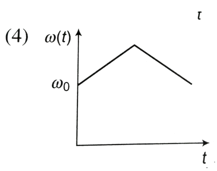
118. A circular plarform is free to rotate in a horizontal plane about a vertical axis passing through its centre. A tortoise is sitting at the edge of the platform. Now, the platform is given an angular velocity ω_0. When the tortoise move along a chord of the platform with a constant velocity (with respect to the platform), the angular velocity of the platform

$\omega(t)$ will vary with time t as

A. 

B. 

C. 

D. 

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119. A man standing on a platform holds weights in his outstretched arms. The system is rotated about a central vertical axis. If the man now pulls the weights inwards close to his body then

A. (i),(ii)

B. (ii),(iii)

C. (ii),(iv)

D. (i),(iii),(iv)

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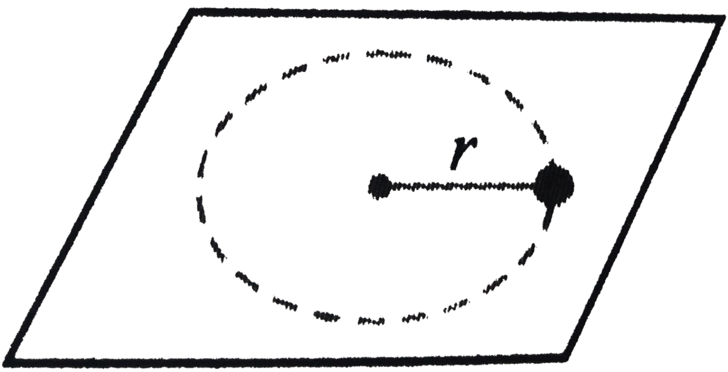
120. A small mass attached to a string rotates on a frictionless table top as shown in Fig. If the tension in the string is increased by pulling the string causing the radius of the circular motion to decrease by a factor of 2, the kinetic energy of the mass will



A. increase by a factor of 4

B. decrease by a factor of 2

C. remain constant

D. increase by a factor of 2

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121. A stone of mass m tied to the end of a string, is whirled around in a horizontal circle. (Neglect the force due to gravity). The length of the string is reduced gradually keeping the angular momentum of the stone about the centre of the circle constant. Then, the tension in the string is given by $T = Ar^n$ where A is a constant, r is the instantaneous radius of the circle and n=....

A. 1

B. -1

C. -2

D. -3

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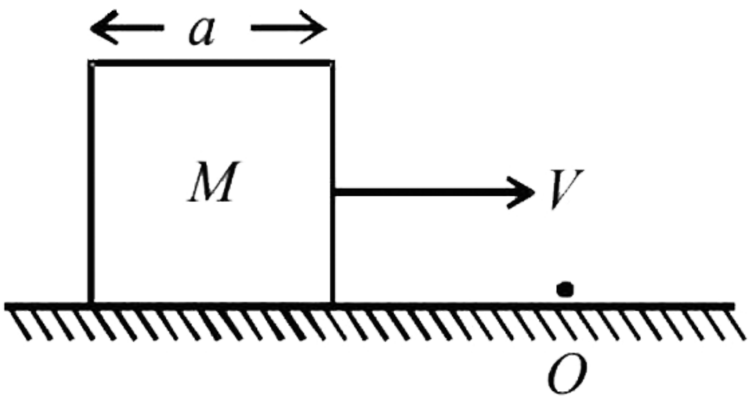
122. A cubical block of side a is moving with velocity V on a horizontal smooth plane as shown in Figure. It hits a ridge at point O. The angular speed of the block after it hits O is



A. $3v / 4a$

B. $3v/2a$

C. $\frac{\sqrt{3}v}{\sqrt{2}a}$

D. zero

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123. A playground merry-go-round is at rest, pivoted about a frictionless axis. A child of mass m runs along a path tangential to the rim with speed v and jumps on to the merry-go-round. If R is the radius of the merry-go-round and I is its moment of inertia, then the angular velocity of the merry-go-round is

A. $\dfrac{mvR}{mR^2 + I}$

B. $\dfrac{mvR}{I}$

C. $\dfrac{mR^2}{mvR}$

D. $\dfrac{I}{mvR}$

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124. A small ball strikes a stationery uniform rod, which is free to rotate, in gravity-free space. The ball does not stick to the rod. The rod will rotate about

A. its center of mass

B. the center of mass of rod plus ball

C. the point of impact of the ball on rod

D. The point about which the $M. I.$ of the "rod plus ball" is minimum

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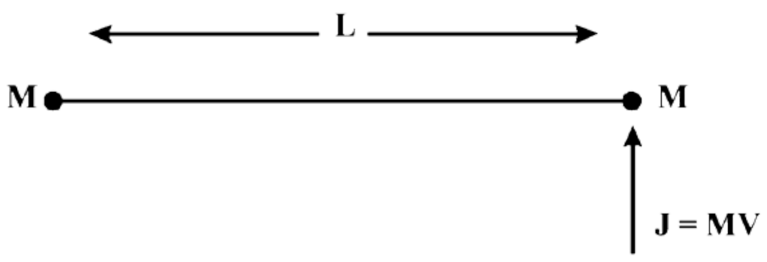
125. Consider a body, shown in figure, consisting of two identical balls, each of mass M connected by a light rigid rod. If an impulse J = MV is imparted to the body at one of its ends what would be it angular velocity?



A. V/L

B. $2V/L$

C. $V/3L$

D. $V/4L$

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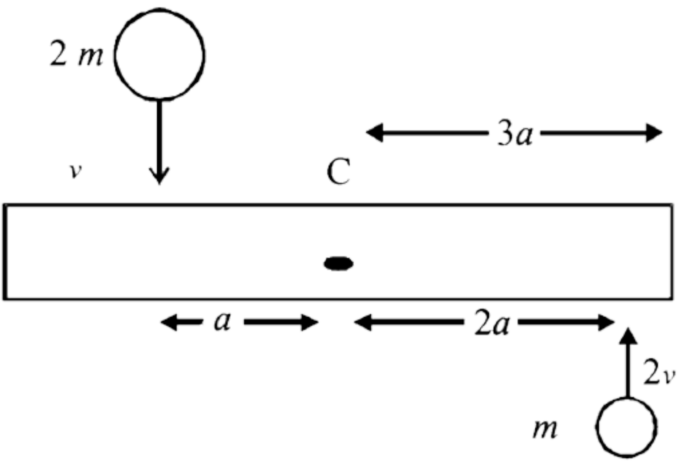
126. A uniform bar of length 6a and mass 8m lies on a smooth horizontal table. Two point masses m and 2m moving in the same horizontal plane with speed 2v and v, respectively, strike the bar [as shown in the fig.] and stick to the bar after collision. Denoting angular velocity (about the centre of mass), total energy and centre of mass velocity by ω, E and v_c respecitvely, we have after collison



A. (i),(ii)

B. (i), (ii), (iii)

C. (ii),(iv)

D. (i),(iii),(iv)

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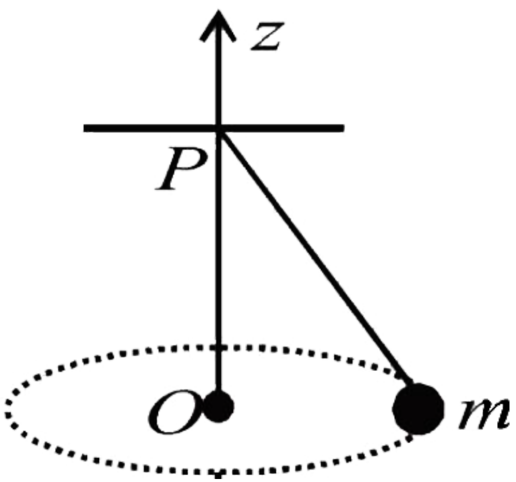
127. A small mass m is attached to a massless string whose other end is fixed at P as shown in the figure. The mass is undergoing circular motion in the x-y plane with centre at O and constant angular speed ω. If the angular momentum of the system. calculated about O and P are denoted. by $\vec{L}_O$ and $\vec{L}_P$ respectively, then.



A. $\vec{L}_0$ and $\vec{L}_P$ do not vary with time

B. $\vec{L}_0$ varies with time while $\vec{L}_P$ remains constant

C. $\overrightarrow{L}_0$ remains constant while $\overrightarrow{L}_P$ varies with time

D. $\overrightarrow{L}_0$ and $\overrightarrow{L}_P$ both vary with time

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128. A constant torque acting on a uniform circular wheel changes its angluar momentum from A_0 to $4A_0$ in $4s$. The magnitude of this torque is equal to.

A. $\frac{3A_0}{4}$

B. A_0

C. $4A_0$

D. $12A_0$

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129. A thin rod of mass m and length $2L$ is made to rotate about an axis passing through its center and perpendicular to it. If its angular velocity changes from O to ω in time t, the torque acting on it is

A. $\dfrac{mL^2\omega}{12t}$

B. $\dfrac{mL^2\omega}{3t}$

C. $\dfrac{mL^2\omega}{t}$

D. $\dfrac{4mL^2\omega}{6t}$

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130. A constant external torque τ acts for a very brief period Δt on a rotating system having moment of inertia I.

(i) The angular momentum of the system will change by $\tau\Delta t$

(ii) The angular velocity of the system will change by $(\tau\Delta t)\,/\,I$.

(iii) If the system was initially at rest, it will acquire rotational kinetic energy $(\tau\Delta t)^2\,/\,2I$.

(iv) The kinetic energy of the system will change by $(\tau\Delta t)^2 I$.

A. (i),(ii)

B. (i),(ii),(iii)

C. (ii),(iv)

D. (i),(iii),(iv)

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131. The torque $\overrightarrow{\tau}$ on a body about a given point is found to be equal to $\overrightarrow{A} \times \overrightarrow{L}$ where $\overrightarrow{A}$ is a constant vector and $\overrightarrow{L}$ is the angular momentum of the body about the point. From this its follows that -

A. $\frac{d\vec{L}}{dt}$ is perpendicular to $\vec{L}$ at all instant of time

B. The component of $\vec{L}$ in the direction of $\vec{A}$ does not change with time

C. The magnitude of $\vec{L}$ does not change with time

D. $\vec{L}$ does not change with time

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132. A wheel rolls without slipping on a horizontal surface such that its velocity of center of mass is v. The velocity of a particle at the highest point of the rim is

A. zero

B. v

C. $2v$

D. $\sqrt{2}v$

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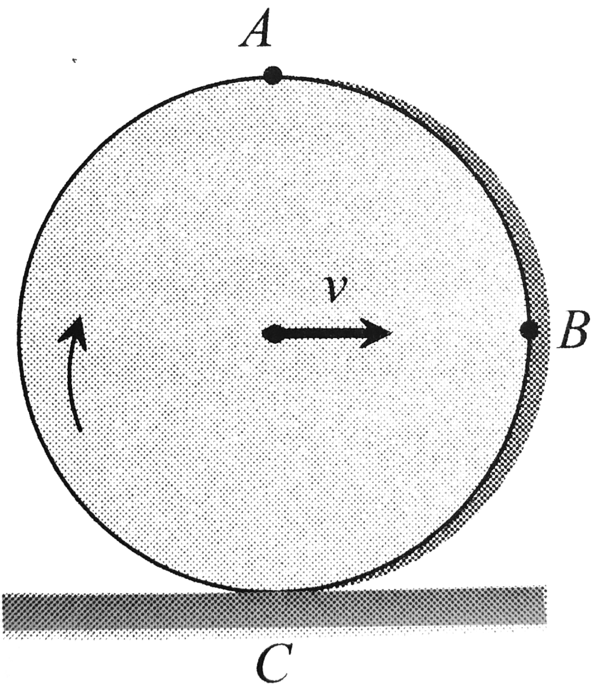
133. A solid disc rolls clockwise without slipping over a horizontal path with a constant speed v. Then the magnitude of the velocities of points A, B and C (see figure) with respect to a standing observer are, respectively,



A. v, v and v

B. $2v$, $\sqrt{2}v$ and zero

C. $2v$, $2v$ and zero

D. $2v$, $\sqrt{2}v$ and $\sqrt{2}v$

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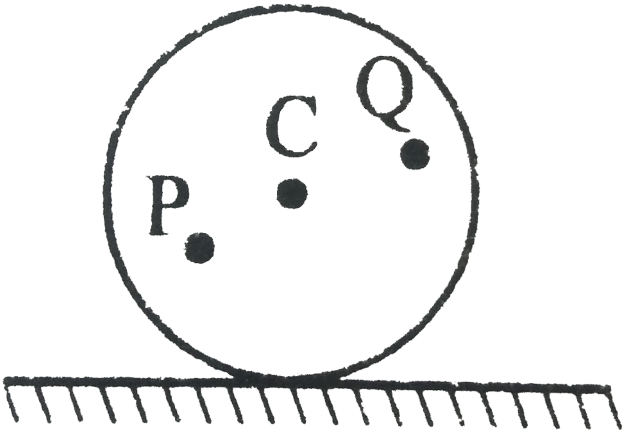
134. A disc is rolling (without slipping) on a horizontal surface. C is its center and Q and P are two points equidistant from C. Let V_P, V_Q and V_C be the magnitude of velocities of points P, Q and C respectively, then



A. $v_Q > v_C > v_P$

B. $v_Q < v_C < v_P$

C. $v_Q = v_P, v_C = v_P$

D. $v_Q < v_C > v_P$

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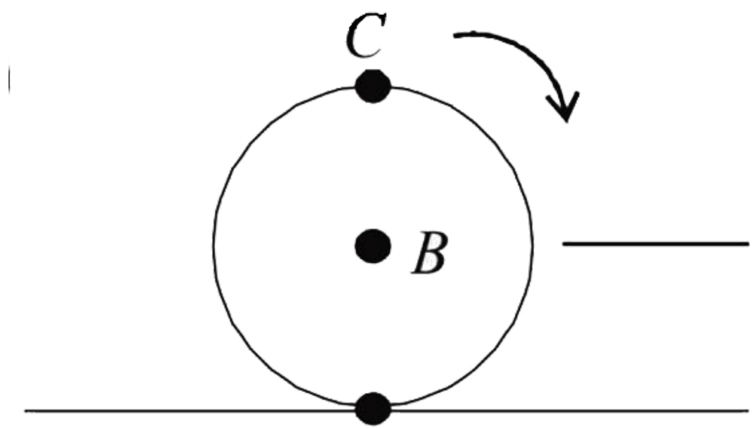
135. A sphere is rolling without slipping on a fixed horizontal plane surface. In the figure, A is the point of contact, B is the centre of the sphere and C is its topmost point. Then



A. (i),(ii)

B. (ii),(iii)

C. (i),(iv)

D. (ii), (iv)

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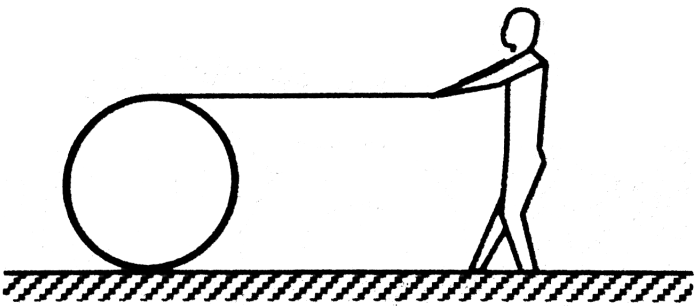
136. A string of negligible thicknes is wrapped several times around a cylinder kept on a rough horizontal surface. A man standing at a distance l from the cylinder holds one end of the sitting an pulls the cylinder towards him figure. There is no slipping anywhere. The length of the string passed through the hand of the man whicle the cylinder reaches his hands is



A. L

B. $2L$

C. $3L$

D. $4L$

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137. A ball rolls without slipping. The radius of gyration of the ball about an axis passing through its centre of mass is k. If radius of the ball be R, then the fraction of total energy associated with its rotation will be.

A. $\frac{k^2}{R^2}$

B. $\dfrac{k^2}{k^2+R^2}$

C. $\dfrac{R^2}{k^2+R^2}$

D. $\dfrac{k^2+R^2}{R^2}$

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138. A solid sphere of mass m and radius R rolls without slipping on a horizontal surface such that $v_{c.m.}=v_0$.

A. The kinetic energy of rotation is $\dfrac{1}{5}mv_0^2$.

B. The total kinetic energy is $\frac{7}{10}mv_0^2$.

C. The mechanical energy (assume the ground as reference) is $mgR + \frac{7}{10}mv_0^2$.

D. All options are correct.

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139. A hollow sphere rolls without slipping on plane surface. The ratio of kinetic energy of rotation to the total kinetic energy is

A. $1/3$

B. $2/5$

C. $1/4$

D. $3/4$

Answer: B

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140. A solid cylinder and a sphere, having the same mass, rolls without slipping with the same linear velocity. If the kinetic energy of the cylinder is $75J$, that of the sphere must be

A. $60J$

B. $70J$

C. $80J$

D. $90J$

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141. An annular ring with inner and outer radii R_1 and R_2 is rolling wihtout slipping with a uniform angular speed. The ratio of the forces experienced by the two particles situated on the inner and outer parts of the ring, $\frac{F_1}{F_2}$ is

A. 1

B. R_1 / R_2

C. R_2 / R_1

D. $(R_1 / R_2)^2$

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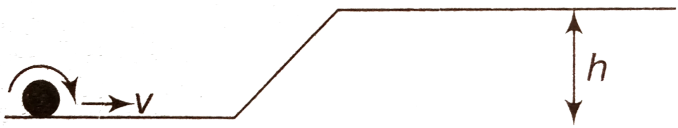
142. A solid sphere is rolling on a frictionless surface, shown in figure with a translational velocity $v m / s$. If it is to climb the inclined surface then v should be :



A. $\geq \sqrt{\frac{10}{7} gh}$

B. $\geq \sqrt{2gh}$

C. $2gh$

D. $\frac{10}{7}gh$

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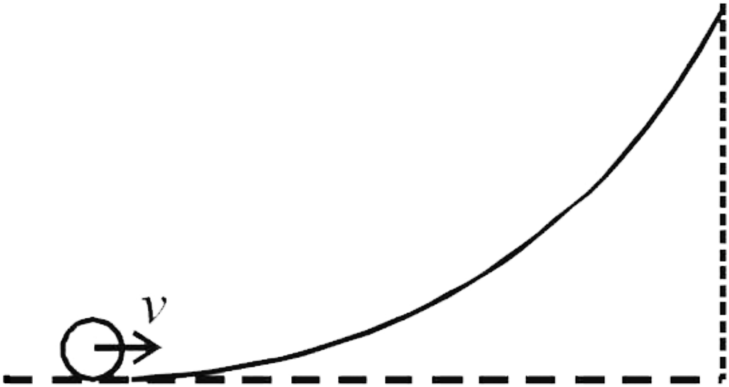
143. A small object of uniform density rolls up a curved surface with an initial velocity v. it reaches up to a maximum height of `(3v^2)/(4g)



with respect to the initial position. The object is

A. ring

B. solid sphere

C. hollow sphere

D. disc

144. A disc of mass M and radius R is rolling with angular speed ω on a horizontal plane as shown in figure. The magnitude of angular momentum of the disc about the origin O is

- $\frac{1}{2}MR^2\omega$
- $MR^2\omega$
- $\frac{3}{2}MR^2\omega$
- $2MR^2\omega$

145. A solid cylinder of mass M and radius R rolls without slipping down an inclined plane of length L and height h. What is the speed of its center of mass when the cylinder reaches its bottom

A. $\sqrt{\frac{3}{4}gh}$

B. $\sqrt{\frac{4}{3}gh}$

C. $\sqrt{2gh}$

D. $\sqrt{2}v$

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146. A body of mass m slides down an incline and reaches the bottom with a velocity v. If the same mass were in the form of a ring which rolls down this incline, the velocity of the ring at the bottom would have been

A. v

B. $\sqrt{2}v$

C. $\frac{1}{\sqrt{2}}v$

D. $\sqrt{\frac{2}{5}}v$

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147. A thin uniform circular ring is rolling down an inclined plane of inclination 30° without slipping. Its linear acceleration along the inclined plane will be

A. $g/2$

B. $g/3$

C. $g/4$

D. $2g/3$

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148. A hollow sphere (i) rolls and (ii) slides down an inclined plane. The ratio of the accelerations in the two cases is

A. $3:4$

B. $3:5$

C. $2:3$

D. $5:7$

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149. A round uniform body of radius R, mass M and moment of inertia 'I' rolls down (without slipping) and inclined plane making an angle θ with the horizontal. Then its acceleration is.

A. $\dfrac{g\sin\theta}{1+\frac{I}{MR^2}}$

B. $\dfrac{g\sin\theta}{1+\frac{MR^2}{I}}$

C. $\dfrac{g\sin\theta}{1-\frac{I}{MR^2}}$

D. $\dfrac{g\sin\theta}{1-\frac{MR^2}{I}}$

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150. A body is rolling down an inclined plane. If $K.E.$ of rotation is 40% of $K.E.$ in translatory state, then the body is a

A. ring

B. cylinder

C. hollow ball

D. solid ball

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151. A solid cylinder rolls down an inclined plane of height $3m$ and reaches the bottom of plane with angular velocity of $2\sqrt{2}rad/s$. The radius of cylinder must be [take $g = 10m/s^2$]

A. $5cm$

B. $0.5cm$

C. $\sqrt{10}cm$

D. $\sqrt{5}m$

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152. A solid sphere, a hollow sphere and a ring are released from top of an inclined plane (frictionless) so that they slide down the plane. Then maximum acceleration down the plane is for (no rolling)

A. solid sphere

B. hollow sphere

C. ring

D. all same

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153. A solid sphere, disc and solid cylinder, all of the same mass, are allowed to roll down (from rest) on inclined plane, them

A. solid sphere reaches the bottom first

B. solid sphere reaches the bottom late

C. disc will reach the bottom first

D. all of them reach the bottom at the same time

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154. A solid ring, sphere and a disc are rolling down from the top of the same height, then the sequence to reach on the surface is

A. ring, disc, sphere

B. sphere, disc, ring

C. disc, ring, sphere

D. sphere, ring, disc

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155. Two solid discs of radii r and $2r$ roll from the top of an inclined plane without slipping. Then

A. The bigger disc will reach the horizontal level first

B. The smaller disc will reach the horizontal level first

C. The time difference or reaching of the discs at the horizontal level will depend on the inclination of the plane

D. Both the discs will reach at the same time

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156. Two solid cylinders P and Q of same mass and same radius start rolling down a fixed inclined plane from the same height at the same time. Cylinder P has most of its mass concentrated near its surface, while Q has most its mass concentrated near the axis. Which statement(s) is (are) correct?

A. Both cylinders P and Q reach the ground at the same time.

B. Cylinder P has larger linear acceleration than cylinder Q.

C. Both cylinders P and Q reach the ground with the same translational kinetic energy.

D. Cylinder Q reaches the ground with larger angular speed.

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157. A solid sphere a hollow sphere and a disc all having same mass and radius, are placed at the top of a moth incline and released. Least time will be taken in reaching the bottom by

A. the solid sphere

B. the hollow sphere

C. the disc

D. all will take the same time

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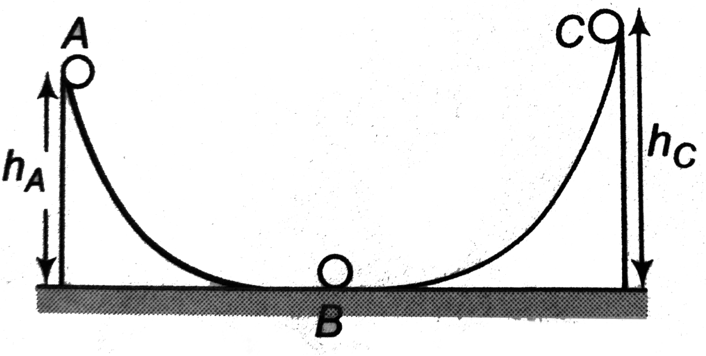
158. 

A ball moves over a fixed track as shown in thre figure. From A to B the ball rolls without slipping. If surface BC is frictionless and K_A, K_B and K_C are kinetic energies of the ball at A, B and C respectively then

(a). $h_A > h_C, K_B > K_C$

(b). $h_A > h_C, K_C > K_A$

(c). $h_A = h_C, K_B = K_C$

(d). $h_A < h_C, K_B > K_C$

A. (i),(ii)

B. (ii),(iv)

C. (i),(ii),(iii)

D. (i),(ii),(iv)

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159. A solid cylinder is rolling down on an inclined plane of angle θ. The minimum value of the coefficient of friction between the plane and the cylinder to allow pure rolling

A. $\frac{1}{3}\tan\theta$

B. $\frac{2}{3}\tan\theta$

C. $\frac{2}{5}\tan\theta$

D. $\frac{4}{5}\tan\theta$

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160. In the previous problem, if $\mu = \frac{1}{6}\tan\theta$ and cylinder is released

A. cylinder will stay at rest

B. it will make pure translational motion

C. it will translate and rotate about center

D. the angular momentum of the sphere about its center will remain constant

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161. A solid cylinder of mass m and radius r is rolling on a rough inclined plane of inclination θ. The coefficient of friction between the cylinder and incline is μ. Then.

A. (i),(ii)

B. (i),(iv)

C. (ii),(iii)

D. (iii),(iv)

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162. A cylinder rolls up an inclined plane, reaches some height, and then rolls down (without slipping throughout these motions). The directions of the frictional force acting on the cylinder are.

A. Up the incline while ascending and down the incline while descending

B. Up the incline while ascending as well as descending

C. Down the incline while ascending and up the incline while descending

D. Down the incline while ascending as well as descending

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163. A soldi sphere a hollow sphere and a disc, all haing same mass and radius are placed at the top of an incline and released. The friction coefficients between the objects and the incline are same and not sufficient to allow pure rolling. Least time will be taken in reaching the bottom by

A. the solid sphere

B. the hollow sphere

C. the disc

D. all will take the same time

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164. In the previous question the smallest kinetic energy at the bottom of the incline will be achieved by

A. the solid sphere

B. the hollow sphere

C. the disc

D. all will achieve same kinetic energy

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165. A sphere cannot roll on

A. a smooth horizontal surface

B. a smooth inclined surface

C. a rough horizontal surface

D. a rough inclined surface

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166. The motion of a sphere moving on a rough horizontal surface changes from pure sliding (without rolling) to pure rolling (without slipping). In this process, the force of friction

(i) intially acts opposite to the direction of motion and late in the direction of motion

(ii) cause linear retardation

(iii) causes angular acceleration

(iv) stops acting when pure rolling begins

A. (i),(ii)

B. (i),(ii),(iii)

C. (ii),(iv)

D. (ii), (iii),(iv)

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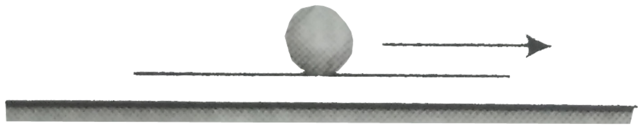
167. A ball rests upon a flat piece of paper on a table top. The paper is pulled horizontally but quickly towards right as shwon. Relative to its initial position with respect to the table, the ball



(i) remains stationary if there is no friction between the paper and the bell.

(ii) moves to the left and starts rolling backwards, i.e. to the left if there is a friction between the paper and the ball.

(iii) moves forward, i.e. in the direction in which the paper is pulled.

(iv) Here, the correct statements/s/is/are

A. Both (i) and (ii)

B. Only (iii)

C. Only (i)

D. Only (ii)

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168. When a bicycle is in motio, the force of friction exerted by the ground on the two wheels is such that it acts

A. (i),(ii)

B. (ii),(iii)

C. (i),(iii)

D. (ii),(iv)

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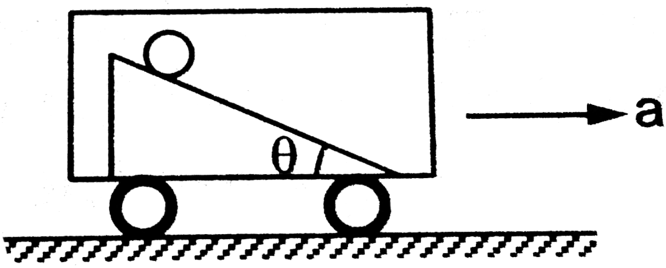
169. Figure shows smooth inclined plane fixed in a car acceleratiing on a horizontal road. The angle of incline θ is related to the acceleration a of the car as $a = \; > an\theta$. If the sphere is set in pure rolling on the incline



A. It will continue pure rolling

B. It will slip down the plane

C. Its linear velocity will increase

D. Its linear velociy will decrease

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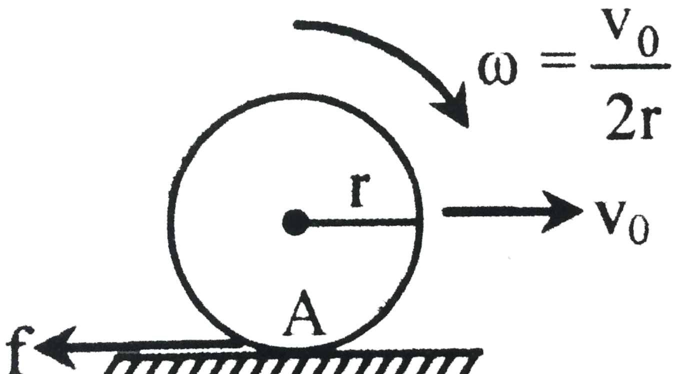
170. A sphere of mass M and radius r shown in figure slips on a rough horizontal plane. At some instant it has translational velocity V_0 and rotational velocity about the centre $\frac{v_0}{2r}$. Find the translational velocity after the sphere starts pure rolling.



A. $\frac{5v_0}{7}$

B. $\frac{6v_0}{7}$

C. $\frac{3v_0}{4}$

D. $\frac{3v_0}{5}$

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171. A solid cylinder of mass $50kg$ and radius $0.5m$ is free to rotate about the horizontal axis. A massless string is wound round the cylinder with one end attached to it and other end hanging freely. Tension in the string required to produce an angular acceleration of 2 revolution s^{-2} is

A. $50N$

B. $78.5N$

C. $157N$

D. $25N$

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172. The ratio of the accelerations for a solid sphere (mass m, $\text{ and } radius R$) rolling down an incline of angle θ without slipping, and slipping down the incline without rolling is

A. $2:3$

B. $2:5$

C. $7:5$

D. $5:7$

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