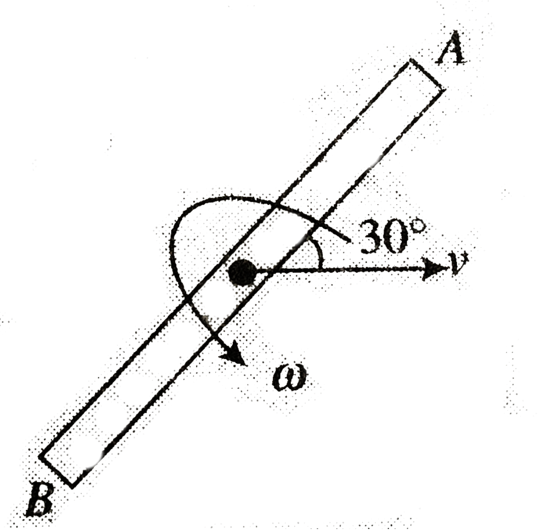
PHYSICS

BOOKS - CENGAGE PHYSICS (ENGLISH)

RIGID BODY DYNAMICS 1

Illustration

1. A uniform rod of length l is spinning with an angular velocity $\omega = 2\frac{v}{l}$ while its centre of mass moves with a velocity v. Find the velocity of the end of the rod.



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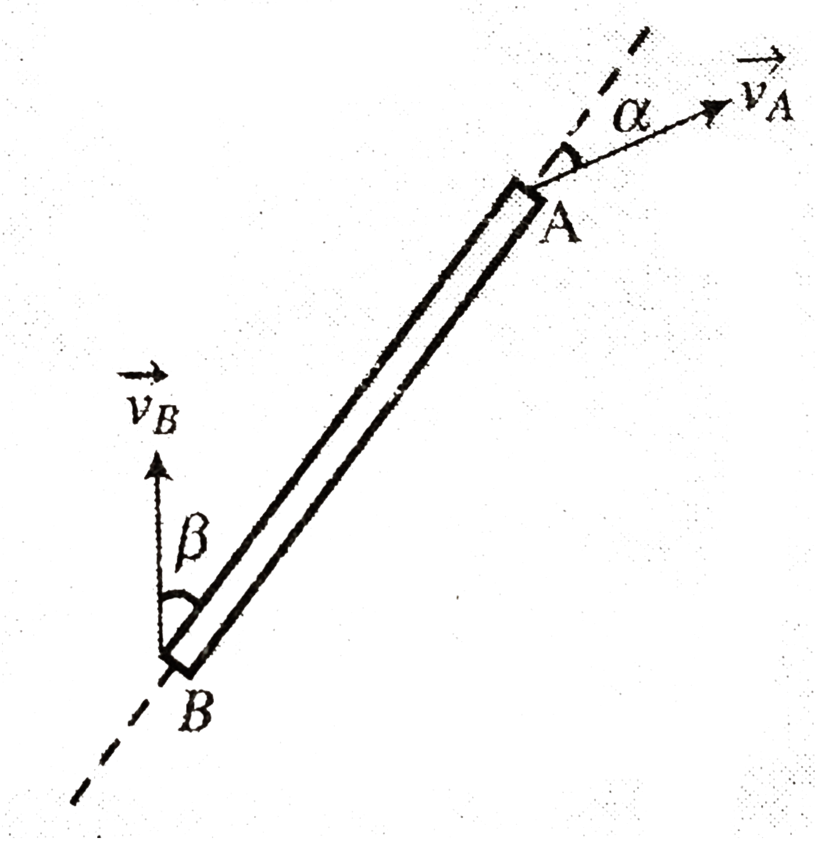
2. The ends A and B of a eod of length l have velocities of magnitudes $\left|\vec{v}_A\right| = v$ and $\left|\vec{v}_B\right| = 2v$ respectively. If the inclination of $\vec{v}_A$ relationn to the rod is α find the

a. Inclination β of $\vec{c}_B$ relative of the rod.

b. angular velocity of the rod.



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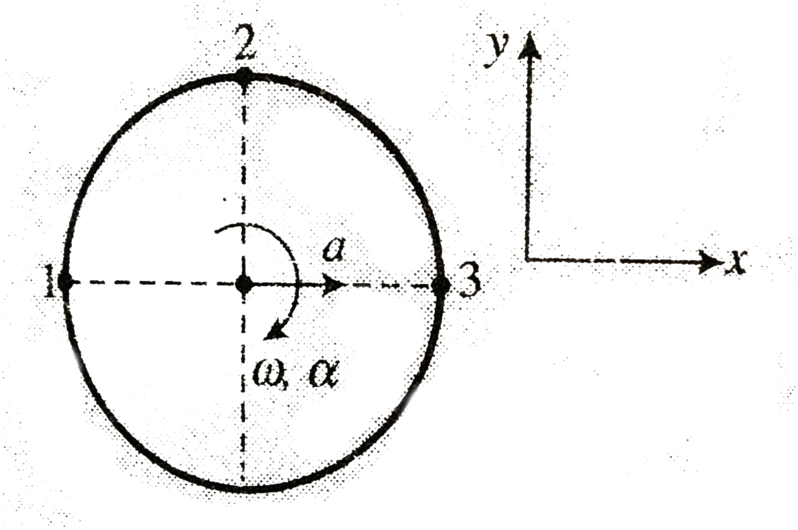
3. A uniiform disc of radius r spins with angular velocity ω and angular acceleration α. If the centre of mass of the disc has linear acceleration a, find the magnitude and direction of aceeleration of the point 1, 2, and 3.



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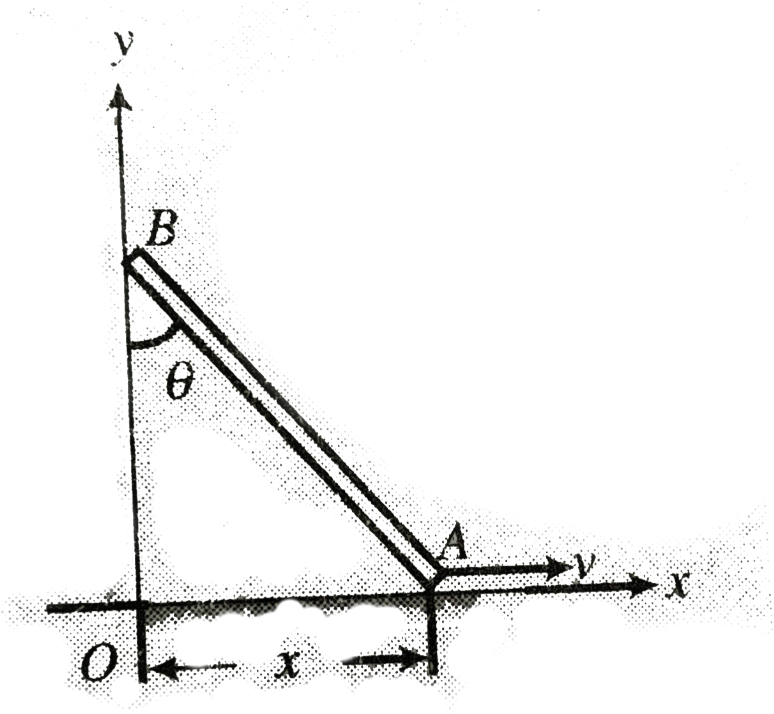
4. A rod of length l is moving in a vertical plane $(x-y)$ when the lowest point A of the rod is moved with a velocity v. find the a angular velocity of the rod and b velocity of the end B.



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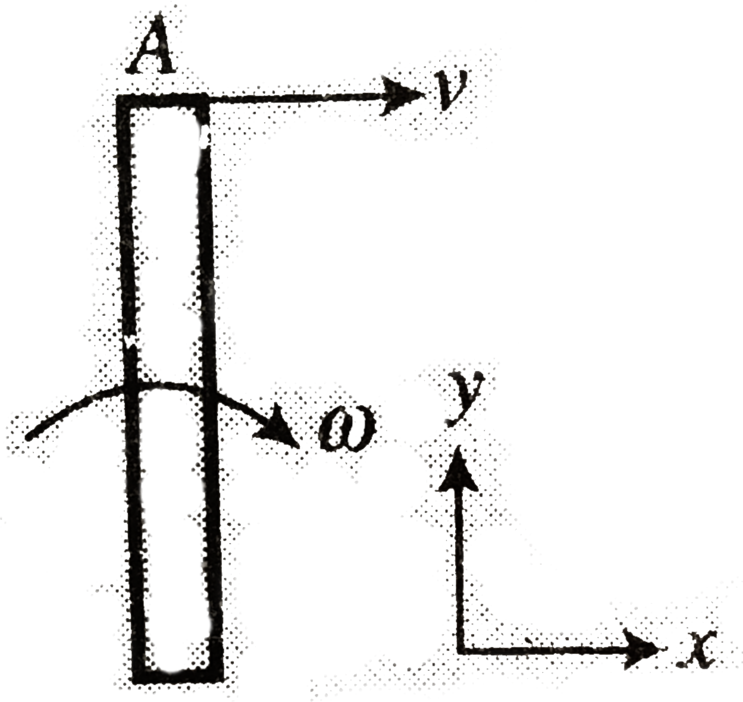
5. Find the instantneous axis of rotation of a rod length l when its end A moves with a velocity $\vec{v}_A = Vi$ and the rod rotates with an angular velocity $\vec{\omega} = -\frac{v}{2l}\hat{k}$.



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6. Four particles each of mass 'm' are kept at the four corners of a square of edge 'a'. Find the moment of inertia of the system about a line perpendicular to the plane of the square and passing through the center of the square.

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7. A uniform rod of mass m and length l_0 is rotating with a constant angular speed ω about a vertical axis passing through its point of suspension. Find the moment of inertia of the rod about the axis of rotation if it make an angle θ to the vertical (axis of rotation).

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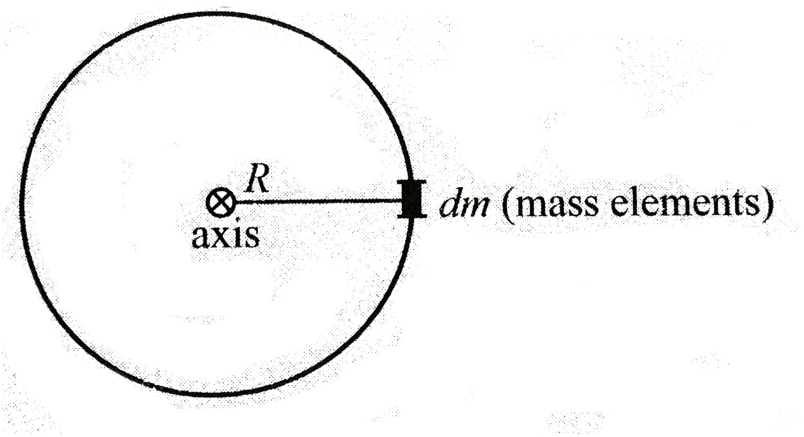
8. Calculate the moment of inertia of a ring having mass M, radius $R$and having uniform mass distribution about an axis passing through the centre of the ring and perpendicular to the plane of the ring?



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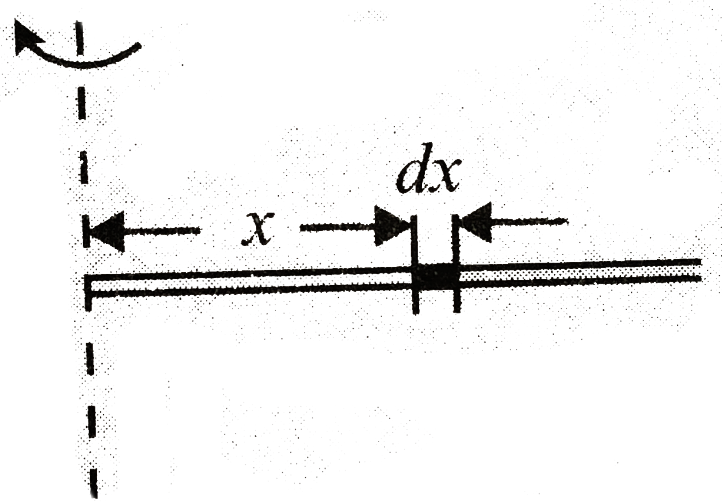
9. Calculate the moment of inertia of a uniform rod of mass M and length l about an axis passing through an end and perpendicular to the rod. The rod can be divided into a number of mass elements along the length of the rod.



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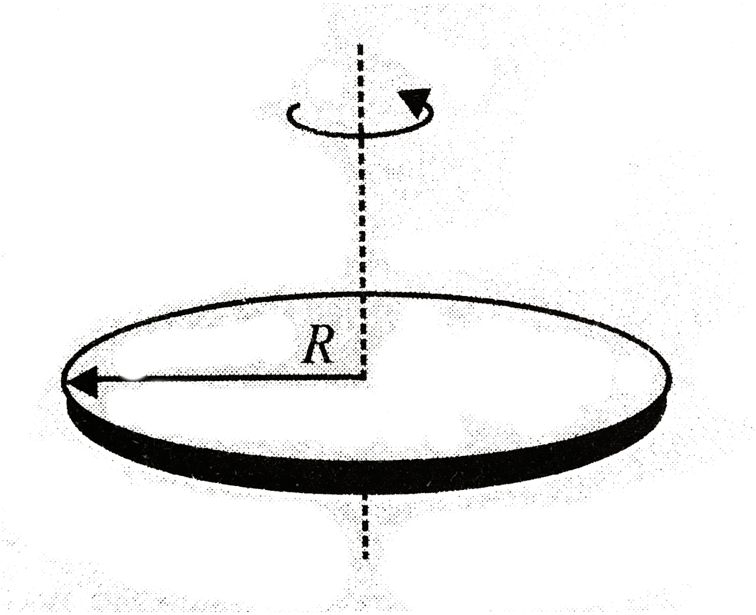
10. Find the moment of inertia of a circular disk or solid cylinder of radius R about the axis through the centre and perpendicular to the flat surface.



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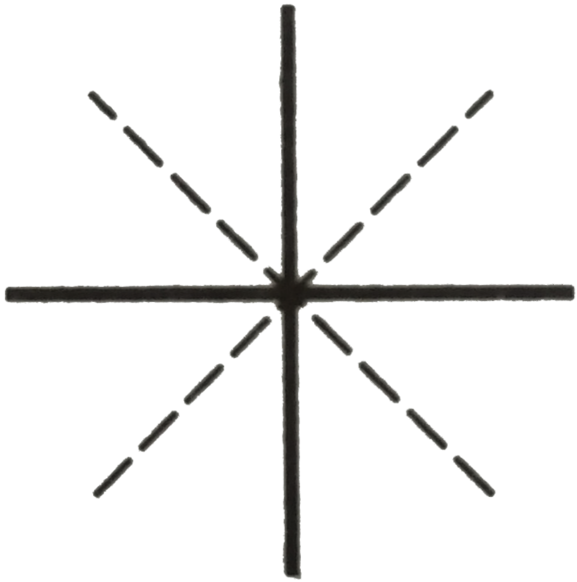
11. Two uniform identicla rods each of mass M and length l are joined to form a cross as shown in figure. Find the momet of inertia of the cross about a bisector as shown doted in the figure



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12. Find the moment of inertia of a solid cylinder of mass M and radius R about a line parallel to the axis of the cylinder and on the surface of the cylinder.

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13. Calculate the moment of inertia of

a. a ring of mass M and radius R about an axis coinciding with the diameter of the ring.

b. as thin disc about an axis coinciding with the diameter.

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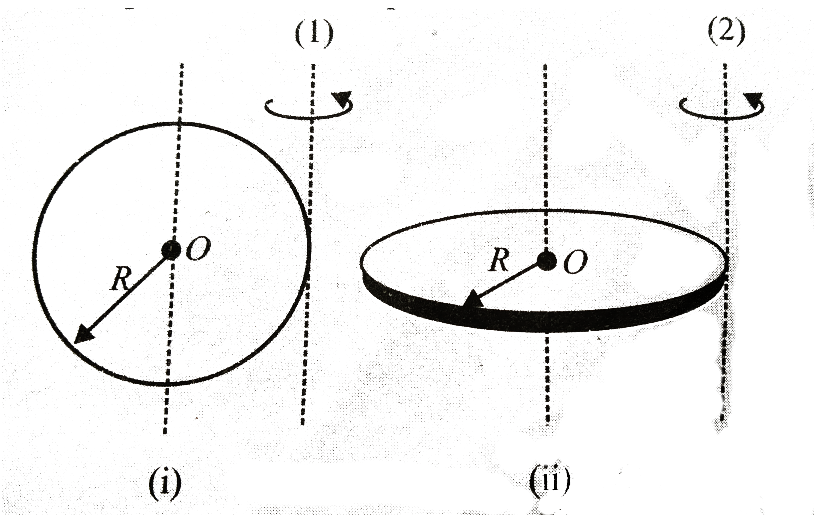
14. Find the out the moment of inertia of a ring having uniform mass distribution of mass M and radius R about an axis which is tangent ot the ring and a in the plane of the ring b. perpendicular to the plane of the ring.



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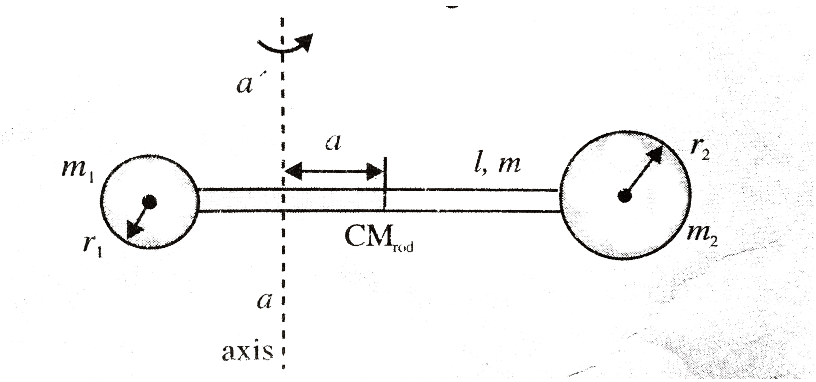
15. Two uniform solid of masses m_1 and m_2 and radii r_1 and r_2 respectively, are connected at the ends of a uniform rod of length l and mass m. Find the moment of inertia of the system about an axis perpendicular to the rod and passing through a point at a distance of a from the centre of mass of the rod as shown in figure.



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16. There are four solid balls with their centres at the four corners of a square of side a. the mass of each sphere is m and radius is r. Find the moment of inertia of the system about one of the sides of the square

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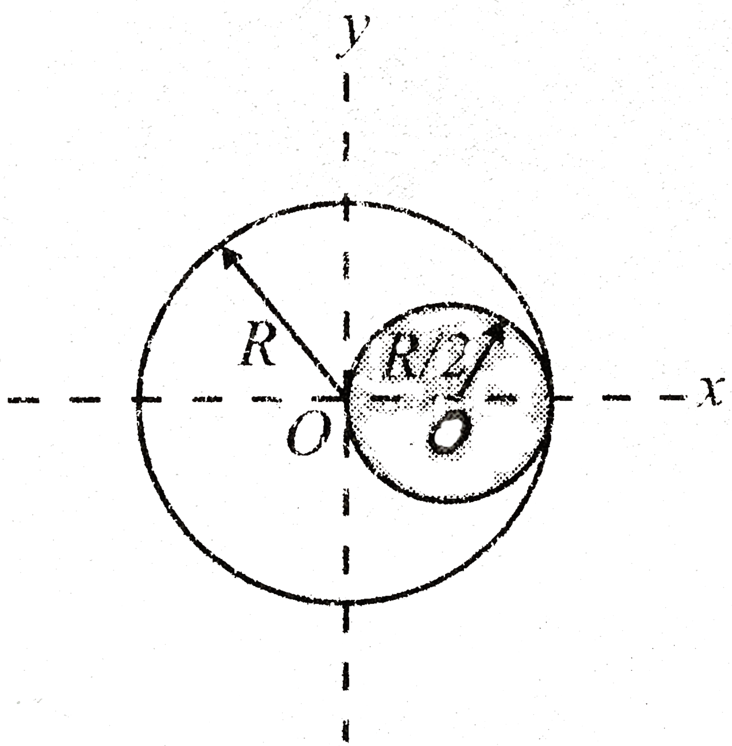
17. A circular hole of radius $R/2$ is cut from a circular disc of radius R. The disc lies in the xy-plane and its centre coincides with the origin. If the remaining mass of the disc is M, then

a. determine the initial mass of the disc and

b. determine its moment of inertia about the z-axis.



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18. Three identical thin rods, each of mass m and length l, are joined to form an equilateral triangular frame. Find the moment of inertia of the frame about an axis parallel to tis one side and passing through the opposite vertex. Also find its radius of gyration about the given axis.

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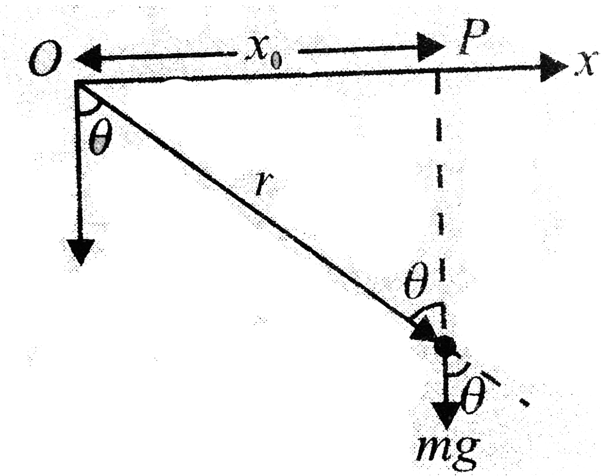
19. A particle of mass m is released in vertical plane from a point P at $x = x_0$ on the x-axis. It falls vertically parallel to the y-axis. Find the torque τ acting on the particle at a time about origin.



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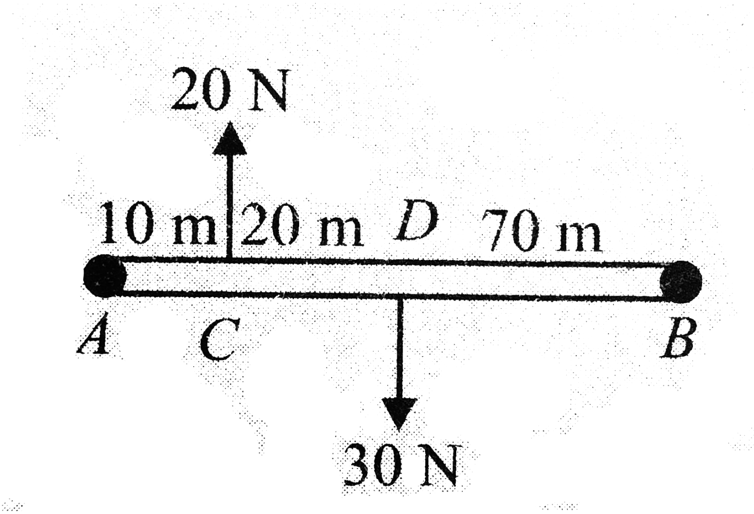
20. Determine the point of application of force, when forces of $20N$ and $30N$ are acting on rod as shown in figure.



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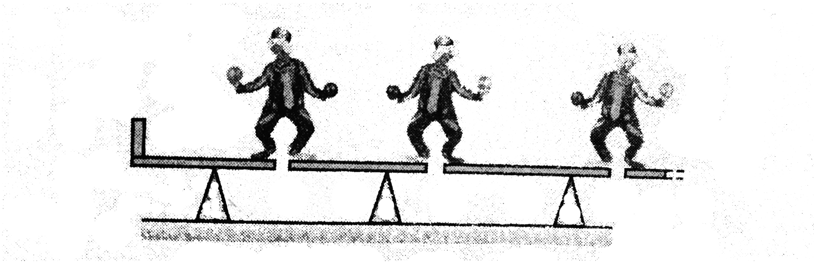
21. In a circus show are used large numbers of light boards, each of which can rotate around a fixed fulcrum. Fulcrum of reach board divides the length of the board in ration $2:1$. At the one end of the left most board is placed a small block of mass $30kg$ and a team of clowns stand keeping their feel at the ends of adjacent boards as shown in figure. the mass of each clown is $80kg$. What maximum number of clowns can keep balance in this way?



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22. Two small kids weighing 10 kg and 15 kg respectively are trying to balance a seesaw of total length 5.0 with the fulcrum at the centre. If one of the kids is sitting at an end where should the other sit?

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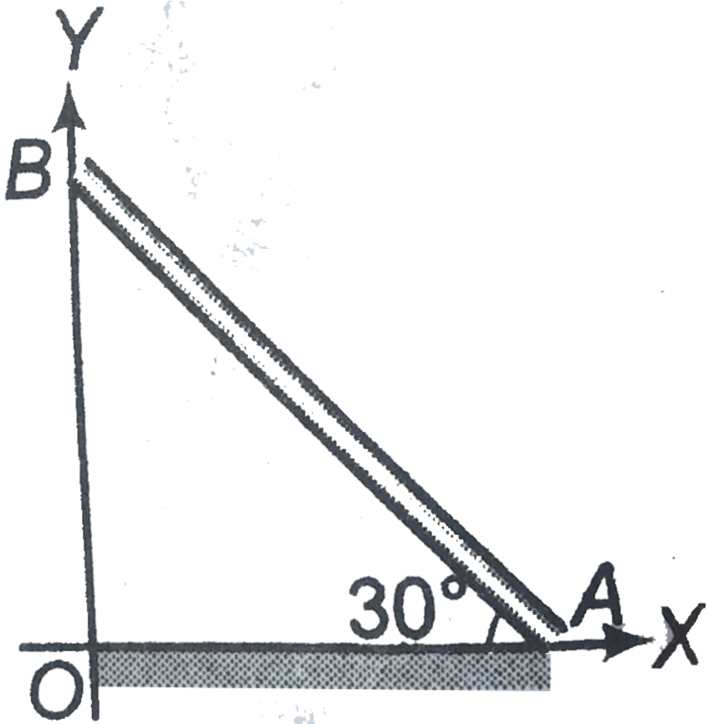
23. A rod AB rests with the end A on rough horizontal ground and the end B against a smooth vertical wall. The rod is uniform and of weight w. If the rod is in equilibrium in the position shown in figure.Find

(a)frictional force shown at A

(b) normal reaction at A

(c) normal reaction at B.



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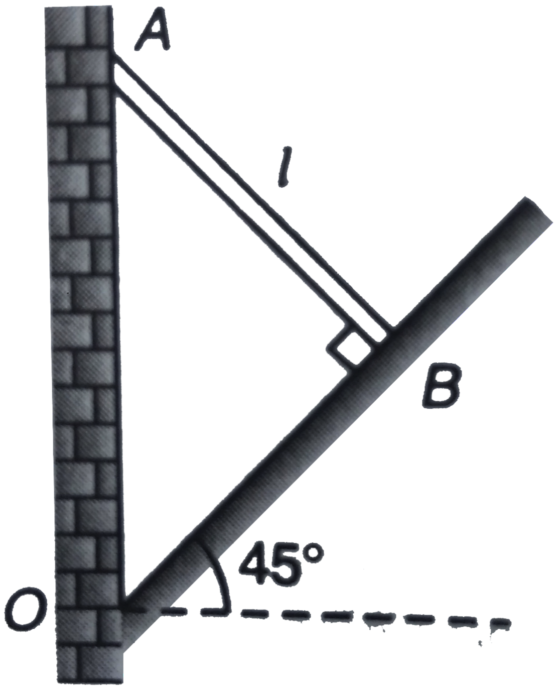
24. At the bottom edge of a smooth wall , an inclined plane is kept at an angle of 45° . A uniform ladder of length l and mass M rests on the inclined plane against the wall such that it is perpendicular to the inclined.



(a) if the plane is also smooth ,which way will the ladder slide .

(b) What is the minimum coefficient of friction neccessary so that the ladder does not slip on the inclined?

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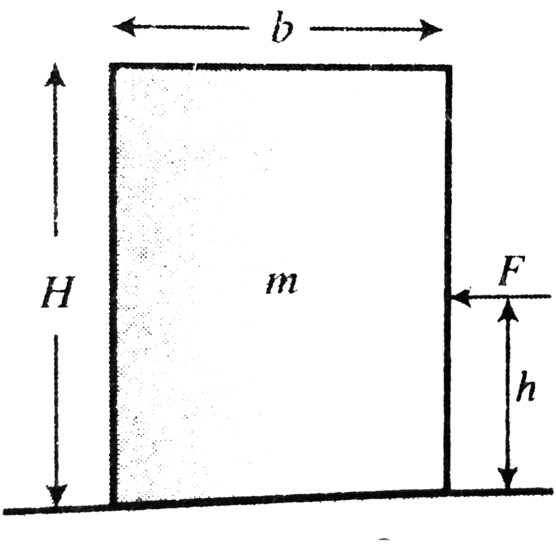
25. A horizontal force F is applied to a homogeneous rectangular block of mass m, width b and height H. The block moves with constant velocity, the coefficient of friction is μ_k.

a. What is the greater height h at which the force F can be applied so that the block will slide without tipping over ?



b. Through which point on the bottom face of the block will the resultant of the friction and normal forces act if $h = H/2$?

c. If the block is at rest and coefficient of static friction is μ_s what are the various criteria for which sliding or tipping occurs?

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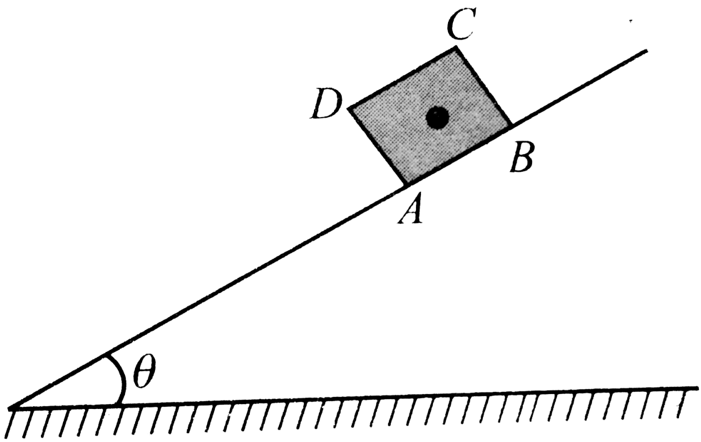
26. A cube of side a is placed on an inclined plane of inclination θ. What is the maximum value of θ for which the cube will not topple?



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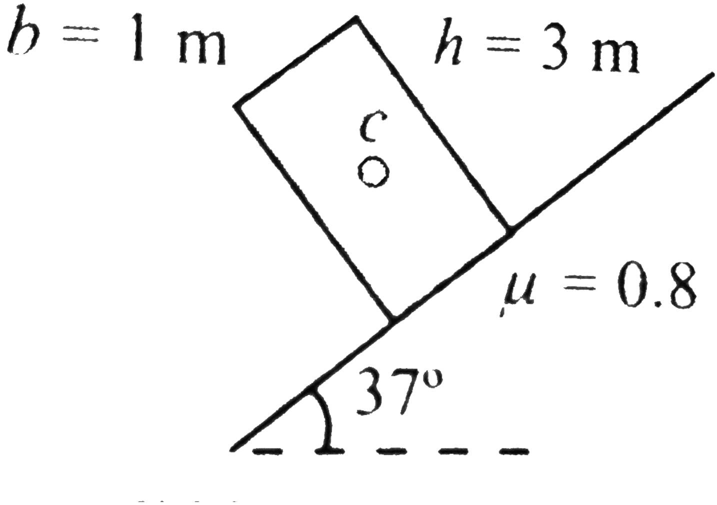
27. A tall block of mass $M = 50kg$ and base width $b = 1m$ and height $h = 3m$ is kept on rough inclined surface with coefficient of friction $\mu = 0.8$ as shown in figure. The angle of inclination with the horizontal is

37°. Determine whether the block slides down or topples over.



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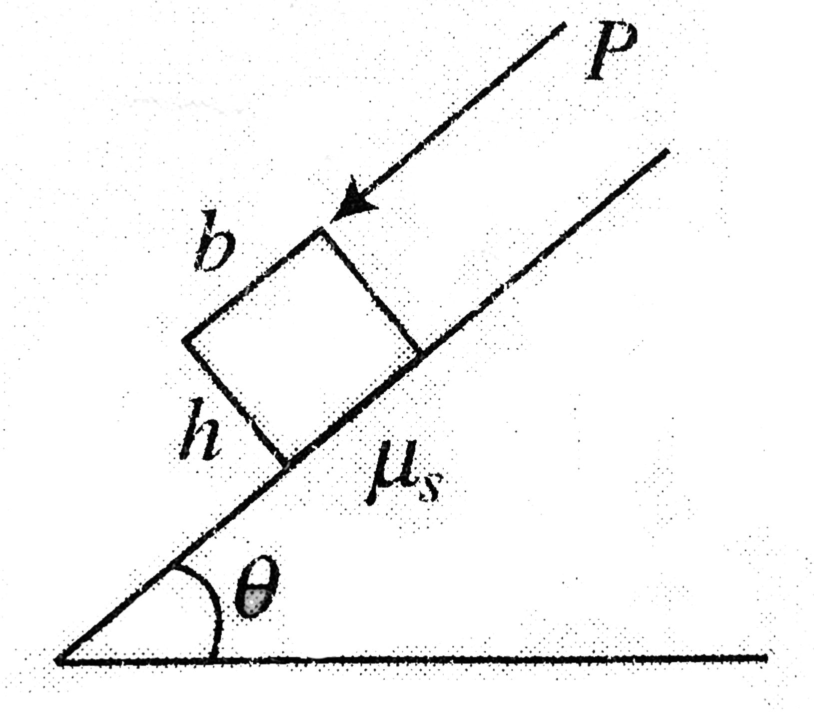
28. Determine the maximum ratio h/b for which the homogenous block will side without tipping under the actionof force P. The coefficient of static friction between the block and the incline is μ_s.



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29. the door of an almirah is 6 ft high, 1.5 ft wide and weights 8 kg. The door is supported by two hinges situated at a distance of 1 ft from the ends. If the magnitude of the forces exerted by the hinges on the door are equal find this magnitude.

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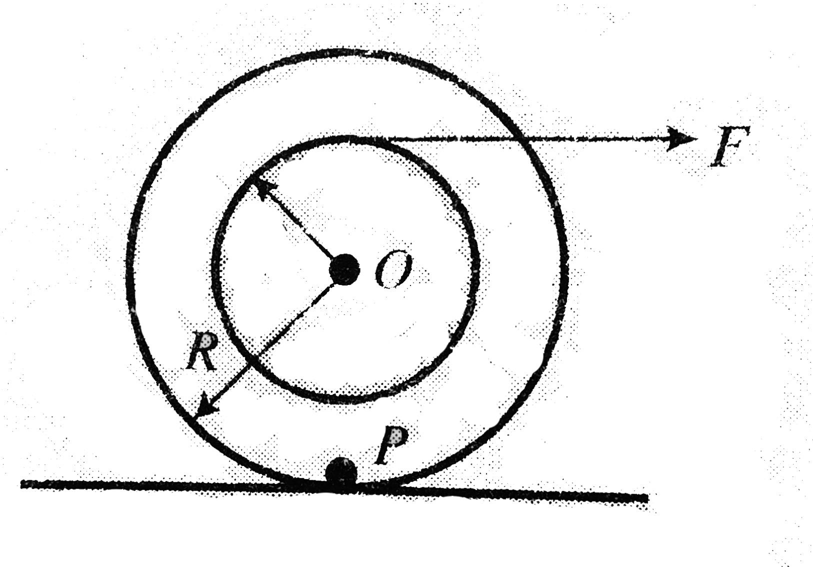
30. A cotton reel of mass m and moment of inertia I is kept at rest on as smooth horizontal surface. The reel has inner and other radius r and R respectively. A horizontal force F starts actings as shown in figure. Find the



a. acceleration of the centre of mass of reel.

b. angular acceleration of the reel

c. net acceleration of point of contact.

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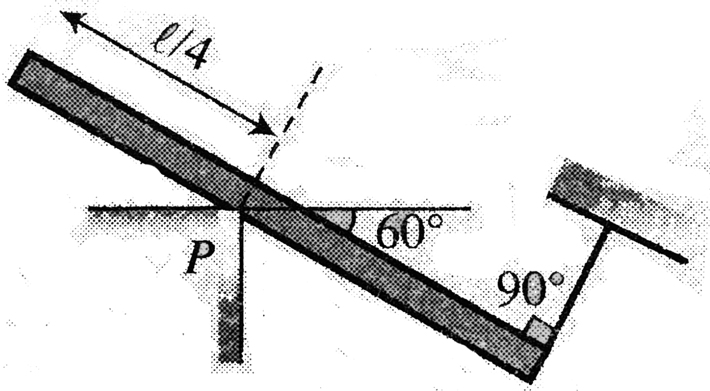
31. A uniform rod of mass m and length l is in equilibrium under the action of constraint forces, gravity and tension in the string. Find the



a. frictional force acting on the rod.

b. tension in the string.

c. normal reaction on the rod.

Now, the string is cut. Find the

d. angular acceleratiion of the rod just after the string is cut.

e. normal reaction on the rod just after the string is cut.

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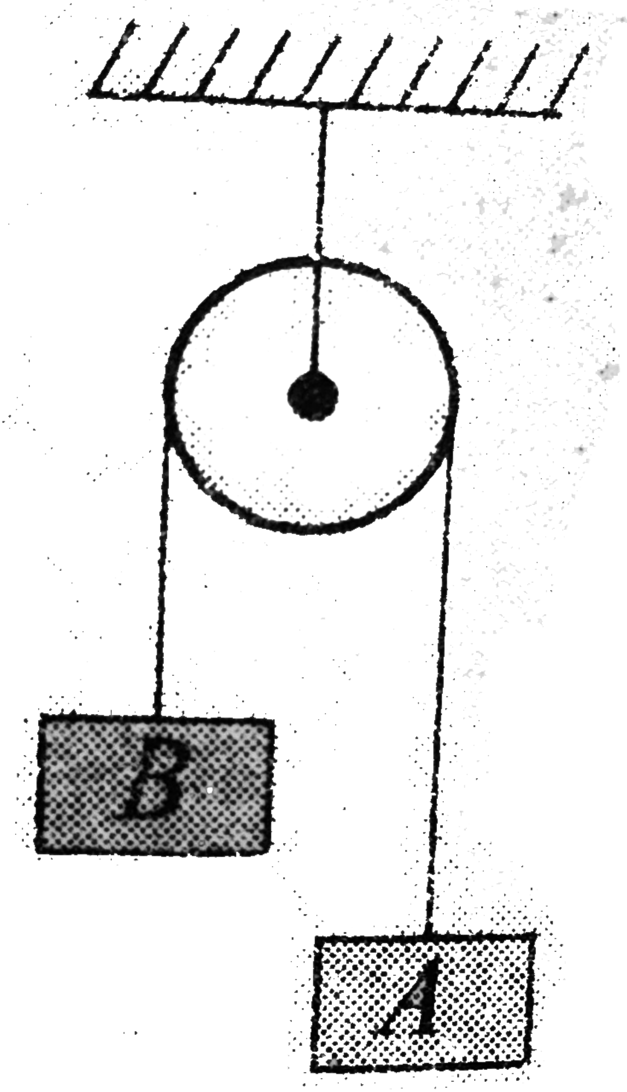
32. In figure calculate the linear acceleration of the blocks.

Mass of block $B = 8kg$

mass of disc shaped pulley $= 2kg$ (take $g = 10m/s^2$)



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33. A block of mass m is attached at the end of an inextensible string which is wound over a rough pulley of mass M and radius R figure a. Assume the string does not slide over the pulley. Find the acceleration of the block when released.

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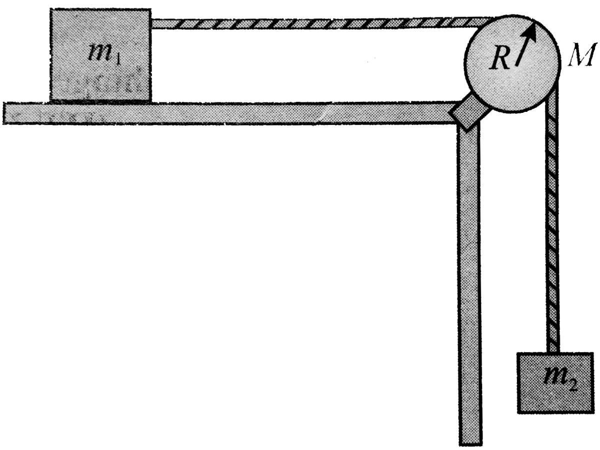
34. In figure mass m_1 slides without friction on the horizontal surface, the frictionless pulley is in the form of a cylinder of mass M and radius R, and a string turns the pulley without slipping. Find the acceleration of each mass, and tension in each part of the string.



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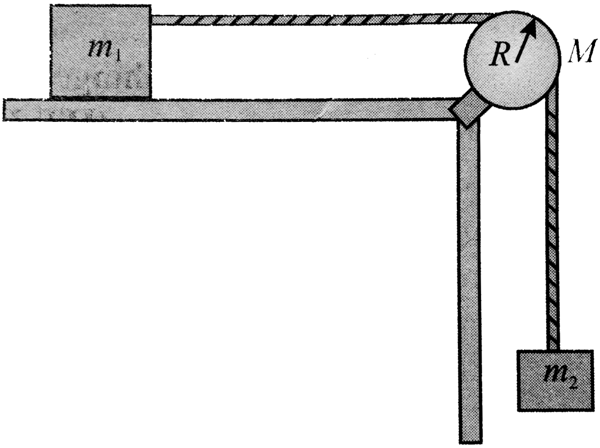
35. In figure mass m_1 slides without friction on the horizontal surface, the frictionless pulley is in the form of a cylinder of mass M and radius R, and a string turns the pulley without slipping. Find the acceleration of each mass, and tension in each part of the string.



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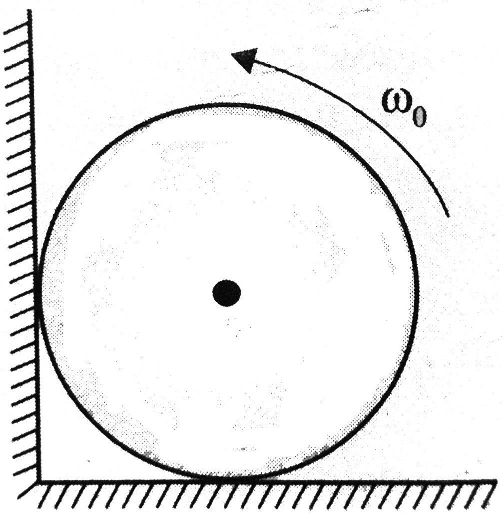
36. A uniform cylinder of radius R is spinned about it axis to the angular velocity ω_0 and then placed into a corner,. The coeficient of friction between the corner walls and the cylinder is μ_k How many turns will the cylinder accomplish before it stops?



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37. A uniform rod of length L and mass M is pivoted freely at one end and placed in vertical position.

a. What is angular acceleration of the rod when it is at ann angle θ with the vertical?

b. What is the tangential linear acceleration of the free end when the rod is horizontal?

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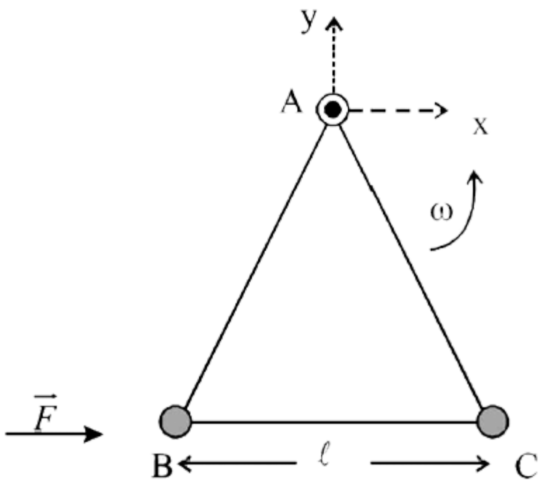
38. Three particles A, B and C each of mass m, are connected to each other by three massless rigid rods to form a rigid, equilateral triangular body of side l. This body is placed on a horizontal frictionless table (x-y plane) and is hinged to it at the point A so that it can move without friction about the vertical axis through A . the body is set into rotational motion on the table about A with a constant angular velocity ω.



(a) Find the magnitude of the horizontal force exerted by the hinge on the body.

(b) At time T, when the side BC is parallel to the x-axis, a force F is applied on B along BC (as shown). Obtain the x-component and the y-component of the force exerted by the hinge on the body, immediately after time T.

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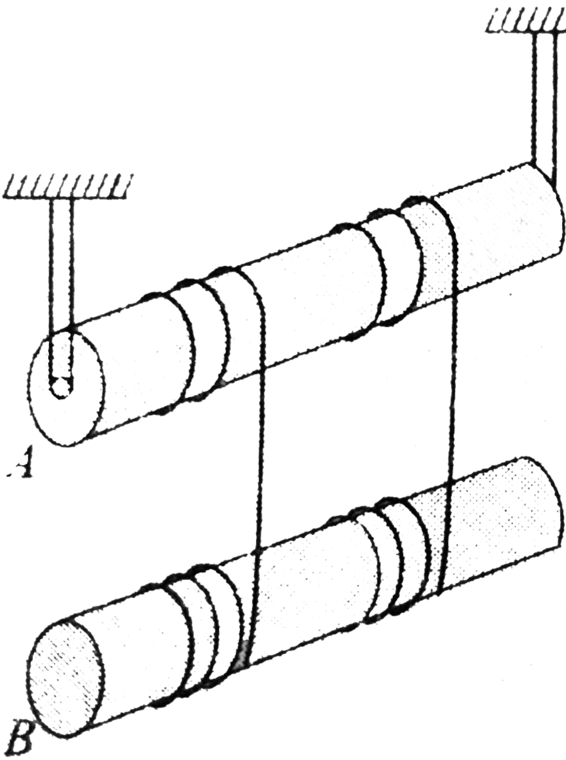
39. The arrangement shown in figure consists of two identical, uniform, solid cylinders, each of mass m, on which two light theads are wound symmetrically.

Find the tensions of each thread in the process of motion. The friction in the axle of the upper cylinder is assumed to be absent.



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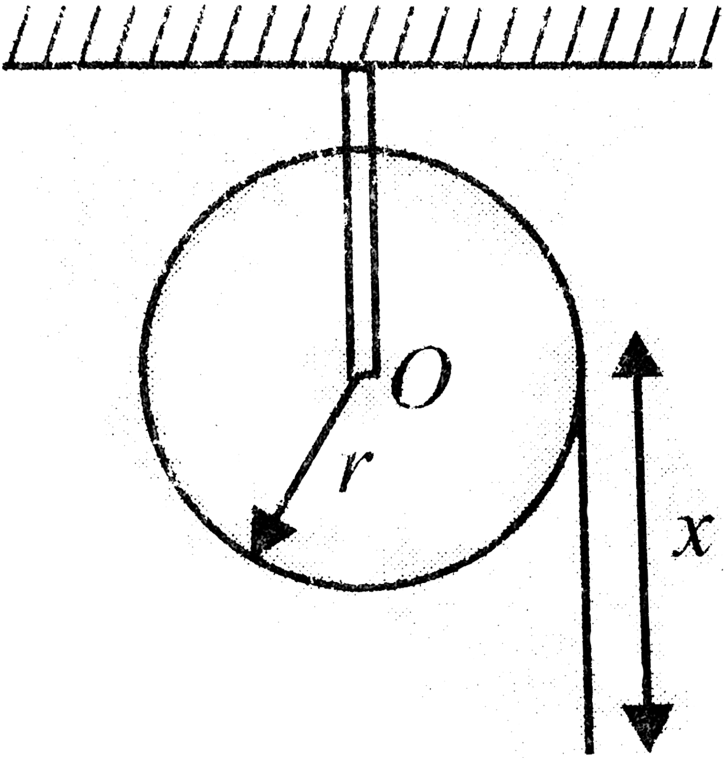
Solved Examples

1. A uniform cylinder of radius r and mass m can rotate freely about a fixed horizontal axis. A thin cord of length l and mass m_0 is would on the cylinder in a single layer. Find the angular acceleration of the cylinder as a function of the length x of the hanging part of the end. the wound part of the cord is supposed to have its centre of gravity on the cylinder axis is shown in figure.



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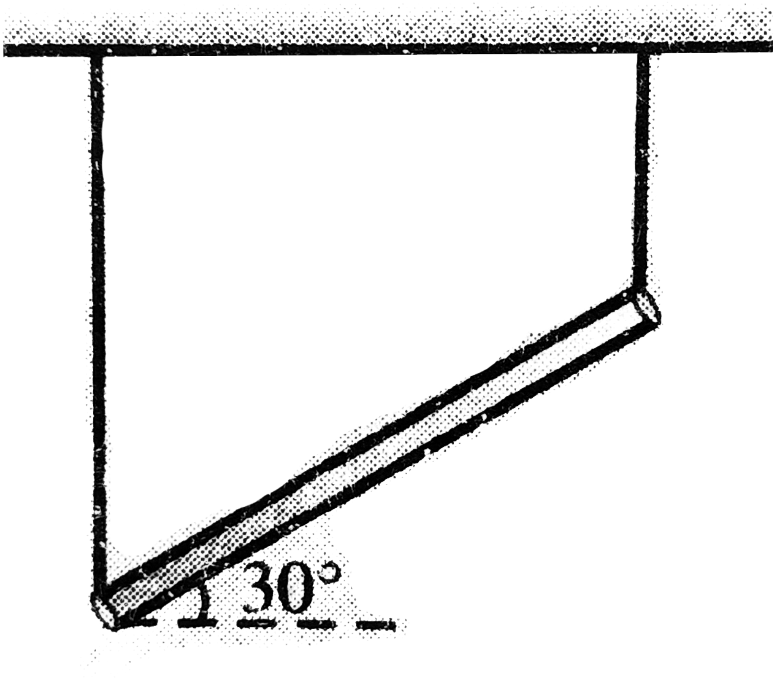
2. A thin uniform bar of mass m and length $2L$ is held at an angle 30° with the horizontal by means of two vertical inextensible strings, at each end as shown in figure. If the string at the right end breaks, leaving the bar to swing, determine the tension in the string at the left end and the angular acceleration of the bar immediately after string breaks.



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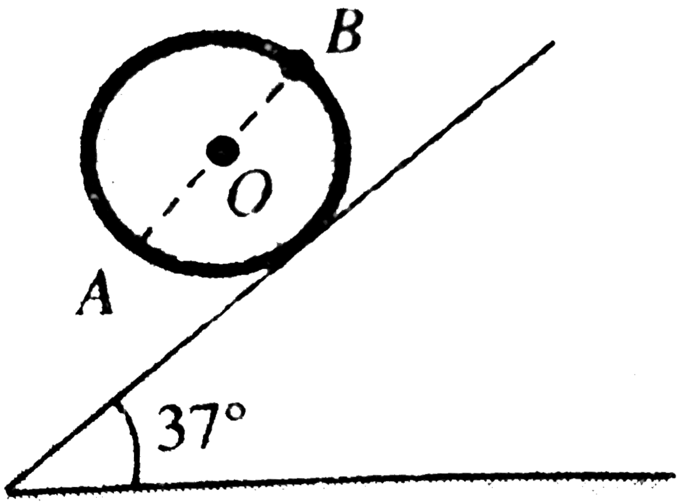
3. A uniform solid sphere of mass $1kg$ and radius 10 cm is kept stationary on a rough inclined plane by fixing a highly dense particle at B. Incination of plane is 37° with horizontal and AB is the diameter of the sphere which is parallel to the plane, as show in figure. Calculate



a. mass of the particle fixed at B

b. minimum required coefficient of friction between sphere and plane to keep sphere in equilibrium.

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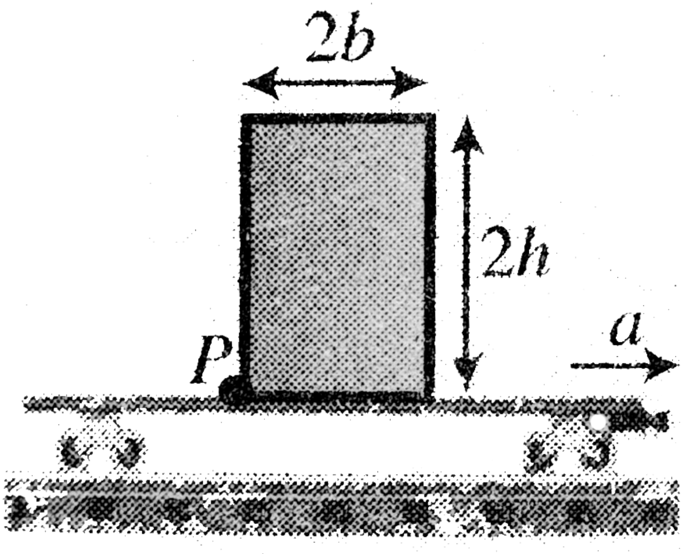
4. A block of mass m height $2h$ and width $2b$ rests on a flat car which moves horizontally with constant acceleration a as shown in figure. Determine



a. the value of the acceleration at which slipping of the block on the car starts, if the coefficient of friction is μ.

b. the value of the acceleration at which block topples about A, assuming sufficient friction to prevet slipping and

c. the shortest distance in which it can be stopped from a speed of $20ms^{-1}$ with constant deceleration so that the block is not disturbed. The following data are given $b = 0.6m, h = 0.9m, \mu = 0.5$ and $g = 10ms^{-2}$

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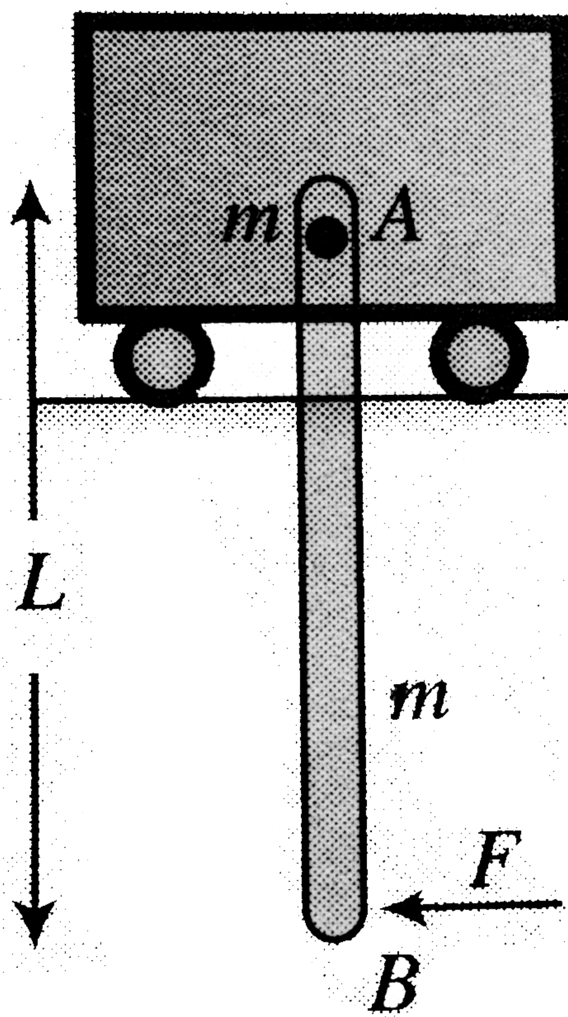
5. A uniform slender bar AB of mass m is suspended as shown from a small cart of the same mass m. Neglecting the effect of the friction, determine the accelerations of points A and B immediately after a horizontal force F has been applied at B.



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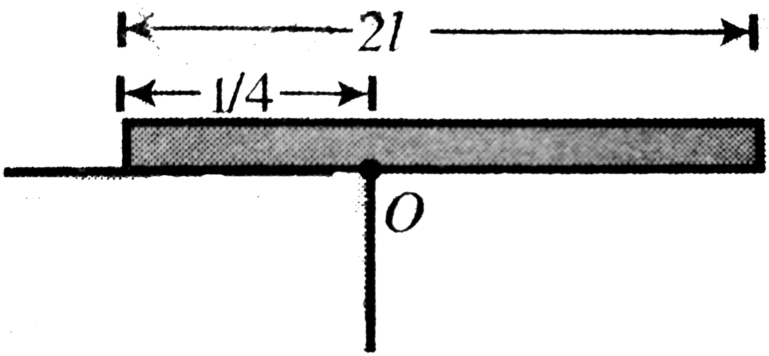
6. One fourth length of a uniform rod of length $2l$ and mass m is place don a horizontal table and the rod is held horizontal. The rod is released from rest. Find the normal reaction on the rod as soon as the rod is released.



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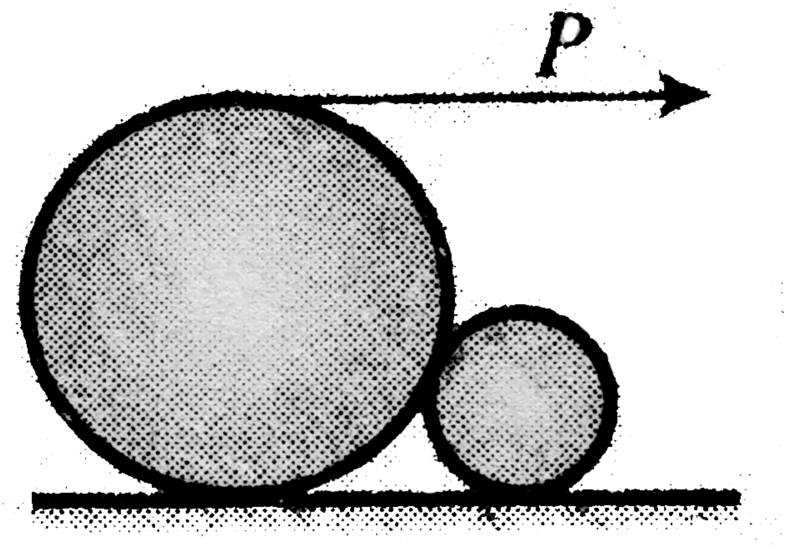
7. Determine the minimum coefficient of friction between a thin rod and a floor at which a person can slowly lift the rod from the floor, without slipping, to the vertical position applying at its end a force always perpendicular to its length.

8. Consider two heavy right circular rollers of the radii R and r respectively and rest on a rough horizontal plane a shown in figure. The larger roller has a string wound around it to which a horizontal force P can be applied as shown. Assuming that the coefficient of friction m has the same value for all surfaces of contact, determine the necessary condition under which the larger roller can be pulled over the smaller one. Assume the smaller cylinder should neither roll nor slide.



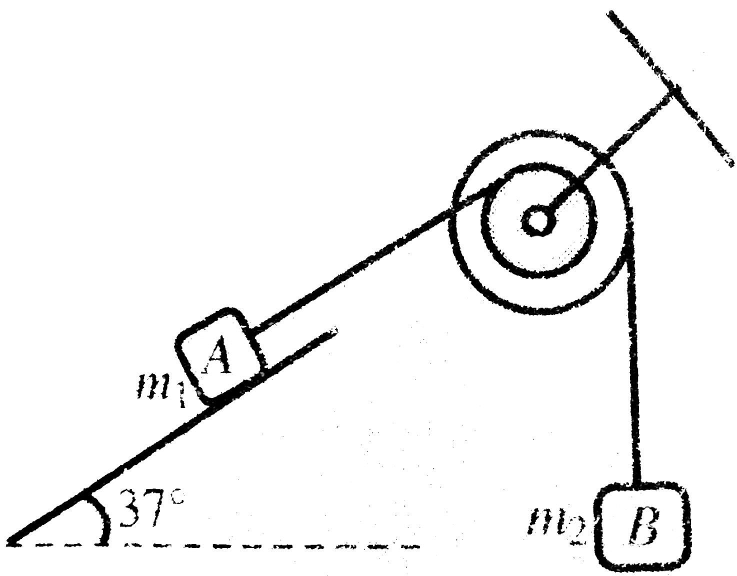
9. In the system shown in the figure blocks A and B have mass $m_1 = 2kg$ and $m_2 = 26/7kg$ respectiely. Pulley having moment of inertia $I = 0.11kgm^{-2}$ can rotate without friction about a fixed axis. Inner and outer radii of pulley are $a = 10cm$ and $b = 15cm$ respectively. B is hanging with the thread wrapped around the pulley, while A lies on a rough inclined plane.

Coefficient of friction being $\mu = \sqrt{3}/10$

Calculate

as. Tension in each thread, and

b. Acceleration of each block $\left(g = 10ms^{-2}\right)$



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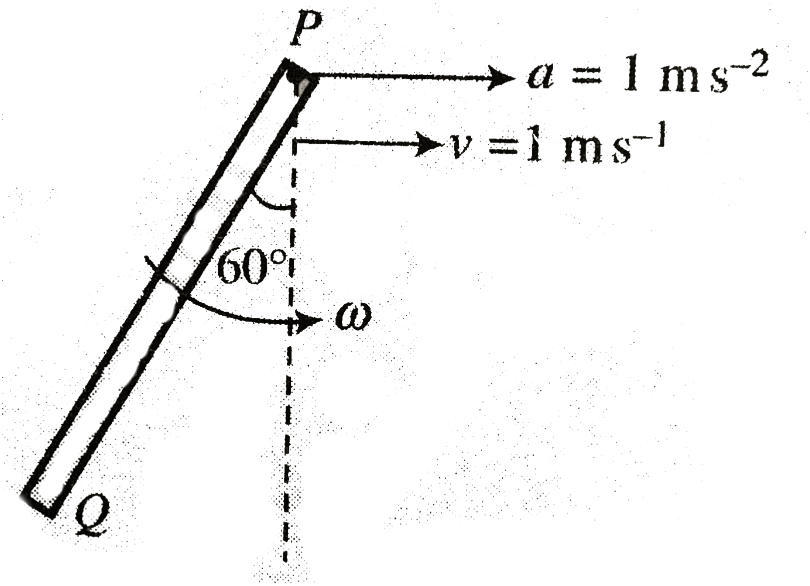
Exercise 2.1

1. The rod of length $l=1m$ rotates with an angular velocity $\omega=2rads^{-1}$ an the point P moves with velocity $v=1ms^{-1}$ and acceleration $a=1ms^{-2}$. Find the velocity and acceleration of Q.



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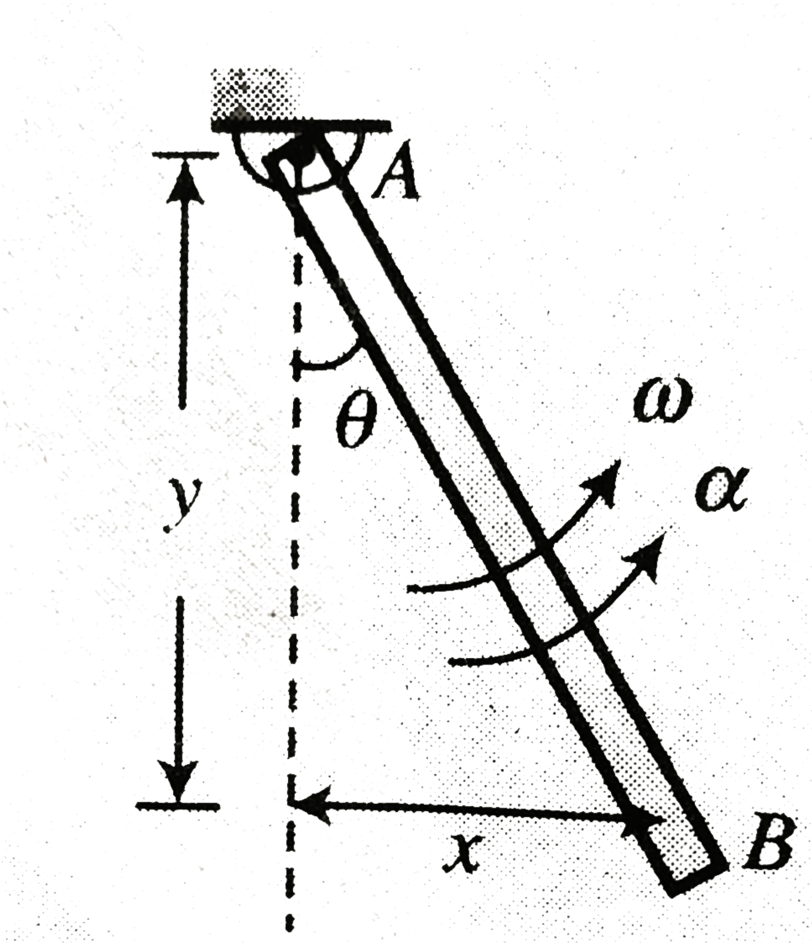
2. The angular velocity and angular acceleration of the pivoted rod are given as ω and α respectively. Fid the x and y components of acceleration of B.



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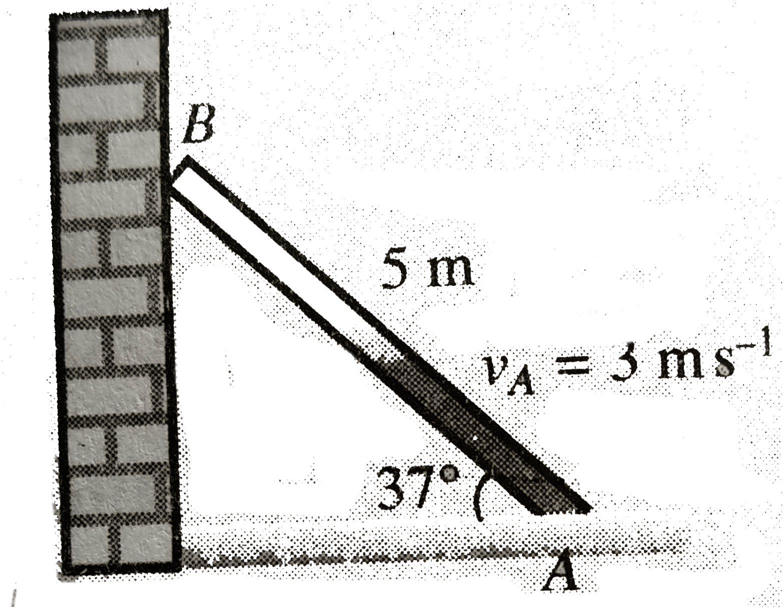
3. A rod AB length $5m$ which remains in vertical plane has its ends A and B constrained to remain contact with a horizontal floor and a vertical wall respectively. Determine the velocity of the end B and angular velocity at the position shown in Fig. , if the point A has a velocity of $3ms^{1}$ rightward.



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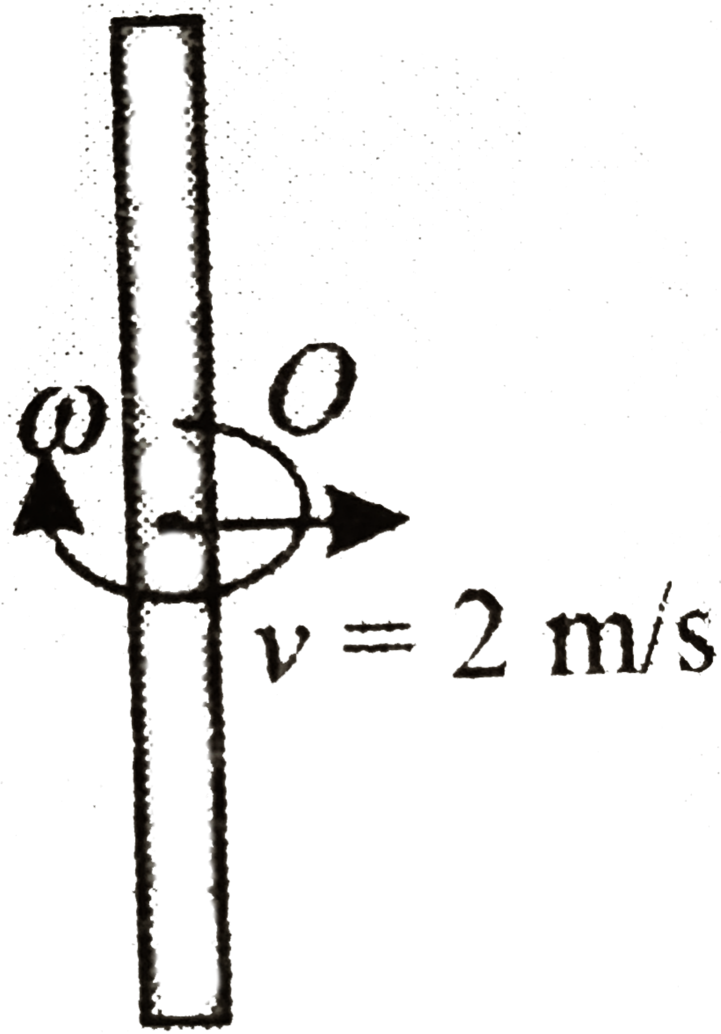
4. Shown in the figure is rod which moves with $v = 2ms^{-1}$ and rotates with $\omega = 2\pi rads^{-1}$. Find the instantaneous axis of rotation.



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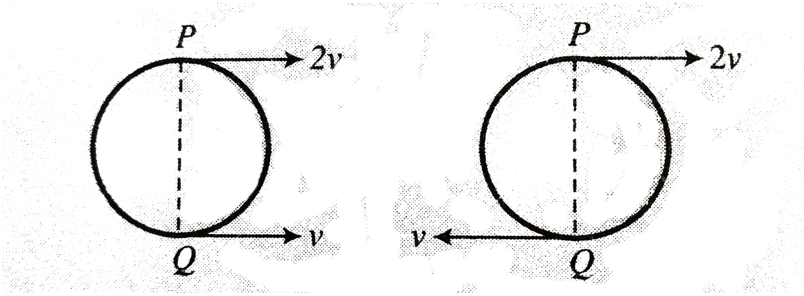
5. Find the position of instantaneous centre of rotation and angular velocity of the disc in the following cases as shown. Radius of disc is R in each case.



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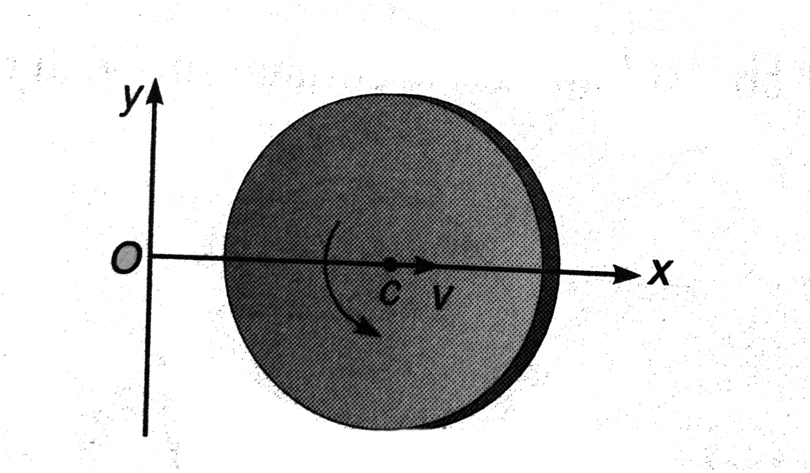
6. 

A rotating disc moves in the positive direction of the x-axis. Find the equation $y(x)$ describing the position of the instantaneous axis of rotation if at the initial moment of the centre c of the disc was located at the point O after which it moved with constant velocity v while the disc started rotating counterclockwise with a constant angular acceleration α. the initial angular velocity is equal to zero.

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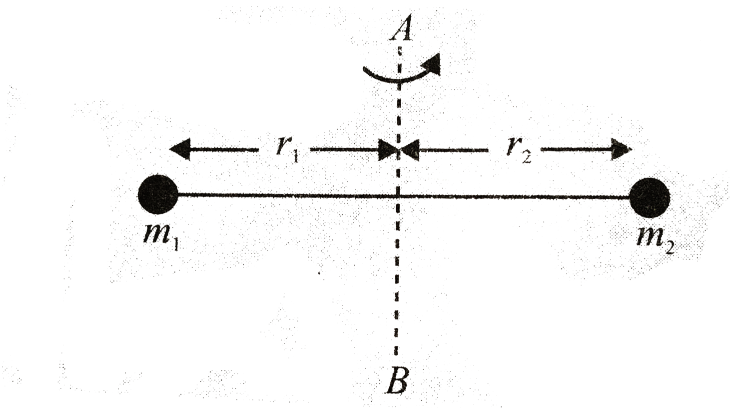
Exercise 2.2

1. Two heavy particles having masses m_1 and m_2 are situated in a plane perendicular to line AB at a distance or r_1 and r_2 respectively.



a. What is the moment of inertia of the system about axis AB?

b. What is the moment of inertia of the system about an axis passing through m_1 and perpendicular to the line joining m_1 and m_2?

c. What is the moment of inertia of the system about an axis passing through m_1 and m_2?

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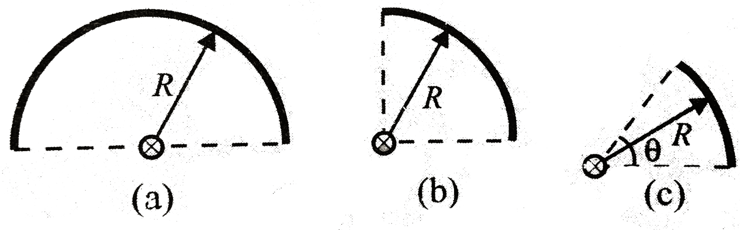
2. Find out the moment of inertia of the circular arcs shown, each having mass M, radius R and having uniform mass distribution about an axis passing through the centre and perpendicular to the plane ?



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3. 

Calculate the moments of inertia of the figures shown, each having mass M, radius R and having uniform mass distribution about an axis perpendicular to the plane and passing through the centre?

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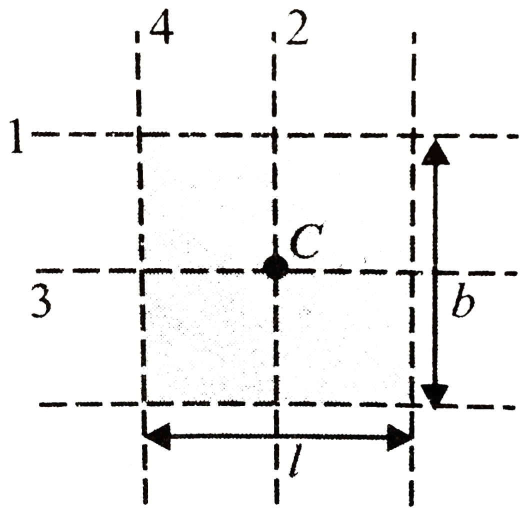
4. In Fig. find moment of inertia of a plate having mass M, length l and width b about axes $1, 2, 3$ and 4. Assume that C is the centre and mass is uniformly distributed.



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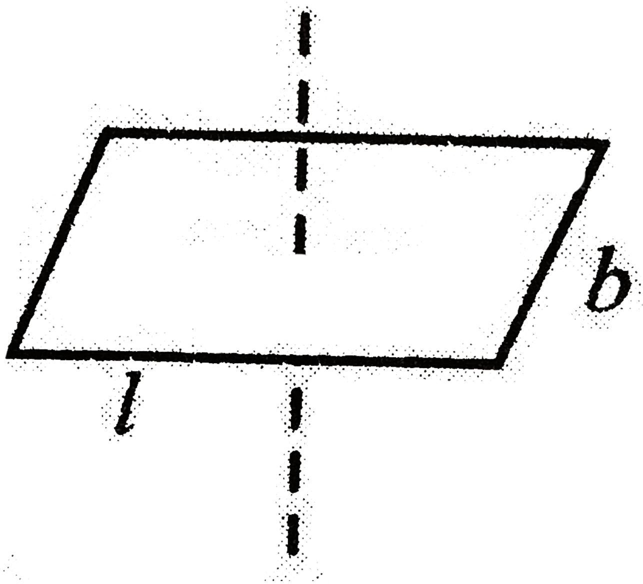
5. Find the moment of inertia of a uniform rectangular plate of mass M and edges of length $'I'$ and $'b'$ about its axis passing through the centre and perpendicular to it.



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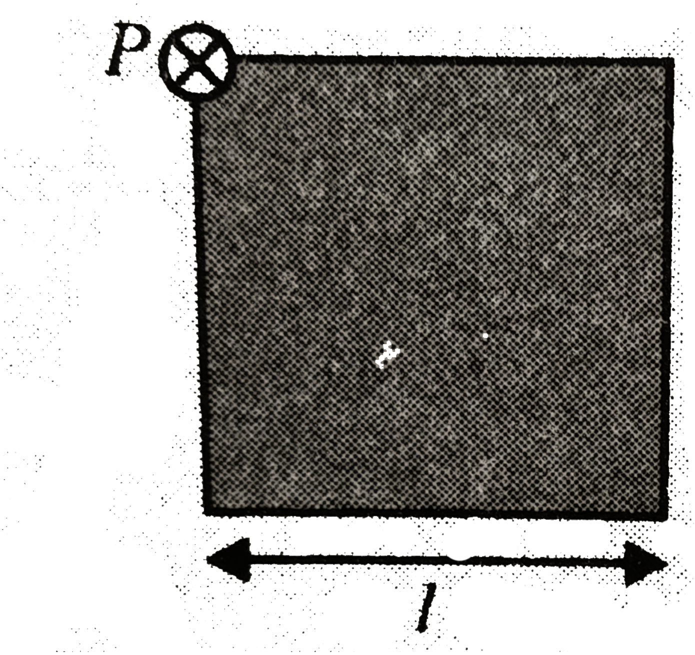
6. Find the moment of inertia of a uniform square plate of mass M and edge of length $'l'$ about its axis passing through P and perpendicular to it.



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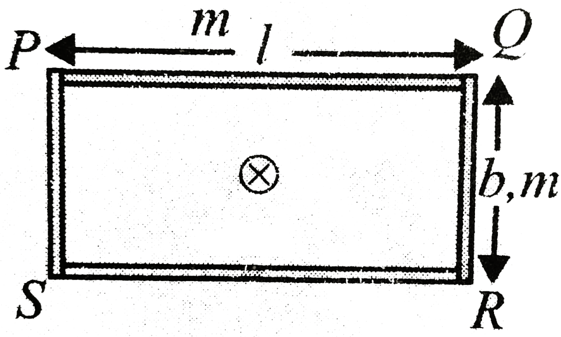
7. Calculate the moment of inertia of a rectangular frame formed by uniform rods having mass m each as shown in about an axis passing through its centre and perpendicular to the plane of frame. Also find moment of inertia about an axis passing through PQ ?



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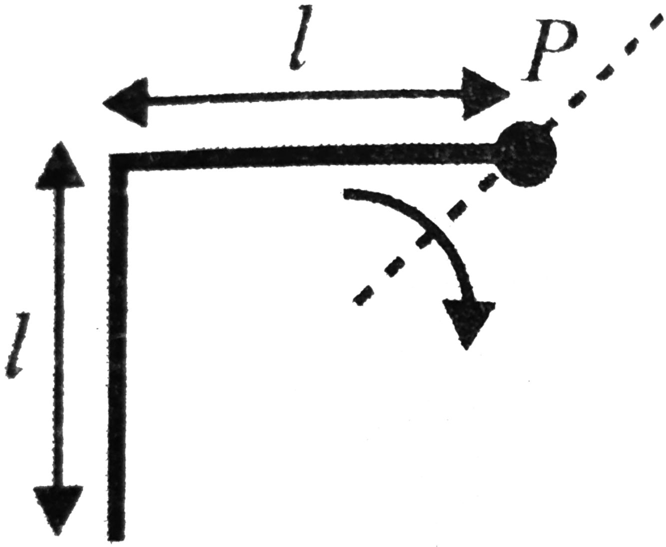
8. Find the moment of inertia of the two uniform joint rods about point P as shown in Fig. Use parallel axis theorem. Mass of each rod is M.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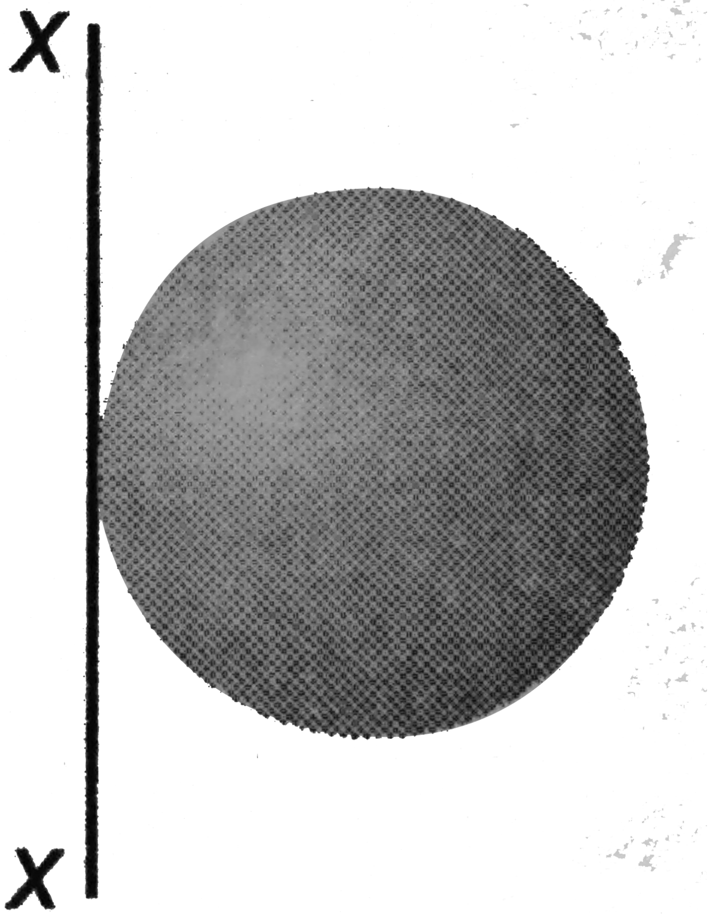

9.

Find the moment of inertia of a solid sphere of mass M and radias R about an axis XX shown in figure. Also find radius of gyration about the given axis.

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10. Find the radius of gyration of a hollow uniform sphere of radius R about its tangent.

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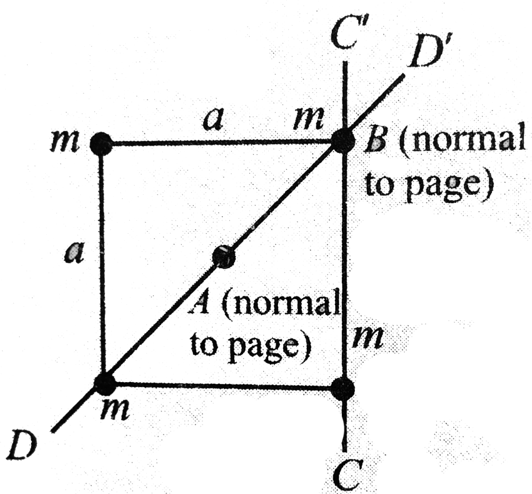
11. The square structure shown in Fig. consists of lour point masses connected by rods of negligible Find the moment of inertia of the structure about the following axes: (a) axis A, passing through the centre of the structure and normal to its plane, (b) axis B passing through one of the point masses and normal to the plane of the structure, (c) axis CC', passing through two adjacent point masses and (d) axis DD', along the diagonal of the structure.



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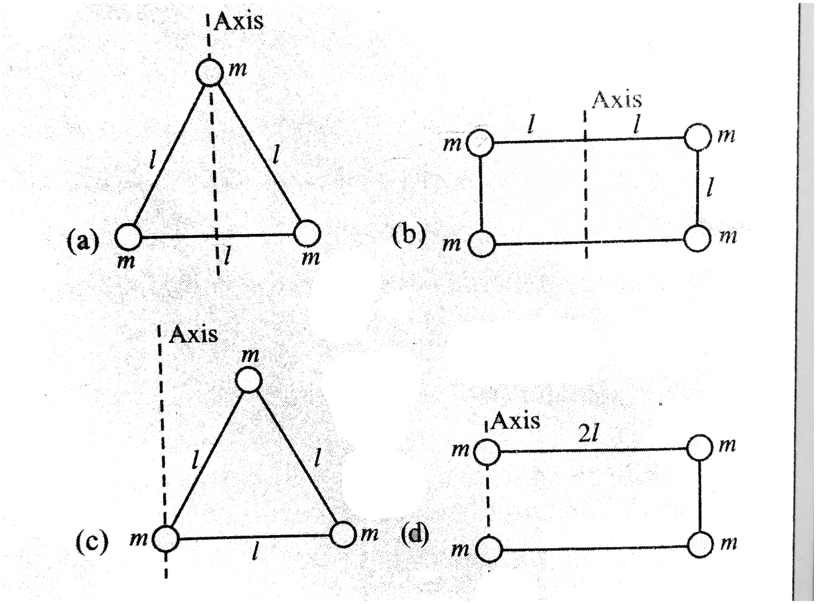
12. Calculate the moment of inertia of each particle in Fig. about the indicated axis of rotation.



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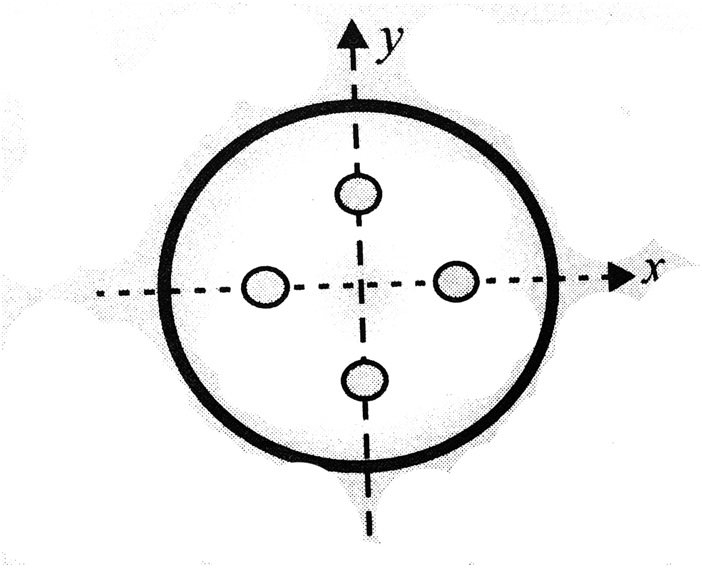
13. A uniform disc of mass m and radius R has an additional rim of mass m as well as four symmetrically placed masses, each of mass $m/4$ tied at positions $R/2$ from the centre as shown in Fig. What is the total moment of inertia of the disc about an axis perpendicular to the disc through its centre?



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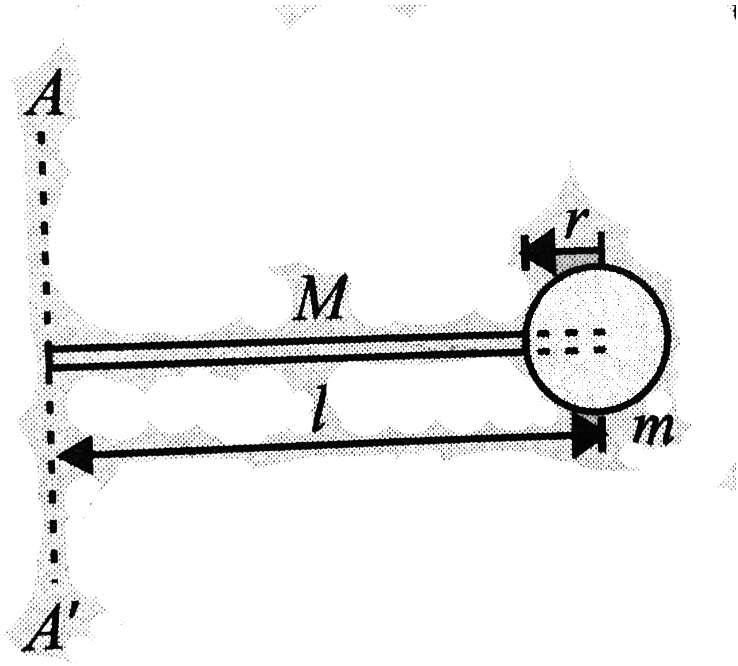
14. Find the moment of inertia A of a spherical ball of mass m and radius r attached at the end of a straight rod of mass M and length l, if this system is free to rotate about an axis passing through the end of the rod

(end of the rod opposite to sphere).



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15. Find the moment of inertia of a cylinder of mass M, radius R and length L about an axis passing through its centre and perpendicular to its symmetry axis. Do this by integrating an elemental disc along the length of the cylinder.

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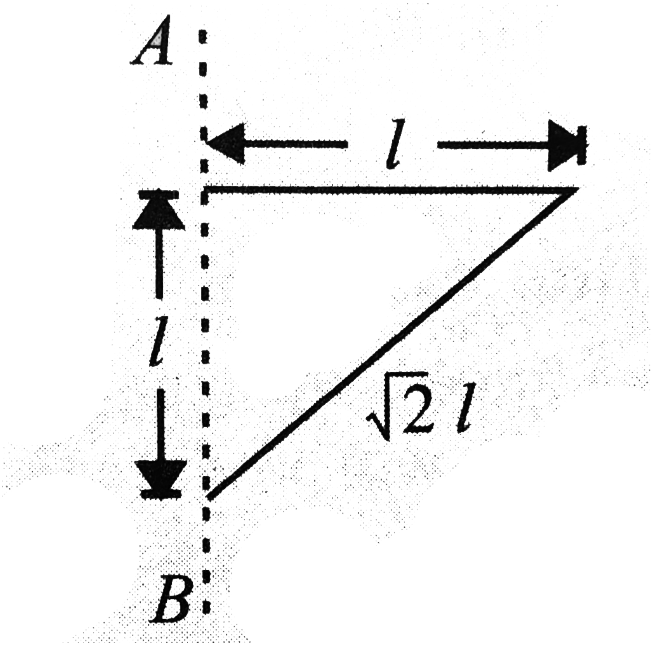
16. Find MI of a triangular lamina of mass M about the axis of rotation AB shown in Fig.



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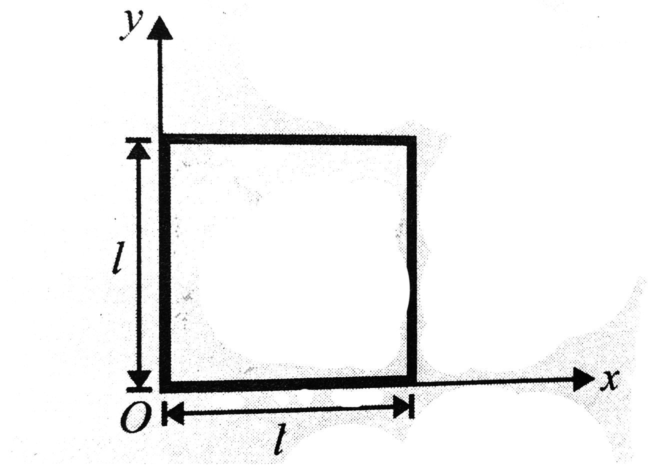
17. Four identical rods, each of mass m and length l, make a square frame in the xy plane as shown in Fig.

a. Calculate its moment of inertia about the x-and y-axes.

b. Also, calculate its moment of inertia about the z-axis.



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Exercise 2.3

1. A uniform cube of side a and mass m rests on a rough horizontal table. A horizontal force F is applied normal to one of the faces at a point directly above the centre of the face, at a height $\frac{3a}{4}$ above the base. What is the minimum value of F for which the cube begins to tip about an edge?

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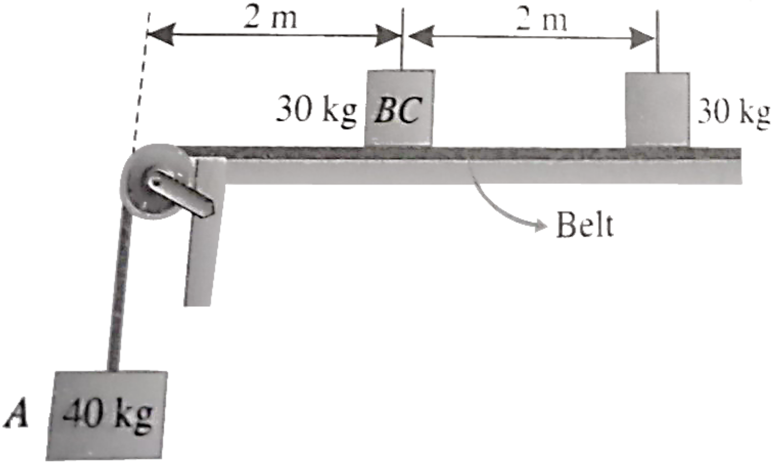

2.

Two 30 kg blocks rest on a massless belt which passes over a fixed pulley and is attached to a 40 kg block. If coefficient of friction between the belt and the table as well as between the belt and the blocks B and C is μ and the system is released from rest from the position shown, the speed with which the block B falls off the belt is

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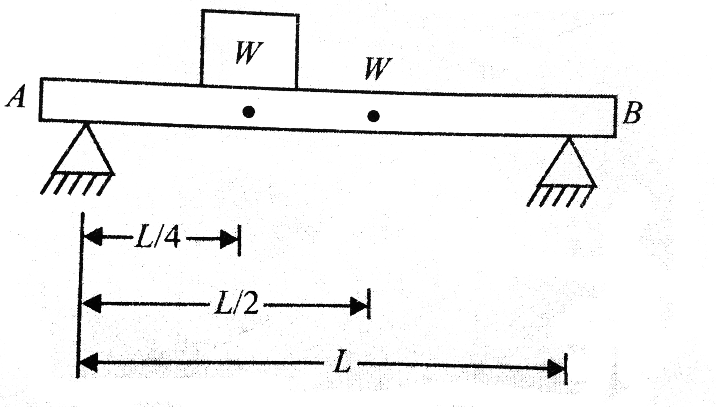
3. A beam of weight W supports a block of weight W. The length of the beam is L. and weight is at a distance $\frac{L}{4}$ from the left end of the beam.

The beam rests on two rigid supports at its ends. Find the reactions of the supports.



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4. A uniform ladder of mass 10 g leans agais ta smooth vertical wall making an angle of 53^0 with it. The other end rests on a rough horizontal floor. Find the normal force and the frictinal force that the floor exerts on the ladder

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5. A uniform ladder of length 10.0 m and mas 16.0 kg is resting against a vertical wall making an angle of 37° with it. An electrician weighing 60.0 kg climbs up the ladder. If the stays on the ladder at a point 8.00 m from the lower end, will be normal force and the force of friction on the ladder by the ground? What should be the minimum coefficient of friction for the electrician to work safely?

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6. A uniform rod of length L rests against a smooth roller as shown in figure. Find the friction coefficeint between the ground and the lower end if the minimum angle that rod can make with the horizontal is θ.

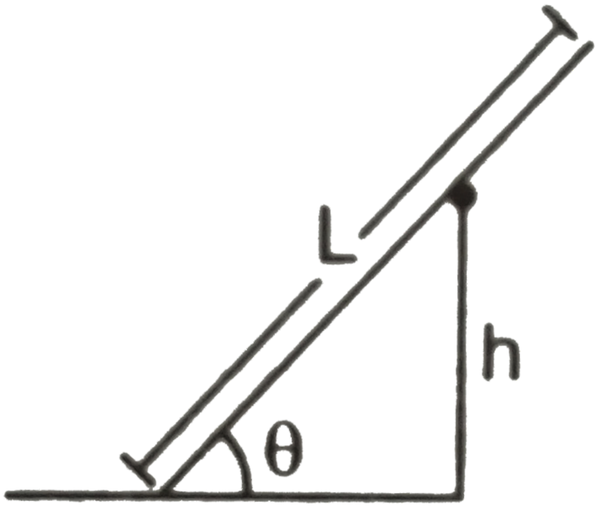

Figure 10-E9

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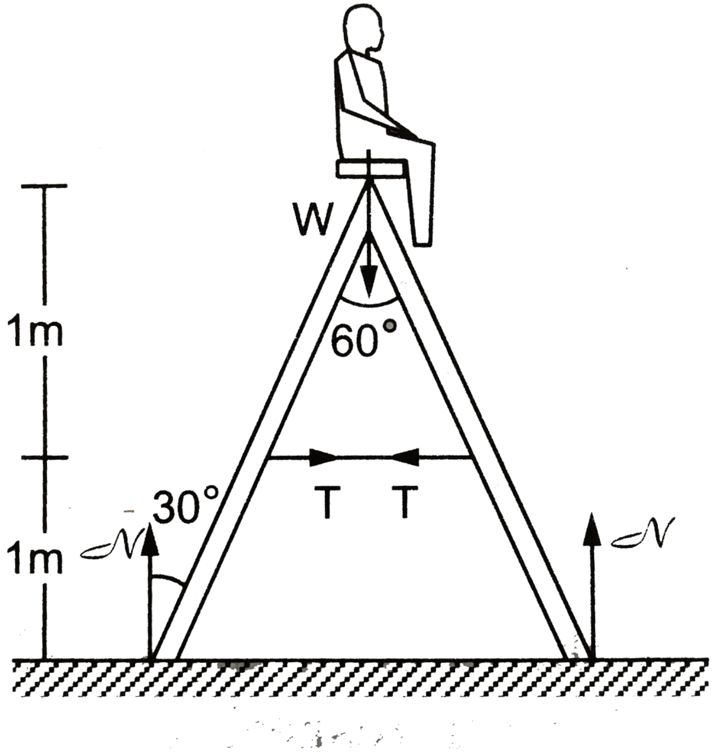
7. The ladder shown in figure has negligible mass and rests on a frictionless floor. The crossbar connects the two legs of the ladder at the middle. The angle between the two legs is 60^0. The fat person sitting on the ladder thas a mas of 80 kg. Find the contact force exerted by the floor on each leg and the tension in the cross bar.



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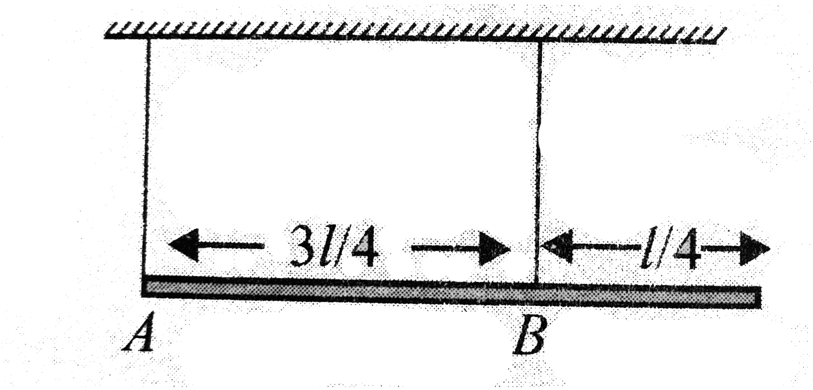
8. A uniform rod of length l and mass m is hung from, strings of equal length from a ceiling as shown in figure. Determine the tensions in the

strings?



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9. A uniform ladder of length L and mass m_1 rests against a frictionless wall. The ladder makes an angle θ with the horizontal. (a) Find the horizontal and vertical forces the ground exerts on the base of the ladder when a firefighter of mass m_2 is a distance x from the bottom. (b) If the ladder is just on the verge of slipping when the firefighter is a distance d from the bottom, what is the coefficient of static friction between ladder and ground?

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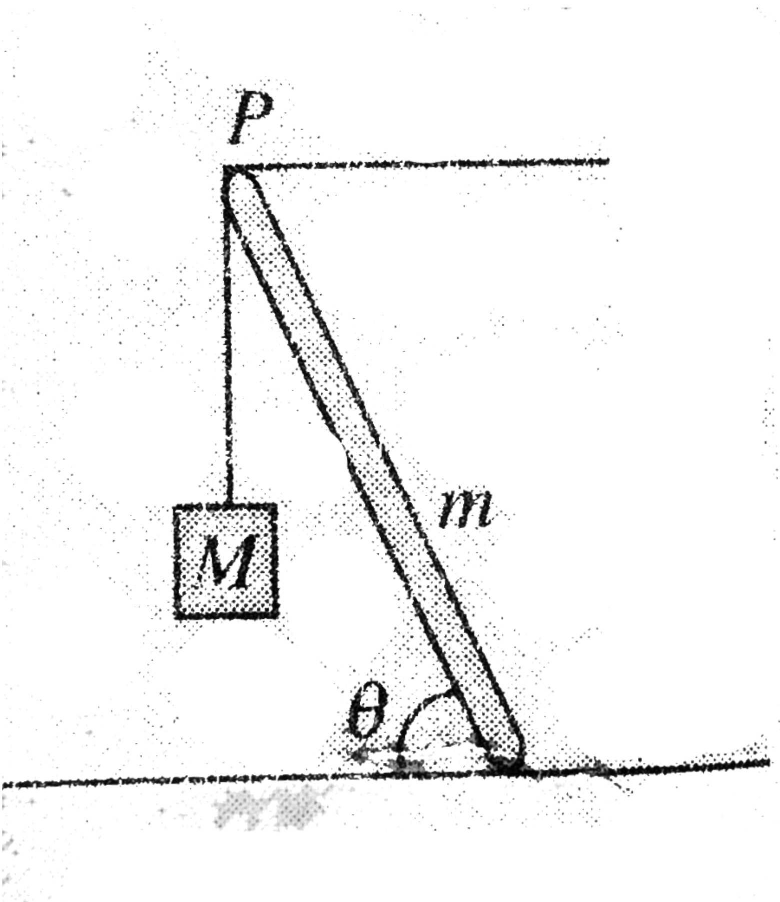
10. A uniform beam of mass m is inclined at an angle θ to the horizontal. Its upper end produces a ninety degree bend in a very rough rope tied to a wall, and its lower end rests on a rough floor (a) If the coefficient of static friction between beam and floor is μ_s determine an expression for the maximum mass M that can be suspended from the top before the beam slips. (b) Determine the magnitude of the reaction force at the floor and the magnitude of the force exerted by the beam on the rope at P in terms of m, M and μ_s



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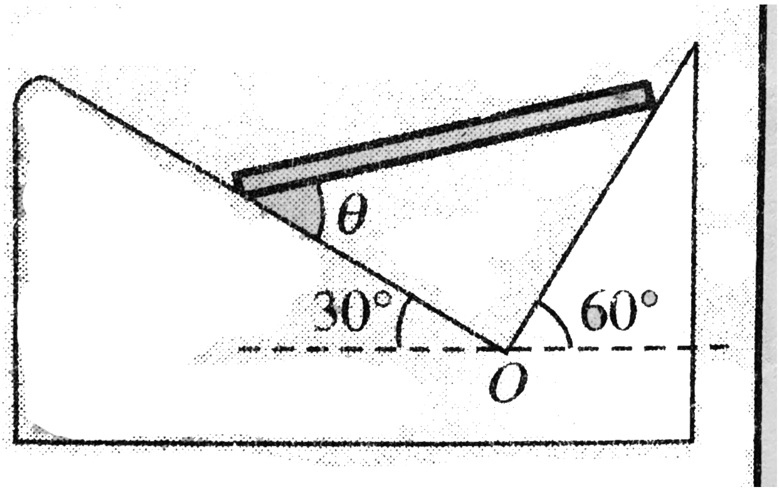
11. A uniform rod of weight F_g and length L is supported at its ends by a frictionless through as shown in figure. (a) Show that the centre of gravity of the rod must be vertically over point O when the rod is in equilibrium. (b) Determine the equilibrium value of the angle θ.



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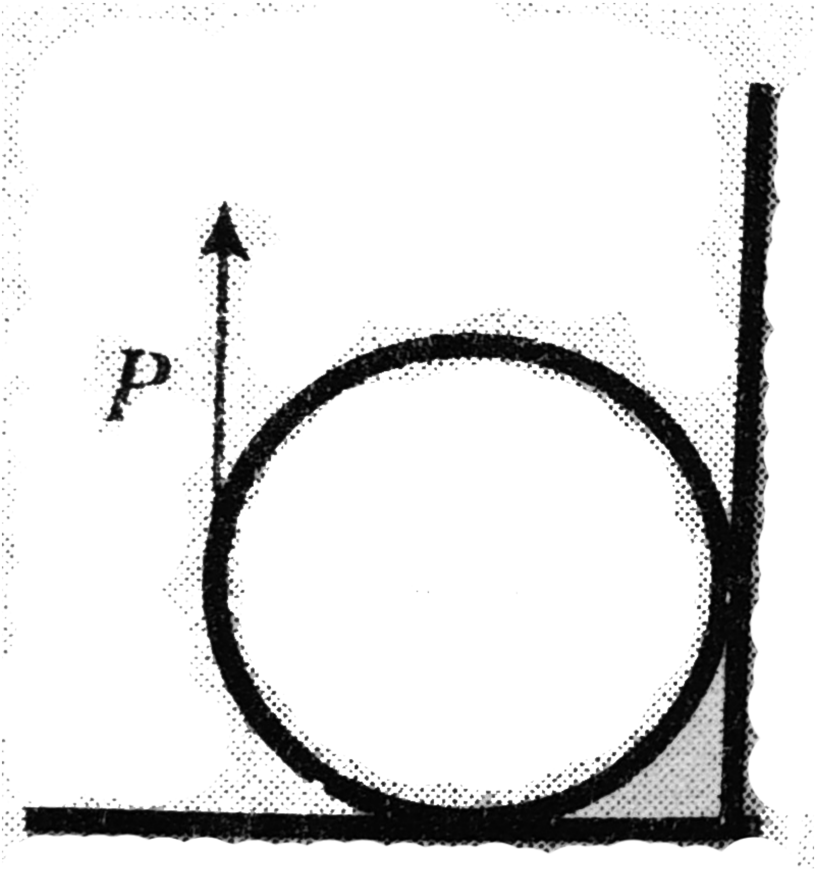
12. Figure shows a vertical force applied tangentially to a uniform cylinder of weight F_g. The coefficient of static friction between the cylinder and all surfaces is 0.500. In terms of F_g , find the maximum force P that can be applied that does not cause the cylinder to rotate.



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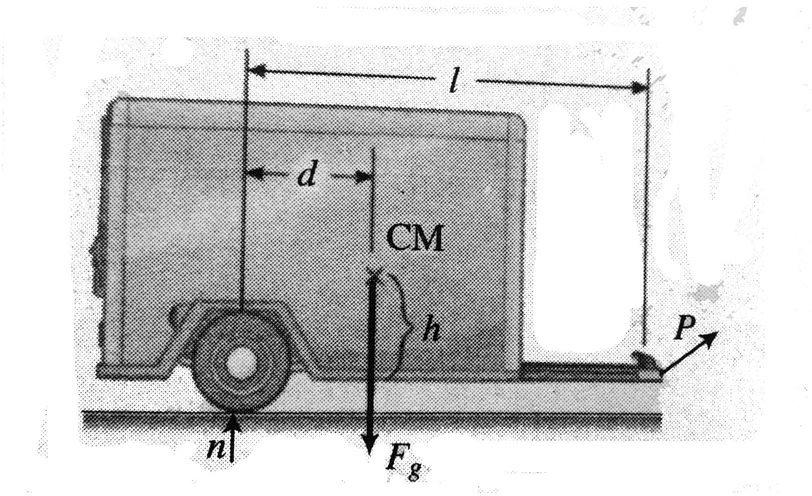
13. A trailer with loaded weight F_g is being pulled by a vehicle with a force P, as in figure. The trailer is loaded such that its centre of mass is located as shown. Neglect the force of rolling friction and let a represent the x component of the acceleration of the trailer. (a) Find the vertical component of P in terms of the given parameters. (b) If a $= 2.00 ms^{-2}$ and $h = 1.50 m$, what must be the value of d in order that $P = 0$ (no vertical load on the vehicle)?



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14. A bicycle is traveling downhill at a high speed. Suddenly, the cyclist sees that a bridge ahead has collapsed, so she has to stop. What is the maximum magnitude of acceleration the bicycle can have if it is not to flip over its front wheel—in particular, if its rear wheel is not to leave the ground? The slope makes an angle of 37° with the horizontal. On level ground, the centre of mass of the woman–bicycle system is at a point $1.0m$ above the ground, $1.0m$ horizontally behind the axle of the front wheel, and 35.0 cm in front of the rear axle. Assume that the tires do not skid.

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15. The weight of an object on the surface of the Earth is 40 N. Its weight at a height equal to the radius of the Earth is

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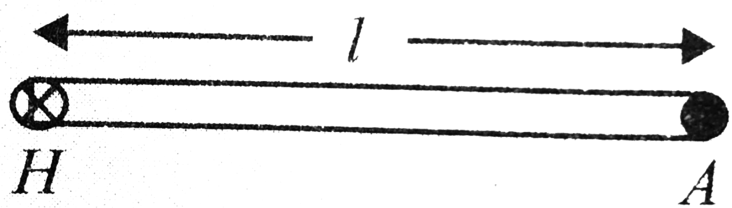
Exercise 2.4

1. A uniform rod of mass m and length l can rotate in a vertical plane about a smooth horizontal axis point H. a. Find angular acceleration α of the rod. just after it is released from initial horizontal position from rest'? b. Calculate the acceleration (tangential and radial) , point A at this moment.



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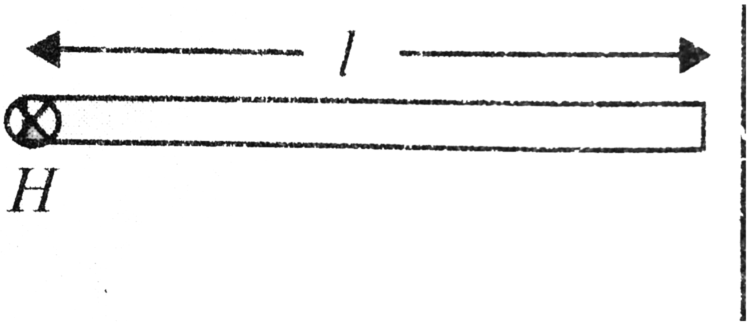
2. A uniform rod of mass m and length l can rotate in a vertical plane abota smooth horizontal axis hinged at point H. Find the force exerted by the hinge just after rod is released from rest, from initial horizontal position?



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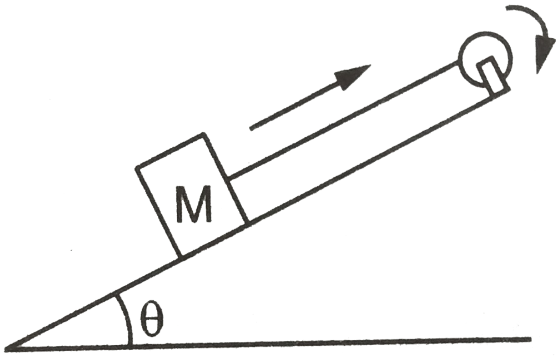
3. A wheel of radius r and moment of inertia I about its axis is fixed at top of an inclined plane of inclination θ as shown in figure. A string is wrapped round the wheel and its free end supports a block of mass M which can slide on the plane. Initially, the wheel is rotating at a speed ω in direction such that the block slides up the plane. How far will the block move before stopping?



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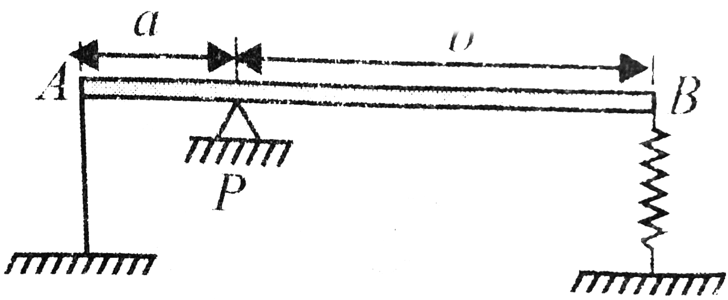
4. A uniform rod AB of mass $m = 2kg$ and length $l = 1.0m$ is placed on a sharp support P such that $a = 0.4m$ and $b = 0.6m$. A. spring of force constant $k = 600N/m$ is attached to end B as shown in Fig. To keep the rod horizontal, its end A is tied with a thread such that the spring is B elongated by $1CM$. Calculate reaction of support P when the thread is burnt.



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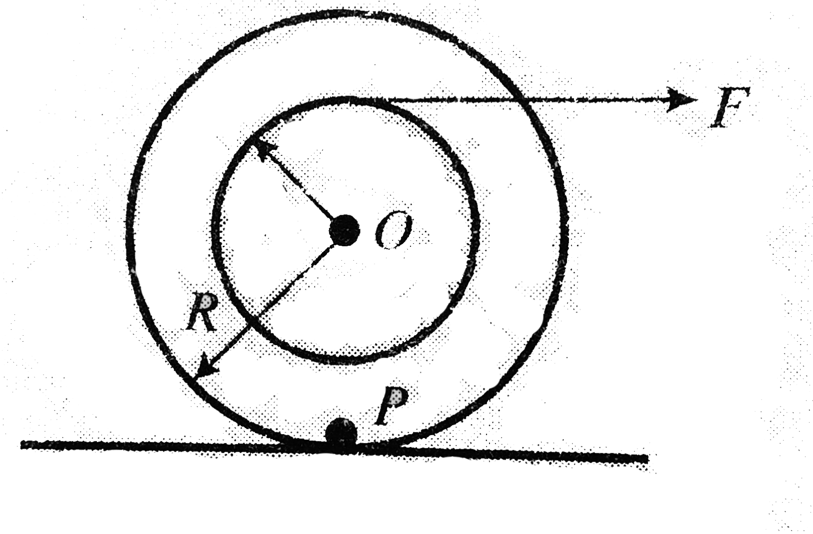
5. A cotton reel of mass m and moment of inertia I is kept at rest on as smooth horizontal surface. The reel has inner and other radius r and R respectively. A horizontal force F starts actings as shown in figure. Find the



a. acceleration of the centre of mass of reel.

b. angular acceleration of the reel

c. net acceleration of point of contact.

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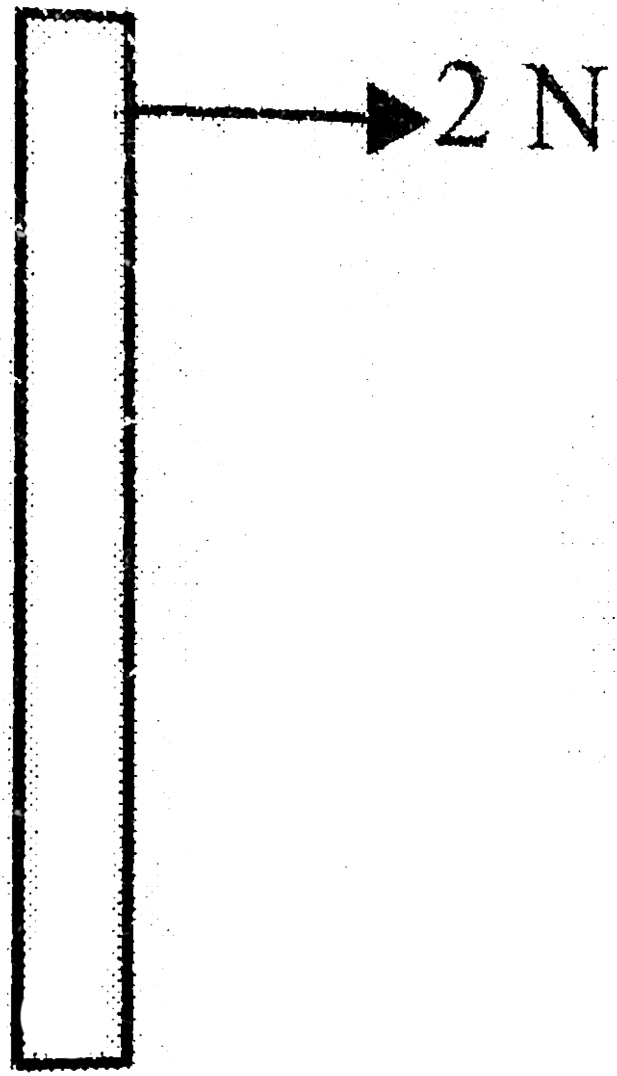
6. Find acceleration a and angular acceleration α. If $F = 2N, m = 1kg$ and $l = 2m$



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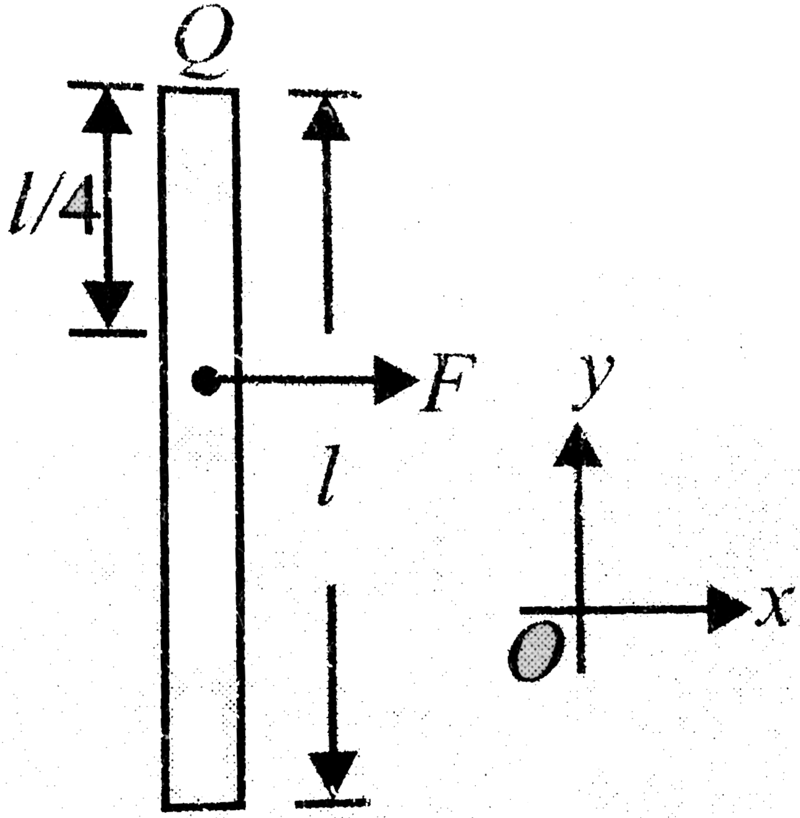

7. Find α, a_Q and the point of zero acceleration when the horizontal force F acts on the smooth rod of mass m and length l which is kept on a horizontal surface.

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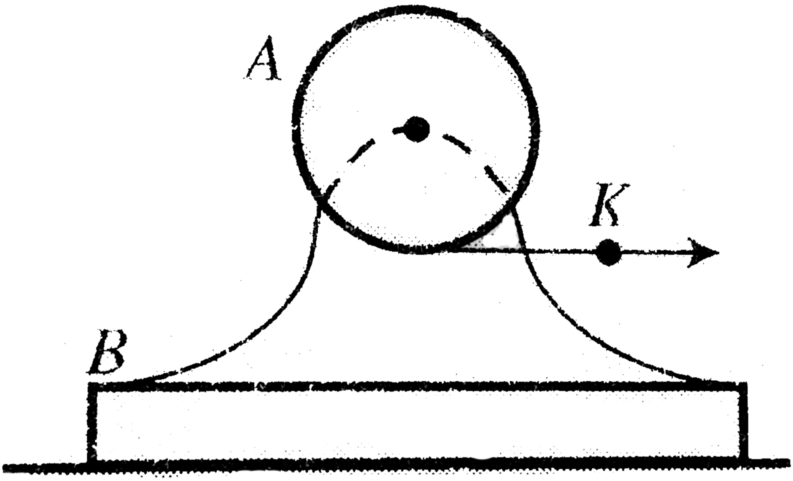
8. A uniform solid. cylinder A of mass can freely rotate about a horizontal axis fixed to a mount of mass m_2. A constant horizontal force F is applied to the end K of a light thread tightly wound on the cylinder. The friction between the mount and the supporting horizontal plane is assumed to be absent. Find the acceleration of the point K.



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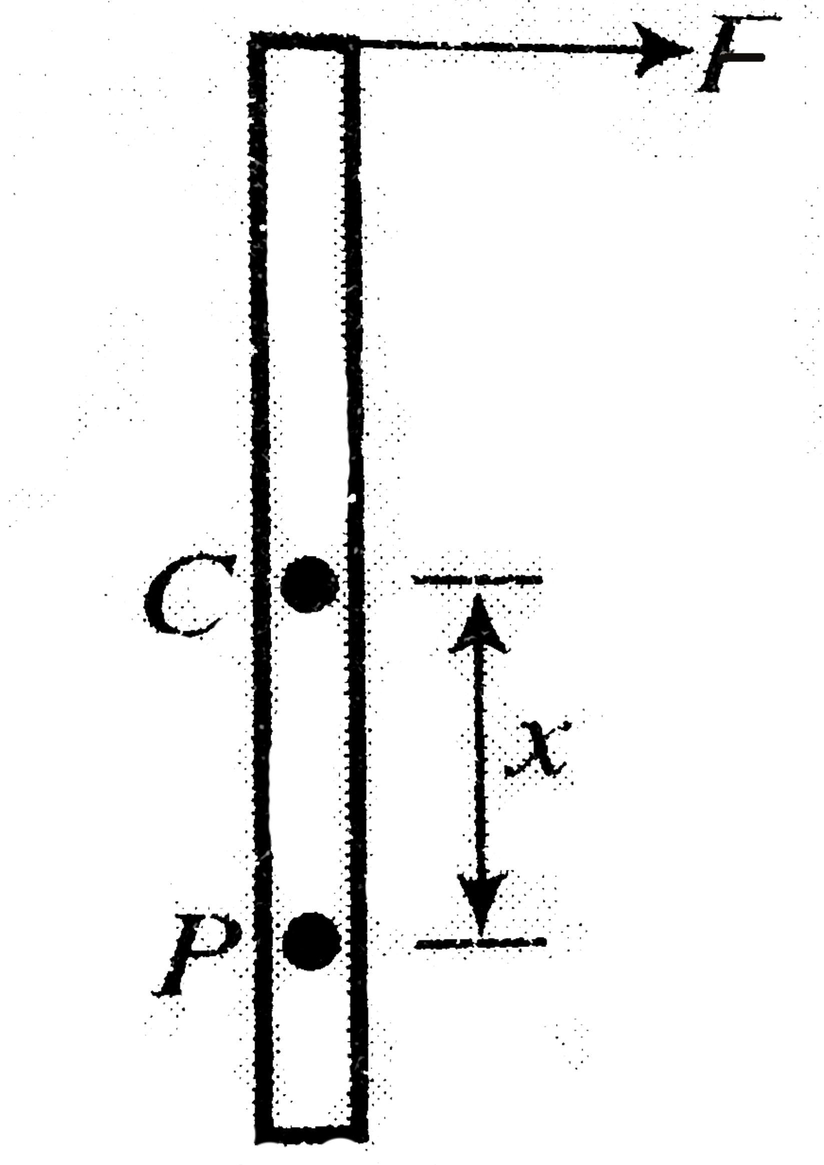
9. For what value of x, the point P on the rod of length $l = 6m$ has zero acceleration if a force F is applied at the end of rod as shown.



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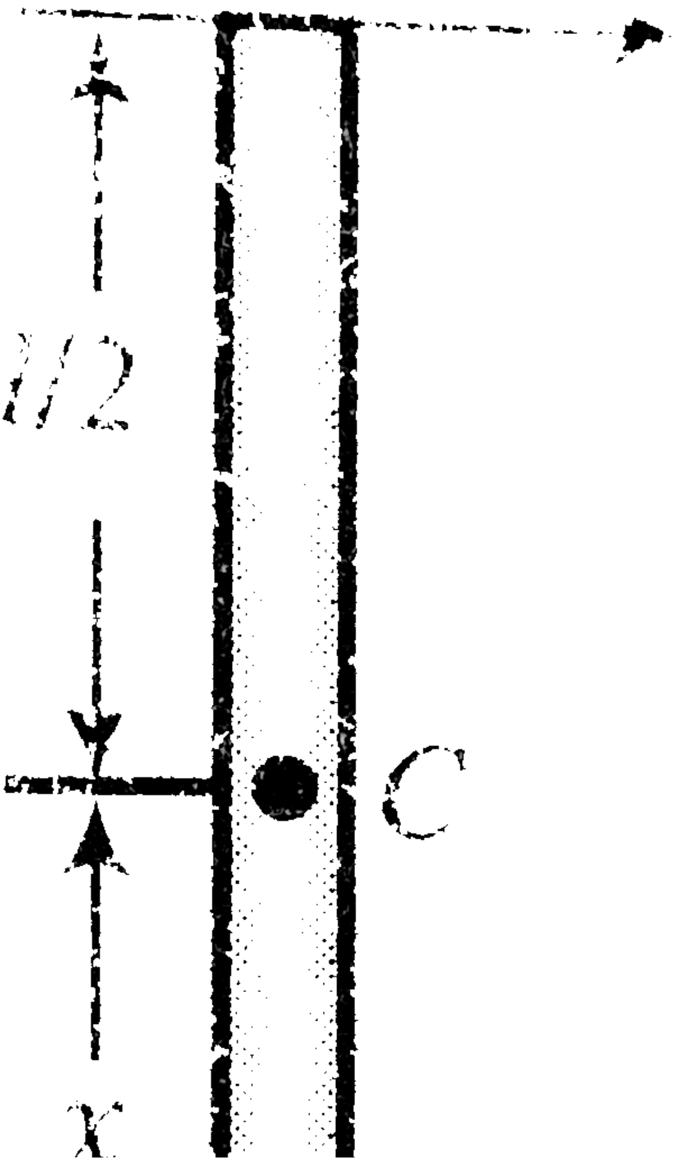
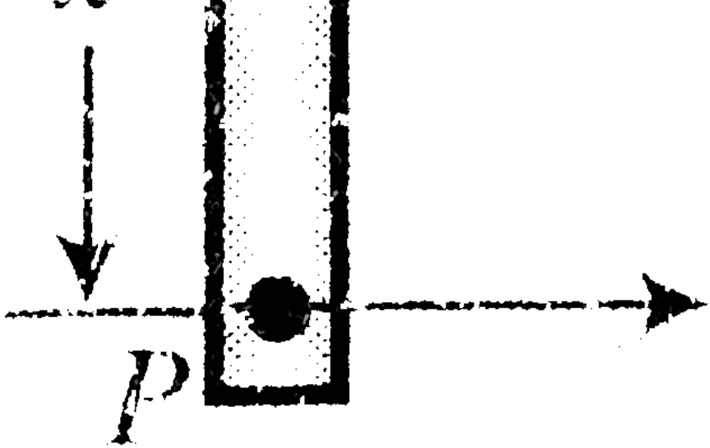
10. A uniform rod of mass m and length is acted upon by the forces F_1 and F_2 Find that:

a. linear-and angular acceleration of the rod.

b. value of x for which the point P does not accelerate.





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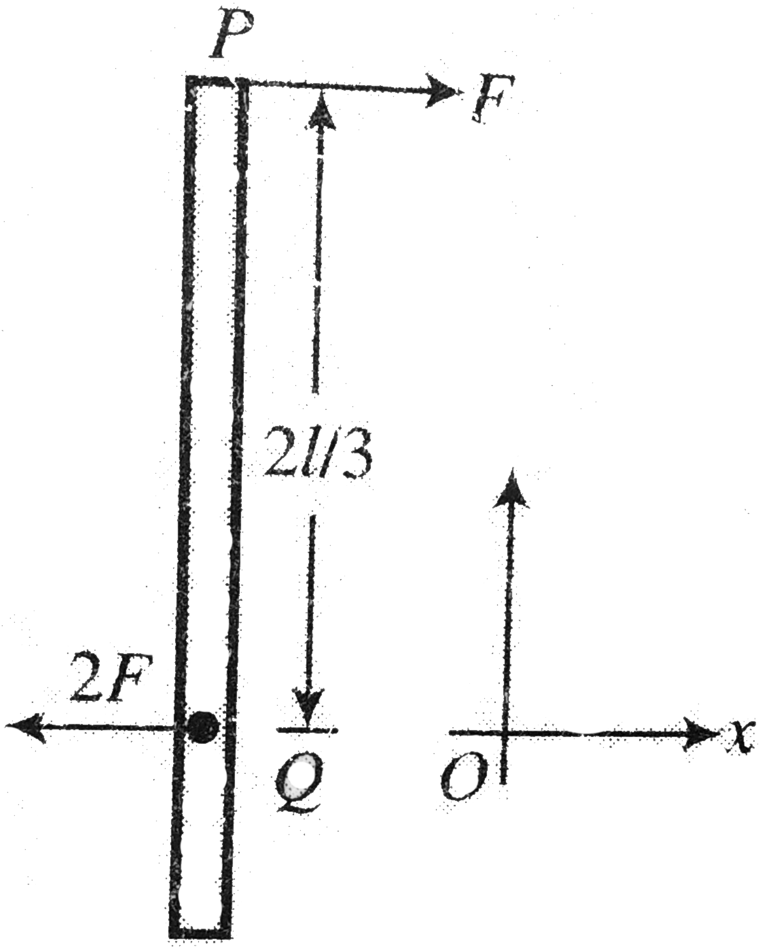
11. Find a_C and α of the smooth rod of mass m and length l.



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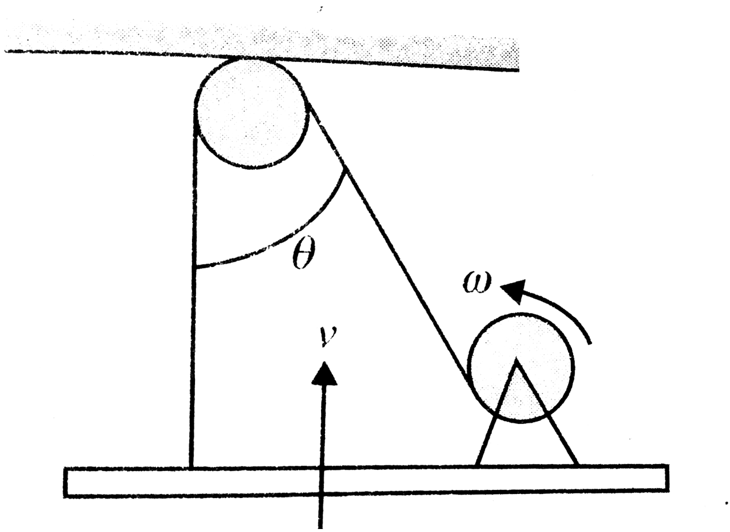
Subjective

1. In the instant shown in the diagram the board is moving up (vertically) with velocity v. The drum winds up at a constant rate ω. If the radius of the drum is R and the board always remains horizontal, find the value of velocity in terms of R, θ, ω.



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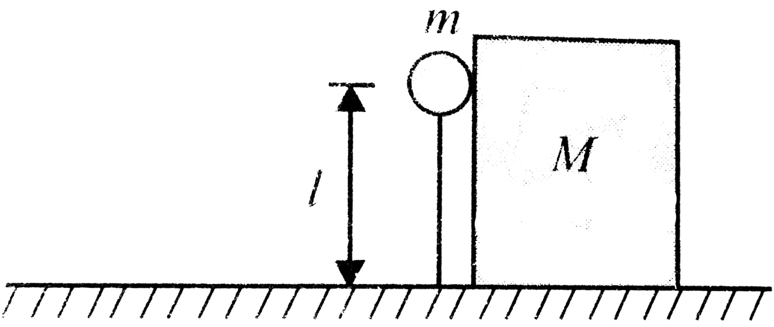
2. A weightless rod of length l with a small load of mass m at the end is hinged at point A as shown and occupies a strictly vertical position, touching a body of mass M. A light jerk sets the system in motion.

a. For what mass ratio M/m will the rod form an angle $\alpha = \pi/6$ with the horizontal at the moment of the separation from the body?

b. What will he the velocity u of the body at this moment? Friction should be neglected.



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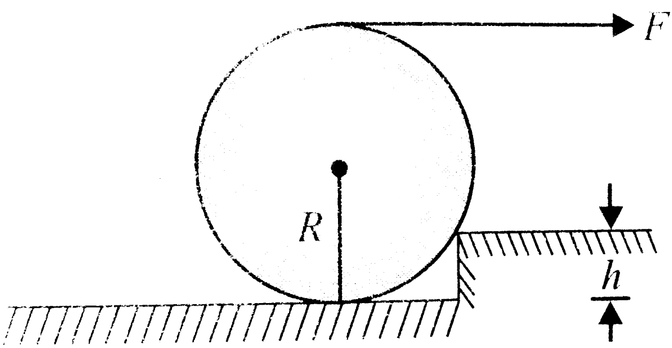
3. A cylinder of weight W and radius R is to be raised onto a horizontal step of height h as shown in Fig. A rope is wrapped around the cylinder and pulled horizontally with force F. Assuming the cylinder does not slip on the step, find the minimum force F necessary to raise the cylinder.



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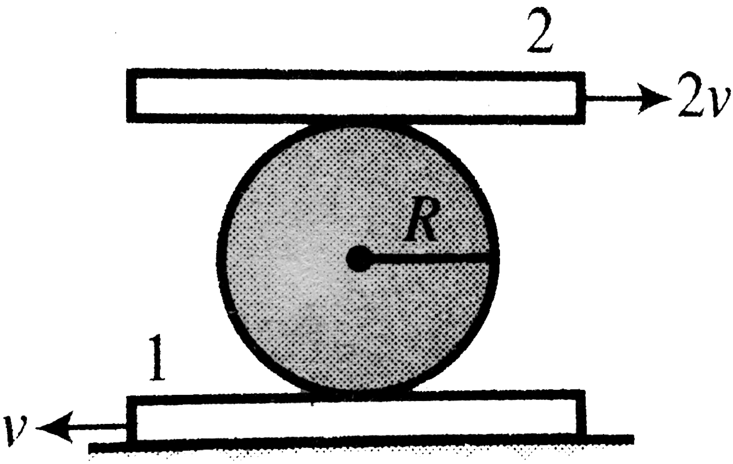
4. A cylinder is rolling without sliding over two horizontal planks (surfaces) 1 and 2. If the velocities of the surfaces A and B are $-v\hat{i}$ and $2v\hat{i}$ respectively, find the:

a. Position of instantaneous axis of rotation.

b. Angular velocity of the cylinder.



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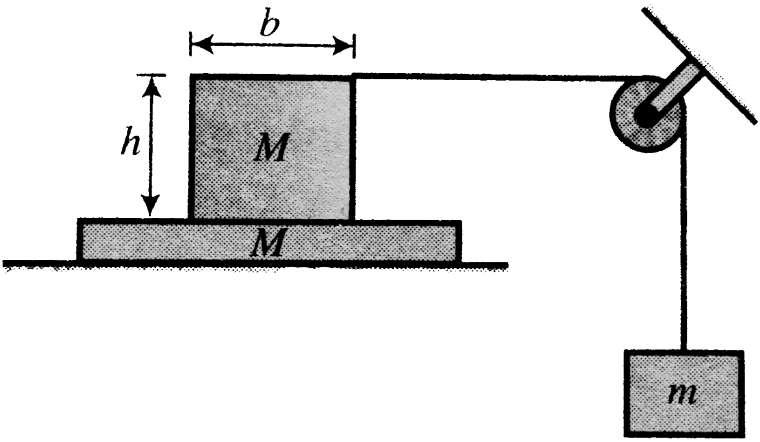
5. A block of mass $M = 4kg$ of height and breath b is placed on a rough plank of same mass M. A light inextensible string is connected to the upper end of the block and passed through a light smooth pulley as shown in figure. A mass $m = 1kg$ is hung to the other end of the string.

a. What should be the minimum value of coefficient of friction between the block and the plank so that, there is no slipping between the block and the wedge?

b. Find the minimum value of b/h so that the block does not topple over the plank, friction is absent between the plank and the ground.



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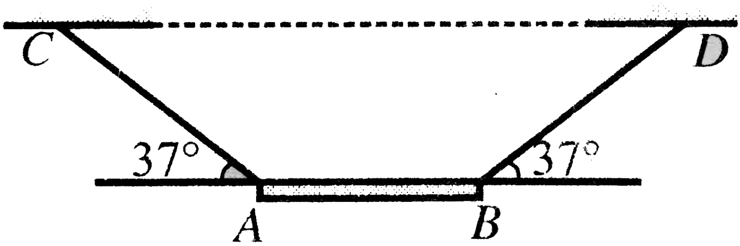
6. A uniform rod AB of mass m and length l is suspended by two massless and inextensible strings AC and BD whose ends C and D are fixed as shown. Find the tension in the string BD immediately after the string at A is cut.



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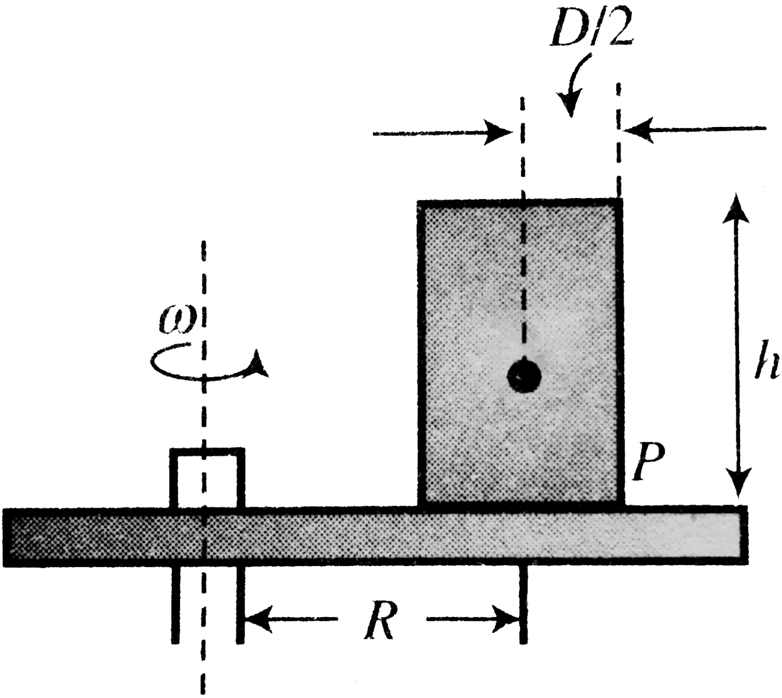
7. A cylinder rests on a horizontal rotating disc, as shown in the figure. Find at what angular velocity, ω, the cylinder falls off the disc, if the distance between the axes of the disc and cylinder is R, and the coefficient of friction $\mu > D/h$ where D is the diameter of the cylinder and It is its height.



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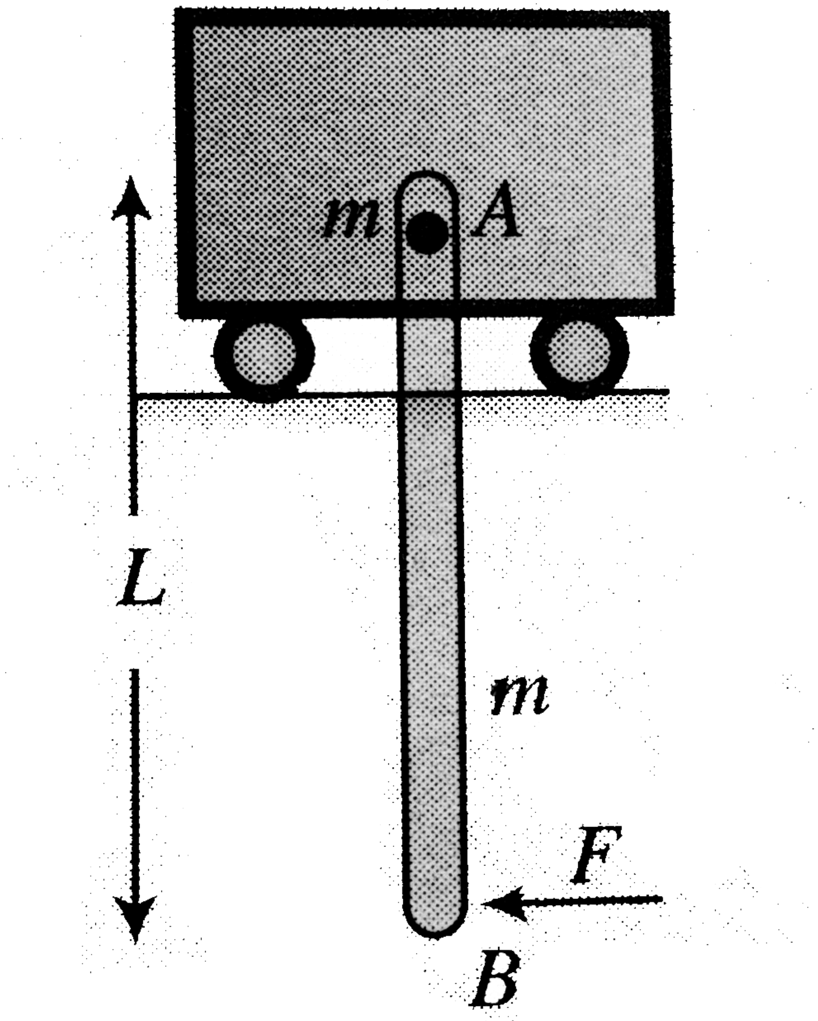
8. A uniform slender bar AB of mass m is suspended as shown from a small cart of the same mass m. Neglecting the effect of the friction, determine the accelerations of points A and B immediately after a

horizontal force F has been applied at B.



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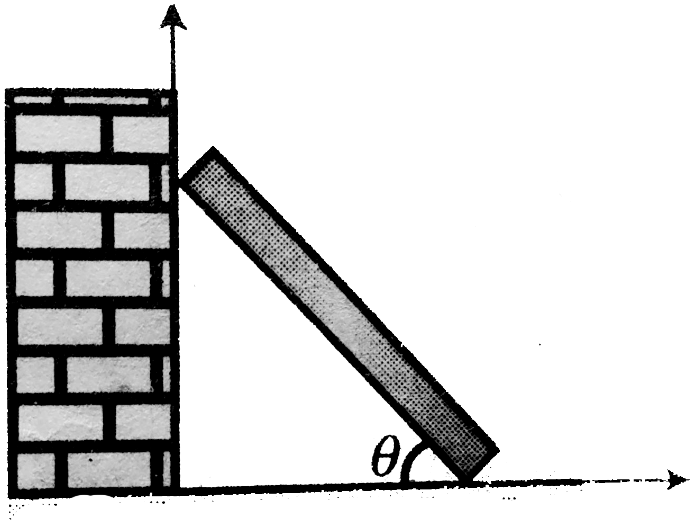
9. A uniform bar of length I and mass m stands vertically touching a vertical wall (y-axis). When slightly displaced, its lower end begins to slide along the floor (x-axis). Obtain an expression for the angular velocity (ω) of the bar as a function of O. Neglect friction everywhere.



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10. A uniform cube of side $'a'$ and mass m rests on a rough horizontal table. A horizontal force F is applied normal to one of the faces at a point directly below the centre of the face, at a height $a/4$ above the base.

a. What is the minimum value of F for which the cube begins to tip about an edge?

b. What is the minimum value of its so that toppling occurs?

c. If $\mu = \mu_{\min}$ find minimum force for topping.

d. Find minimum μ_s so that $F_{\min}$ can cause toppling.

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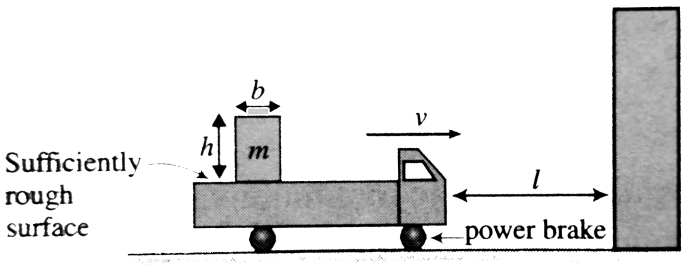
11. Find minimum value of l so that truck can avoid the dead end, without toppling the block kept on it.



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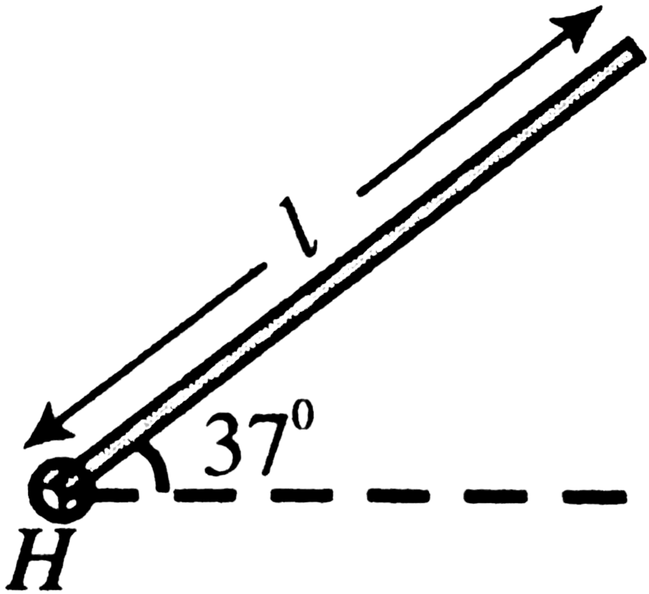
12. A uniform rod of mass m and length l can rotate in vertical plane about a smooth horizontal axis hinged at point H. Find angular acceleration α of the rod just after it is released from initial position making an angle of 37° with horizontal from rest?



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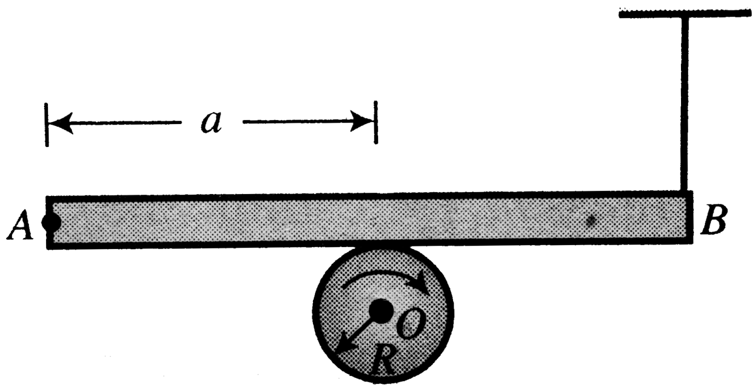
13. A wheel of radius $R = 10cm$ and moment of inertia $I = 0.05kgm^2$ is rotating about a fixed horizontal axis O with angular velocity

$\omega_0 = 10 rads^{-1}$. A uniform riigid rod of mass $m = 3kg$ and length $l = 50cm$ is hinged at one end A such that it can rotate at end A in a vertical plane. End B of the rod is tied with a thread as shown in figure such that the rod is horizontal and is just in contact with the surface of rotating wheel. Horizontal distance between axis of rotation O of cylinder and A is equal to $a = 30cm$.

If the wheel stops rotating after one second after the thread has burnt, calculate coefficient of friction ,μ between the rod and the surface of the wheel. $(g = 10ms^{-2})$



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Single Correct

1. Two rings of same radius and mass are placed such that their centres are at a common point and their planes are perpendicular to each other. The moment of inertia of the system about an axis passing through the centre and perpendicular to the plane of one of the rings is (mass the ring $= m$, radius $= r$)

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

B. mr^2

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

D. $2mr^2$

Answer: C

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2. The moment of inertia of a solid sphere about an axis passing through the centre radius is $\frac{2}{5}MR^2$, then its radius of gyration about a parallel axis t a distance $2R$ from first axis is

A. $5R$

B. $\sqrt{\frac{22}{5}}R$

C. $\frac{5}{2}R$

D. $\sqrt{\frac{12}{5}}R$

Answer: B

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3. From a given sample of uniform wire, two circular loops P and Q are made, P of radius r and Q of radius nr. If the M.I. of Q about its axis is four times that of P about its axis (assuming the wire to be of diameter much smaller than either radius), the value of n is

A. $(4)^{\frac{2}{3}}$

B. $(4)^{\frac{1}{3}}$

C. $(4)^{\frac{1}{2}}$

D. $(4)^{\frac{1}{4}}$

Answer: B

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4. Two circular discs A and B of equal masses and thicknesses. But are made of metals with densities d_A and $d_B(d_A > d_B)$. If their moments of inertia about an axis passing through the centre and normal to the circular faces be I_A and I_B, then.

A. $I_A = I_B$

B. $I_A > I_B$

C. $I_A < I_B$

D. $I_A \geq I_B$

Answer: C

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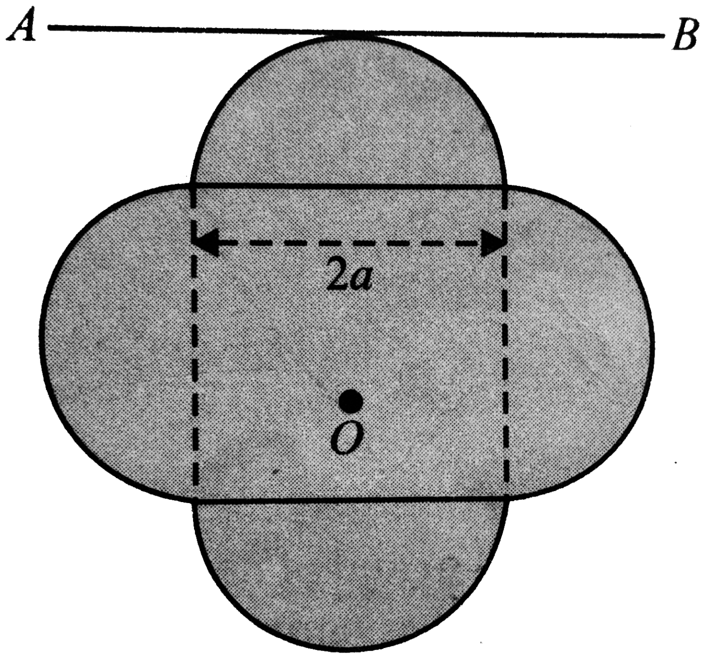
5. A symmetric lamina of mass M consists of a square shape with a semicircular section over of the edge of the square as shown in Fig. The side of the square is $2a$. The moment of inertia of the lamina about an axis through its centre of mass and perpendicular to the plane is $1.6Ma^2$. The moment of inertia of the lamina about the tangent AB in the plane of the lamina is___.



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

B. $\frac{Ml^2}{4}$

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

D. none of these

Answer: D

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6. 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. A. twice as large

B. B. four times as large

C. C. eight times as large

D. D. 16 times as large

Answer: D

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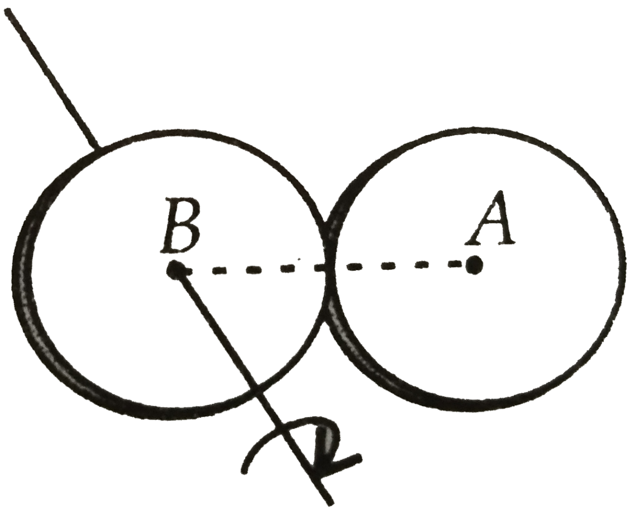
7. Two thin discs each of mass M and radius r metre are attached to form a rigid body as shown in figure. The rotational inertia of this body about an axis perpendicular to the plane of disc B and passing through its centre is



A. $2Mr^2$

B. $3Mr^2$

C. $4Mr^2$

D. $5Mr^2$

Answer: D

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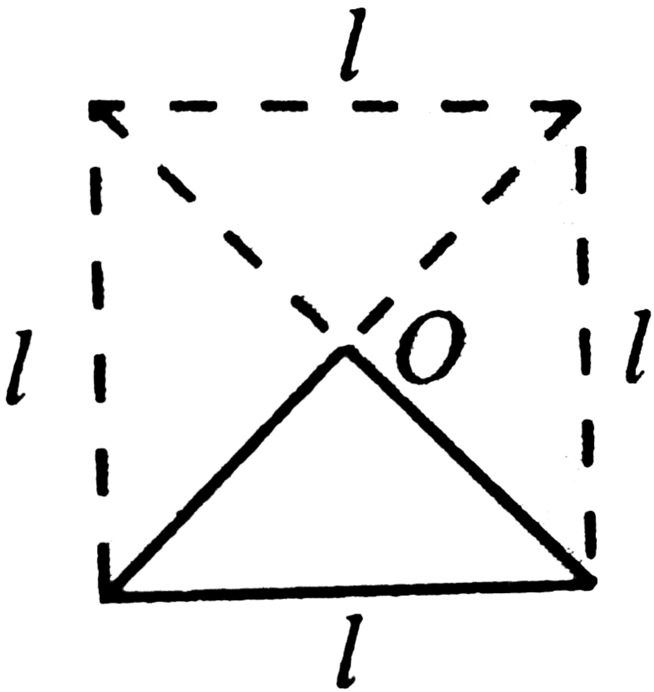
8. An isosceles triangular piece is cut a square plate of side l. The piece is one-fourth of the square and mass of the remaining plate is M. The moment of inertia of the plate about an axis passing through O and perpendicular to its plane is



A. $\frac{Ml^2}{6}$

B. $\frac{Ml^2}{12}$

C. $\frac{Ml^2}{24}$

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

Answer: A

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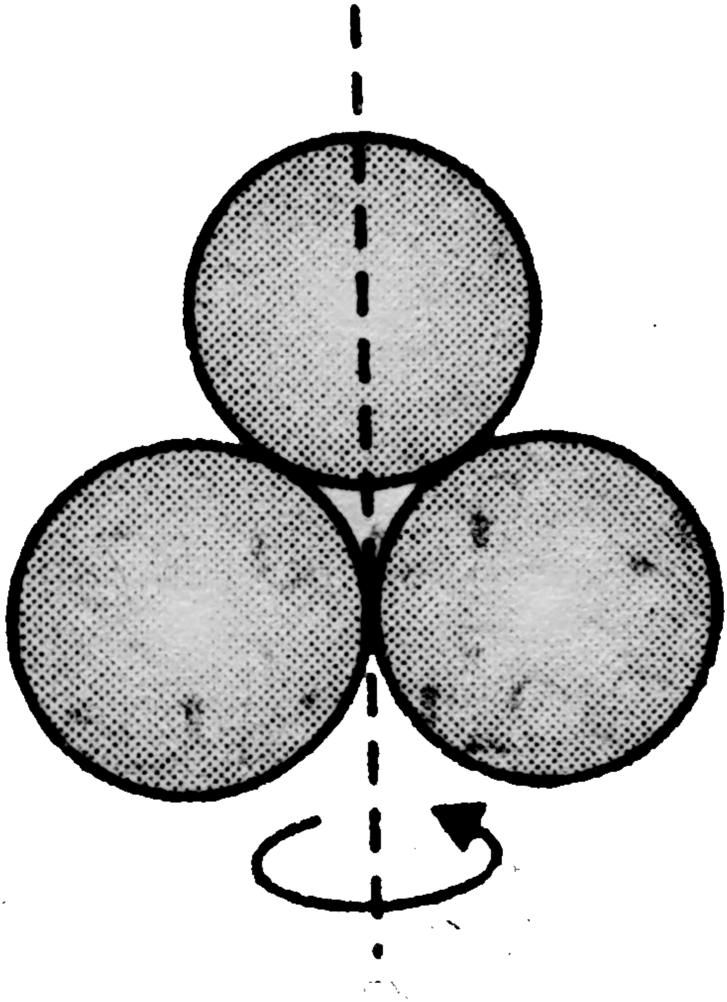
9. Three rings, each of mass m and radius r, are so placed that they touch each other. Find the moment of inertia about the axis as shown in Fig.



A. $5mr^2$

B. $\frac{5}{7}mr^2$

C. $7mr^2$

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

Answer: D

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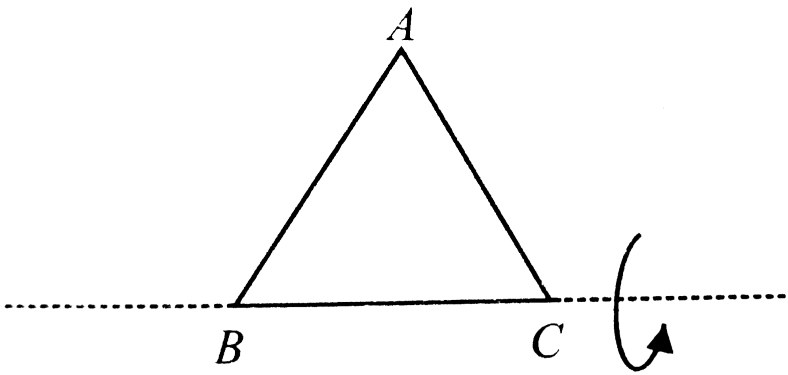
10. Three identical rods, each of mass m and length l, form an equaliteral triangle. Moment of inertia about one of the sides is



A. $\frac{ml^2}{6}$

B. ml^2

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

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

Answer: D

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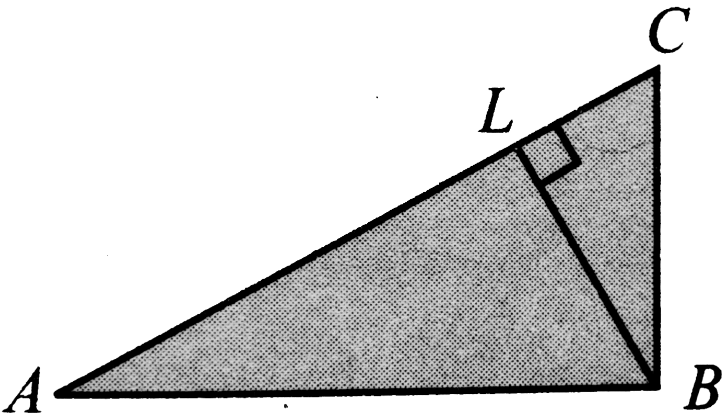
11. About which axis moment of inertia in the given triangular lamina is maximum?



A. AB

B. BC

C. AC

D. BL

Answer: B

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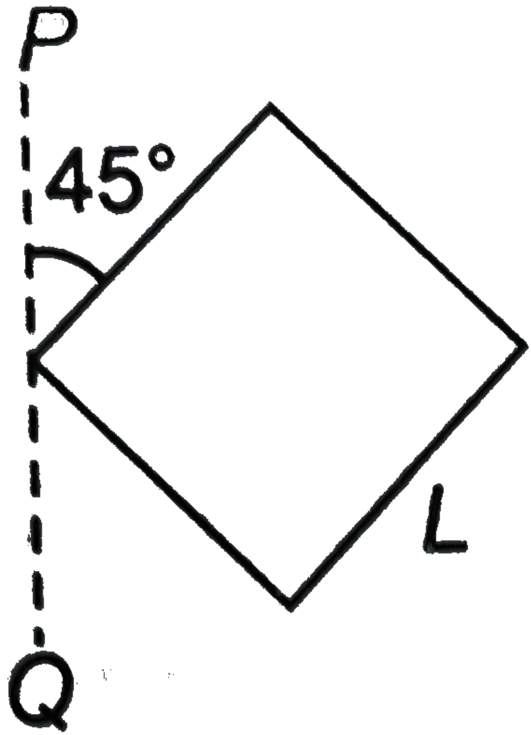

12.

A square is made by joining four rods each of mass M and length L. Its moment of inertia about an axis PQ, in its plane and passing through one one of its corner is

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

B. $2ml^2$

C. $3ml^2$

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

Answer: D

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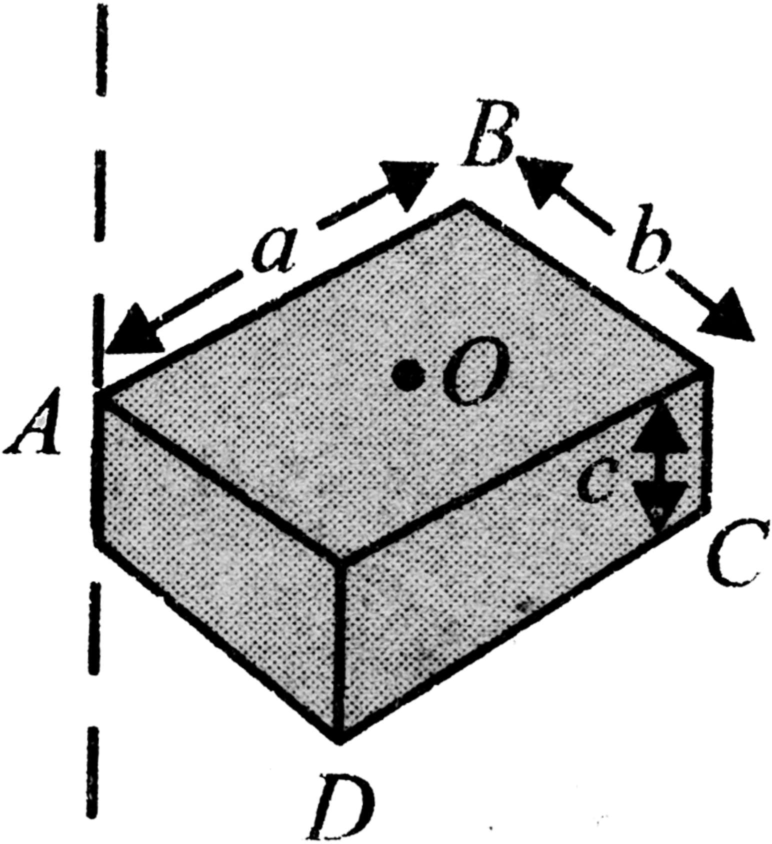
13. Figure shows a uniform solid block of mass M and edge lengths a, b and c. Its $M.I.$ about an axis through one edge and perpendicular (as shown) to the large face of the block is



A. $\frac{M}{3}\left(a^2+b^2\right)$

B. $\frac{M}{4}\left(a^2+b^2\right)$

C. $\frac{7M}{12}\left(a^2+b^2\right)$

D. $\frac{M}{12}\left(a^2+b^2\right)$

Answer: A

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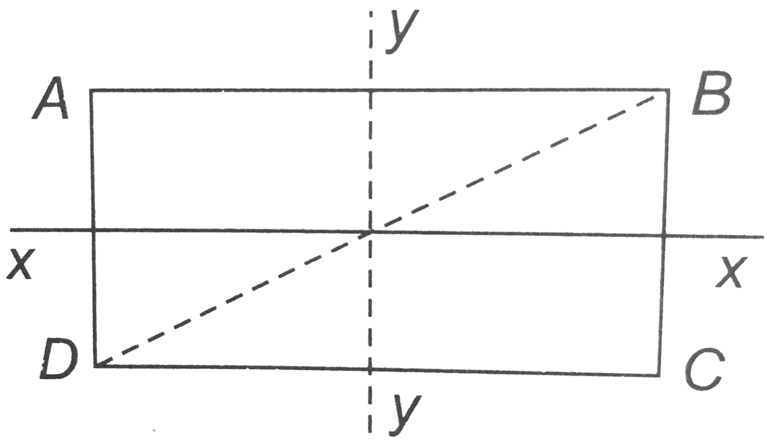
14. In a rectangle $ABCD$, $AB = 2l$ and $BC = l$. Axes $\times$ and yy pass through centre of the rectangle. The moment of inertia is least about :



A. DB

B. BC

C. xx

D. yy

Answer: C

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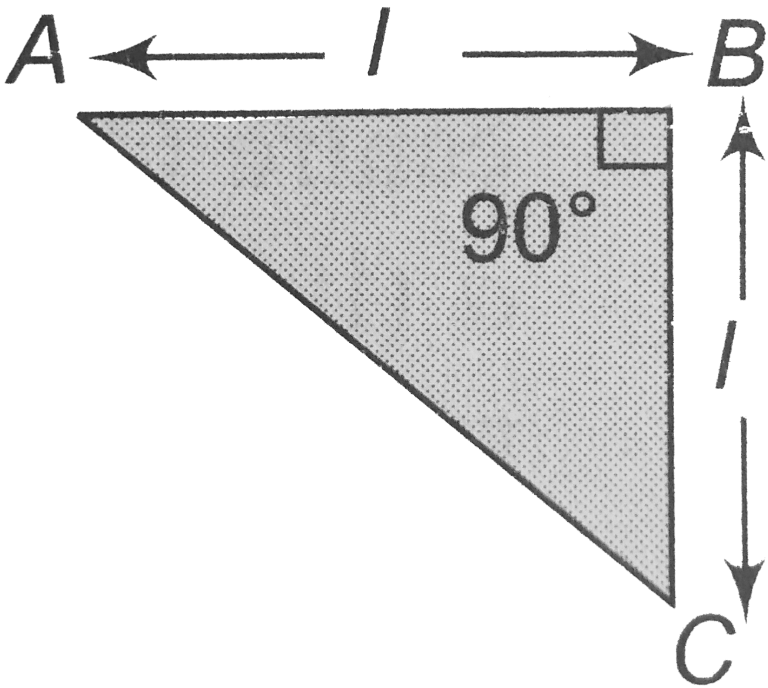
15. Figure shows a thin metallic triangular sheet ABC. The mass of the sheet is M. The moment of inertia of the sheet about side AC is :



A. A. $\frac{Ml^2}{18}$

B. B. $\frac{Ml^2}{12}$

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

D. D. $\frac{Ml^2}{4}$

Answer: B

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16. The moment of inertia of a door of mass m, length $2l$ and width l about its longer side is.

A. $\frac{11ml^2}{24}$

B. $\frac{5ml^2}{24}$

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

D. none of these

Answer: C

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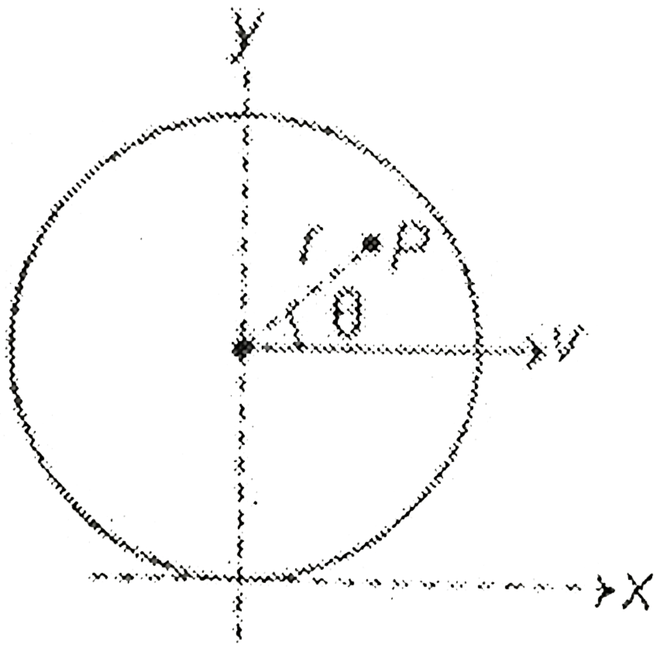
17. A disc of radius R rolls without slipping at spped v along positve x-axis.

Velocity of point P at the instant shown in figure is



A. $\vec{V}_P = \left(v + \frac{vr\sin\theta}{R}\right)\hat{i} + \frac{vr\cos\theta}{R}\hat{j}$

B. $\vec{V}_P = \left(v + \frac{vr\sin\theta}{R}\right)\hat{i} - \frac{vr\cos\theta}{R}\hat{j}$

C. $\vec{V}_P = \frac{vr\sin\theta}{R}\hat{i} + \frac{vr\cos\theta}{R}\hat{j}$

D. $\vec{V}_P = \frac{vr si\theta}{R}\hat{i} - \frac{vr\cos\theta}{R}\hat{j}$

Answer: B

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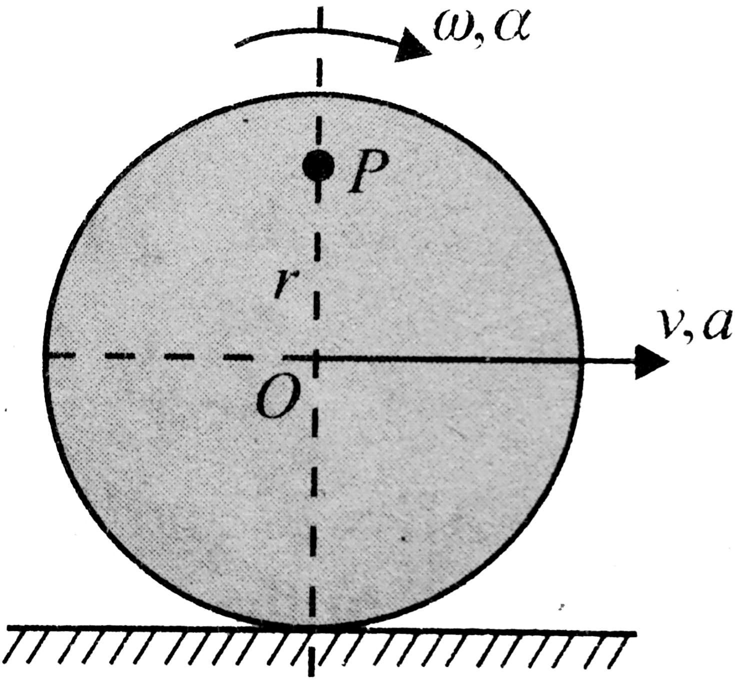
18. Choose the correct option:

A disc of radius R rolls on a horizontal ground with linear acceleration a and angular acceleration α as shown in Fig. The magnitude of acceleration of point P as shown in the figure at an instant when its linear velocity is v and angular velocity is ω will be a



A. $\sqrt{(a + r\alpha)^2 + (r\omega^2)^2}$

B. $\frac{ar}{R}$

C. $\sqrt{r^2\alpha^2 + r^2\omega^4}$

D. $r\alpha$

Answer: A

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19. A uniform disc of mass M and radius R is mounted on an axle supported in frictionless bearings. A light cord is wrapped around the rim of the disc and a steady downward pull T is exerted on the cord. The angular acceleration of the disc is

A. $\frac{T}{MR}$

B. $\frac{MR}{T}$

C. $\frac{2T}{M}R$

D. $\frac{MR}{2T}$

Answer: C

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20. Two rings of same radius and mass are placed such that their centres are at a common point and their planes are perpendicular to each other. The moment of inertia of the system about an axis passing through the centre and perpendicular to the plane of one of the rings is (mass the ring $= m$, radius $= r$)

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

B. mr^2

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

D. $2mr^2$

Answer: c

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21. The moment of inertia of a solid sphere about an axis passing through the centre radius is $\frac{2}{5}MR^2$, then its radius of gyration about a parallel axis t a distance $2R$ from first axis is

A. $5R$

B. $\sqrt{\frac{22}{5}}R$

C. $\frac{5}{2}R$

D. $\sqrt{\frac{12}{5}}R$

Answer: b

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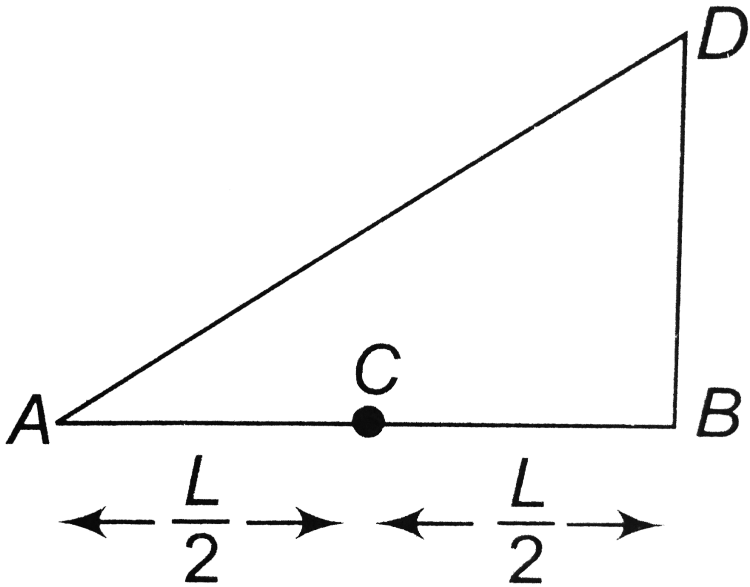
22. A triangular plate of uniform thickness and density is made to rotate about an axis perpendicular to the plane of the paper and

(i) passing through A,

(ii) passing through B, by the application of some force F at C (mid - point AB) as shown in the figure. In which case angular acceleration is more ?



A. a. in case a

B. b. in case b

C. c. both a and b

D. d. none of these

Answer: B

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23. A uniform rod of length L and mass M is pivoted freely at one end and placed in vertical position.

a. What is angular acceleration of the rod when it is at an angle θ with the vertical?

b. What is the tangential linear acceleration of the free end when the rod is horizontal?

A. $g \sin \theta$

B. $\frac{g}{L} \sin \theta$

C. $\frac{3g}{2L} \sin \theta$

D. $6gL \sin \theta$

Answer: C

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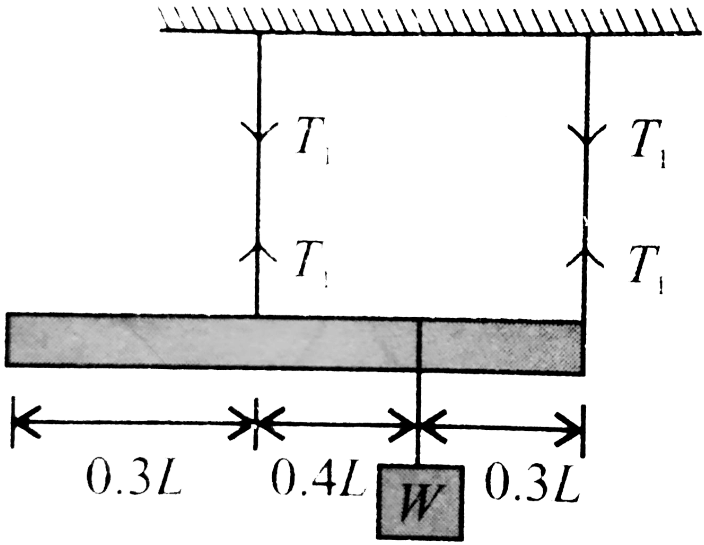
24. In Fig, the bar is uniform and weighing $500N$. How large must W be if T_1 and T_2 are to be equal?



A. $500N$

B. $300N$

C. $750N$

D. $1500N$

Answer: D

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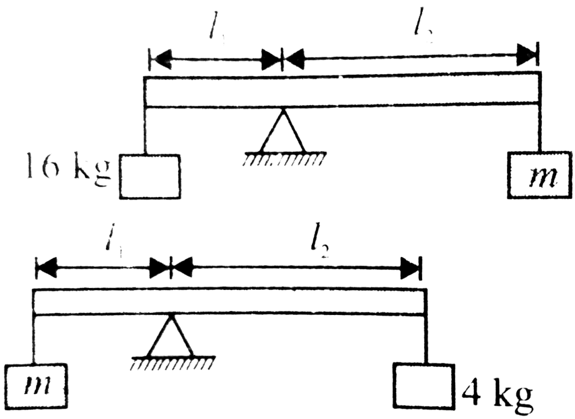
25. In an experiment with a beam balance, an unknown mass m is balanced by two known masses of $16kg$ and $4kg$ shown in Fig. The value of the unknown mass m is



A. $10kg$

B. $6kg$

C. $8kg$

D. $12kg$

Answer: C

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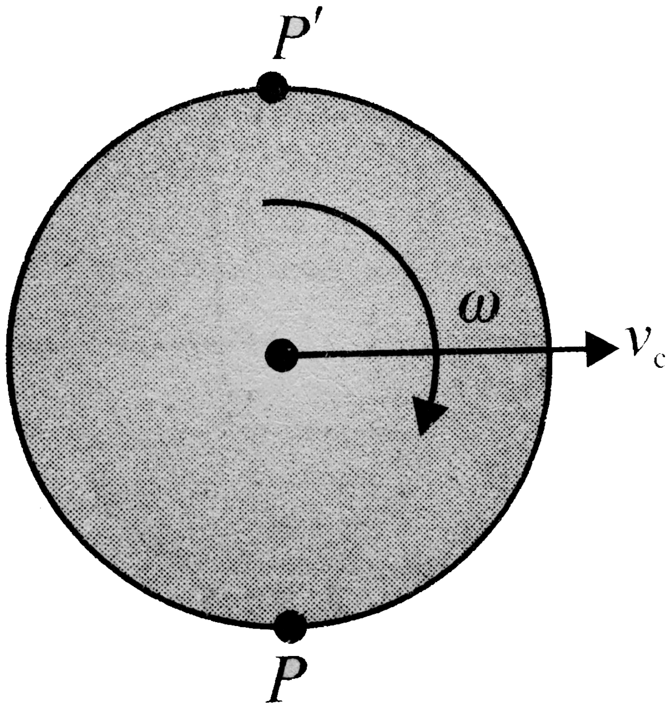
26. A sphere is moving towards the positive x-axis with a velocity v_c and rotates clockwise with angular speed ω shown in Fig. such that $v_c > \omega R$. The instantaneous axis of rotation will be



A. on point P

B. on point P'

C. inside the sphere

D. outside the sphere

Answer: D

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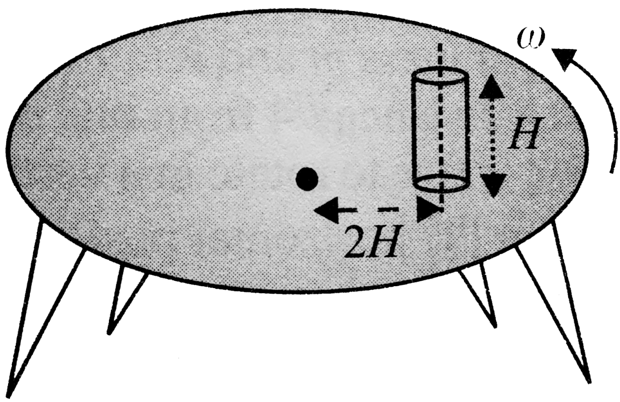
27. A cylinder of height H and diameter $H/4$ is kept on a frictional turntable as shown in Fig. The axis of the cylinder is perpendicular to the surface of the table and the distance of axis of the cylinder is $2H$ from the centre of the table. The angular speed of the turntable at which the cylinder will start toppling (assume that friction is sufficient to prevent slipping) is



A. $\sqrt{\frac{g}{2}\left(\frac{1}{2}-H\right)}$

B. $\sqrt{g\left(\frac{1}{2}-H\right)}$

C. $\sqrt{\frac{g}{4H}}$

D. $\sqrt{\frac{g}{8H}}$

Answer: D

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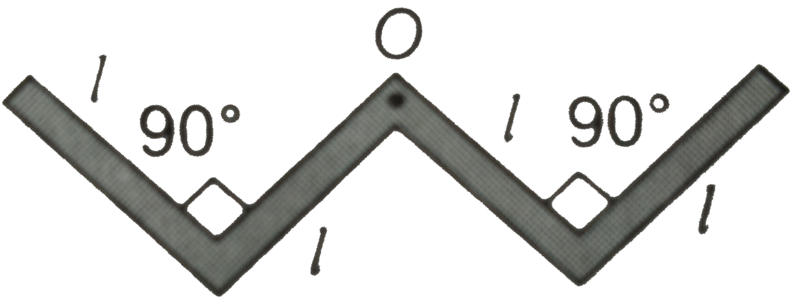

28.

A thin rod of length 4l, mass 4 m is bent at the point as shown in the figure. What is the moment of inertia of the rod about the axis passing through O and perpendicular to the plane of the paper?

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

B. $\frac{10Ml^2}{3}$

C. $\frac{Ml^2}{12}$

D. $\frac{Ml^2}{24}$

Answer: B

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29. Three point masses m_1, m_2 and m_3 are located at the vertices of an equilateral triangle of side α. What is the moment of inertia of the system about an axis along the altitude of the triangle passing through m_1?

A. $(m_1 + m_2)\frac{a^2}{4}$

B. $(m_2 + m_3)\frac{a^2}{4}$

C. $(m_1 + m_3)\frac{a^2}{4}$

D. $(m_1 + m_2 + m_3)\frac{a^2}{4}$

Answer: B

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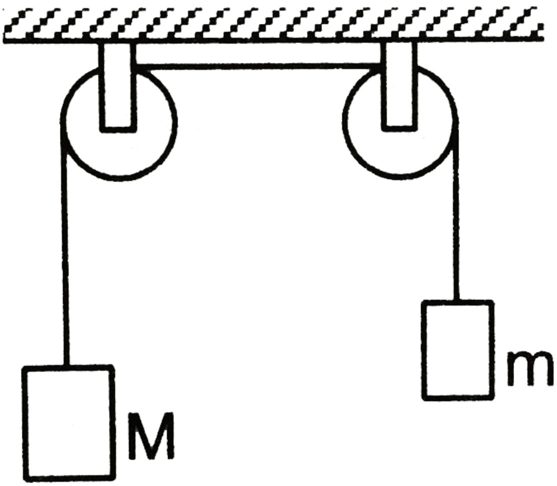
30. The pulleys in figure are identical, each having a radius R and moment of inertia I. Find the acceleration of the block M.



A. $\frac{(M-m)g}{\left(M+m+\frac{2l}{r^2}\right)}$

B. $\frac{(M-m)g}{\left(M+m-\frac{2l}{r^2}\right)}$

C. $\frac{(M-m)g}{\left(M+m+\frac{I}{r^2}\right)}$

D. $\frac{(M-m)g}{\left(M+m-\frac{I}{r^2}\right)}$

Answer: A

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31. A uniform cube of side a and mass m rests on a rough horizontal table. A horizontal force F is applied normal to one of the faces at a point directly above the centre of the face, at a height $\frac{3a}{4}$ above the base. What is the minimum value of F for which the cube begins to tip about an edge?

A. mg

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

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

D. $\frac{3}{4}mg$

Answer: B

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32. A ladder of length l and mass m is placed against a smooth vertical wall, but the ground is not smooth. Coefficient of friction between the ground and the ladder is μ. The angle θ at which the ladder will stay in equilibrium is

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

B. $\theta = \tan^{-1}(2\mu)$

C. $\theta = \tan^{-1}\left(\frac{\mu}{2}\right)$

D. none of these

Answer: D

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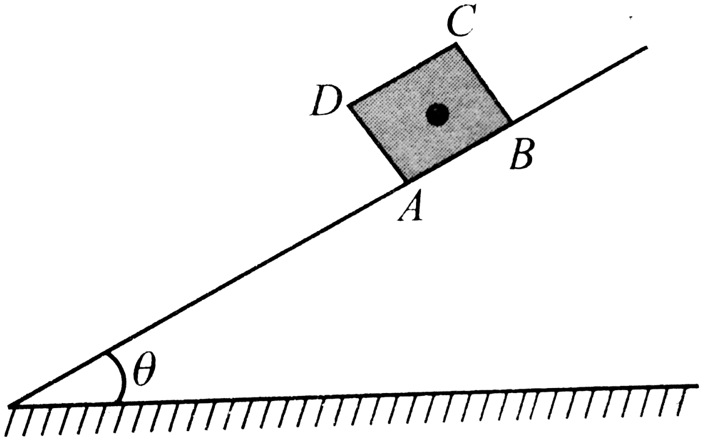
33. A cube of side a is placed on an inclined plane of inclination θ. What is the maximum value of θ for which the cube will not topple?



A. 15°

B. 30°

C. 45°

D. 60°

Answer: C

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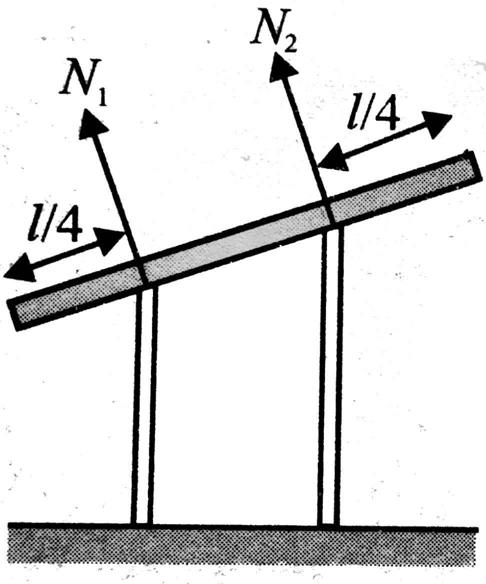
34. A uniform rod of length l is placed symmetrically on two walls as shown in Fig. The rod is in equilibrium. If N_1 and N_2 are the normal forces exerted by the walls on the rod, then



A. $N_1 > N_2$

B. $N_1 < N_2$

C. $N_1 = N_2$

D. N_1 and N_2 would be in the vertical directions

Answer: C

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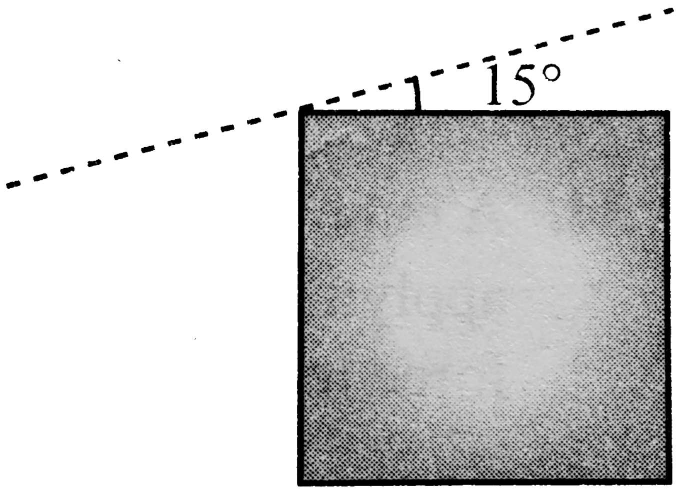
35. A square plate of mass M and edge L is shown in the figure. The moment of inertia of the plate about the axis in the plane of plate and passing through one of its vertex making an angle 15° horizontal is `



A. $\frac{ML^2}{12}$

B. $\frac{11ML^2}{24}$

C. $\frac{7ML^2}{12}$

D. none of these

Answer: B

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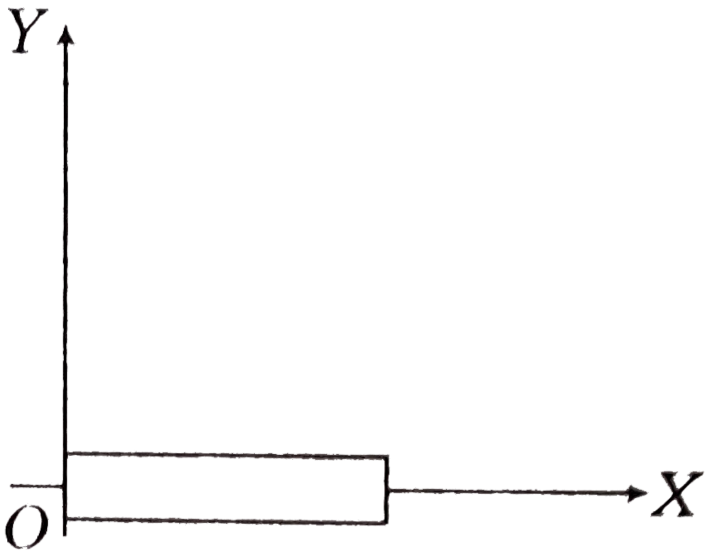
36. The figure shows a uniform rod lying along the X-axis. The locus of all the points lying on the XY-plane, about which the moment of inertia of the rod is same as that about O is



A. an ellipse

B. a circle

C. a parabola

D. a striaght line

Answer: B

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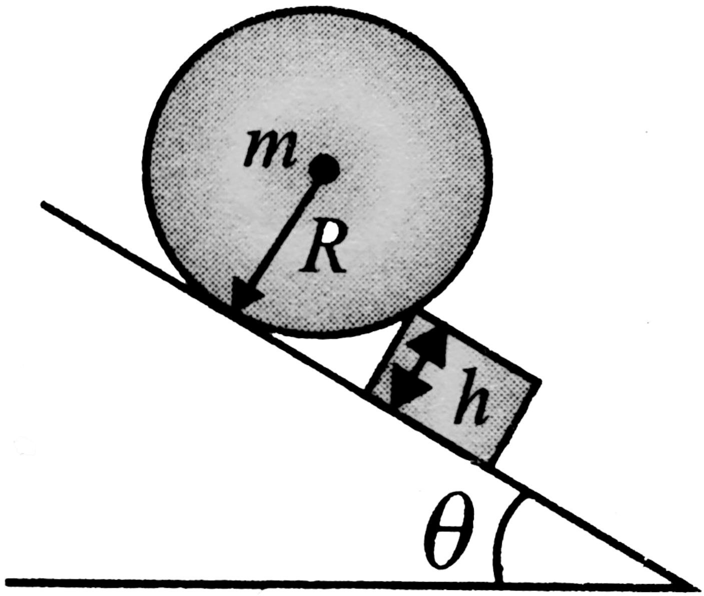
37. Find the minimum height of the obstacle so, that the sphere can stay in equilibrium.



A. $\frac{R}{1+\cos\theta}$

B. $\frac{R}{1+\sin\theta}$

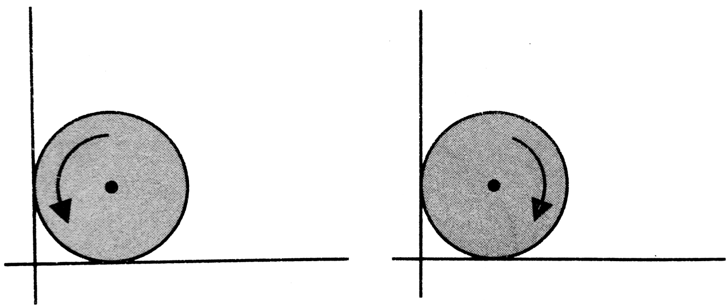
C. $R(1-\sin\theta)$

D. $R(1 - \cos\theta)$

Answer: D

Watch Video Solution

38. A sphere is placed rotating with its centre initially at rest in a corner as shown in Figs.(a) and (b). Coefficient of friction between all surfaces and the sphere is $1/3$. Find the ratio of the friction forces f_a/f_b by ground in situations (a) and (b).



(a) (b)

A. 1

B. $\frac{9}{10}$

C. $\frac{10}{9}$

D. none of these

Answer: B

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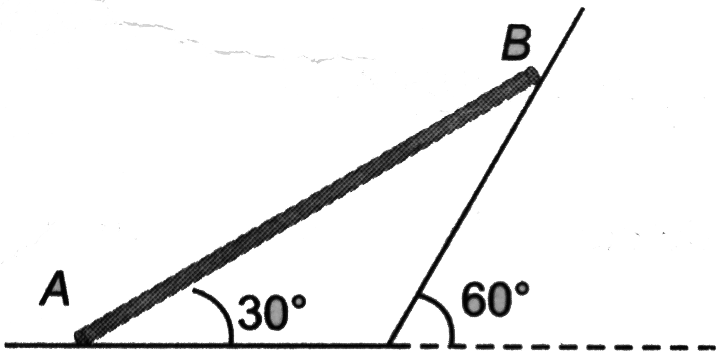
39.



In the figure shown, the instantaneous speed of end A of the rod is v to the left. Find angular velocity of the rod at given instant.

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

B. $\frac{v}{L}$

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

D. none of these

Answer: B

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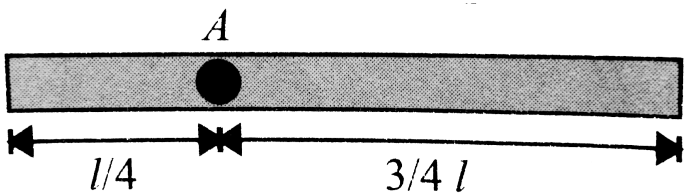
40. A uniform rod of mass m and length l is fixed from Point A, which is at a distance $l/4$ from one end as shown in the figure. The rod is free to rotate in a vertical plane. The rod is released from the horizontal position.



What is the reaction at the hinge, when kinetic energy of the rod is maximum?

A. $\frac{4}{7}$

B. $\frac{5}{7}mg$

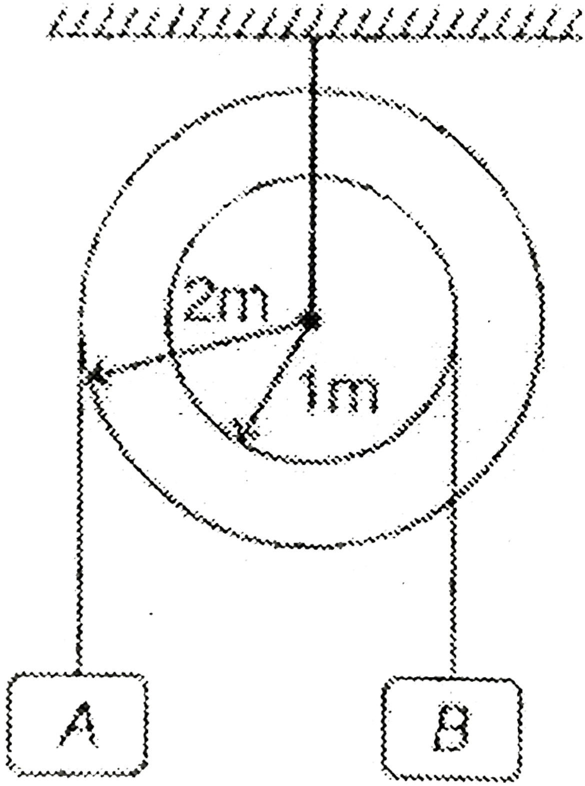
C. $\frac{13}{7}mg$

D. $\frac{11}{7}mg$

Answer: C

Watch Video Solution

41. In the pully system shown, if radii of the bigger and smaller pulley are 2m and 1m respectively and the acceleration of block A is $5m/s^2$ in the downward direction, then the acceleration of block B will be



A. $0 m s^{-2}$

B. $5 m s^{-2}$

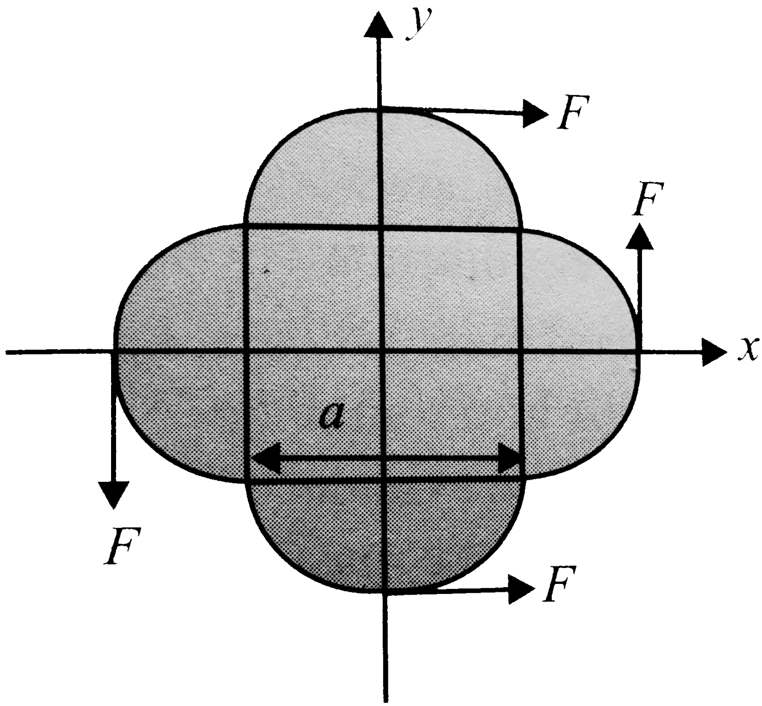
C. $10 m s^{-2}$

D. $\frac{5}{2} m s^{-2}$

Answer: D

Watch Video Solution

42. A planar object made up of a uniform square plate and four semicircular discs of the same thickness and material is being acted upon by four forces of equal magnitude as shown in Fig. The coordinates of point of application of forces is given by



A. $(0, a)$

B. $(0, \ -a)$

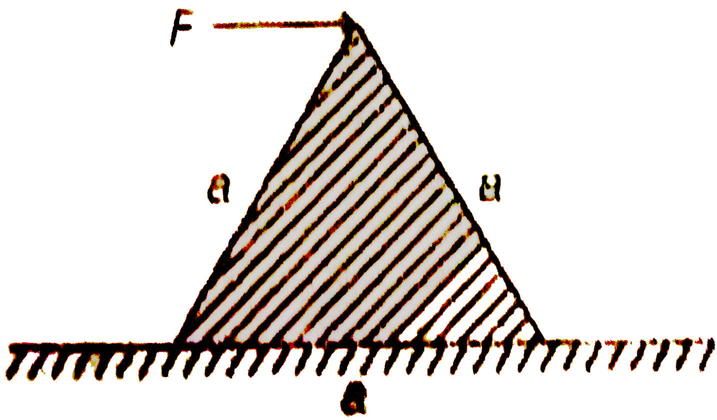
C. $(a, 0)$

D. $(-a, 0)$

Answer: B

Watch Video Solution

43. An equilateral prism of mass m rests on a rough horizontal surface with cofficent of friction μ. A horizontal force F is applied on the prism as shown in the figure. If the cofficent of the friction is sufficently high so that the prism does not slide before toppling, then the minimum force required to topple the prism is



A. $\frac{mg}{\sqrt{3}}$

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

C. $\frac{\mu mg}{\sqrt{3}}$

D. $\frac{\mu mg}{4}$

Answer: A

Watch Video Solution

44. A uniform disc of radius R lies in x-y plane with its centre at origin. Its moment of inertia about z-axis is equal to its moment of inertia, about line y=x+c. The value of c is

A. $-\frac{R}{2}$

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

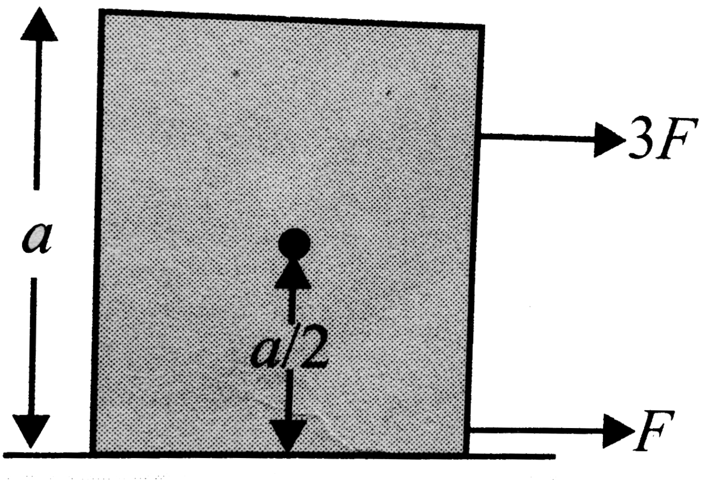
C. $+\frac{R}{4}$

D. $-R$

Answer: B

Watch Video Solution

45. A rectangular block of mass M and height a is resting on a smooth level surface. A force F is applied to one corner as shown in Fig. At what point should a parallel force $3F$ be applied in order that the block shall undergo pure translational motion? Assume normal contact force a between the block and surface passes through the centre of gravity of the block.



A. $\frac{a}{3}$ vertically above centre of gravity

B. $\frac{a}{6}$ vertically above centre of gravity

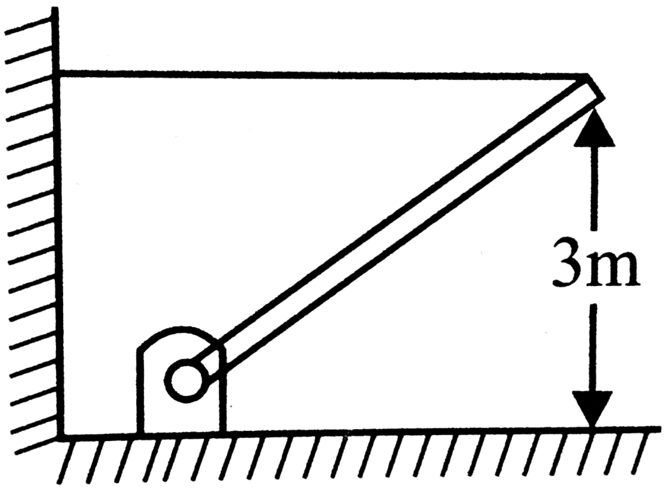
C. no such point exists

D. it is not possible

Answer: B

Watch Video Solution

46. A uniform rod of mass $15kg$ is held stationary at 37 degree with the help of a light string as shown in Fig. The tension in the string is



A. $150N$

B. $225N$

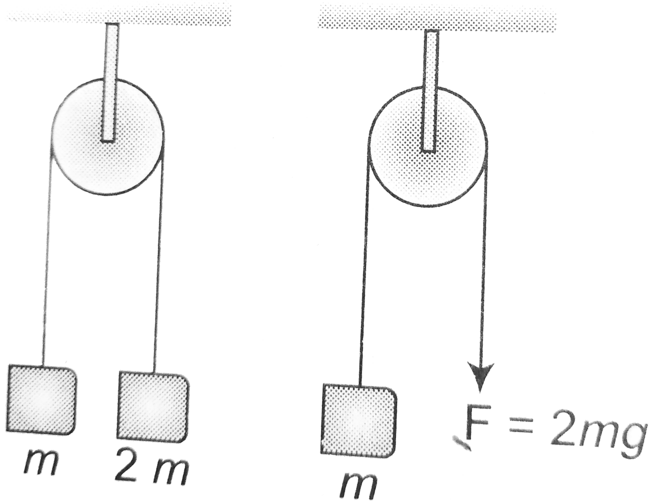
C. $100N$

D. none of these

Answer: C

Watch Video Solution

47. Figure shown two pulley arrangments for lifting a mass m . In case-1, the mass is lifting by attaching a mass 2m while in case-2 the mass is lifted by pulling the other end with a downward force $F = 2mg$. If a_a and a_b are the accelerations of the two masses then (Assumme string is massless and pulley is ideal).



A. $\alpha_A = \alpha_B$

B. $\alpha_A > \alpha_B$

C. $\alpha_A < \alpha_B$

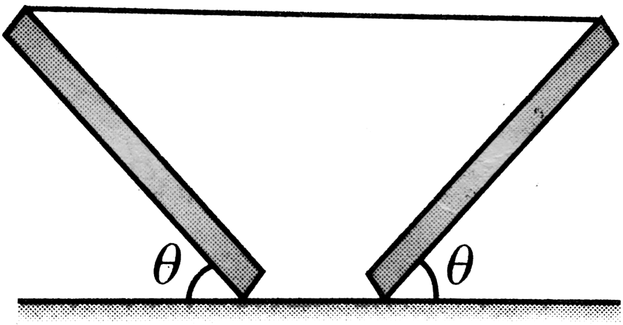
D. none of these

Answer: B

Watch Video Solution

48. Two uniform boards, tied together with the help of a string, are balanced on a surface as shown in Fig.

The coefficient of static friction between boards and surface is 0.5. The minimum value of θ, for which this type of arrangement is possible is



A. 30°

B. 45°

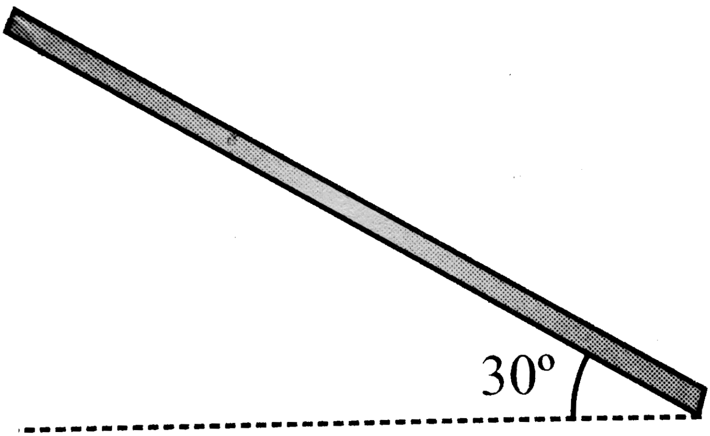
C. 37°

D. it is not possible to have this type of balanced arrangement

Answer: B

Watch Video Solution

49. A slender rod of mass m and length L is pivoted about a horizontal axis through one end and released from rest at an angle of 30° above the horizontal. The force exerted by the pivot on the rod at the instant when the rod passes through a horizontal position is



A. $\sqrt{\frac{10}{4}}$ mg along horizontal

B. mg along vertical

C. $\frac{\sqrt{10}}{4}mg$ alonng a line making an angle of $\tan^{-1}\left(\frac{1}{3}\right)$ with the horizontal

D. $\frac{\sqrt{10}}{4}$mg along a line making an angle of $\tan^{-1}(3)$ with the horizontal

Answer: C

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50. Two painters are working from a wooden hoard $5m$ long suspended from the top of a building by two ropes attached to the ends of the plank. Either rope can withstand a maximum tension of $1040N$. Painter A of mass $80kg$ is working at a distance of $1m$ from one end. Painter B of mass $60kg$ is working at a distance of x in from the centre of mass of the board on the other side. Take mass of the board as $20kg$ and $g = 10ms^{-2}$. The range of x so that both the painters can work safely is

A. $\frac{1}{3} < x < \frac{11}{6}$

B. $0 < x < \frac{11}{6}$

C. $0 < x < 2$

D. $\frac{1}{3} < x < 2$

Answer: C

Watch Video Solution

51. In Fig. a massive rod AB is held in horizontal position by two massless strings. If the string at B breaks and if the horizontal acceleration of centre of mass, vertical acceleration and angular acceleration of rod about the centre of mass are a_x, $a_y$and 'alpha' respectively, then

A. a. $2\sqrt{3}a_y = \sqrt{3}\alpha l + 2a_x$

B. b. $\sqrt{3}_y = \sqrt{3}\alpha l + a_x$

C. c. $a_y = \sqrt{3}\alpha l + 2a_x$

D. d. $2a_y = \alpha l + 2\sqrt{3}a_x$

Answer: D

Watch Video Solution

52. A rod of length L is held vertically on a smooth horizontal surface. The top end of the rod is given a gentle push. At at certain instant of time, when the rod makes an angle 37° with horizontal the velocity of COM of the rod of $2m/s$. The velocity of the end of the rod in contact with the surface at that instant is

A. $2ms^{-1}$

B. $1ms^{-1}$

C. $4ms^{-1}$

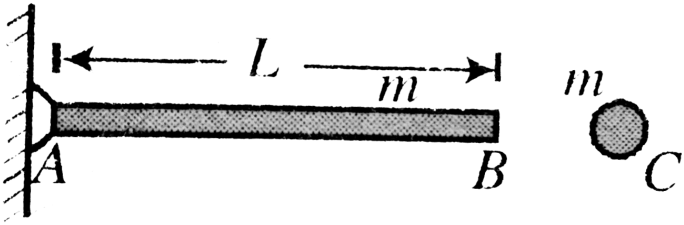
D. $1.5ms^{-1}$

Answer: D

Watch Video Solution

53. A uniform bar AB of mass m and a ball of the same mass are released from rest from the same horizontal position. The bar is hinged at end A. There is gravity downwards. What is the distance of the point from point

B that has the same acceleration as the ball, immediately after release?



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

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

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

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

Answer: B

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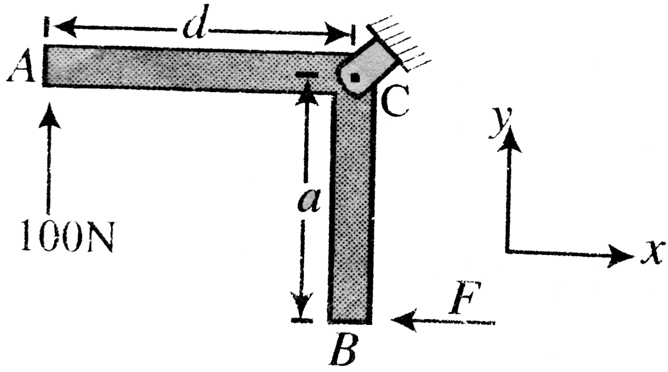
54. Find force F required to keep the system in equilibrium. The dimensions of the system are $d = 0.3m$ and $a = 0.2m$. Assume the rods to be massless.



A. $150(\hat{i})$

B. $150(-\hat{k})$

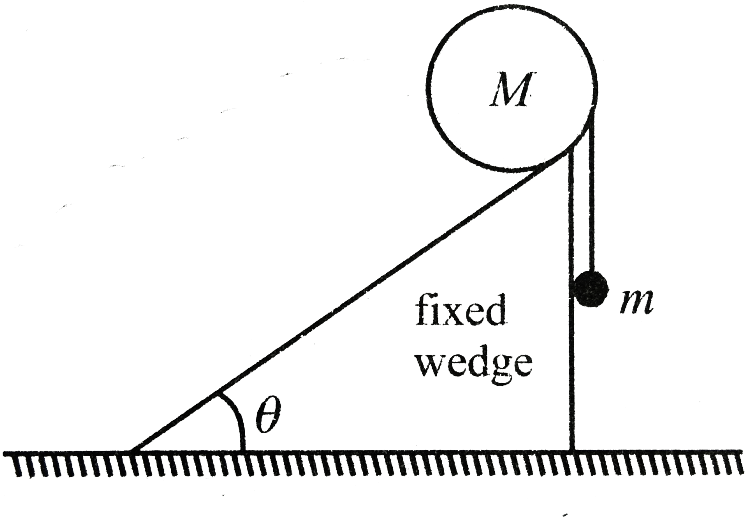
C. $150(-\hat{i})$

D. it cannot be in equilibrium

Answer: C

Watch Video Solution

55. A uniform cylinder of mass m lies on a fixed plane inclined at a angle θ with the horizontal. A light string is tied to the cylinder at the rightmost point, and a mass m hangs from the string as shown. Assume that the coefficient of friction between the cylinder and the incline plane is sufficiently large to prevent slipping. for the cylinder to remain static the value of m is



A. $\dfrac{M\sin\theta}{1-\sin\theta}$

B. $\dfrac{M\cos\theta}{1+\sin\theta}$

C. $\dfrac{M\sin\theta}{1+\sin\theta}$

D. $\dfrac{M\cos\theta}{1-\sin\theta}$

Answer: A

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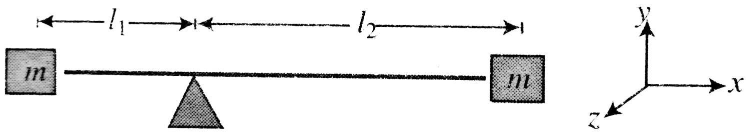
56. Two blocks each of the mass m are attached to the ends, a massless rod which pivots as shown in figure. Initial the rod is held in the horizontal position and then release, Calculate the net torque on this system above pivot.



A. $(ml_2g - ml_1g)\hat{k}$

B. $(ml1g - ml_2g)\hat{k}$

C. $(ml_1g + ml_2g)\hat{k}$

D. $-(ml1g + ml_2g)\hat{k}$

Answer: B

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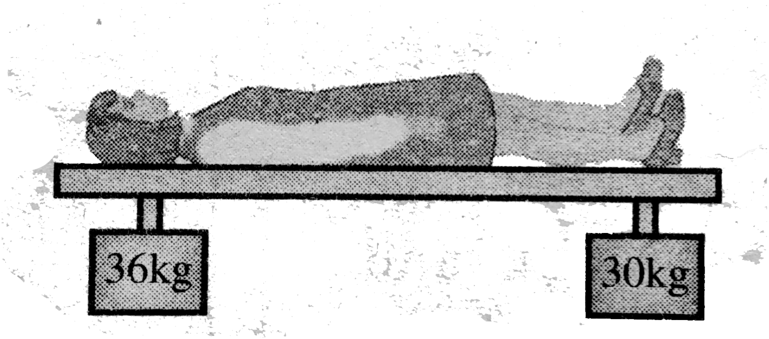
57. A $198 - cm$ tall girl lies on a light (massless) board which is supported by two scales one under the top of her heal and one beneath the bottom of her feet. The two scales read respectively 36 and $30 kg$. What distance is the centre of gravity of this girl from the bottom of her feet? .



A. $99 cm$

B. $90 cm$

C. $108 cm$

D. $82 cm$

Answer: C

Watch Video Solution

58. The wheels of an airplane are set into rotation just before landing so that the wheels do not slip on the ground. If the airplane is travelling in the east direction, what should be the direction of angular velocity vector of the wheels?

A. east

B. west

C. south

D. north

Answer: D

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59. A wheel rotates with a constant acceleration of $2.0ra\frac{d}{s^2}$. If the wheel starts from rest, how many revolutions will it make in the first 10 seconds?

A. 3

B. 6

C. 9

D. 12

Answer: A

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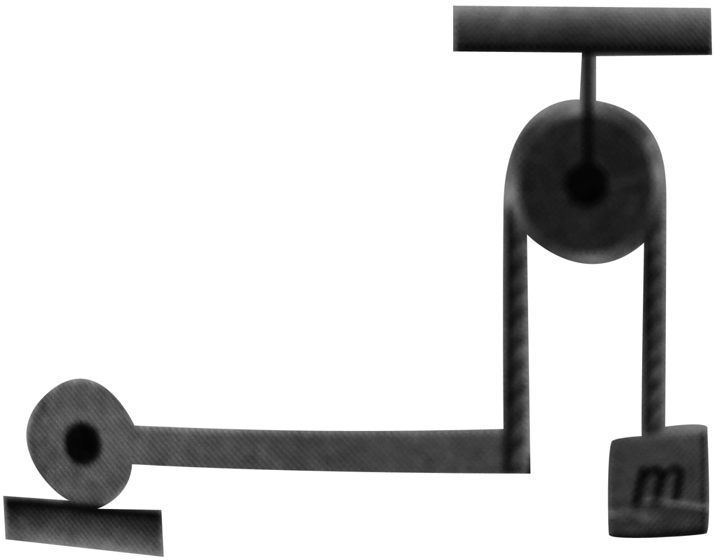

60.

Uniform rod AB is hinged at end A in horizontal position as shown in the figure. The other end is connected to a block through a massless string as shown. The pulley is smooth and massless. Mass of block and rod is same and is equal to m Then acceleration of block just after release from this position is

A. $6g/13$

B. $g/4$

C. $3g/8$

D. none of these

Answer: C

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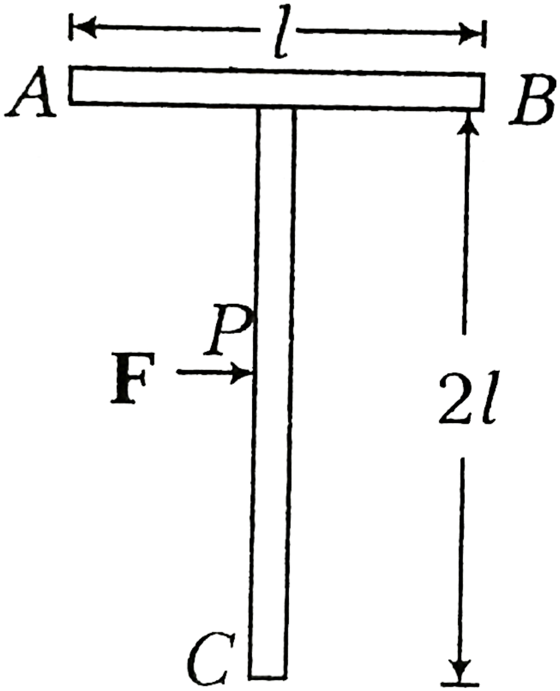
61. A 'T' shaped object with dimension shown in the figure, is lying on a smooth floor. A force F is applied at the point P parallel to AB, such that the objects has only hte translational motion without rotation. Find the location of P with respect to C.



A. $(3/4)l$

B. l

C. $(4/3)l$

D. $(3/2)l$

Answer: C

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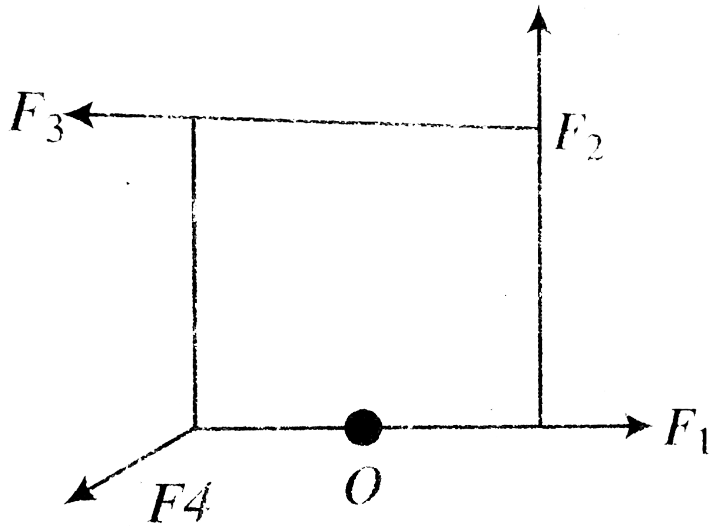
62. Four forces of the same magnitude act on a square as shown in figure. The square can rotate about point O, mid point of one of the edges. The force which can produce greatest torque is



A. F_1

B. F_2

C. $F3$

D. $F4$

Answer: C

Watch Video Solution

63. Given a uniform disc of mass M and radius R. A small disc of radius $R/2$ is cut from this disc in such a way that the distance between the centres of the two discs is $R/2$. Find the moment of inertia of the remaining disc about a diameter of the original disc perpendicular to the line connecting the centres of the two discs

A. $3MR2/32$

B. $5MR2/16$

C. $11MR2/64$

D. none of these

Answer: C

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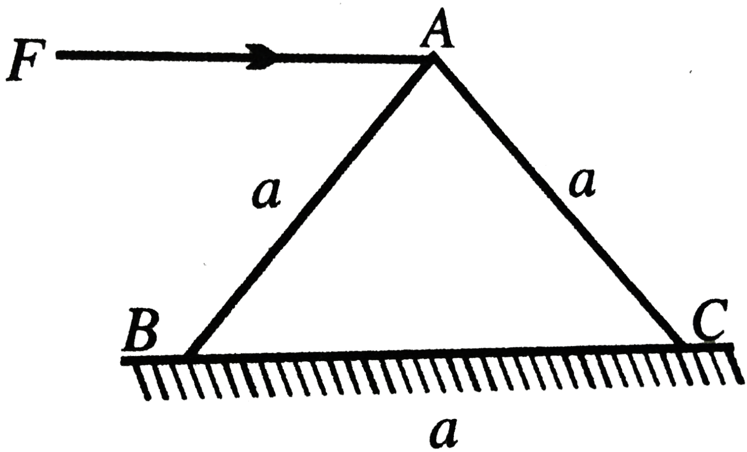
64. A horizontal force F is applied at the top of an equilateral triangular block having mass m. The minimum coefficient of friction required to topple the block before translation will be



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

B. $\frac{1}{3}$

C. $\frac{1}{\sqrt{3}}$

D. $\frac{1}{2}$

Answer: C

Watch Video Solution

65. The line of action of the resultant of two like parallel forces shifts by one-fourth 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. $3 : 5$

Answer: D

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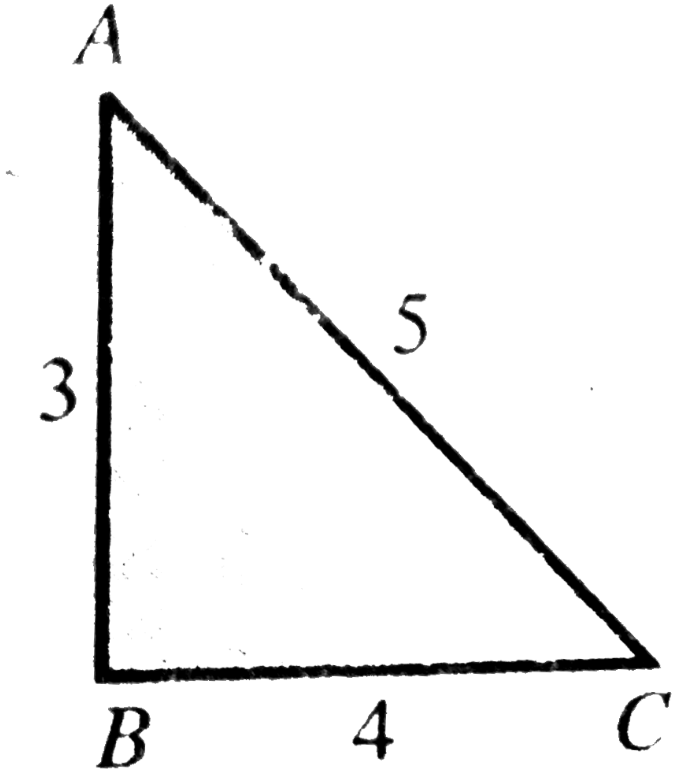
66. ABC is a triangular plate of uniform A thickness. The sides are in the ratio shown in the figure. I_{AB}, I_{BC}, I_{CA} are the moments of inertia of the plated about AB, BC and CA respectively. Which one of the following relation is correct?



A. I_{CA} is maximum

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

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

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

Answer: B

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67. Let I be the moment of inertia of a uniform square plate about an axis AB that passes through its centre and is parallel to two of 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

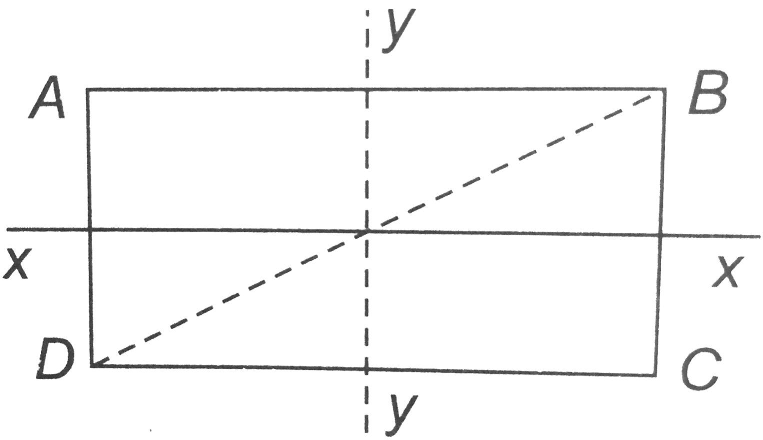
B. $I\sin^2\theta$

C. $I\cos^2\theta$

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

Answer: A

68. In a rectangle $ABCD$, $AB = 2l$ and $BC = l$. Axes $\times$ and yy pass through centre of the rectangle. The moment of inertia is least about :



A. DB

B. BC

C. xx

D. yy

Answer: C

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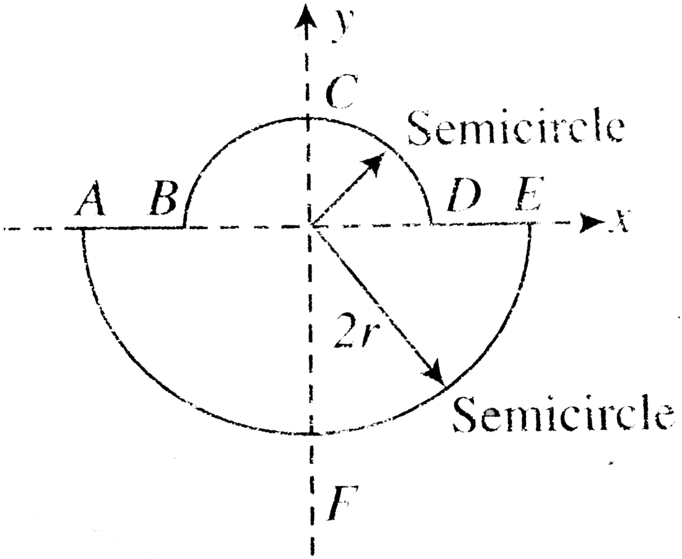
69. A uniform thin rod is bent in the form of closed loop $ABCDEFA$ as shown in the figure. The ratio of moment of inertia of the loop about x-axis to that about y-axis is



A. > 1

B. < 1

C. $= 1$

D. $1/2$

Answer: B

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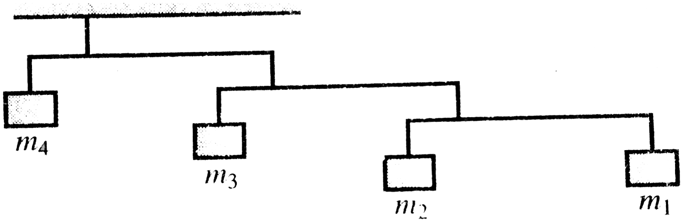
70. Figure shows an arrangement of masses hanging from a ceiling. In equilibrium, each rod is horizontal, has negligible mass and extends three times as far to the right of the wire supporting it as to the left. If mass m_4 is $48kg$ then mass m_1 is equal to



A. $1kg$

B. $2kg$

C. $3kg$

D. $4kg$

Answer: A

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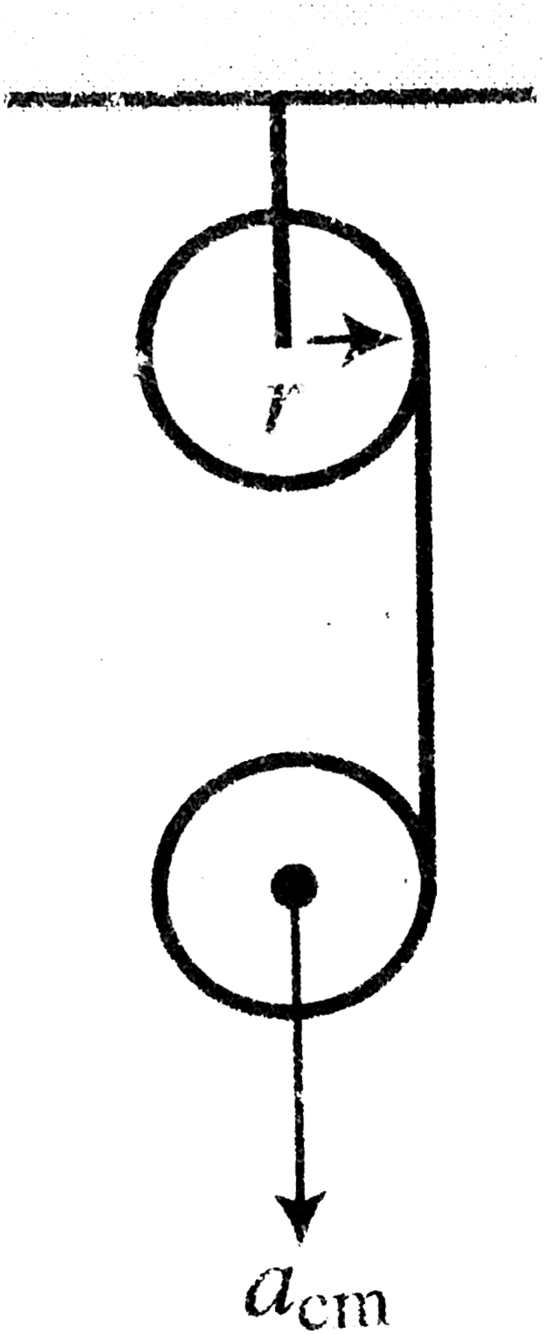
71. Two identical uniform discs of mass m and radius r are arranged as shown in the figure. If α is the angular acceleration of the lower disc and a_{cm} is acceleration of centre of mass of the lower disc, then relation among a_{cm}, α and r is



A. $a_{cm} = \frac{\alpha}{r}$

B. $a_{cm} = 2\alpha r$

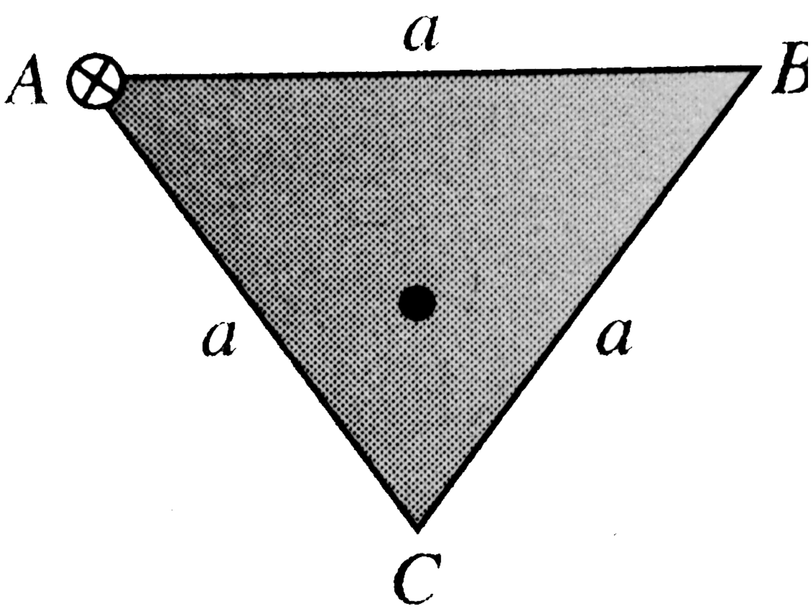
C. $a_{cm} = \alpha r$

D. none of these

Answer: B

Watch Video Solution

72. A uniform triangular plate $ABCof$ moment of mass m and inertia I (about an axis passing through A and perpendicular to plane of the plate) can rotate freely in the vertical plane about point $'A'$ as shown in figure. The plate is released from the position shown in the figure. Line AB is horizontal. The acceleration of centre of mass just after the release of plate is



A. $\frac{mga^2}{\sqrt{3}I}$

B. $\frac{mga^2}{4I}$

C. $\frac{mga^2}{2\sqrt{3}I}$

D. $\frac{mga^2}{3I}$

Answer: C

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73. ABC is an equilateral triangle with O as its centre. F_1, F_2 and F_3 represent three forces acting along the sides AB, BC and AC respectively. If the total about O is zero, then the magnitude of F_3 is

A. $2(F_1 + F_2)$

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

C. $F_1 - F_2$

D. $F_1 + F_2$

Answer: D

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74. Two discs have same mass and thickness. Their materials are of densities π_1 and π_2. The ratio of their moment of inertia about central axis will be

A. $\pi_1 : \pi_2$

B. $\pi_1 \pi_2 : 1$

C. $1 : \pi_1 \pi_2$

D. $\pi_2 : \pi_1$

Answer: D

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75. 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 massof the body but B does not. Choose the correct option.

A. $I_A < I_B$

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

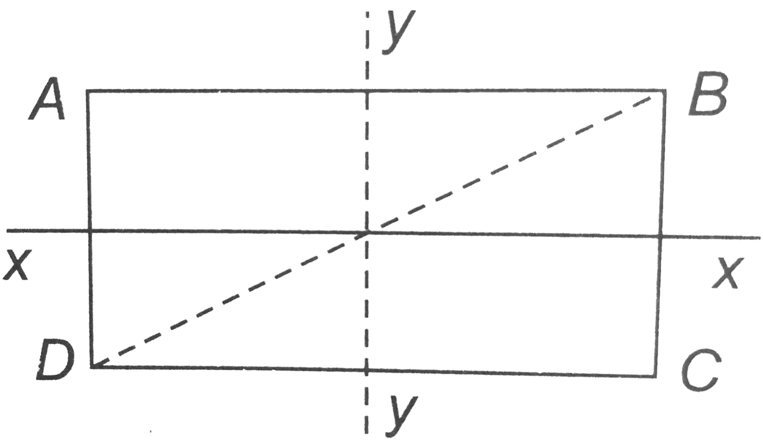
C. If the axes are parallel $I_A < I_B$

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

Answer: C

Watch Video Solution

76. In a rectangle $ABCD$, $AB = 2l$ and $BC = l$. Axes $\times$ and yy pass through centre of the rectangle. The moment of inertia is least about :



A. BC

B. BD

C. HF

D. EG

Answer: D

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

A. a ring of radius l

B. a disc of radius l

C. a square lamina of side $2l$

D. Four rods forming square of side $2l$

Answer: D

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78. A uniform plane sheet of metal in the form of a triangle ABC has $BC > AB > AC$. Its moment of inertia will be smallest

A. about AC as axis

B. about AB as axis

C. about BC as axis

D. with a line through C normal to its plane as axis,

Answer: C

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79. The masses of two uniform discs are in the ratio $1:2$ and their diameters in the ratio $2:1$. The ratio of their moment, of inertia about the axis passing through their respective centres and perpendicular to their planes is

A. $1:1$

B. $1:2$

C. $2:1$

D. $1:4$

Answer: C

Watch Video Solution

80. There are four solid balls with their centres at the four corners of a square of side a. the mass of each sphere is m and radius is r. Find the moment of inertia of the system about one of the sides of the square

A. $\frac{8}{5}mr^2 + mb^2$

B. $\frac{8}{5}mr^2 + 2mb^2$

C. $\frac{8}{5}mr^2 + 4mb^2$

D. none of these

Answer: B

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81. if l_1 is the moment of inertia of a thin rod about an axis perpendicular to its length and passing through its centre of mass and l_2 te moment of inertia of the ring formed by the same rod about an axis passing through the centre of mass of the ring and perpendicular tot he plane of the ring. then find the ratio $\frac{l_1}{l_2}$.

A. $I_1 : I_2 = 1 : 1$

B. $I_1 : I_2 = \pi^2 : 3$

C. $I_1 : I_2 = \pi : 4$

D. $I_1 : I_2 = 3 : 5$

Answer: B

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82. Moment of inertia of a uniform rod of length L and mass M, about an axis passing through $L/4$ from one end and perpendicular to its length is

A. $\dfrac{ML^2}{3}$

B. $\dfrac{ML^2}{6}$

C. $\dfrac{ML^2}{9}$

D. $\dfrac{ML^2}{12}$

Answer: C

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83. A small hole is made in a disc of mass M and radius R at a distance $R/4$ from centre. The disc is supported on a horizontal peg through this hole. The moment of inertia of the disc about horizontal peg is

A. $\dfrac{MR^2}{9}$

B. $\dfrac{5}{16}MR^2$

C. $\dfrac{9}{16}MR^2$

D. $\dfrac{5}{4}MR^2$

Answer: C

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84. Two rings of same radius and mass are placed such that their centres are at a common point and their planes are perpendicular to each other. The moment of inertia of the system about an axis passing through the centre and perpendicular to the plane of one of the rings is (mass the ring $= m$, radius $= r$)

A. MR^2

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

C. $2MR^2$

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

Answer: B

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85. We have a solid sphere and a very thin spheical shell their masses and moments of inertia about a diameter are same. The ratio of their radii will be :

A. $5:7$

B. $3:5$

C. $\sqrt{3}:\sqrt{5}$

D. $\sqrt{3}:\sqrt{7}$

Answer: C

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86. 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 massof the body but B does not. Choose the correct option.

A. $I_A < I_B$

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

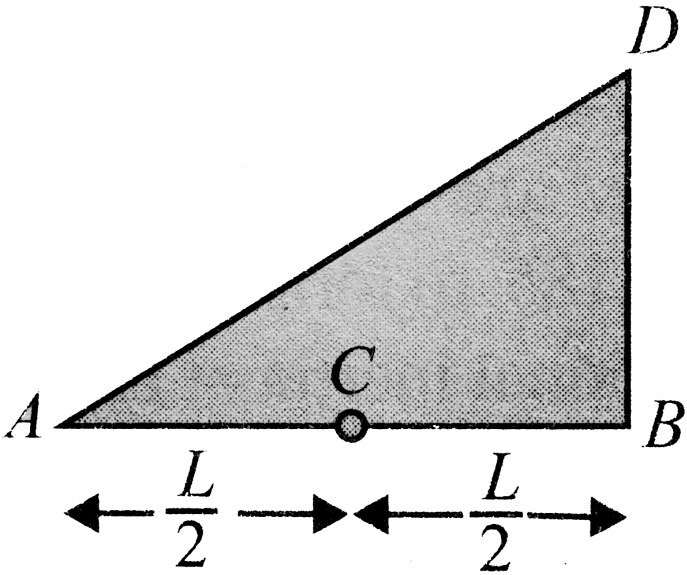
C. If the axes are paralel $I_A < I_B$

D. if the axes are not parallel the $I_A \geq I_B$

Answer: C

Watch Video Solution

87. A triangular platge of uniform thickness and densilty ismade to rotate about an axis perpendicular to the plane of the paper an a. passing through A b. passing through B, by the application of some foce F at C (mid point of AB) as show in figure. In which case is angular acceleration more?



A. angular acceleration in both the cases is the same

B. angular acceleration for case (a) is larger

C. angular acceleration for case (b) is larger

D. there would be no angular acceleration for case (a)

Answer: C

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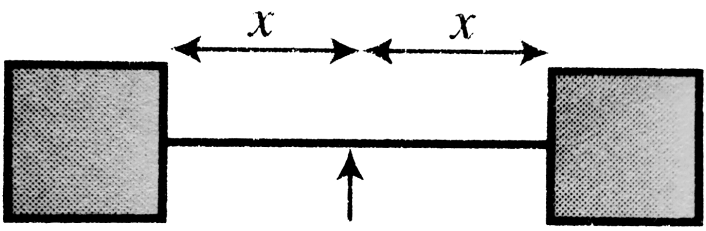
88. Two identical masses are connected to a horizontal thin massless rod as shown in the figure. When their distance from the pivot is x, a torque produces an angular acceleration α_1. If the masses are now repositioned so that they are at distance $2x$ each from the pivot, the same torque will produce an angular acceleration α_2 such that ,



A. $\alpha_2 = 4\alpha_1$

B. $\alpha_2 = \alpha_1$

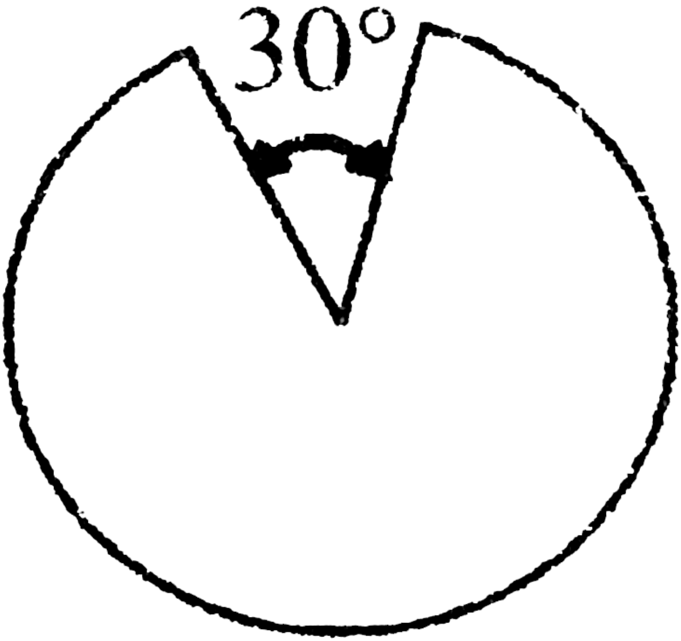
C. $\alpha_2 = \frac{\alpha_1}{2}$

D. $\alpha_2 = \frac{\alpha_1}{4}$

Answer: D

Watch Video Solution

89. From a complete ring of mass M and radius R, a 30° sector is removed. The moment of inertia of the incomplete ring about an axis passing through the centre of the ring and perpendicular to the plane of the ring is



,

A. $\frac{9}{12}MR^2$

B. $\frac{11}{12}MR^2$

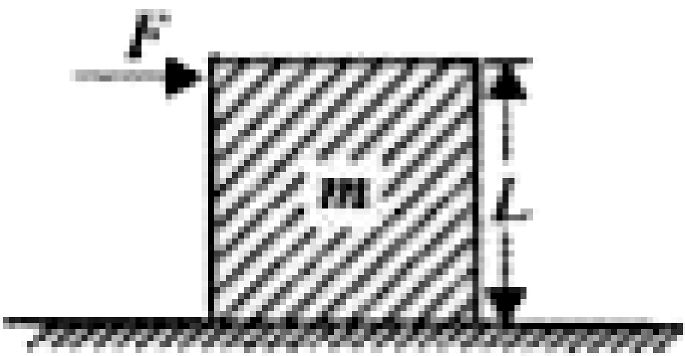
C. $\frac{13}{12}MR^2$

D. MR^2

Answer: B

Watch Video Solution

90. A cubical box of side L rests on a rough horizontal surface with coefficient of friction p. A horizontal force F is a applied on the block as shown in Fig. 15.4.6. If the coefficient of friction is sufficiently high so that the block does not slide before toppling, the minimum force required to topple the block is



A. infinitesimal

B. $\frac{mg}{34}$

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

D. $mg(1 - \mu)$

Answer: C

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91. The density of a rod continuously increases from A to B. It is easier to set it into rotation by

A. clamping the rod at A and applying a force F at B, perpendicular to the rod

B. clamping the rod at B and applying a force F at A, perpendicular to the rod

C. clamping the rod at mid point of AB and applying a force F at A, perpendicular to the rod

D. clamping the rod at mid-point of AB and applying force F at B, perpendicular to the rod.

Answer: B

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92. Three children are sitting on a see-saw in such a way that is balances. A $20kg$ and a $30kg$ boy are on opposite sides at a distance of $2m$ from the pivot. It the third boy jumps off, thereby destroying balance, then the initial angular acceleration of the board is: (Neglect weight of board)

A. A. $0.01rads^{-2}$

B. B. $1.0rads^{-2}$

C. C. $10rads^{-2}$

D. D. $100rads^{-2}$

Answer: B

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93. A wheel of radius R has an axle of radius $R/5$. A force F is applied tangentially to the wheel. To keep the system in a state of "rotational" rest, a force F' is applied tangentially to the axle. The value of F' is

A. F

B. $3F$

C. $5F$

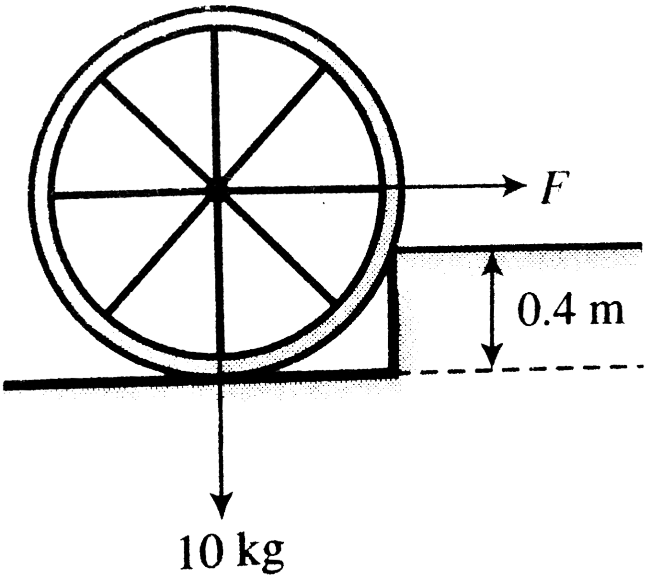
D. $7F$

Answer: C

Watch Video Solution

94. Calculate the force F that is applied horizontally at the axle of the wheel which is necessary to raise the wheel over the obstacle of height

$0.4m$. Radius of wheel is $1m$ and $mass = 10kg$. F is



A. $100N$

B. $66N$

C. $167N$

D. $133.3N$

Answer: D

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95. A rigid body is rotating about a vertical axis. In t second, the axis gradually becomes horizontal. But the rigid body continues to make v rotations per second throughout the time interval of 1 second. If the moment of inertia I of the body about the axis of rotation can he taken as constant, then the torque acting on the body is

A. $2\pi v$I

B. $2\sqrt{2}\pi v$I

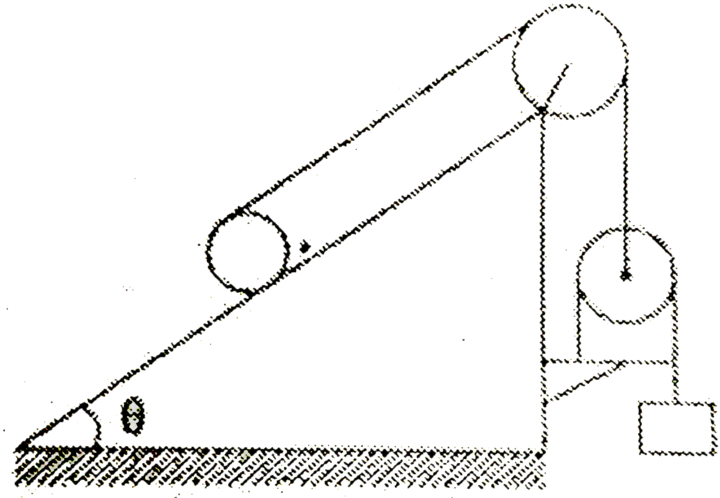
C. $\frac{2\sqrt{2}\pi v}{t}$I

D. $\frac{2\sqrt{2}\pi v l}{t}$I

Answer: D

Watch Video Solution

96. A string is warapped around a cylinder of mass m and radius r. The string is also connected to a block of same mass m with the help of another pulley as shown in figure. The angular acceleration of the cylinder is (friction is sufficient for rolling) (all pulleys are ideal)



A. $2Mg/3$

B. $Mg/2$

C. $Mg/3$

D. $Mg/6$

Answer: C

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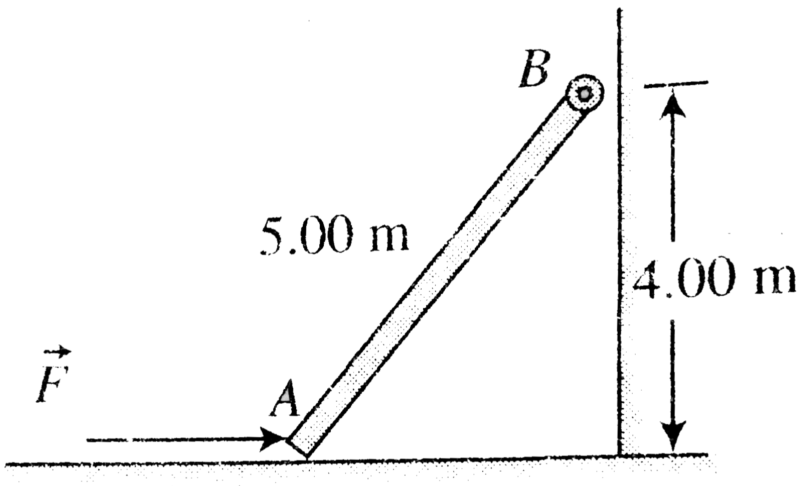
97. End A of the bar AB in figure rests on a frictionless horizontal surface and end B is hinged. A horizontal force $\vec{F}$ of magnitude $120N$ is exerted on end A. You can ignore the weight of the bar. What is the net force exerted by the bar on the hinge at B?



A. $200N$

B. $140N$

C. $100N$

D. none of these

Answer: A

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Multiple Correct

1. A rigid body is in pure rotation, that is, undergoing fixed axis rotation. Then which of the following statement(s) are true?

A. a. . You can find two points in the body in a plane perpendicular to the axis of A. a. rotation having the same velocity.

B. b. You can find two points in the body in a plane perpendicular to the axis of rotation having the same acceleration.

C. c. Speed of all the particles lying on the curved surface of a cylinder whose axis coincides with the axis of rotation is the same.

D. d. Angular speed of the body is the same as seen from any point in the body.

Answer: C::D

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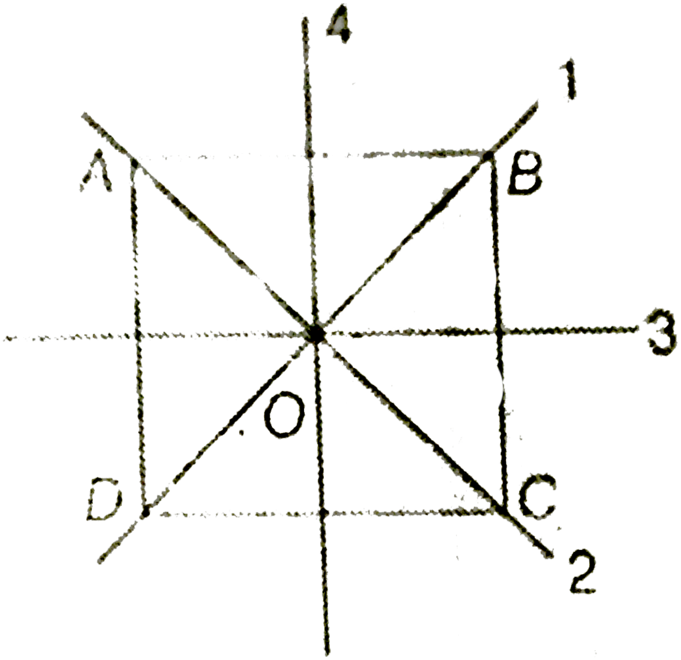
2. The moment of inertia of a thin square plate ABCD of uniform thickness about an axis passing through the centre O and perpendicular to plate is



A. $I_1 + I_2$

B. $I_3 + I_4$

C. $I_1 + I_3$

D. $I_1 + I_2 + I_3 + I_4$

Answer: A::B::C

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3. A bucket of water of mass $21kg$ is suspended by a rope wrapped around a solid cylinder $0.2m$ in diameter. The mass of the solid cylinder is $21kg$. The bucket is released from rest. Which of the following statements are correct?

A. The tension in the rope is $70N$.

B. The acceleration of the bucket is $\left(\frac{20}{3}\right)m/s^2$

C. The acceleration of the bucket is independent of the mass of the bucket.

D. All of these

Answer: A::B::C::D

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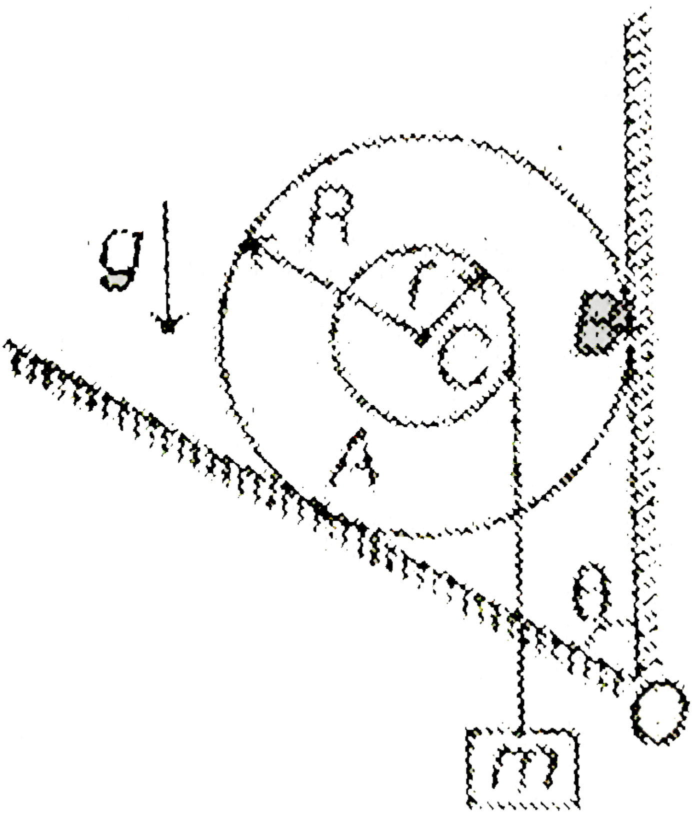
4. A massles spool of inner radius r and other radius R is placed against vertical wall and tilted split floor as shown. A light inextensible thread is tightly wound around the spool through which a mass m is hanging. There exists no friction at point A, while the coefficient of friction between spool and point B is μ. The angle between two surface is θ



A. the magnitude of force on the spool at B in order to maintain equilibrium is $mg\sqrt{\left(\frac{r}{R}\right)^2 + \left(1 - \text{ or } \frac{r}{R}\right)^2 \frac{1}{\tan^2\theta}}$

B. the magnitude of force on the spool at B in order to maintain equilibrium is $mg\left(1 - \frac{r}{R}\right)\frac{1}{\tan\theta}$

C. the minimum value of μ for the system to remain in equilibrium $\frac{\cot\theta}{\left(\frac{R}{r}\right) - 1}$

D. the minimum value of p for the system to remain equilibrium is $\frac{\tan\theta}{\left(\frac{R}{r}\right) - 1}$

Answer: A::D

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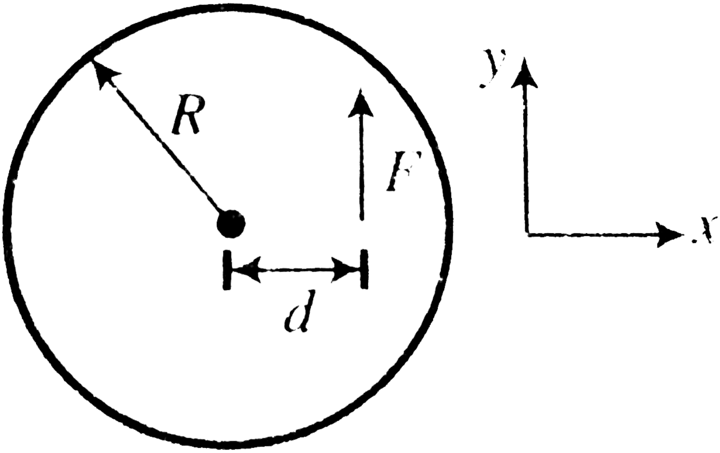
5. A uniform thin flat isolated disc is floating in space. It has radius R and mass m . A force is applied to it at a distance $d = \left(\frac{R}{2}\right)$ from the centre in the y-direction. Treat this problem as two-dimensional. Just after the force is applied:



A. acceleration of the centre of the disc is F/m.

B. angular acceleration of the disk is F/mR.

C. acceleration of leftmost point on the, disc is zero

D. point which is instantaneously unaccelerated is the rightmost point.

Answer: A::B::C

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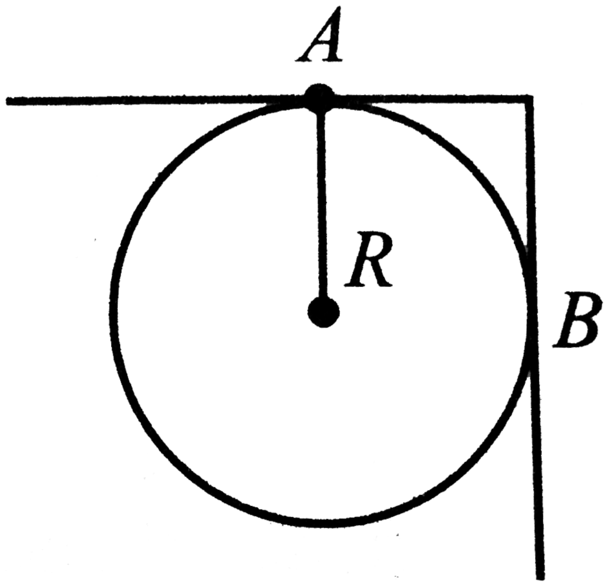
6. A rod bent at right angle along its centre line is placed on a rough horizontal fixed cylinder of radius R as shown in the figure. Mass of the rod is $2m$ and the rod is in equilibrimu. Assume that the friction force on rod at A and B is equal in magnitude.



A. a. Normal force applied by cylinder on rod at A is $3mg/2$

B. b. Normal force applied by cylinder on rod at B must be zero.

C. c. Friction force acting on rod at B is upward.

D. d. Normal force applied by cylinder on rod at A is mg.

Answer: A::C

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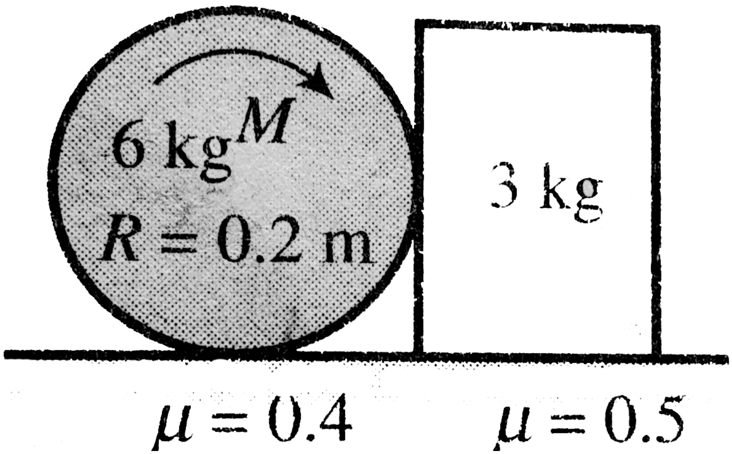
7. A clockwise torque of $6N - m$ is applied to the circular cylinder as shown in the figure. There is no friction between the cylinder and the block.



A. A) The cylinder will be slipping but the system does not move forward

B. B)The system cannot move forward for any torque applied to the cylinder

C. C)The acceleration of the system will be $1m/s^2$ forward

D. D)The angular acceleration of the cylinder is $10rads^{-2}$

Answer: C::D

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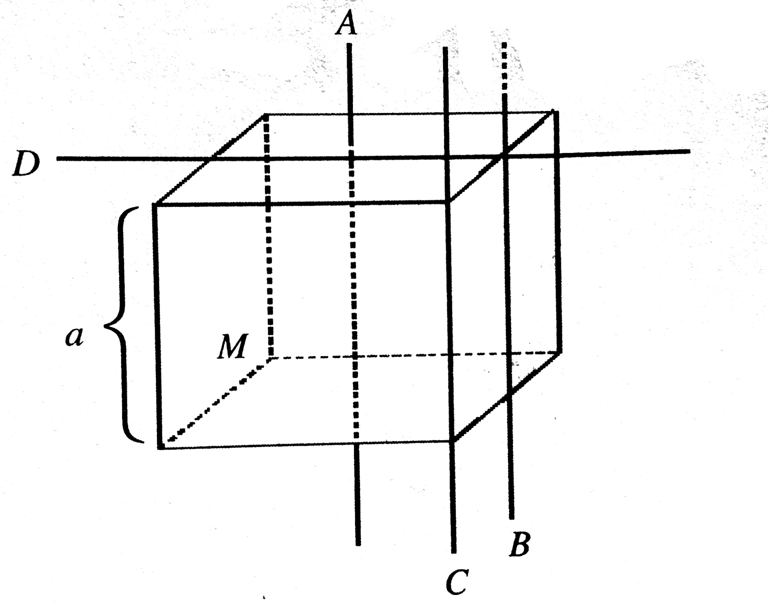
8. Illustrated is a uniform cubical block of mass M and side a Mark the correct statement (s)



A. A. The moment of inertia about axis A, passing through the centre of mass is $IA = \frac{1}{6} Ma^2$

B. B. The moment of inertia about axis B, which bisects one of the cube faces is $lB = \frac{5}{12} Ma^2$

C. C. The moment of inertia about axis C, along one of the cube edge is $IC = \frac{2}{3} Ma^2$

D. D. The moment of inertia about axis D, whch bhisects one of the horizontal cube face is $\frac{7}{12}$

Answer: A::B::C

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9. The moment of inertia of a body depends upon

A. shape and mass of the body

B. nature of distribution of mass

C. axis of rotation

D. all of the above

Answer: B::C

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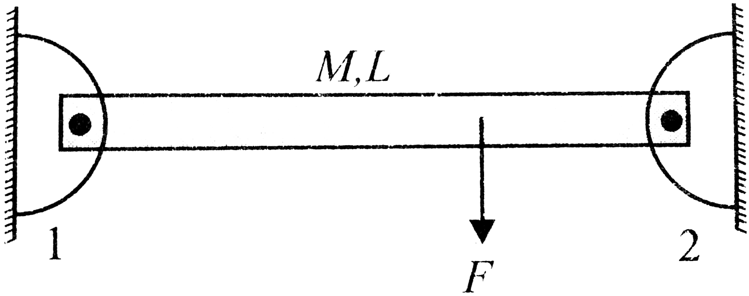
Linked Comprehension

1. A uniform rod of mass $M = 2kg$ and length L is suspended by two smooth hinges 1 and 2 as shown in Fig. A force $F = 4N$ is applied downward at a distance $L/4$ from hinge 2. Due to the application of force F, hinge 2 breaks. At this instant, applied force F is also removed. The rod starts to rotate downward about hinge 1. ($g = 10m/s^2$)



The reaction at hinge 1, before hinge 2 breaks, is

A. $24N$

B. $12N$

C. $11N$

D. $10N$

Answer: C

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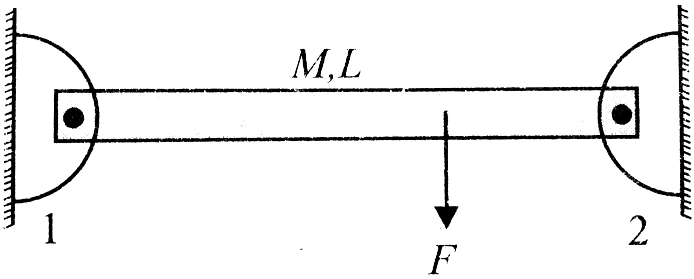
2. A uniform rod of mass $M = 2kg$ and length L is suspended by two smooth hinges 1 and 2 as shown in Fig. A force $F = 4N$ is applied downward at a distance $L/4$ from hinge 2. Due to the application of force F, hinge 2 breaks. At this instant, applied force F is also removed. The rod starts to rotate downward about hinge 1. $(g = 10m/s^2)$



The reaction at hinge 1, just after breaking of hinge 2, is

A. $20N$

B. $10N$

C. $5N$

D. 0

Answer: C

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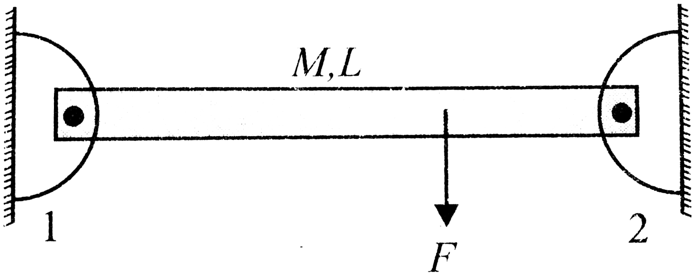
3. A uniform rod of mass $M = 2kg$ and length L is suspended by two smooth hinges 1 and 2 as shown in Fig. A force $F = 4N$ is applied downward at a distance $L/4$ from hinge 2. Due to the application of force F, hinge 2 breaks. At this instant, applied force F is also removed. The rod starts to rotate downward about hinge 1. $(g = 10m/s^2)$



The reaction at hinge 1, just after breaking of hinge 2, is

A. $30m/s^2$

B. $20m/s^2$

C. $10m/s^2$

D. 0

Answer: A

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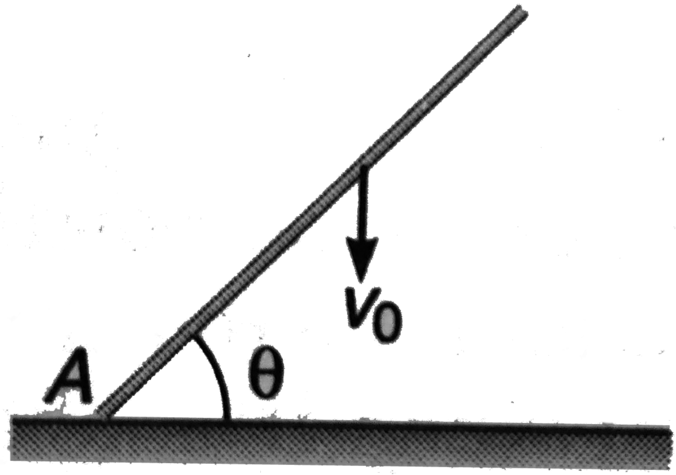
4. 

A rod of length l forming an angle θ with the horizontal strikes a frictionless floor at A with its centre of mass velocity v_0 and no angular velocity. Assuming that the impact at A is perfectly elastic. Find the angular velocity of the rod immediately after the impact.

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

B. $\frac{4}{5}v_0$

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

D. $\frac{5}{4}v_0$

Answer: B

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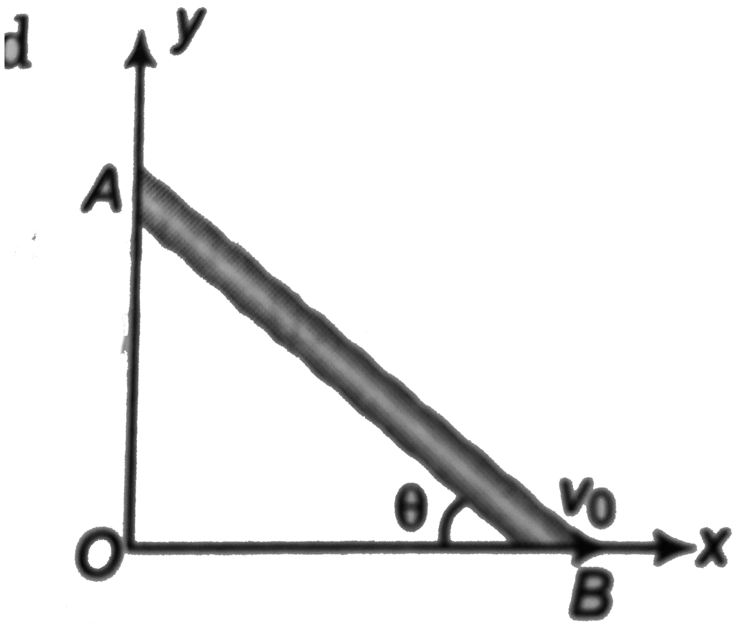

5.

The end B of the rod AB which makes angle θ with the floor is being pulled with a constant velocity v_v as shown. The length of the rod is l.

A. $\frac{5v_0}{3l}$

B. $\frac{3v_0}{5l}$

C. $\frac{5v_0}{4l}$

D. $\frac{4v_0}{5l}$

Answer: A

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6.

- $\frac{5}{7}v_0$ at $\frac{\tan^{-1}4}{3}$ below horizontal
- $\frac{5}{7}v_0$ at $\frac{\tan^{-1}3}{4}$ below horizontal
- $\frac{5}{6}v_0$ at $\frac{\tan^{-1}3}{4}$ below horizontal
- $\frac{5}{6}v_0$ at $\frac{\tan^{-1}4}{3}$ below horizontal

Answer: D

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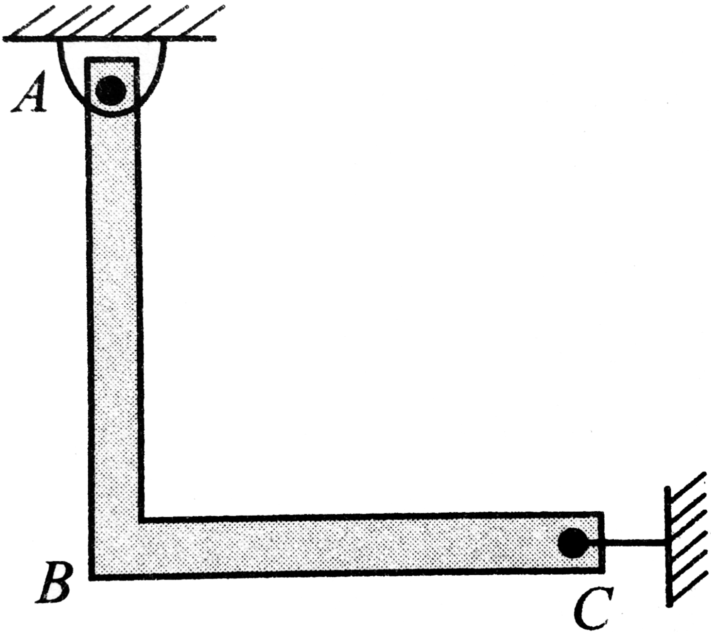
7. An L shaped uniform rod of mass $2M$ and length $2L(AB = BC = L)$ is held as shown in Fig. with a string fixed between C and wall so that AB is vertical and BC is horizontal. There is no friction between the hinge and the rod at A.



Find the tension in the string

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

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

C. Mg

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

Answer: D

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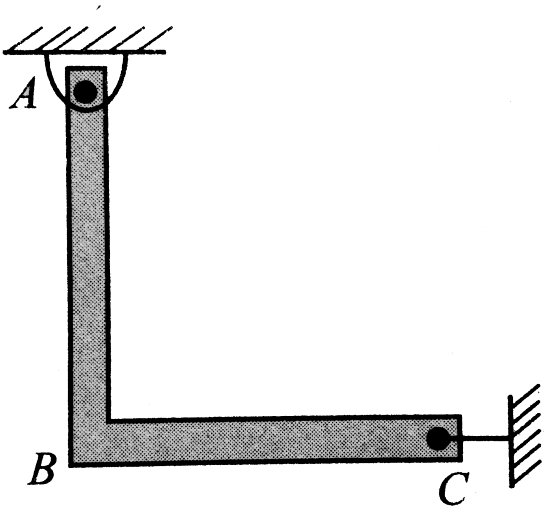
8. An L shaped uniform rod of mass $2M$ and length $2L(AB = BC = L)$ is held as shown in Fig. with a string fixed between C and wall so that AB is vertical and BC is horizontal. There is no friction between the hinge and the rod at A.



What will be the reaction between hinge and rod at point A?

A. $\sqrt{65}\frac{Mg}{4}$

B. $2Mg$

C. $\sqrt{17}\frac{Mg}{4}$

D. $\sqrt{17}\frac{Mg}{2}$

Answer: D

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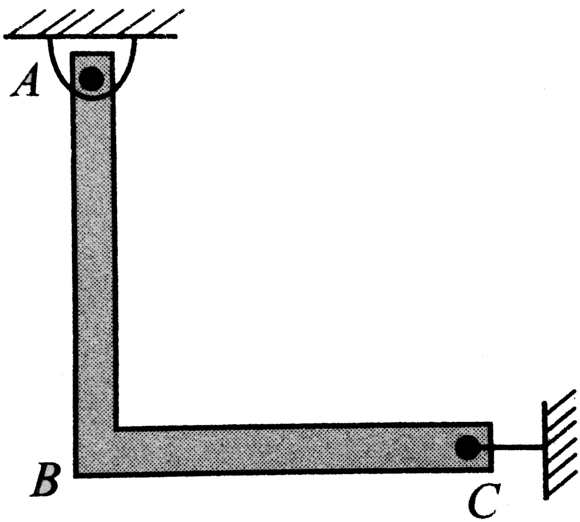
9. An L shaped uniform rod of mass $2M$ and length $2L(AB = BC = L)$ is held as shown in Fig. with a string fixed between C and wall so that AB is vertical and BC is horizontal. There is no friction between the hinge and the rod at A.



If the string is burnt, find the angle between AB and the vertical at equilibrium position.

A. $\tan^{-1}\left(\frac{1}{3}\right)$

B. $\tan^{-1}\left(\frac{1}{4}\right)$

C. $\tan^{-1}(3)$

D. $\tan^{-1}\left(\frac{1}{2}\right)$

Answer: A

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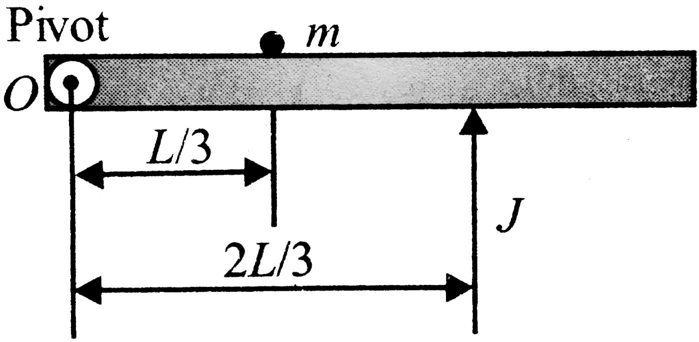
10. A uniform rod of length L and mass M is lying on a frictionless horizontal plane and is pivoted at one of its ends as shown in Fig. There is no friction at the pivot. An inelastic ball of mass m is fixed with the rod at a distance $L/3$ from O. A horizontal impulse J is given to the rod at a distance $2L/3$ from O in a direction perpendicular to the rod. Assume that the ball remains in contact with the rod after the collision and impulse J acts for a small time interval $\triangle t$. Now answer the following questions:



Find the impulse acted on the ball during the time $\triangle t$

A. A. N$\dfrac{3J}{(m+3M)L}$

B. B. $\dfrac{6J}{(m+3M)L}$

C. C. $\dfrac{3J}{(3m+M)L}$

D. D. $\dfrac{6J}{(3m+M)L}$

Answer: B

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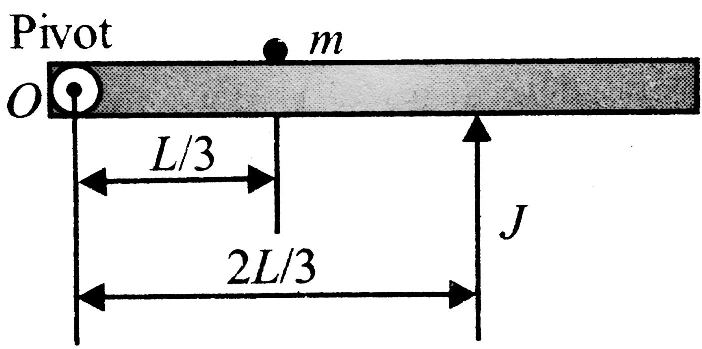
11. A uniform rod of length L and mass M is lying on a frictionless horizontal plane and is pivoted at one of its ends as shown in Fig. There is no friction at the pivot. An inelastic ball of mass m is fixed with the rod at a distance $L/3$ from O. A horizontal impulse J is given to the rod at a distance $2L/3$ from O in a direction perpendicular to the rod. Assume that the ball remains in contact with the rod after the collision and impulse J acts for a small time interval $\triangle t$. Now answer the following questions:



Find the impulse acted on the ball during the time $\triangle t$

A. $\frac{2MJ}{(3m+M)}$

B. $\frac{2MJ}{(m+3M)}$

C. $\frac{2mJ}{(3m+M)}$

D. $\frac{2mJ}{(m+3M)}$

Answer: D

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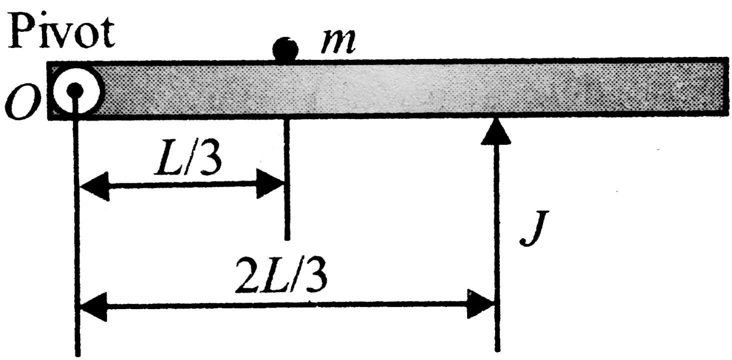
12. A uniform rod of length L and mass M is lying on a frictionless horizontal plane and is pivoted at one of its ends as shown in Fig. There is no friction at the pivot. An inelastic ball of mass m is fixed with the rod at a distance $L/3$ from O. A horizontal impulse J is given to the rod at a distance $2L/3$ from O in a direction perpendicular to the rod. Assume that the ball remains in contact with the rod after the collision and impulse J acts for a small time interval $\triangle t$. Now answer the following questions:



Find the magnitude of the impulse applied on the pivot during the time interval $\triangle t$

A. $\frac{mJ}{(m+3M)}$

B. $\dfrac{mJ}{(3m+M)}$

C. $\dfrac{MJ}{(m+3M)}$

D. $\dfrac{MJ}{(3m+M)}$

Answer: A

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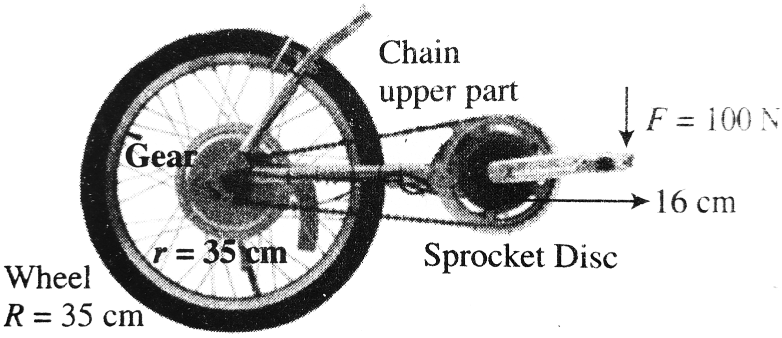
13. A bicycle has pedal rods of length $16cm$ connected to sprocketed disc of radius $10cm$. The bicycle wheels are $70cm$ in diameter and the chain runs over a gear of radius $4cm$. The speed of the cycle is constant and the cyclist applies $100N$ for, that is always perpendicular to the pedal rod, as shown in figure. Assume tension in the lower part of chain is negligible. The cyclist is peddling at a constant rate of two revolutions per second. Assume that the force applied by other foot is zero when one foot is exerting $100N$ force. Neglect friction within cycle parts and the rolling friction.



The tension in the upper portion of the chain is equal to

A. $100N$

B. $120N$

C. $160N$

D. $240N$

Answer: C

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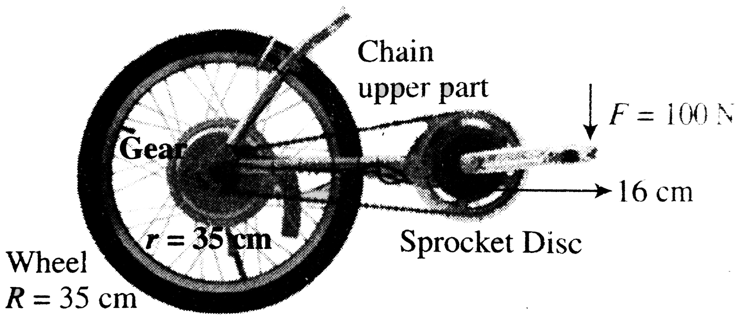
14. A bicycle has pedal rods of length $16cm$ connected to sprocketed disc of radius $10cm$. The bicycle wheels are $70cm$ in diameter and the chain runs over a gear of radius $4cm$. The speed of the cycle is constant and the cyclist applies $100N$ for, that is always perpendicular to the pedal rod, as shown in figure. Assume tension in the lower part of chain is negligible. The cyclist is peddling at a constant rate of two revolutions per second. Assume that the force applied by other foot is zero when one foot is exerting $100N$ force. Neglect friction within cycle parts and the rolling friction.



The speed of the bicycle is

A. zero

B. $16Nm$

C. $6.4N - m$

D. $4.8N - m$

Answer: A

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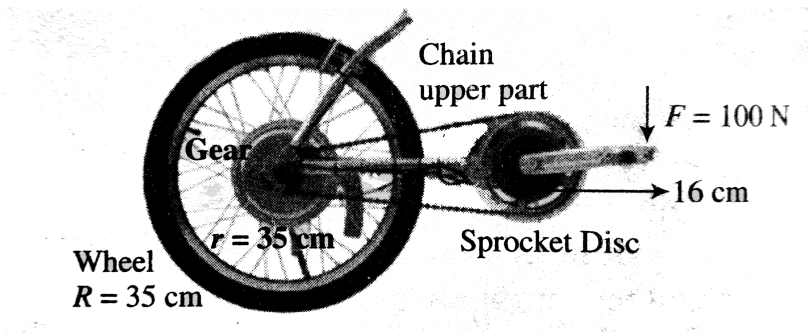
15. A bicycle has pedal rods of length $16cm$ connected to sprocketed disc of radius $10cm$. The bicycle wheels are $70cm$ in diameter and the chain runs over a gear of radius $4cm$. The speed of the cycle is constant and the cyclist applies $100N$ for, that is always perpendicular to the pedal rod, as shown in figure. Assume tension in the lower part of chain is negligible. The cyclist is peddling at a constant rate of two revolutions per second. Assume that the force applied by other foot is zero when one foot is exerting $100N$ force. Neglect friction within cycle parts and the rolling friction.



The power delivered by the cyclist is equal to

A. $280W$

B. $100W$

C. $64\pi W$

D. $32W$

Answer: C

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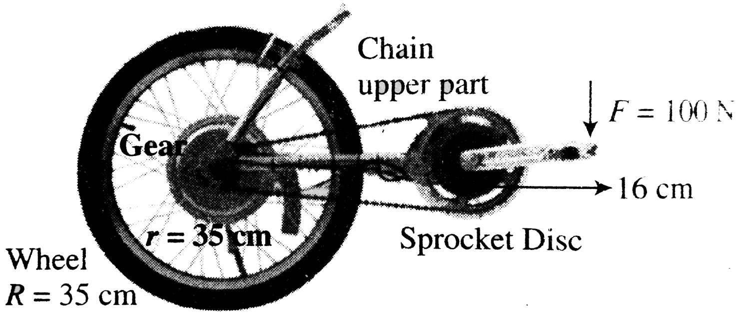
16. A bicycle has pedal rods of length $16cm$ connected to sprocketed disc of radius $10cm$. The bicycle wheels are $70cm$ in diameter and the chain runs over a gear of radius $4cm$. The speed of the cycle is constant and the cyclist applies $100N$ for, that is always perpendicular to the pedal rod, as shown in figure. Assume tension in the lower part of chain is negligible. The cyclist is peddling at a constant rate of two revolutions per second. Assume that the force applied by other foot is zero when one foot is exerting $100N$ force. Neglect friction within cycle parts and the rolling friction.



The speed of the bicycle is

A. $6.4\pi ms^{-1}$

B. $3.5\pi ms^{-1}$

C. $2.8\pi ms^{-1}$

D. $6.5\pi ms^{-1}$

Answer: B

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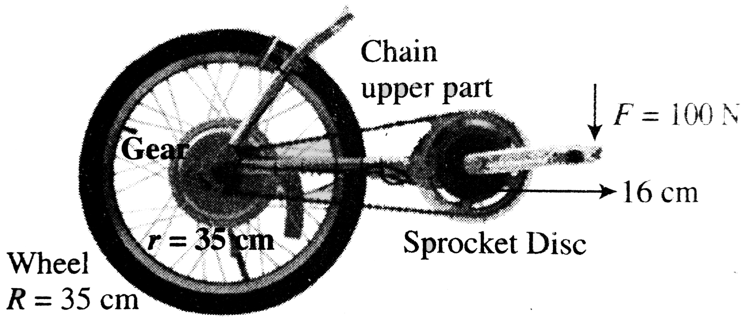
17. A bicycle has pedal rods of length $16cm$ connected to sprocketed disc of radius $10cm$. The bicycle wheels are $70cm$ in diameter and the chain runs over a gear of radius $4cm$. The speed of the cycle is constant and the cyclist applies $100N$ for, that is always perpendicular to the pedal rod, as shown in figure. Assume tension in the lower part of chain is negligible. The cyclist is peddling at a constant rate of two revolutions per second. Assume that the force applied by other foot is zero when one foot is exerting $100N$ force. Neglect friction within cycle parts and the rolling friction.



The net force of the friction on the rear wheel due to the road is:

A. $100N$

B. $62N$

C. $32.6N$

D. $18.3N$

Answer: D

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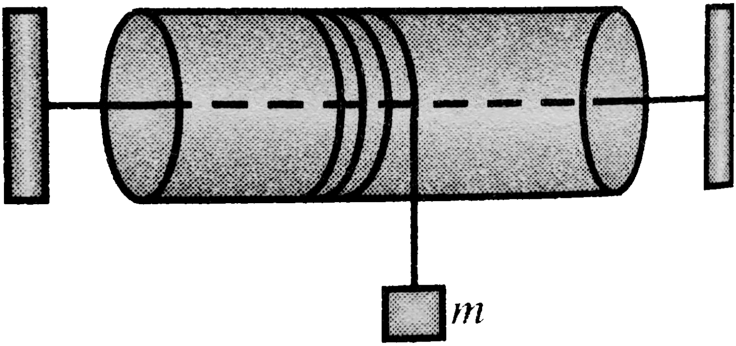
18. A cord is wound round the circumference of a solid cylinder radius R and mass M. The axis of the cylinder is horizontal. A weight mg is attached to the end of the cord and falls from rest. After falling through a distance h.



If the mass starts from rest and falls a distance h, then its speed at that instant is:

A. $\dfrac{2mg}{M+2m}$

B. $\sqrt{\dfrac{2gh}{R^2}}$

C. $\left(\dfrac{\sqrt{4mgh}}{(M+2m)R^2}\right)$

D. $\sqrt{\dfrac{4mgh}{M+2m}}$

Answer: C

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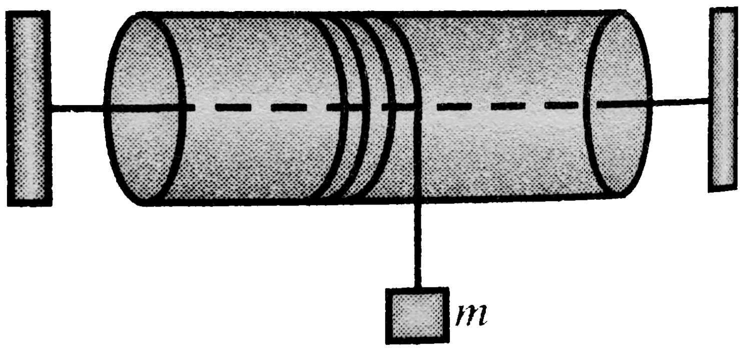
19. A cord is wound round the circumference of a solid cylinder radius R and mass M. The axis of the cylinder is horizontal. A weight mg is attached to the end of the cord and falls from rest. After falling through a distance h.



If the mass starts from rest and falls a distance h, then its speed at that instant is:

A. proportional to R

B. proportional to $\frac{1}{R}$

C. propotional to $\frac{1}{R^2}$

D. independent of R

Answer: D

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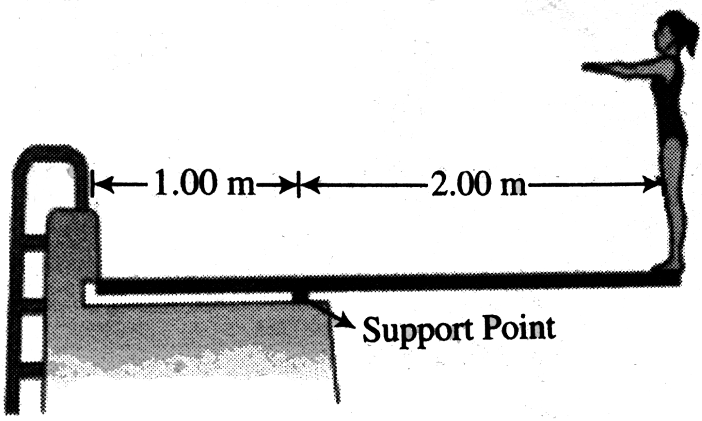
20. A diving board $3.00m$ long is supported at a point $1.00m$ from the end and a diver weighing $500N$ stands at the free end. The diving board is of uniform cross section and weighs $280N$. Find.



The force at the support point

A. $780N$

B. $220N$

C. $1920N$

D. $1140N$

Answer: C

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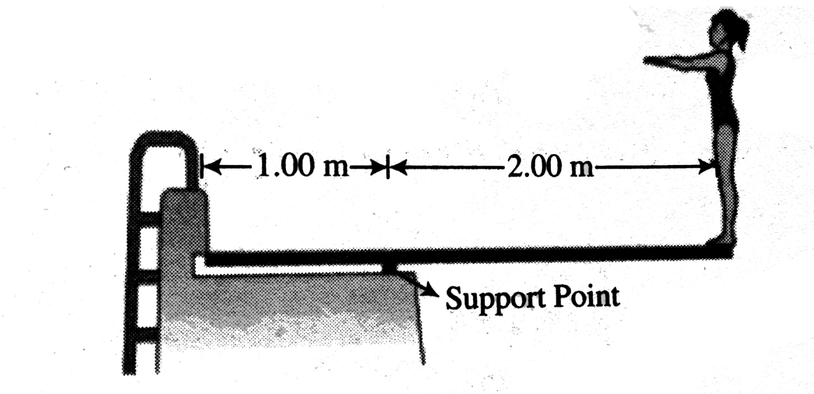
21. A diving board $3.00m$ long is supported at a point $1.00m$ from the end and a diver weighing $500N$ stands at the free end. The diving board is of uniform cross section and weighs $280N$. Find.



The force at the end that is held down.

A. $780N$

B. $220N$

C. $1920N$

D. $1140N$

Answer: D

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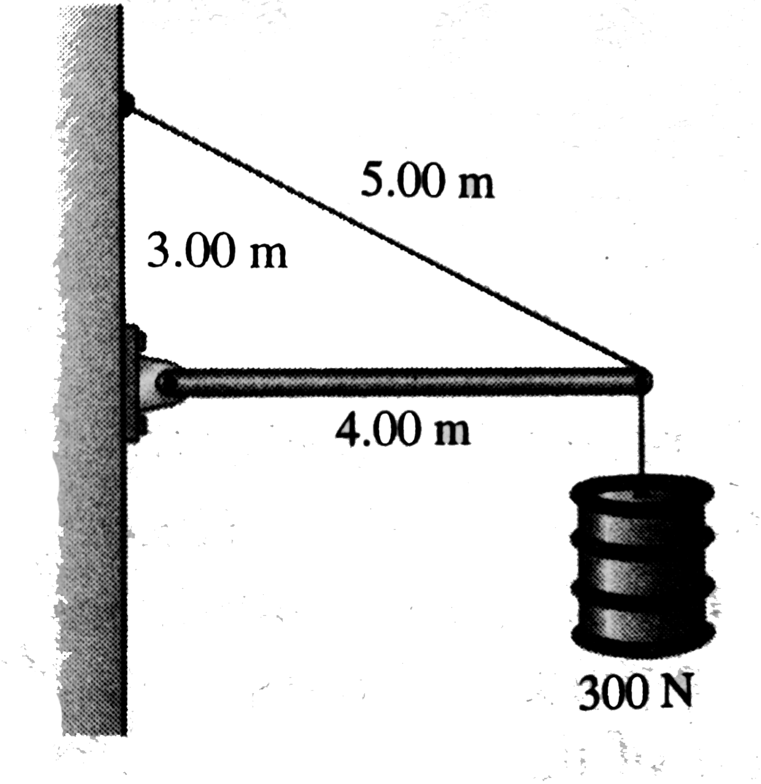
22. The horizontal beam in figure weighs $150N$, and its centre of gravity is at its centre. Find



The tension in the cable

A. $75N$

B. $500N$

C. $300N$

D. $625N$

Answer: B

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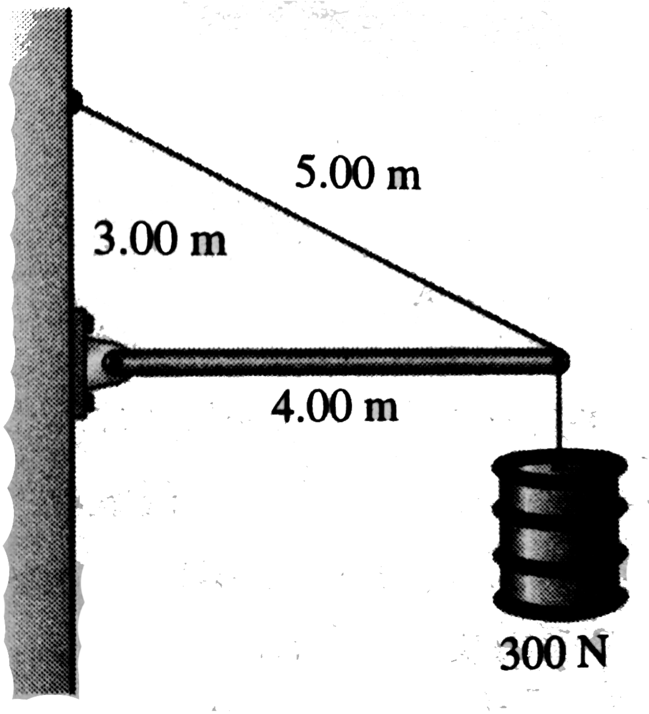
23. The horizontal beam in figure weighs $150N$, and its centre of gravity is at its centre. Find



The horizontal and vertical components of the force exerted on the beam at the wall,

A. Horizontal component is $500N$ towards left and vertical component $75N$ downwards

B. Horizontal component is $500N$ towards right and vertical component $75N$ upwards

C. Horizontal component is $625N$ towards left and vertical component $150N$ upwards

D. Horizontal component is $625N$ towards right and vertical component $150N$ downwards

Answer: A

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24. A uniform ladder $5.0m$ long rests against a frictionless, vertical wall with its lower end $3.0m$ to from the wall. The ladder weighs $160N$. The coefficient of static friction between the foot of the ladder and the ground is 0.40. A man weighing $740N$ climbs slowly up the ladder.

What is the actual frictional force when the man has climbed $1.0m$ along the ladder?

A. $360N$

B. $171N$

C. $900N$

D. $740N$

Answer: B

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25. A uniform ladder $5.0m$ long rests against a frictionless, vertical wall with its lower end $3.0m$ to from the wall. The ladder weighs $160N$. The coefficient of static friction between the foot of the ladder and the ground is 0.40. A man weighing $740N$ climbs slowly up the ladder. What is the actual frictional force when the man has climbed $1.0m$ along the ladder?

A. A. $360N$

B. B. $171N$

C. C. $900N$

D. D. $740N$

Answer: C

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26. A uniform ladder $5.0m$ long rests against a frictionless, vertical wall with its lower end $3.0m$ to from the wall. The ladder weighs $160N$. The coefficient of static friction between the foot of the ladder and the ground is 0.40. A man weighing $740N$ climbs slowly up the ladder. What is the actual frictional force when the man has climbed $1.0m$ along the ladder?

A. $3m$

B. $5m$

C. $2.7m$

D. $1.25m$

Answer: A

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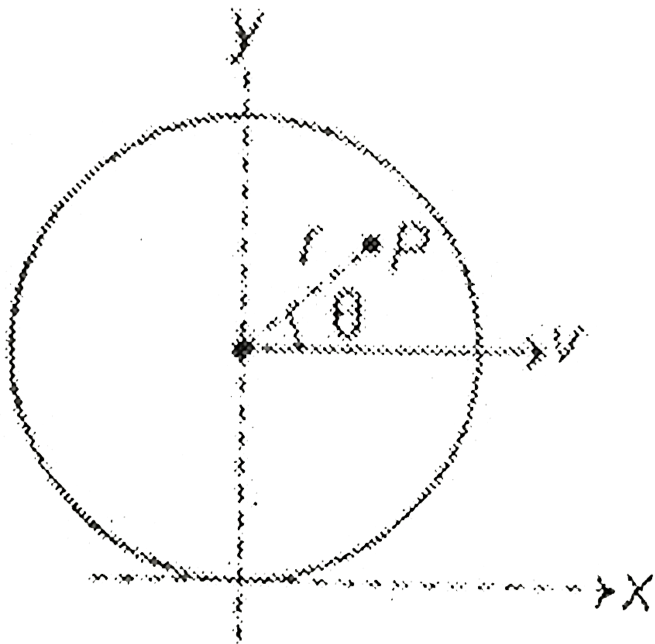
27. A disc of radius R rolls without slipping at spped v along positve x-axis.

Velocity of point P at the instant shown in figure is



A. $\dfrac{v\sqrt{x^2+y^2}}{R}$

B. $\dfrac{v\sqrt{x^2+(y+R)^2}}{R}$

C. $\dfrac{v\sqrt{v^2 + (y - R)^2}}{R}$

D. none of these

Answer: B

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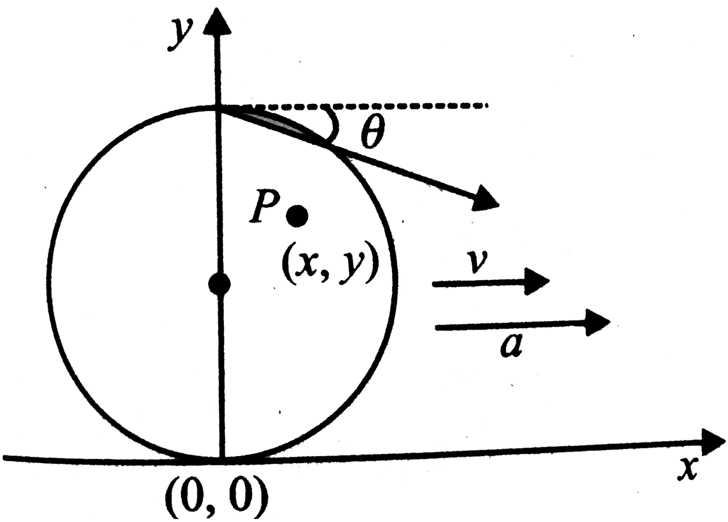
28. A disc having radius R is rolling without slipping on a horizontal ($x - z$) plane. Centre of the disc has a velocity v and acceleration a as shown.



If $v = \sqrt{2aR}$ the angle θ between acceleration of the top most point and the horizontal is

A. 0

B. 45°

C. $\tan^{-1} 2$

D. $\tan^{-1}\left(\frac{1}{2}\right)$

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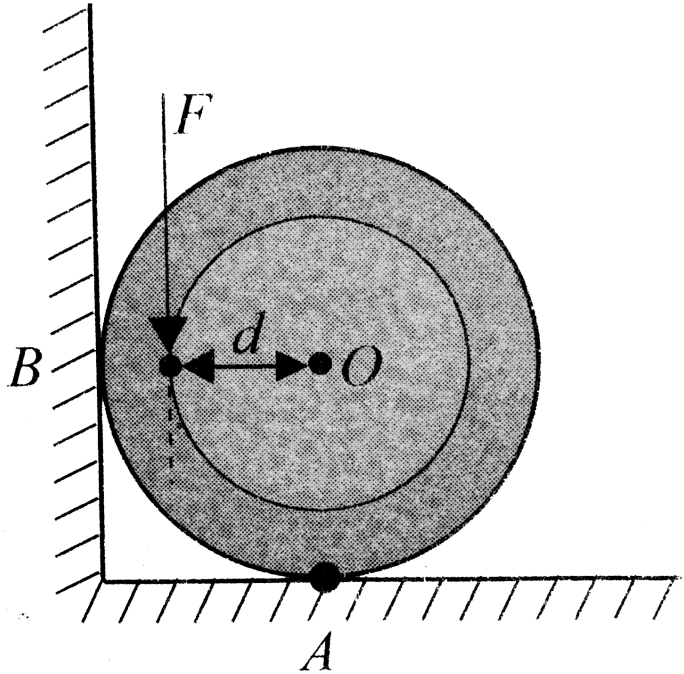
Integer

1. A solid cylinder with $r = 0.1m$ and mass $M = 2kg$ is placed such that it is in contact with the vertical and a horizontal surface as shown in Fig. The coefficient of friction is $\mu = (1/3)$ for both the surfaces. Find the distance (in CM) from the centre of the cylinder at .which a force $F = 40N$ should be applied vertically so that the cylinder just starts rotating in anticlockwise direction.



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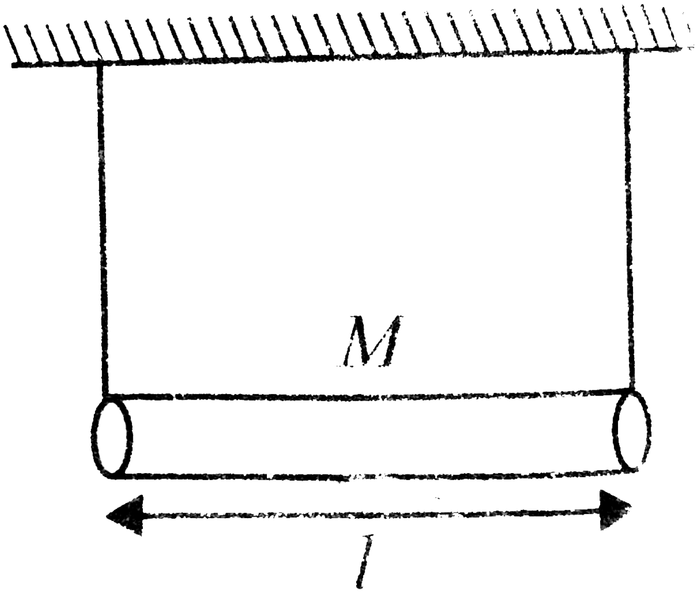
2. A uniform rod of length $1m$ and mass $2kg$ is suspended. Calculate tension T (in N) in the string at the instant when the right string snaps

$(g = 10m/s^2)$.



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3. In all the four situations depicted in Column-I, a ball of mass m is connected to a string. In each case, find the tension in the string and match the appropriate entries in Column-II.

$(A)(\#\#VMC_PHY_XI_WOR_BOK_{01}_C04_E03_{050}_Q01\#\#)$Conical pendul
$(B)(\#\#VMC_PHY_XI_WOR_BOK_{01}_C04_E03_{050}_Q02\#\#)$Pendulum is sw
$(C)(\#\#VMC_PHY_XI_WOR_BOK_{01}_C04_E03_{050}_Q03\#\#)$The car is movi
$(D)(\#\#VMC_PHY_XI_WOR_BOK_{01}_C04_E03_{050}_Q04\#\#)$The car is movi

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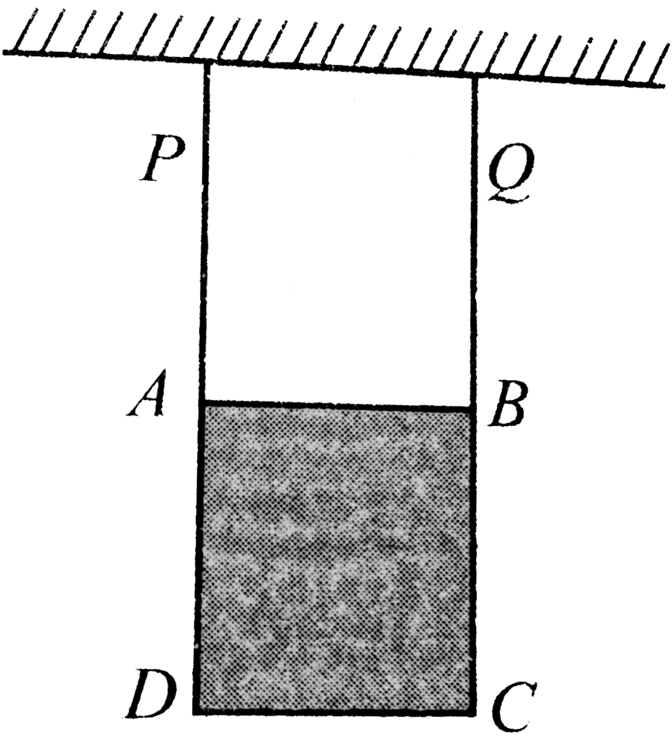
4. A square plate $ABCD$ of mass m and side l is suspended with the help of two ideal strings P and Q as shown. Determine the acceleration (in m/s^2) of corner A of the square just at the moment the string Q is cut. $(g = 10m/s^2)$.



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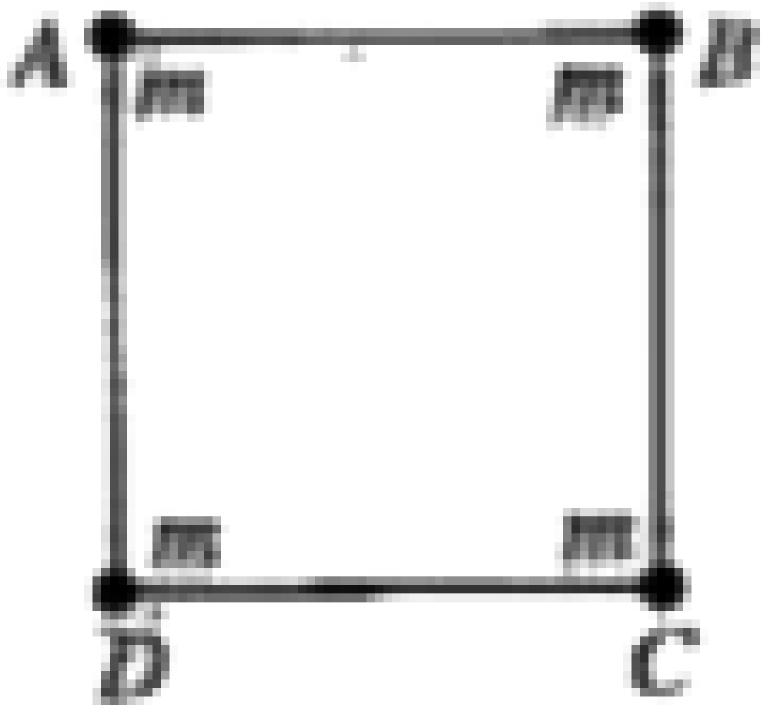
5. Four spheres A, B, C, D, each of mass m and diameter 2 a are placed with their centres at die four corners of a square of side b. What is the moment of inertia of the system about any side of the square ?



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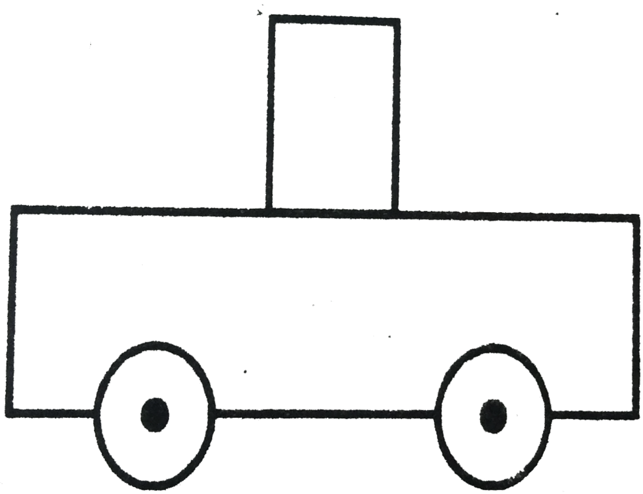
6. A uniform cylinder rests on a cart as shown. The coefficient of static friction between the cylinder and the cart is 0.5 If the cylinder is $4cm$ in diameter and $10cm$ in height, which of the following is the minimum acceleration of the cart needed to cause the cylinder to tip over ?



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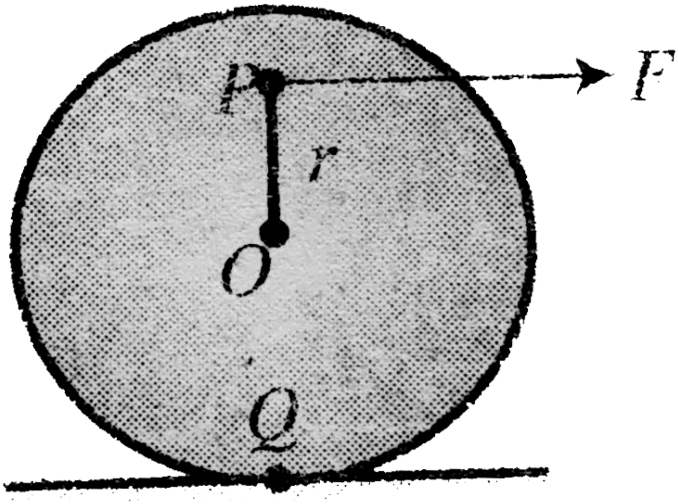
7. A uniform disc of mass m, radius R is placed on a smooth horizontal surface. If we apply a horizontal force F at P as shown in the figure. If $F = 4N, m = .1kg, R = 1m$ and $r = \frac{1}{2}m$ then, find the:



acceleration of the CM (in ms^2)

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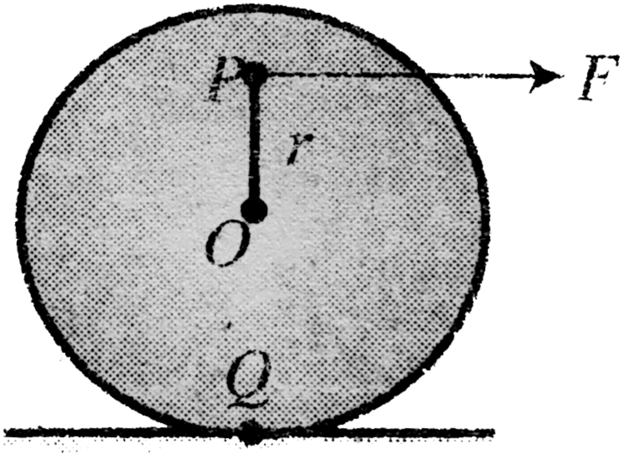
8. A uniform disc of mass m, radius R is placed on a smooth horizontal surface. If we apply a horizontal force F at P as shown in the figure. If $F = 4N, m = .1kg, R = 1m$ and $r = \frac{1}{2}m$ then, find the:



angular acceleration of the disc. $(rads^{-1})$

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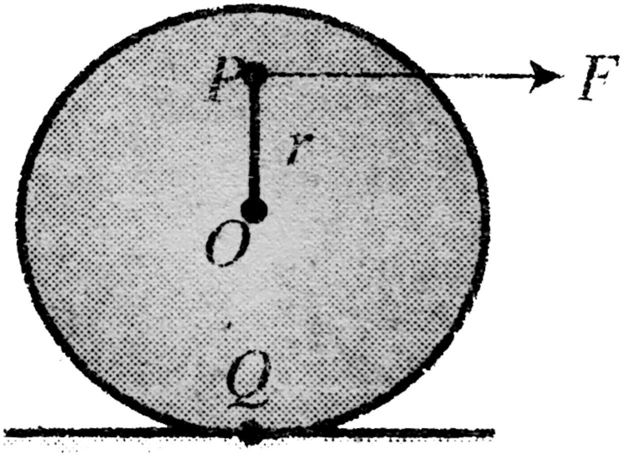
9. A uniform disc of mass m, radius R is placed on a smooth horizontal surface. If we apply a horizontal force F at P as shown in the figure. If $F = 4N$, $m = .1kg$, $R = 1m$ and $r = \frac{1}{2}m$ then, find the:



angular acceleration of the disc. $(rads^{-1})$

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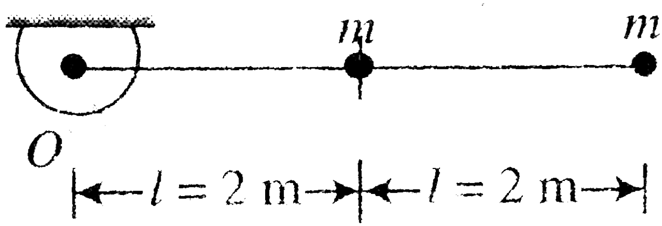
10. A light rigid rod of length $4m$ is connected rigidly with two identical particles each of mass $m = 2kg$. the free end of the rod is smoothly pivoted at O. The rod is released from rest from its horizontal position at $t = 0$. Find the



angular acceleration of the rod at $t = 0$ (in $rads^{-2}$).

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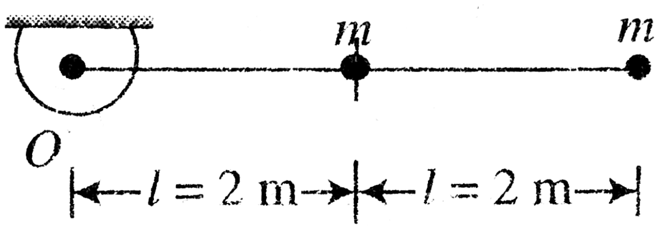
11. A light rigid rod of length $4m$ is connected rigidly with two identical particles each of mass $m = 2kg$. the free end of the rod is smoothly pivoted at O. The rod is released from rest from its horizontal position at $t = 0$. Find the



reaction offered by the pivot at $t = 0$ (in N).

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