PHYSICS

BOOKS - PRADEEP PHYSICS (HINGLISH)

SYSTEMS OF PARTICLES AND ROTATIONAL MOTION

Sample problem

1. In a carbon monoxide molecule, the carbon and the oxygen atoms are separated by a distance $1.2 \times 10^{-10} m$. The distance of the centre of mass from the carbon atom is

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

B. $\frac{7}{4}$d

C. $\frac{8}{7}$d

D. $\frac{7}{8}$d

Answer: A

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2. Three particles of masses $0.2kg, 0.3kg$ and $0.4kg$ are situated at the vertices A, B and C of a right angled traingle ABC with $\angle A = 90^\circ, AB = 2cm$ along X-axis and $BC = 2.5cm$. Find the distance of centre of mass from A.

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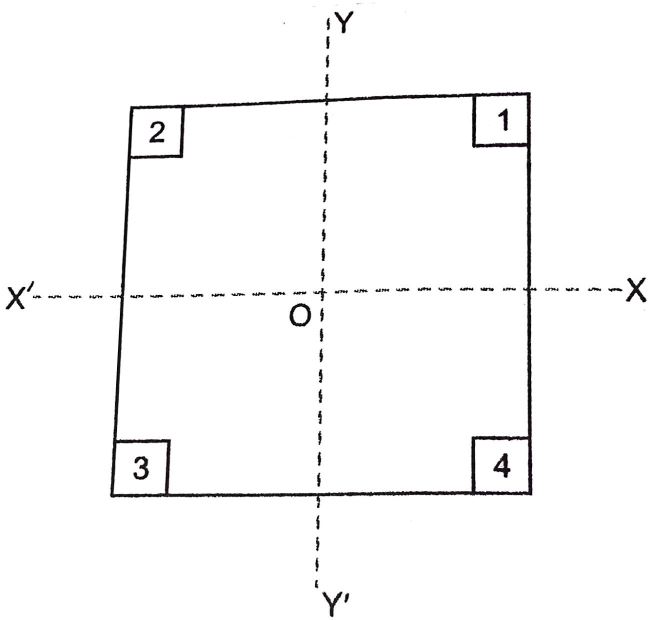
3. Fig. shown a uniform square plate from identical squares at the corners can be removed. (a) Where is the centre of mass of the plate originally ? (b) Where is it after square 1 is removed ?

(c) where is it after squares 1 and 2 are removed ? (d) Where is $c.m$ after squares $1, 2, 3,$ are removed ?

(f) Where is $c.m$ after all the four squares are removed ? Answer in terms of quadrants and axes.



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4. The speed of a motor increase from 600 rpm to 1200 rpm in 20 seconds. What is its angular acceleration, and how many revolutions does it make during this time ?

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5. Find the torque of a force $\left(5\hat{i}-2\hat{j}+7\hat{k}\right)$ about the origin, which acts on a particle whose position vector is $\left(2\hat{i}-\hat{j}+\hat{k}\right)$.

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6. To mainntain a rotor at a uniform angular speed of $200s^{-1}$, an engine needs to transmit a torque of $180N - m$. What is the power of the engine required ?

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7. An electron of mass $9 \times 10^{-31} kg$ revolues in a circle of radius $0.53A$ around the nucles of hydrogen with a velocity of $2.2 \times 10^{6} ms^{-1}$.

Show that angular momentum of electron is $h/2\pi$, where h is plack's constant.

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8. The motor of an engine is erotating about its axis with an angular velocity of 100 rev/minute. It comes to rest in 15 s, after being switched off. Assumgn cnstant angular decelertion, calculate the number of revolutions made by it before coming to rest.

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9. A wheel of mass $10kg$ and radius of gyration $25cm$ is rotating at 600 rpm. What is its moment of inerta ?

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10. A body of moment of inertia $0.5kgm^2$ is rotating about a given axis at the rate $1rps$. What is kinetic energy of rotation of the body about that axis ?

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11. Calculate the angular acceleration produced in a grind stone of moment of inertia $3kgm^2$ under the action of a torque of $3\pi N - m$.

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12. Calculate angular momentum of earth rotating about its axis. Take $I = \frac{2}{5}MR^2$, where $M = 6 \times 10^{24} kg$ and $R = 6400 Km$.

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13. A wheel of moment of inertia $0.500 kg - m^2$ and radius 20.0 cm is rotating about its axis at an angular speed of 20.0 rad/s. It picks up a stationary particle of mass 200 g at its edge. Find the new angular speed of the wheel.

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14. Calculate moment of inertia of a uniform circular ring of mass $1.5kg$ and diameter $50cm$ about a diameter of the ring.

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15. Calculate moment of inertia of a uniform circular disc of mass $10kg$ and diameter $0.5m$ about a tangent perpendicular to the plane of the disc.

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16. Show that the radii of gyration of a circular ring and circular disc of the same radius about an axis passing through their centres and perpendicular to their plane are in the ratio $\sqrt{2} : 1$.

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17. A thin hollow cylinder, open at both ends and weighing $5kg$ (a) slides with a speed of $10m/s$ without rotating (b) rolls with the same speed without slipping. Compare the kinetic energies of the cylinder in the two cases.

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18. A cylinder of mass $10kg$ is rolling perfectly on a plane of inclination 30°. Find the force of friction between the cylinder and the surface of inclined plane.

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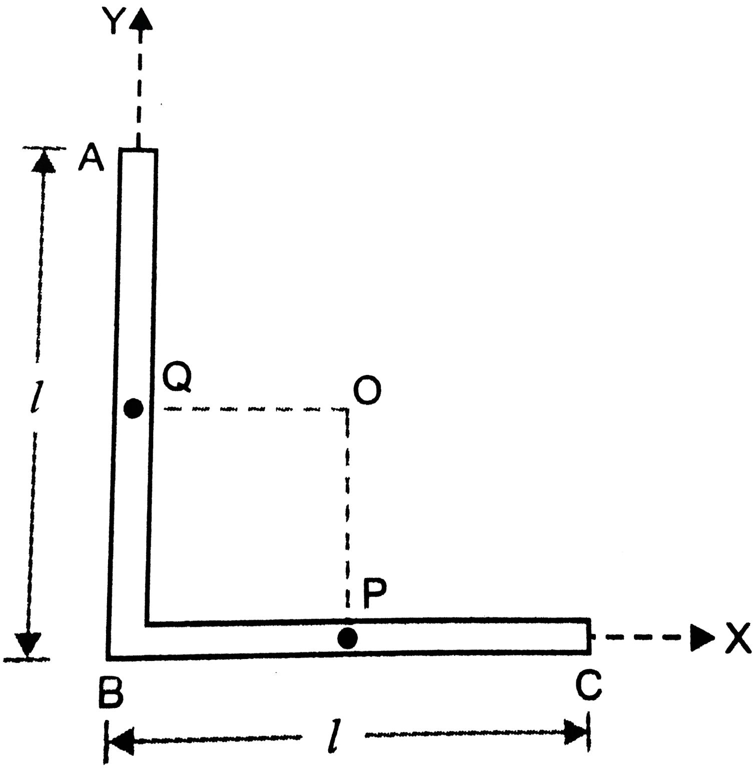
SOLVED EXAMPLES TYPE A

1. Two identical uniform rods of length l are joined to from L shaped frame, as shown is Fig. Locate the centre of mass of the frame.



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2. Calculate the KE of rotation of a circular disc of mass $1kg$ and radius $0.2m$ rotating about an axis passing through its centre and perpendicular to its plane. The disc is making $30/\pi$ rotations per minute.

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SOLVED EXAMPLES

1. Find the centre of mass of a uniform triangula lamina.

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2. Find the centre of mass of three particle at the vertices of an equilateral triangle. The masses of the particle are $100g, 150g, \text{ and } 200g$ respectively. Each side of the equilateral triangle is $0.5m$ along.

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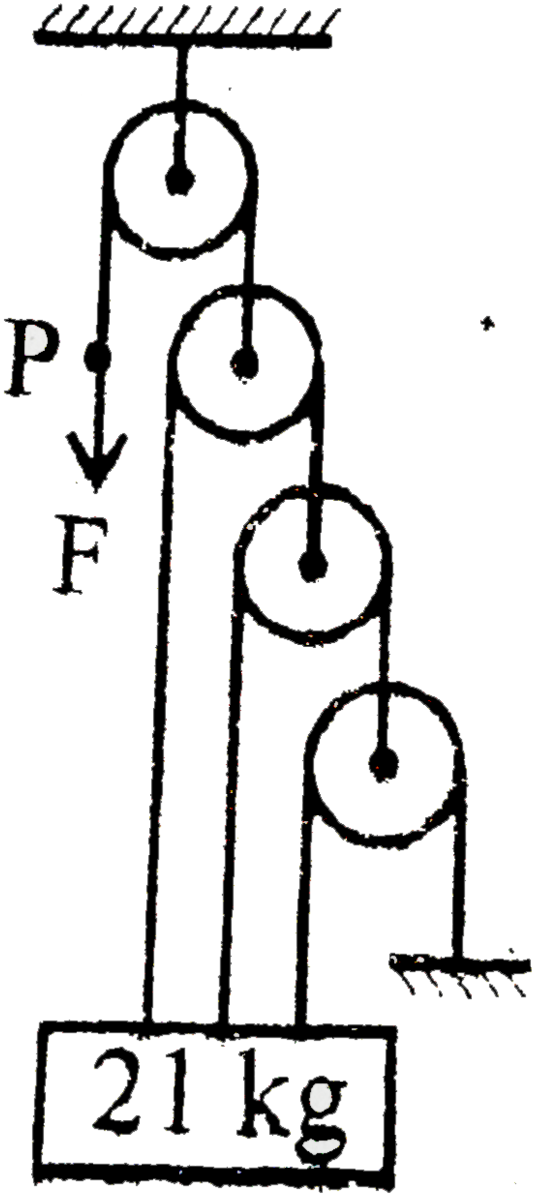
3. Find the centre of mass of a uniform L shaped lamina (a thin flat plate) with dimension as shown in Fig. The mass of the lamina is $3kg$.



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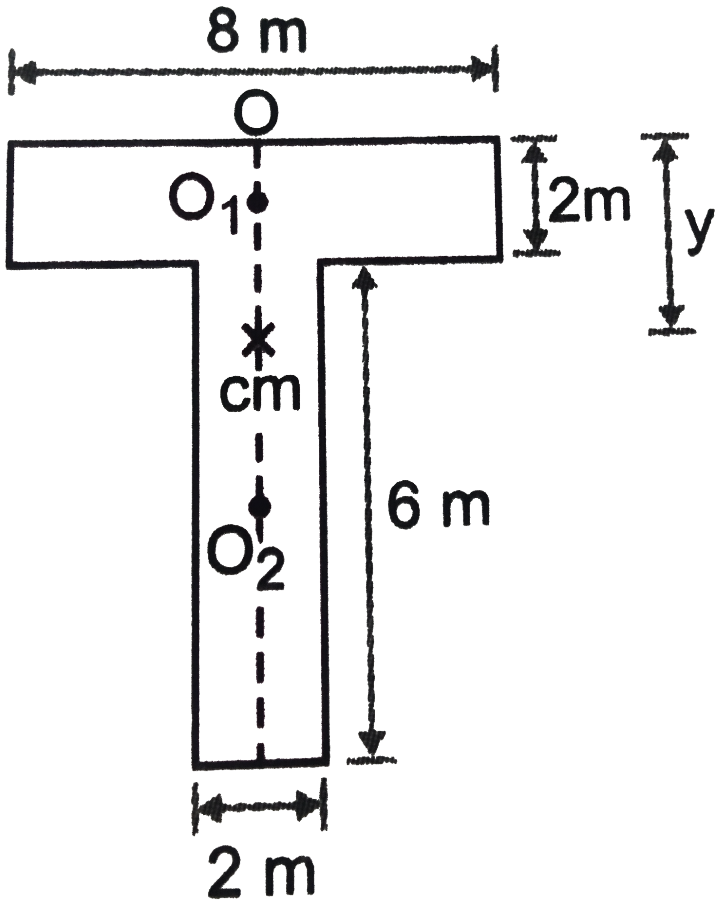
4. Find the position of centre of mass of the T-shaped plate from O, in Fig.



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5. From a uniform circular disc of radius R, a circular disc of radius $R/6$ and having centre at a distance $R/2$ from the centre of the disc is removed. Determine the centre of mass of remaining portion of the disc.

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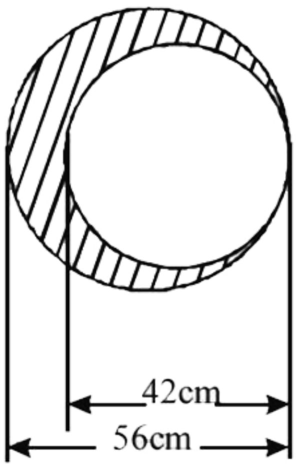
6. A circular plate of uniform thickness has a diameter fo 56cm. A circular portion of diameter 42 cm is removed from one edge of the plate as shown in figure. Find the position of the centre of mass of the remaining portion.



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7. Determine the coordinates of the centre of mass of a right circular soild cone of base radius R and height h.

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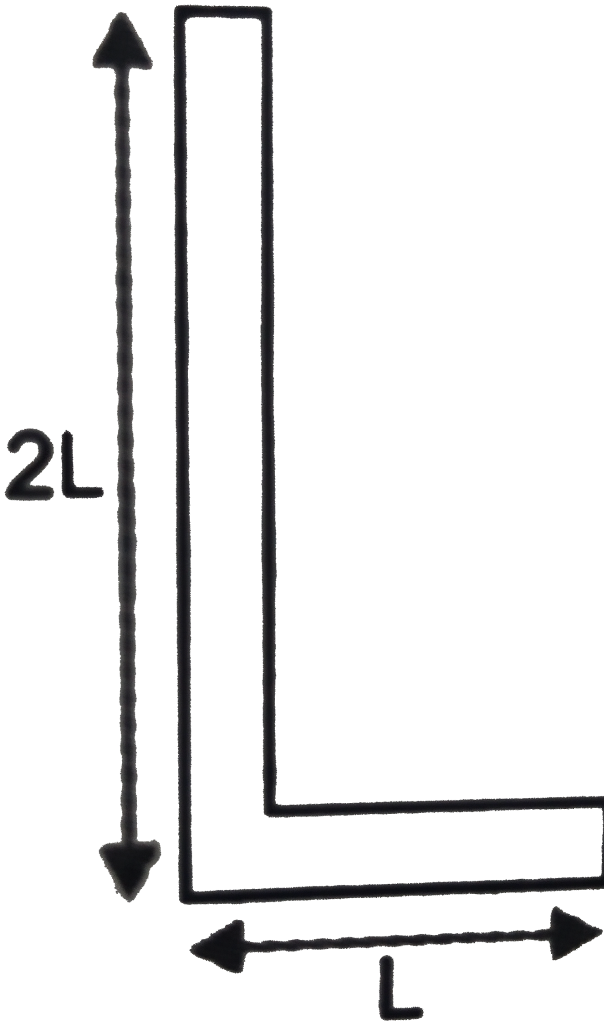
8. A uniform thin rod of length $3L$ is bent at right angles at a distance L from one end as shown in Fig. If length of rod is $1.8m$, find the co-ordinates and position vector of the mass of the system.



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9. A man of mass m_1 is standing on a platform of mass m_2 kept on a smooth horizontal surface. If the man moves a distance d w.r.t., the platform, find the displacement of the platform w.r.t., ground.

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10. A torque of $10^3 N - m$ acting on a rigid body, turns it throughr 30° in 0.2 second. Calculate work done by the body and power of torque.

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11. A constant torque is acting on a wheel. If starting from rest, the wheel makes n rotations in t seconds, show that the angular acceleration is given by $\alpha = \frac{4\pi n}{t^2} rads^{-2}$.

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12. A torque of $20N-m$ is applied on a wheel initially at rest. Calculate the angular

momentum of the wheel after 3 sec.

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13. Show that angular momentum of a satellite of mass M_s revolving around earth of mass M_e in an orbit of radius r is $\sqrt{GM_s^2M_er}$.

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14. Calculate angular momentum to Neptune about the sun. Given, mass of neptune

$= 10^{12} m$ and period of revolution around the sun $= 5 \times 10^{9} s$.

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15. At any instant, $\overrightarrow{F} = \left(4.0\hat{j}\right)N$ acts on a $0.25kg$ object that has position vector $\overrightarrow{r} = \left(2.0\hat{i} - 2.0\hat{k}\right)m$ and velocity $\overrightarrow{v} = \left(-5.0\hat{i} + 5.0\hat{k}\right)m/s$. About the origin, what are angular momentum and torque acting on the object ?

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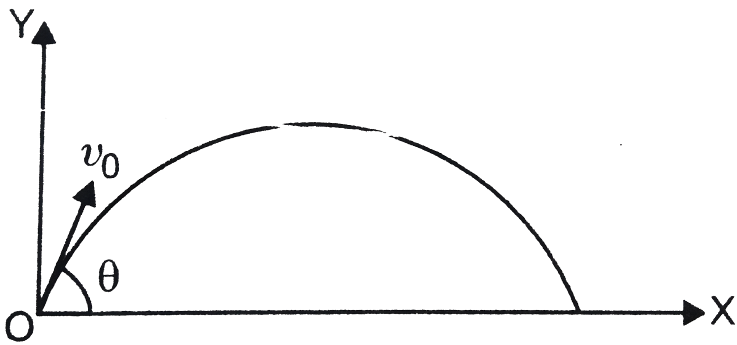
16. A small particle of mass m is projected at an angle θ with x-axis with initial velocity v_0 in x-y plane as shown in Fig. Calculate the momentum of the particle

at $t < \dfrac{v_0 \sin\theta}{g}$.



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17. A car of mass $2500kg$ is moving in a circular track of diameter $100m$ with a speed of $72km/h$. What is the angular momentum of the car ?

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18. The radius of a wheel of car is $0.4m$. The car is accelerated from rest by an angular acceleration of $1.5rad/s^2$ for $20s$. How much distance will the wheel cover in this time and what will be its linear velaocity ?

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19. A flywheel rotating at a speed of 600 rpm about its axis is brough to rest by applying a constant torque for 10 seconds. Find the angular deceleration and angular velocity 5 second after the application of the torque.

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20. Obtain the equation $\omega = \omega_0 \alpha t$ from first principles.

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21. A flywheel of mass 1 metric ton and radius $1m$ is rotating at the rate of 420 rpm. Find the constant retarding torque required to stop the wheel in 14 rotations, assuming mass to be concentrated at the rim of the wheel.

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22. A dics rotates about the central axis starting from rest and accelerates with constant angular accelertion. At one time, it is rotating at $10rps$, 60 revoluting later, its angular speed is $15rps$. Calculate (i) angular acceleration (ii) time required to complate 60 revols (iii) the time required to reach $10rev/\sec$ angular speed and (iv) number of revoluting from rest until the time the disc reaches $10rps$ angular speed.

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23. A disc of radius $0.5m$ is rotating about an axis passing through its centre and perpendicular to its plane. A tangential force of $2000N$ is applied to bring the disc to rest $2s$. Calculate its abgular momentum.

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24. A moton car is travelling at $30m/s$ on a circular road of radius $500m$. It is increasing in speed at the rate of $2ms^{-2}$. What is its acceleration ?

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25. An energy of $484J$ is spent in increasing the speed of a flywheel from 60 rpm to 360 rpm. Calculate moment of inertia of flywheel.

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26. A soild sphere is rolling on a frictionless plane surface about the axis of symmetry. Find the rotational energy of the sphere. Also, find the ratio of rotational $K.E.$ to total energy.

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27. The moment of inertia of a body about a given axis is $1.2kgm^2$. Initially, the body is at rest. In order to produce a rotational KE of

$1500j$, for how much duration, an acceleration of $25rads^{-2}$ must be applied about that axis ?

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28. A thin hollow cylinder open at both ends and weight $5kg$ (i) slides with a speed of $5m/s$ without rotating and (ii) rolls with the same speed without slipping. Compare the KE of the cylinder in the two cases.

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29. A spherical ball of radius r and mass m is rolling without slipping on a horizontal table. Calculate the percentage of KE, which is translational.

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30. A disc of radius $0.5m$ is rotating about an axis passing through its centre and perpendicular to its plane. A tangential force of $2000N$ is applied to bring the dics to rest $2s$. Calculate its abgular momentum.

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31. A flywheel of mass $25kg$ has a radius of $0.2m$. It is making 240 rpm. What is the torque necessary to bring it to rest in $20s$? If the torque is due to a force applies tangentially on the rim of the wheel, what is the magnitude of the force ? Assume that mass of flywheel is concentrated at its rim.

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32. Show that the angular momentum about any point of a single particle moving with constant velocity remains constant throughout the motion.

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33. Show that moment of a couples does not depend on the point about which you take the moments.

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34. A metal bar $70cm$ long and $4.00kg$ in mass is supported on two knife edges placed $10cm$ from each end. A $6.00kg$ weight is suspended at $30cm$ from one end. Find the reactions at the knife edges. Assume the bar to be of uniform cross-section and homogeneous.

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35. A car moves on a road with a speed of $54kmh^{-1}$. The radius of its wheels is $0.35m$. What is the average negative torque transmitted by its brakes to the wheels if the car is brought to rest in $15s$? Moment of inertia of the wheels about the axis of rotation is $3kgm^2$.

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36. A grindstone has moment of inertia of $6kgm^2$. A constant torque is applied and the grindstone is found to have a speed of 150 rpm, 10 second after satrting from rest. Calculate the torque.

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37. A body whose moment of intertia is $3kgm^2$ is at rest. It is rotated for $20s$ with a moment of force $6N - m$. Find angular displacement of the body. What is work done ?

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38. A wheel, initially at rest, rotates for $2s$ under angular acceleration of $3rads^{-2}$. Find

(i) angular velocity acquired in $2s$.

(ii) angular displacement in $2s$.

(ii) torque acting on the wheel if its moment of inertia is $12kgm^2$.

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39. A cylinder of mass $5kg$ and radius $30cm$ and free to rotate about its axis receives an angular impulse of $3kgm^2s^{-1}$ initially, followed by a similar impulse after every 4 second. What is the angular speed of the cylinder $30s$ after the initial impulse ? The cylinder is at rest initially.

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40. To speed up a flywheel from 60rpm to 120 rpm, energy equal to $9000J$ is requires. Calculate the moment of inertia of flywheel. Also calculate change in angular momentum of flywheel.

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41. What will be the duration of the day, if the earth suddenly shrinks to $1/64th$ of its original volume, mass remaining unchenged ?

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42. The maximum and minimum distances of a comet from the sun $1.4 \times 10^{12} m$ and $7 \times 10^{10} m$. If its velocity nearest of the sun is $6 \times 10^{4} ms^{-1}$. What is its velocity at the farthest position ? Assume that path of commet in both the instantaneous position is circular.

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43. A horizontal disc ratating about a vertical axis passing through its centre makes 180 rpm. A small piece of wax of mass $10g$ falls vertically on the disc and stricks to it at a distance reduced to $150r \pm$, calculate moment of inertia of the disc.

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44. A ball tied to a string takes $4s$ to complete one revoluting along a horizontal circule. If by pulling the cord, the radius of the circle is reduced to half, how much time will the ball take to complete one revolution ?

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45. A preson is standing on the centre of a rotating table with his arms outstretched. The table is rotating freely with an angular his hands towards his chest. The moment of inertia reduces to $\frac{3}{5}$ time the original moment of inertia. Calculate angular speed of the man when he withdraws his hands.

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46. If the earth suddenly contracts to one third of its present size, calculate by how much would the day be shortened ?

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47. A disc of moment of inertia I_1 is rotating freely with angular speed ω_1 when another non-rotating disc of moment of inertia I_2 is dropped on it. The two discs then rotate as one unit. Find the final angular speed.

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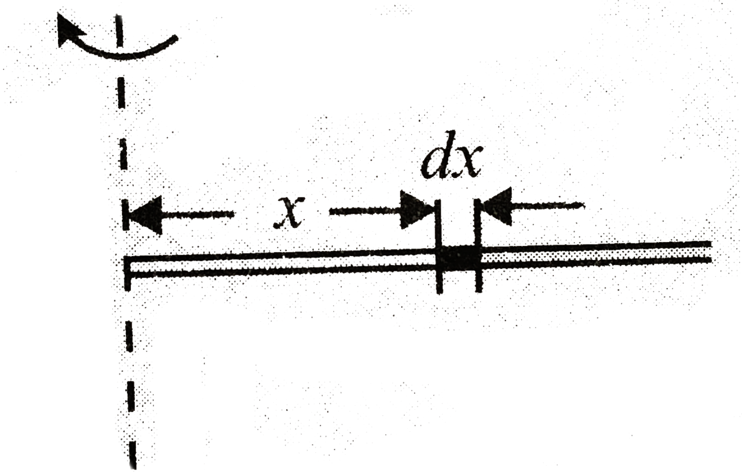
48. Calculate the moment of inertia of a uniform rod of mass M and length l about an axis passing through an end and perpendicular to the rod. The rod can be divided into a number of mass elements along the length of the rod.



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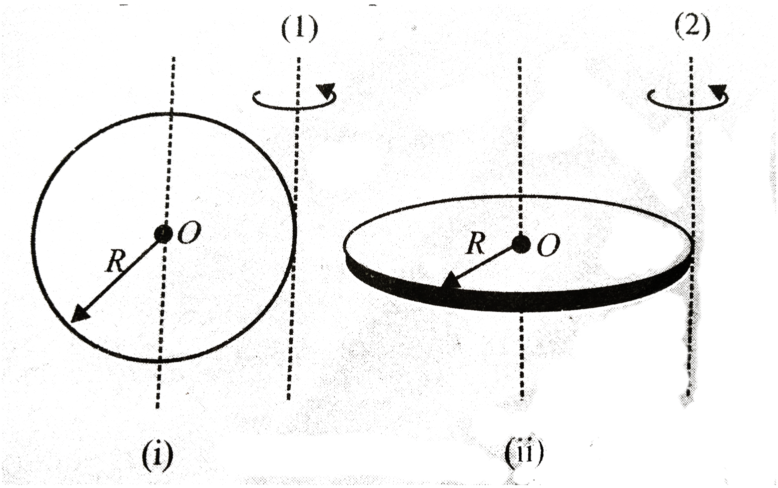
49. Find the out the moment of inertia of a ring having uniform mass distribution of mass M and radius R about an axis which is tangent ot the ring and (a) in the plane of the ring (b). perpendicular to the plane of the ring.



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50. Four spheres, each of diameter $2a$ and $mass M$ are placed with their centres on the four corners of a square of side b. Calculate one side of the square taken as the axis.

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51. Find the moment of inertia of a rectangular bar magent about an axis passing through its centre and parallel to its thickness. Mass of magent is $100g$, its length is $12cm$, breadth is $3cm$ and thickness is $2cm$.

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52. Calculate the moment of inertia of a cylinder of length $1.5m$, radius $0.05m$ and density $8 \times 10^3 kg/m^3$ about the axis of the cylinder.

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53. Three balls of masses $1kg, 2kg$ and $3kg$ are arranged at the corners of an equilateral triangle of side $1m$. What will be the moment of inertia of the system and perpendicular to the plane of the triangle.

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54. A circular ring of radius $10cm$ is made of a wire of mass $0.02g/cm$. Calculate its radius of gyration and moment of inertia about an axis passing perpendicular to its plane through the centre of the ring.

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55. A soild cylinder rolls down an inclined plane. Its mass is $2kg$ and $radius0.1m$. It the height of the inclined plane is $4m$, what is its rotational $K.E.$ when it reaches foot of the plane ? Assume that the surfaces are smooth. Take $M.I.$ of soild cylinder about its axis = $mr^2/2$.

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56. A $70kg$ man stands in contact against the inner wall of a hollow cylindrical drum of radius $3m$ rotating about its verticle axis. The coefficient of friction between the wall and his clothing is 0.15 . What is the minimum rotational speed of the cylinder to enable the man to remain stuck to the wall (without falling) when the floor is suddenly removed?

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57. A $3m$ along ladder weighing $20kg$ leans on a frictionless wall. Its feet rest on the floor $1m$ from the wall. Find the rection forces of the wall and the floor.

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58. The angular speed of a moton wheel is increased from 1200 rpm to 3120 rpm in 16 seconds. (i) What is the angular acceleration, assuming the acceleration to be uniform ? (ii)

How many revolutions does the engine make during this time ?

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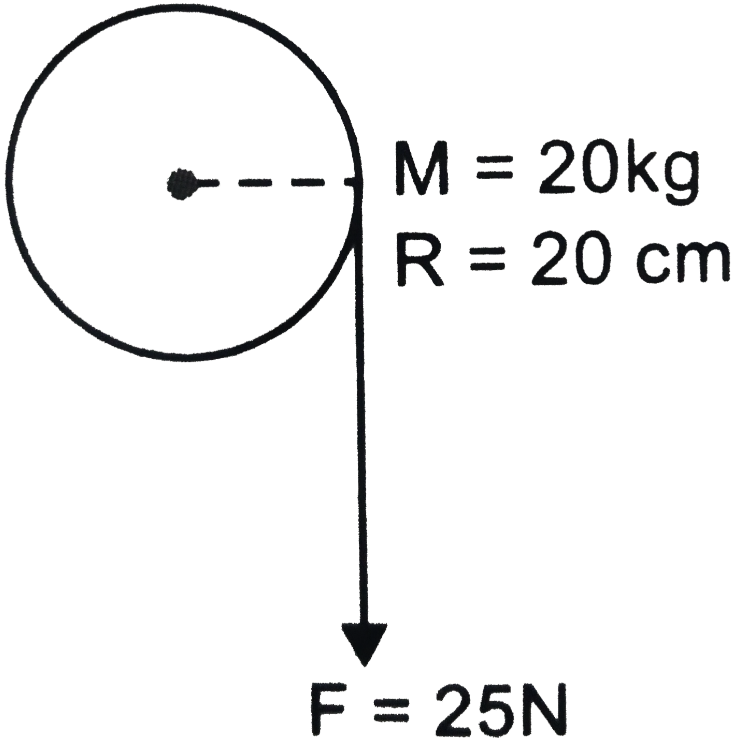
59. A cord of negligible mass is wound round the rim of a flywheel of mass $20kg$ and radius $20cm$. A steady pull of $25N$ is applied on the cord as shown in Fig. The flywheel is mounted on a horizontal axle with frictionless bearings.



(a) Compute the angular acceleration of the wheel.

(b) Find the work done by the pull, when $2m$ of the cord is unwound.

(c) Find also the kinetic energy of the wheel at this point. Assume that the wheel stars from rest.

(d) Compare answers to parts (b)and (c).

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60. Three bodies, a ring, a soild cylinder and a soild sphere roll down the same inclined plane without slipping. They start from rest. The radii of the bodies are identical. Which of the bodies reaches the ground with maximum velocity ?

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61. A body of mass $5kg$ is attached to a weightless string wound round a cylinder of mass $8kg$ and radius $0.3m$. The body is allowed to fall. Calculate (i) tension in the string, (ii) acceleration with which the body falls and (iii) angular acceleration of the cylinder.

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

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SOLVED EXAMPLES TYPE B

1. Find the torque of a force $\left(5\hat{i}-2\hat{j}+3\hat{k}\right)$ about the origin, which acts on a particle whose position vector is $\left(\hat{i}-\hat{j}+\hat{k}\right)$.

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2. What constant torque should be appiled to a disc of mass $10kg$ and diameter $50cm$ so that it acquires an angular velocity of 2π rad/s in $4s$? The disc is initially at rest and rotates about an axis through the centre of the disc and in a plane perpendicular to the disc.

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SOLVED EXAMPLES TYPE C

1. On application of a constant torque, a wheel is turned from rest through an angle of 200 radius in $8s$. What is its angular acceleration ? If the same torque continues to act, what will be the angular velocity of the wheel $16s$ from the start ?

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2. A star of mass equal to two solar masses and radius $10^6 km$ rotates about its axis with an angular speed of $10^{-6} rads^{-1}$. What is the angular speed of the star, when it collapses (due to inward gravitational forces) to a radius of $10^4 km$?

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SOLVED EXAMPLES TYPE D

1. The motor of an engine is rotating about its axis with an angular velocity of 100rpm. It comes to rest in $15s$, after being switched off. If angular deceleration is constant, what is the number to revolutions made by it before coming to rest ?

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2. What is the moment of intertia of a circular disc about one of its diameters ?

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CONCEPTUAL PROBLEMS I.

1. Is centre of mass of reality ?

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2. Why is moment of inertia called rotational inertia ?

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CONCEPTUAL PROBLEMS

1. What is the advantage of concept of centre of mass ?

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2. Prove that the centre of mass of two particle divides the line joining the particles in the inverse ratio of their masses.

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3. In a stationary railway compartment, there are several passengers. If they start moving in the compartment, will CM of the compartment change ? Will the CM of the system of compartment and passengers change ?

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4. A body A of mass M while falling wertically downwards under gravity brakes into two parts, a body B of mass $\frac{1}{3}$ M and a body C of mass $\frac{2}{3}$ M. The center of mass of bodies B and C taken together shifts compared to that of body A towards

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5. Can centre of mass of a body coincide with the geometrical centre of the body ?

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6. An insulated particle of mass m is moving in a horizontal plane (x - y) along X-axis. At a certain height above the ground, it suddenly explodes into two fragments of masses $m/4$ and $3m/4$. An instant later, the smaller fragment is at $Y = +15$. The larger fragment

at this instant is at :

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7. Which physical quantities are expressed by the following :

(i) rate of change of angular momentum

(ii) moment of linear momentum ?

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8. Torque and work are both equal to force time distance. How do they differ ?

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9. If a body is rotating, is it necessarily being acted upon by an external torque ?

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10. Why is the handle of a screw made wide ?

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11. A particle is moving along a stright line parallel to x-axis with constant velocity. Does its angular momentum about the origin decrease with time or increase with time or remain constant ?

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12. A particle performing uniform circular motion has angular frequency is doubled & its kinetic energy halved, then the new angular momentum is

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13. Does the moment of inertia of abody change with the speed of rotation ?

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14. What is the advantage of a flywheel ?

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15. Why spokes are provided in a bicycle wheel

?

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16. The moment of inertia of a soild sphere about a tangent is $\frac{5}{3}mr^2$. What would be its moment of inertia about its diameter.

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17. Find radius of gyration of a rod of length l and mass m about an axis perpendicular its length through one end.

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18. For a given mass and size, moment of inertia of a soild disc is smaller than that of a

ring. Why ?

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19. In a fly wheel, most of the mass is concentrated at the rim ? Explain why.

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20. Two satellites of equal masses, which can be considered as particles are orbiting the earth at different heights. Will their moment of inertia be same or different ?

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21. How will you distinguish between a hard boiled egg and a raw egg by spinning each on a table top ?

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22. If earth were to shrink suddenly, what would happen to the length of the day ?

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23. If two circular disks of the weight and thickness are made from metals having different densities. Which disk, if either will have the larger moment of inertia about its central axis.

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24. The moments of inertia of two rotating bodies A and B are I_A and I_B. $(I_A > I_B)$ and their angular momenta are equal. Which one has greater $K.E.$?

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25. If polar ice caps melt, then the time duration of one day

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26. If no external torque acts on a body, will its angular velocity remain conserved ?

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27. How does an ice-skater, a ballet dancer or an acrobat take advantage of the principle of conservation of angular momentum ?

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28. Explain why the speed of a whirl wind in a tornado is alarmingly high ?

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29. Explain how is a cat able to land on its feet after a fall taking advantage of the principle of conservation of angular momentum ?

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30. If angular momentum is conserved in a system whose moment of inertia is decreased, will its rotational kinetic energy be also conserved ? Explain.

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31. When there is no external torque acting on a rotating body, which of the following quantities can change ? (i) Angular acceleration (ii) Angular momentum (iii) Angular speed.

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32. Equal torques are applied on a cylinder and a hollow sphere. Both have same mass and radius. The cylinder rotates about its axis and the sphere rotates about one of its diameters. Which will acquire greater speed ? Explain.

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33. A soild sphere is made to roll down from the same height on two inclined planes having different angles of inclination. In which case will it take less time to reach the bottom ?

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34. A thin wheel can stay upright on its rim for a considerable length of time when rolled with a considerable velocity, while it falls from its upright position at the slightest disturbance, when stationary. Explain.

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35. Two identical cylinders 'runa race' starting from rest at the top of an inclined plane, one slides without rolling and other rolls without slipping. Assuming that no mechanical energy is dissipated in heat, which one will win ?

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36. A one kg rolling on a smooth horizontal surface at $20ms^{-1}$ comes to the bottom of an inclined plane making an angle of 30° with the horizontal. Calculate $K.E.$ of the ball when it is at the bottom of incline. How far up the incline will the ball roll ? Neglect friction.

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37. A very small particle rests on the top of a hemisphere of radius $20cm$. Calculate the smallest horizontal velocity to be given to it if it is to leave the hemisphere without sliding down its surface, take $g = 9.8 m / s^2$.

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38. The angular velocity of earth around the sun increases when it comes closer to the sun. Why ?

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

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CONCEPTUAL PROBLEMS II.

1. Can the couple acting on a rigid body produce translatory motion ?

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2. A planet revolves round a massive star in a highly elliptical orbit. Is its angular momentum constant over the entire orbit ?

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VERY SHORT ANSWER QUESTIONS I.

1. What is the position vector of centre of mass of two particles of equal masses ?

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2. Is moment of inertia a scalar or a vector ?

Watch Video Solution

VERY SHORT ANSWER QUESTIONS

1. If one of the particles is heavier than mass other, to which side will their centre of mass shift?

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2. Does centre of mass of a system of two particles lie on the line joining the particles ?

Watch Video Solution

3. Can centre of mass of a body lie where there is absolutely no mass ?

Watch Video Solution

4. Can centre of mass of a body coincide with geometrical centre of the body ?

Watch Video Solution

5. Does centre of mass of a rigid body lie always on the body ?

Watch Video Solution

6. On what factors does the position of cm of a rigid body depend ?

Watch Video Solution

7. Find the centre of mass of a uniform triangula lamina.

Watch Video Solution

8. Determine the coordinates of the centre of mass of a right circular solid cone of base radius R and height h.

Watch Video Solution

9. What is nature of motion of cm of an isolated system ?

Watch Video Solution

10. Find the centre of mass of a uniform triangula lamina.

Watch Video Solution

11. What is an isolated system ?

Watch Video Solution

12. Name the rotational analouge of force. What ar its units ?

Watch Video Solution

13. Write an expression for torque. Which rule is used for finding its direction ?

Watch Video Solution

14. Write the dimensional formula of angular momentum. Is it scalar or vector ?

Watch Video Solution

15. Name the physical quantity whose dimensions are same as that of angular momentum ?

Watch Video Solution

16. Which physical quantity is conserved when a planet revolves around the sun ?

Watch Video Solution

17. What is angular velocity of earth spinning around its own axis ?

Watch Video Solution

18. Moment of inertia of a hollow cylinder of mass M and radius R, about the axis of cylinder is

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19. What is moment of inertia of a solid cylinder of mass m, length l and radius$r$ about the axis of the cylinder ?

Watch Video Solution

20. What is radius of gyration of a soild sphere of mass m and radius r about its diameter ?

Watch Video Solution

21. On what factors does the radius of gyration of a body depend ?

Watch Video Solution

22. A ring and a circular disc of different materials have equal masses and equal radii. Which one will have a larger moment of inertia about an axis passing through its centre of mass perpendicular to its plane ?

Watch Video Solution

23. A disc of metal is melted and recast in the from of a soild sphere. What will happen to the moment of inertia anout a vertical axis passing through the centre ?

Watch Video Solution

24. What are the units and dimensions of moment of inertia ? Is it a vector ?

Watch Video Solution

25. What is rotational analogure of mass of a body ?

Watch Video Solution

26. State the two theorems of moment of inertia.

Watch Video Solution

27. What is moment of inertia of a solid sphere about its diameter ?

Watch Video Solution

28. What is the moment of inertia of a hollow sphere about an axis passing through its centre ?

Watch Video Solution

29. What are the factors on which moment of inertia of a body depend ?

Watch Video Solution

30. Is radius of gyration of a body constant quantity ?

Watch Video Solution

31. There are two spheres of same mass and same radius, one is solid and other is hollow. Which of them has a larger moment of inertia about its dimeter ?

Watch Video Solution

32. Two solid spheres of the same are made of metals of different densities. Which of them has a larger moment of inertia about a diameter ?

Watch Video Solution

33. Name the rotational analogue of force. What are its units ?

Watch Video Solution

34. A cannot ball and a marble ball roll from rest down an incline. Which goes to the buttom first ?

Watch Video Solution

35. Can a body in translatory motion have angular momentum ? Explain.

Watch Video Solution

36. Why spin angular velocity of a star is greatly enhanced when it collapses under gravitational pull and becomes a neutron star ?

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37. Fill in the blanks :

(i) $\overrightarrow{\tau} = \overrightarrow{r} \times \ldots$ (ii) $\overrightarrow{L} = \overrightarrow{r} \times \ldots$

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38. How are torque and angular momentum related ?

Watch Video Solution

39. Complete the statement : Angular momentum of a particle is equal to twice... .

Watch Video Solution

40. Rolling motion can be treated as a combination of .... Fill in the blanks.

Watch Video Solution

41. Write an expression for kinetic energy of rolling body.

Watch Video Solution

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

Watch Video Solution

43. Angle traced by a rotating body in nth seconds is $\theta_{nth} =$ ....where symbols have their usual meaning.

Watch Video Solution

44. the centre of gravity of a body on the earth coincides with its centre of mass for a small object whereas for an extended object it may not ,what is the qualitaitve meaning of small and extended in this regard ?

for which of the following two coincides ? A building , a pond , a lake ,a mountain ?

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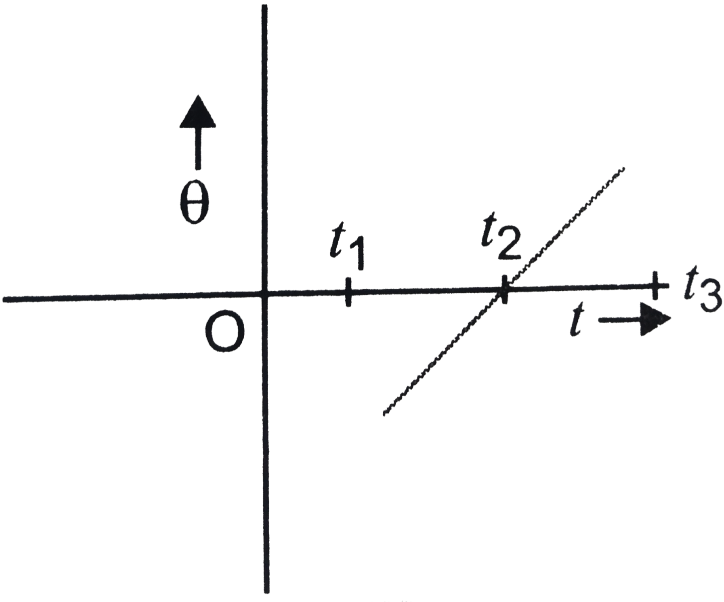
45. Why does a solid sphere have smaller moment of inertia than a hollow cylinder of same mass and radius, about an axis passing through their axes of symmentry ?

Watch Video Solution

46. The variation of angular position θ, of a point on a rotating rigid body, with time t is shown in Fig. Is the body rotating clock wise or

anti-clockwise ?



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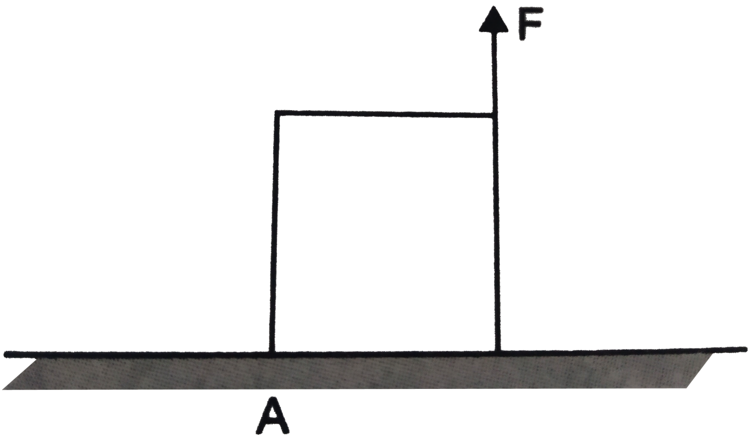
47. A unifrom cube of mass m and side a is placed on a frictionless horizontal surface. A vertical force F is applied to the edge as shown in Fig. Match the following (most appropriate choice) :

(a)$mg/4 < F < mg/2$ (i) Cube will move up.

(b) $F > mg/2$ (ii) Cube will not exhibit motion.

(c) $F > mg$ (iii) Cube will begin to rotate and slip at A.

(d) $F = mg/4$ (iv) Normal reaction effectively at $a/3$ from A, no motion.



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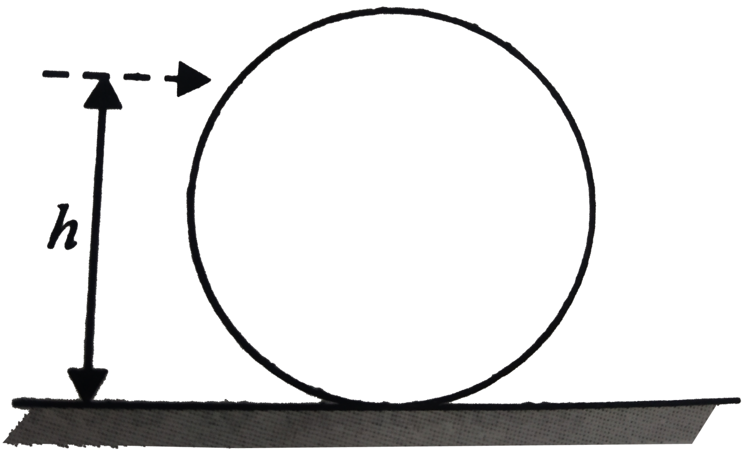
48. A uniform sphere of mass m and radius R is placed on a rough horizontal surface [Fig.] The sphere is struck horizontally at a hight h from the floor. Match the following :

(a) $h = R/2$ (i) Sphere rolls without slipping with a constant velocity and no loss of energy.

(b) $h = R$ (ii) Sphere spins clockwise, loses energy by friction.

(c) $h = 3R/2$ (iii) Sphere spins anti-clockwise, loses energy by friction.

(d) $h = 7R/5$ (iv) Sphere has only a translational motion, looses energy by friction.



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VERY SHORT ANSWER QUESTIONS II.

1. Which physical quantity is represented by the product of the moment of inertia and the angular velocity ?

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2. A ballet-dancer stretches her hands out for slowing down. This is based on principle of conservation of ... .

Watch Video Solution

SHORT ANSWER QUESTIONS I.

1. Find the centre of mass of a uniform triangula lamina.

Watch Video Solution

2. About which axis would the moment of inertia of a body be minimum ?

Watch Video Solution

SHORT ANSWER QUESTIONS

1. Two particles of masses m_1 and m_2 move with velocities v_1 and v_2 towards eachother on a smooth horizontal surface. What is the velocity of their centre of mass ?

Watch Video Solution

2. Two balls of mass m each are placed at the two vertices of an equilateral triangle. Another ball of mass $2m$ is placed at the third vertex of the triangle. Locate the centre of mass of the system.

Watch Video Solution

3. the length of seconds hand of a clock is $10cm$. The speed of the tip of the hand is ....

Watch Video Solution

4. Is torque a scalar or vector ? If it is a vector, what rule is used to determine its direction ?

Watch Video Solution

5. Why do we perfect to use a when with a long arm ?

Watch Video Solution

6. What is the dimensional formula of angular momentum and what are its units ? Is it a scalar ?

Watch Video Solution

7. Is the angular speed of rotation of hour hand of a watch greater or smaller than the angular speed of earth's rotation about its axis ?

Watch Video Solution

8. A body is in rotational motion. Is it necessary that a torque be acting on it ?

Watch Video Solution

9. Why are doors provided with handles near the outer edges, far away from the hinges ?

Watch Video Solution

10. It is difficult to open or close the door by pushing/pulling it at the hinges. Why ?

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11. To open or close a heavy door, why force is applied at right angles to the door.

Watch Video Solution

12. Why is it easier to open a tap with two fingers than with onw finger ?

Watch Video Solution

13. What is angular impulse ?

Watch Video Solution

14. Which component of linear momentum does not contribute to angular momentum ?

Watch Video Solution

15. Is a body in circular motion in equillibrium ?

Watch Video Solution

16. A particle moves in a circular path with decreasing speed. What happens to its angular momentum ?

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17. Explain that torque is only due to transverse component of force. Radial component as nothing to do with torque.

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18. Show that centre of mass of an isolated system moves with a uniform velocity along a straight line path.

Watch Video Solution

19. Locate the centre of mass of uniform triangular lamina and a uniform cone.

Watch Video Solution

20. Explain the concepts of torque and angular momentum.

Watch Video Solution

21. Explain what is meant by centre of gravity.

Watch Video Solution

22. About what axis would a uniform cube have its minimum moment of inertia?

Watch Video Solution

23. Is radius of gyration of a body constant quantity ?

Watch Video Solution

24. Speed of rotation of a body affects the radius of gyration of the body. Comment.

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25. A solid disc is recast into a thin walled cylinder of same radus. Which will have larger moment of inertia ?

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26. Two satellites of equal masses, which can be considered as particles are orbiting the earth at different heights. Will their moment of inertia be same or different ?

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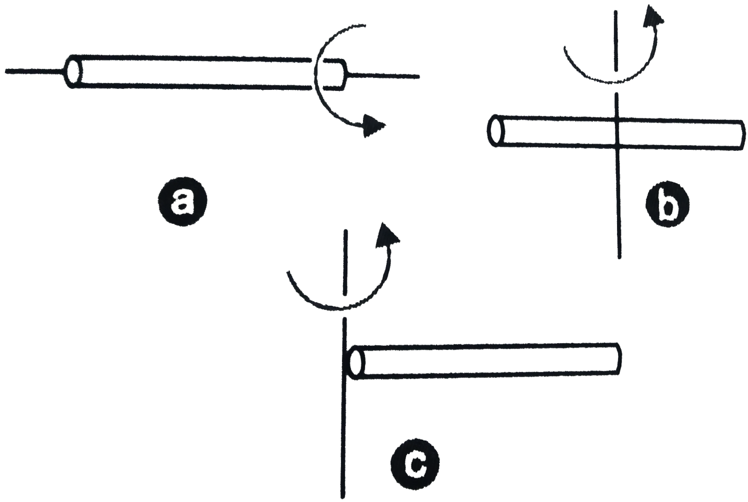
27. In which of the following cases shown Fig. it is most difficult to rotate the rod ? Explain why ?



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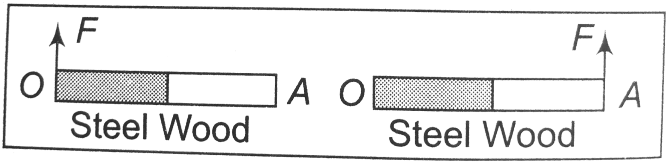
28. In first figure a meter stick, half of which is wood and the other half steel is pivoted at the wooden end at A and a force is applied at the steel and at O. On second figure the stick is pivoted at the steel end at O and the same force is applied at the wooden end at A. The angular acceleration.



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29. 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.

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30. The radius of gyration of an uniform rod of length L about an axis passing through its centre of mass and perpendicular to its length is.

Watch Video Solution

31. Why there two propellers in a helicopter ?

Watch Video Solution

32. A solid wooden sphere rolls down two different inclined planes of the same height but of different inclinations. (a) Will it reach the bottom with same speed in each case ?

(b) Will it take longer to roll down one inclined plane than other ? Explain.

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33. Using expressisions for power and kinetic energy of rotational motion, derive the relation $\tau = I\alpha$, where letters have their usual meaning.

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34. A thin uniform circular disc of mass M and radius R is rotating in a horizontal plane about an axis passing through its centre and perpendicular to its plane with an angular velocity ω. Another disc of the same dimensions but of mass $M/4$ is placed gently on the first disc co-axially. show that angular velocity o fthe system is $4\omega/5$.

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35. Is angular momentum of a system always conserved ?

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36. A flywheel is revolving with a constant angular velocity. A chip of its rim breaks and flies away. How is its angular velocity affected ?

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37. Why are not able to rotate a wheel by pulling or pushing along its radius ?

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38. Explain why the speed of a whirl wind in a tornado is alarmingly high ?

Watch Video Solution

39. State the two theorems of moment of inertia.

Watch Video Solution

40. Explain the physical significance of moment of inertia and radius of gyration.

Watch Video Solution

41. Obtain expression for $K.E.$ of rolling motion.

Watch Video Solution

42. State the laws of rotational motion.

Watch Video Solution

43. The vector sum of a system of non-collinear forces acting on a rigid body is given to be non-zero. If the vector sum of all torques due to the system of forces about a centain point is found to be zero, does this mean that it is necessarily zero about any arbitrary point ?

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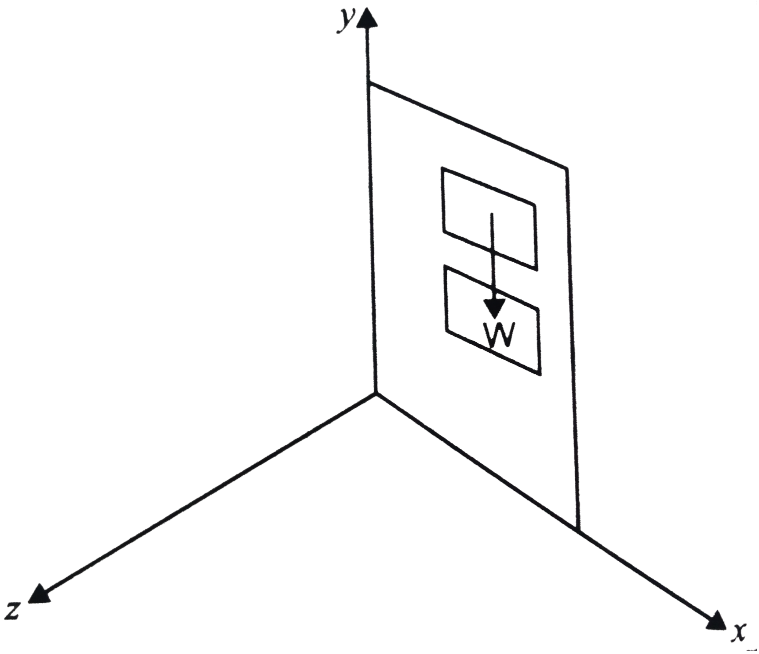
44. A wheel in uniform motion about an axis passing through its centre and perpendicular plus is considered to be in mechanical (translational plus rotational) equilibrium because no net external force or torqure is reqired to sustain its motion However , the particles than constitute the wheel do experience a centripeteal the acceleration wheel being in equilibrium ?

how would you set a half wheel into unifrom motion about an axis passing throgh the centre of mass of the wheel and perpendicular to its plane ? will ypu require external forces to sustain the motion ?

Watch Video Solution

45. A door is hinged at one and is free to rotate about a vertical axis [Fig.] Does its weight cause any torque the axis ? Given reason for you answer.



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46. $(n-1)$ equal point masses each of mass m are placed at the vertices of a angular n-

polygon. The vacent vertex has a position vector a with respect to the centre of the polygon. Find the position vector of centre of mass.

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SHORT ANSWER QUESTIONS II.

1. Can a body in translatory motion have angular momentum ? Explain.

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2. (i) A person sits near the edge of a circular platform revolving with a uniform angualr speed. What will be the change in the motion of the platform ?

(ii) What if the person stars moving from the edge towards the centre of the platform ?

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LONG ANSWER QUESTIONS

1. Obtain an expression for the position vector of centre of mass of a two particle system.

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2. Obtain an expression for the position vector of centre of mass of a system of n particles.

Watch Video Solution

3. Show that centre of mass of an isolated system moves with a uniform velocity along a

straight line path.

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4. Discuss atleast three examples of the motion of centre of mass.

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5. Briefly discuss the concept of torque or moment of a force.

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6. Derive an expression for torque in cartesian co-ordinates.

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7. Obtain a expression for torque in polar co-ordinates.

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8. Explain the concept of angular momentum and obtain an expression for it in cartesion co-ordinates.

Watch Video Solution

9. Discuss the physical meaning of angular momentum.

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10. Briefly explain equilibrium of a rigid body. When is a body said to be in partial equilibrium ?

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11. Obtain an expression for kinetic energy of rotation of a body. Hence define moment of inertia of the body. Explain its physical significance.

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12. Establish a relation between torque and moment of inertia of a rigid body.

Watch Video Solution

13. Establish a relation between angular momentum and moment of inertia of a rigid body.

Watch Video Solution

14. State and explain the principle of conservation of angular momentum. Give atleast two examples.

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15. State and prove theorem of parallel axes.

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16. State and prove theorem of perpendicular axes.

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17. Derive an expression for moment of inertia of a thin circular ring about an axis passing through its centre and perpendicular to the plane of the ring.

Watch Video Solution

18. Obtain an expression for moment of inertia of a uniform circular disc about a diameter of the disc.

Watch Video Solution

19. Discuss rolling without slipping of a cylinder down a rough inclined plane and obtain an expression for the coefffcient of friction necessary for the same.

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20. Draw analogy between rotational motion and translational motion.

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21. Find the centre of mass of a unifrom (a) half-disc,(b) quarter-disc.

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

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

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

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

(d) Account for this loss.

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23. A disc of radius R is rotating with an angular speed ω_0 about a horizontal axis. It is placed on a horizontal table. The coefficient of kinetic friction is μ_k.

(a) What was the velocity of its centre of mass before being brought in contact with the table ?

(b) What happens to the linear velocity of a point on its rim when placed in contact with the table ?

(c) What happens to the linear speed of the centre of mass when disc is placed in contact with the table ?

(d) Which force i sresponsible for the effects in (b) and (c).

(e) What condition should be satisfied for rolling to begin ?

(f) Calculate the time taken for the rolling to begin.

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24. Two cylindrical hollow drums of radii R and $2R$, and of a commom height h, are rotating with angular velocities ω (anti-clockwise) and ω (clockwise), respectively. Their axes, fixed are parallel and in a horizontal plane separated by $(3R + \delta)$. They are now brought in contact $(\delta \rightarrow 0)$.

(a) Show the frictional forces just after contact.

(b) Identify forces and torque external to the system just after contact.

(c) What would be the ratio of final angular velocities when friction ceases ?

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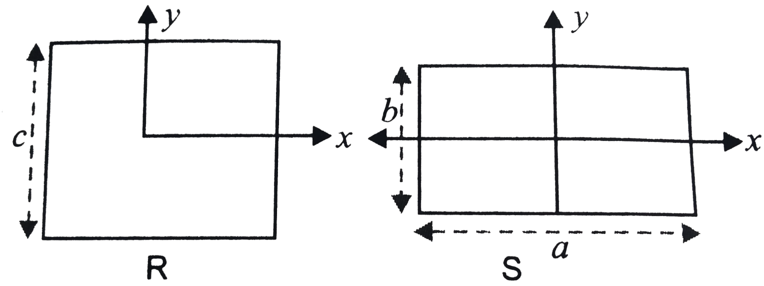
25. A unifrom square plate $S(side c)$ and a unifrom rectangular plate $R(side b, a)$ have identical areas and mass [Fig.]

Show that

(i) $I_{xR} / I_{xS} < 1$, (ii) $I_{yR} / I_{yS} > 1$, (iii)

$I_{zR} / I_{zS} > 1.$



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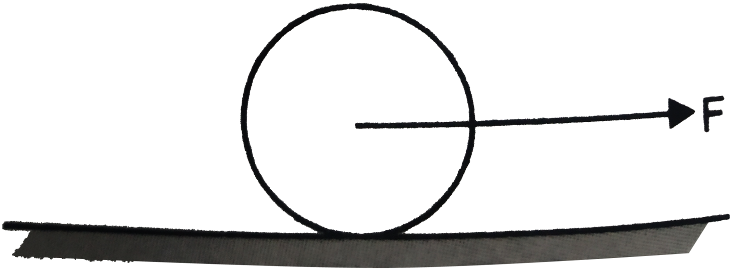
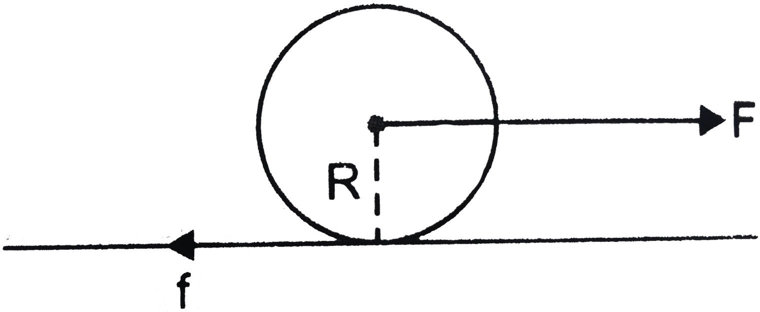
26. A unifrom disc of radius R, is resting on a table on its rim. The coefficient of friction between disc and table is μ Fig. Now the disc is spulled with a force F as shown in the Fig. What is the maximum value of F for which the disc rolls without slipping ?





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SOLVED EXAMPLES TYPE E

1. A cylinder of mass $5kg$ and radius $30cm$ and free to rotate about its axis receives an angular impulse of $3kgm^2s^{-1}$ initially, followed by a similar impulse after every 4 second. What is the angular speed of the cylinder $30s$ after the initial impulse ? The cylinder is at rest initially.

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ADVANCED PROBLEMS FOR COMPETITIONS

1. A $70kg$ man stands in contact against the inner wall of a hollow cylindrical drum of radius $3m$ rotating about its verticle axis. The coefficient of friction between the wall and his clothing is 0.15 . What is the minimum rotational speed of the cylinder to enable the man to remain stuck to the wall (without falling) when the floor is suddenly removed?

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2. A solid cylinder at rest at top of an inclined plane of height $2.7m$ rolls down without slipping. If the same cylinder has to slide down a frictionaly inclined plane and acquires the same velocity as that acquired by centre of mass of rolling cylinder at the bottom of the incline, what should be the height of inclined plane ?

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3. Find the maximum speed at which a car can turn round a curve of $30m$ radius on a level road if coefficient of friction between the tyress and road is $0.4. Take g = 10m/s^2$.

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4. A tube of length L is filled completely with an incomeressible liquid of mass M and closed at both the ends. The tube is then rotated in a horizontal plane about one of its ends with a uniform angular velocity ω. The force exerted by the liquid at the other end is

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5. A particle describes a horizontal circule on the smooth inner surface of a coincal funnel as shown in Fig. If the height of the plane of the circle above the vertex is $9.8cm$, find the speed of the particle.

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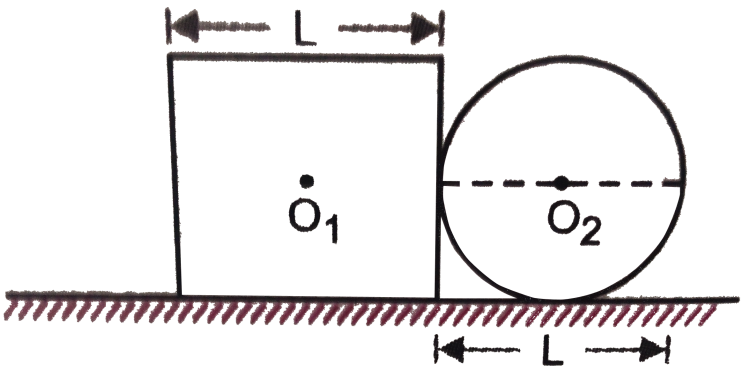
6. A uniform square plate and a disc having same mass per unit area are kept in contact as shown in Fig. The side of square and diameter of circle are both equal to L. Locate the position of centre of mass of the system w.r.t. the centre of the square.



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7. Find the centre of mass of a uniform semicircular ring of radius R and mass M.

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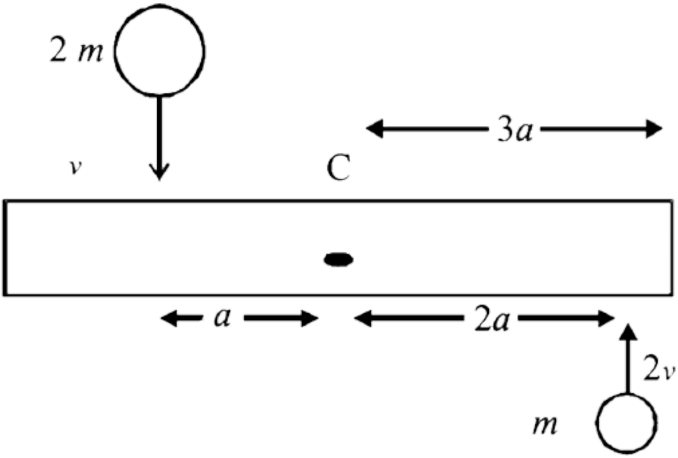
8. A uniform bar of length 6a and mass 8m lies on a smooth horizontal table. Two point masses m and 2m moving in the same horizontal plane with speed 2v and v, respectively, strike the bar [as shown in the fig.] and stick to the bar after collision. Denoting angular velocity (about the centre of

mass), total energy and centre of mass velocity by ω, E and v_c respecitvely, we have after collison



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9. Half of the recrtangular plate shown in figure is made of a material of density ρ_1 and

the other half of density ρ_2. The length of the plate is L. Locate the centre of mass of the plate.

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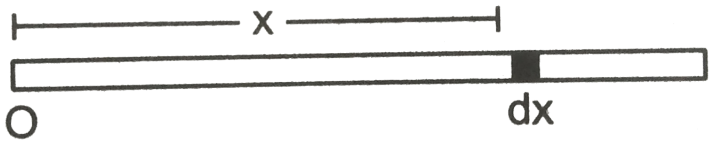
10. Find the location of centre of mass of a uniform semicirular plate of radius R and mass M.

Watch Video Solution

11. The density of a linear rod of length L varies as $\rho = A + Bx$ where x is the distance from the left end. Locate the centre of mass.



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12. A cubical block of ice of maas m and edge L is placed in a large tray of maas M. If the ie melts, how far does the centre of maas of the system "ice plus tray" come down?

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13. A string is wrapped around the rim of a wheel of moment of inertia 0.20 $kg-m^2$ nd radius 20 cm. The wheel is free to rotate about it axis. Initially, thewheel is t rest. The string is now pulled by a force of 20 N. Find the angular velocity of the wheel after 5.0 seconds.

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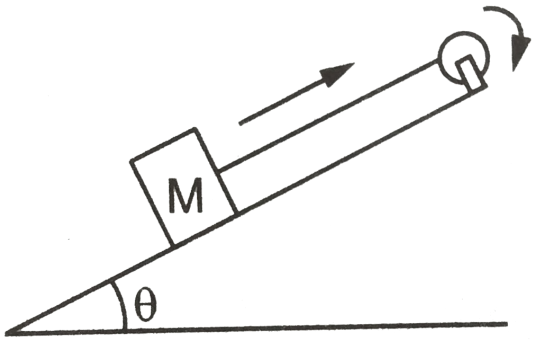
14. A wheel of rdius r and moment of inertia I about its axis is fixed at top of an inclined plane of inclination θ as shownin figure. A string is wrapped round the wheel and its free end supports a block of mass M which can slide on the plane. INitialy, tehwheel is rotating at a speed ω in direction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



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15. A solid sphere of mass $3kg$ and radius $2m$ is free to rotate about an axis passing through its centre. Find a constant tangential force F required to rotate the sphere with a velocity of $10rad/s$ in $2\sec$. Starting from rest. Also, find the number of rotations made by the sphere in that time interval.

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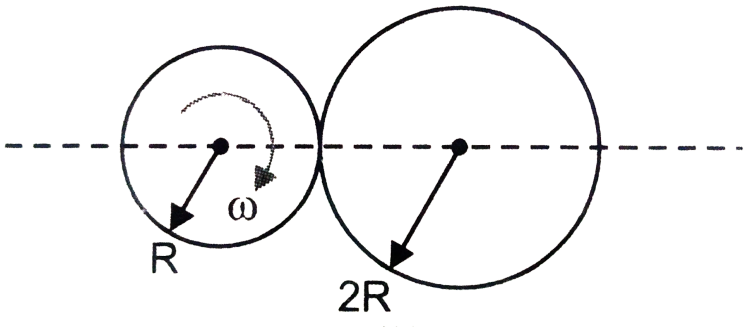
16. Two discs of radii R and $2R$ are pressed against eachother. Initially, disc wit radius R is rotating with angular velocity ω and other disc is stationary. Both discs are hinged at their respective centres and are free to rotate about them. Moment of inertiaof smaller disc is I and of bigger disc is $2I$ about their respective axis of rotation. Find the angular velocity of bigger disc after long time.



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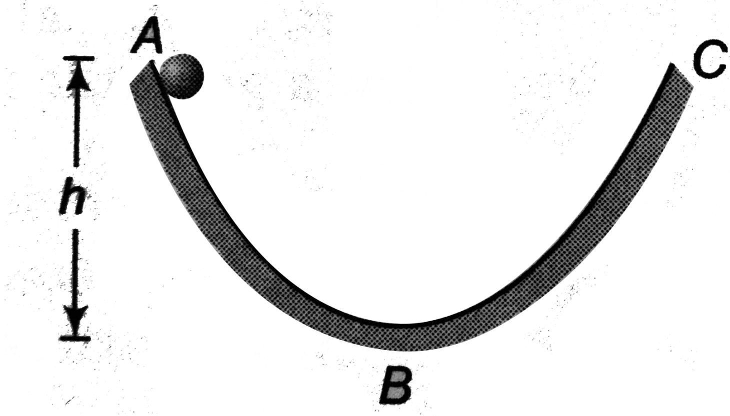

17.

A solid ball rolls down a parabolic path ABC from a height h as shown in figure. Portion AB of the path is rough while BC is smooth. How high will the ball climb in BC?

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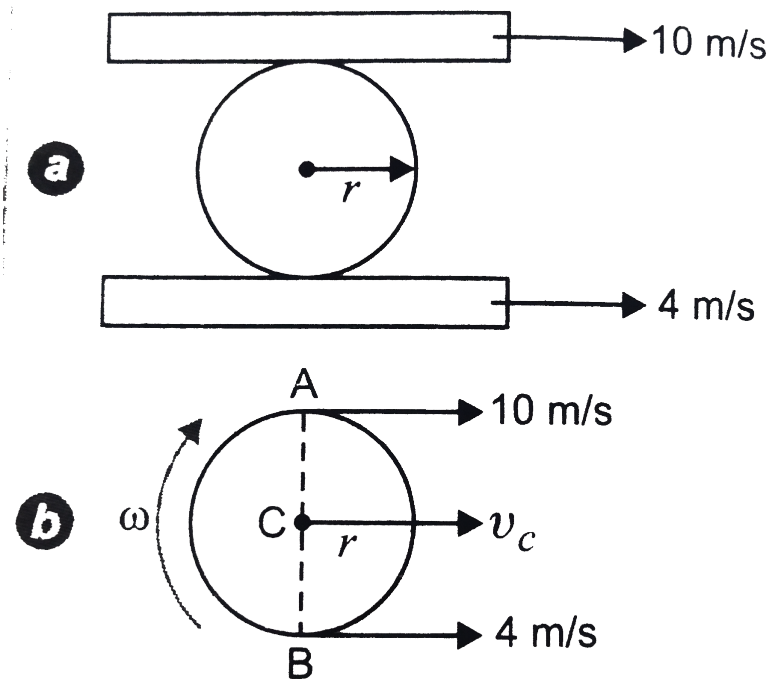
18. A cylinder of mass $2kg$ and radius $10cm$ is held between two planks as shown in Fig. Calculate KE of the cylinder when there is no slipping at any point.



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19. A rod of mass m and length l is himged about one of its ends. The rod is released from horizontal position. When the rod becomes vertical, calculate (i) angular speed of the rod (ii) Hinge reaction.

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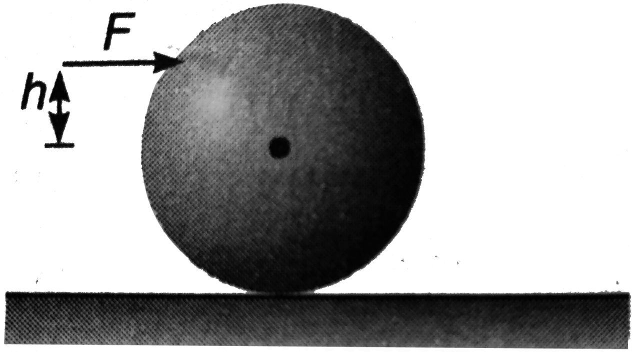
20.



A billiard ball, initially at rest, is given a sharp impulse by a cue. The cue is held horizontally a distance h above the centre line as shown in figure. The ball leaves the cue with a speed v_0 and because of its backward slipping eventually acquires a final speed $\frac{9}{7}v_0$ show that $h = \frac{4}{5}R$

Where R is the radius of the ball.

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NCERT

1. Given the location of the centre of mass of a (i) sphere, (ii) cylinder, (iii) ring, and (iv) cube, each of uniform mass density. Does the centre of mass of a body necessarily lie on the body ?

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2. In the HCI molecule, the separation between the nuclei of the two atoms is about $1.27\text{Å}(1\text{Å} = 10^{-10}m)$. Find the approximate location of the c.m of the molecule, given that a chorine atom ia about 35.5 times as massive as a hydrogen atom and nearly all the mass of an atom is cocentrated in its uncleus ?

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3. A child is sitting at one end of a long trolley moving with a uniform speed v on a smooth horizontal track. If the child starts running towards the other end of the trolley with a speed u (w.r.t. trolley), the speed of the centre of mass of the system will.

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4. Show that the area of the triangle contained between the vector $\vec{r}$ and $\vec{b}$ is one half of the magnitude of $\vec{a} \times \vec{b}$

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5. Show that $\vec{a}.\left(\vec{b} \times \vec{c}\right)$ is equal in magnitude to the volume of the parallelopiped formed on the three vectiors, $\vec{a}, \vec{b}$ and $\vec{c}$.

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6. Find the components along the x, y, z axes of the angular momentum $\overrightarrow{L}$ of a particle, whose position vector is $\overrightarrow{r}$ with components x, y, z and momentum is $\overrightarrow{p}$ with components p_x, p_y and p_z. Show that if the particle moves only in the $x - y$ plane, the angular momentum has only a z-component.

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7. Two particles each of mass m and speed v, travel in opposite direction along parallel lines separated by a distance d. Show that the vector angular momentum of this system of particles is the same about any point taken as origin.

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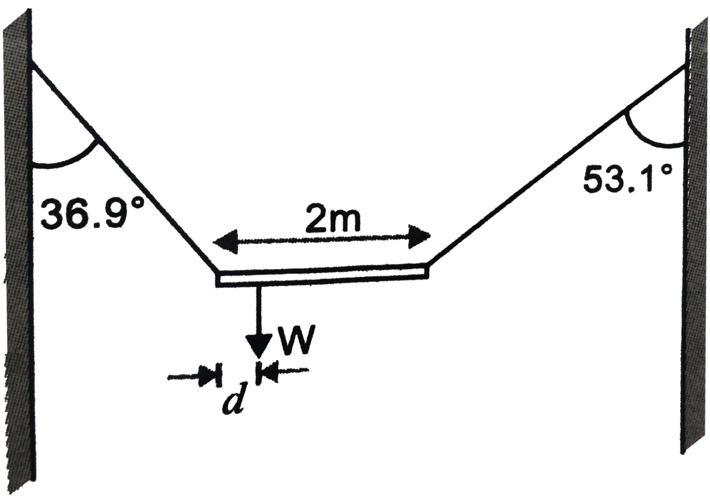
8. A non-uniform bar of weight W is suspended at rest by two strings of negligible weight as shown in Fig. The angles made by the strings with the vertical are 36.9° and 53.1° respectively. The bar is $2m$ long. Calculate the distance d of the centre of gravity of the bar from its left end.



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9. A car weighs $1800kg$. The distance between its front and back axles is $1.8m$. Its centre of gravity is $1.05m$ behind the front axle. Determine the force exerted by the level ground on each front wheel and each back wheel.

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10. (a) Find the moment of inertia of a sphere about a tangent to the sphere, given the moment of inertia of the sphere about any of its diameters to be $2MR^2/5, where M$ is the mass of the sphere and R is the radius of the sphere.

(b) Given the moment of inertia of a disc of mass M and radius R about any of its diameters to be $\frac{1}{4}MR^2$, find the moment of inertia about an axis normal to the disc passing through a point on its edge.

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11. Torques of equal magnitude are applied to hollow cylinder and a solid sphere, both having the same mass and same radius. The cylinder is free to rotate aabout its standard axis of symmetry, and the sphere is free to rotate about an axis passing through its centre. which of the two will aquire a greater angular speed after a given time ?

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12. A solid cylinder of mass $20kg$ rotates about its axis with angular speed $100s^{-1}$. The radius of the cylinder is $0.25m$. What is the kinetic energy associated with the rotation of the cylinder ? What is the magnitude of angular momentum of the cylinder about its axis ?

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13. A child stands at the centre of a turn table with his two arms outstretched. The turn table

is set rotating with an angular speed of 40 rpm. How much is the angular speed of the child, if he folds his hands back reducing the moment of inertia to $(2/5)$ time the initial value ? Assume that the turn table rotates without friction.

(b) Show that the child's new $K.E.$ of rotation is more than the initial $K.E.$ of rotation. How do you account for this increase in $K.E.$?

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14. A rope of negligible mass is wound around a hollow cylinder of mass $3kg$ and radius $40cm$. What is the angular acceleration of the cylinder, if the rope is pulled with a force of $30N$? What is the linear acceleration of the rope ? Assume that there is no slipping.

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15. To maintain a rotor at a uniform angular speed of $200s^{-1}$, an engine needs to transmit a torque of $180N - m$. What is the power of the engine required ?

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16. From a uniform disc of radius R, a circular section of radius $R/2$ is cut out. The centre of the hole is at $R/2$ from the centre of the original disc. Locate the centre of mass of the resulating flat body.

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17. A metre stick is balanced on a knife edge at its centre. When two coins, each of mass $5g$ are put one on of the other at the $12cm$ mark, the stick is found to balanced at $45cm$. The mass of the metre stick is.

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18. A solid wooden sphere rolls down two different inclined planes of the same height but of different inclinations. (a) Will it reach the bottom with same speed in each case ?

(b) Will it take longer to roll down one inclined plane than other ? Explain.

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19. A hoop of radius $2m$ weight $100kg$.It rolls along a horizontal floor so that its centre of mass has a speed of $20cms^{-1}$. How much work has to be done to stop it ?

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20. The oxygen molecule has a mass of $5.30 \times 10^{-26} kg$ and a moment of inertia of $1.94 \times 10^{-46} kgm^2$ about an axis through its centre perpendicular to the line joining the two atoms. Suppose the mean speed of such a molecule in a gas is $500 m/s$ and that its kinetic energy of rotation is two thirds of its kinetic energy of translation. Find the average angular velocity of the molecule.

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21. A sphere rolls up an inclined plane whose inclination is 30°. At the bottom of the inclined plane, the center of mass of the sphere has a translational speed of $5ms^{-1}$ (a) How far does the sphere travel up the plane? (b) How long does it take to return to the bottom?

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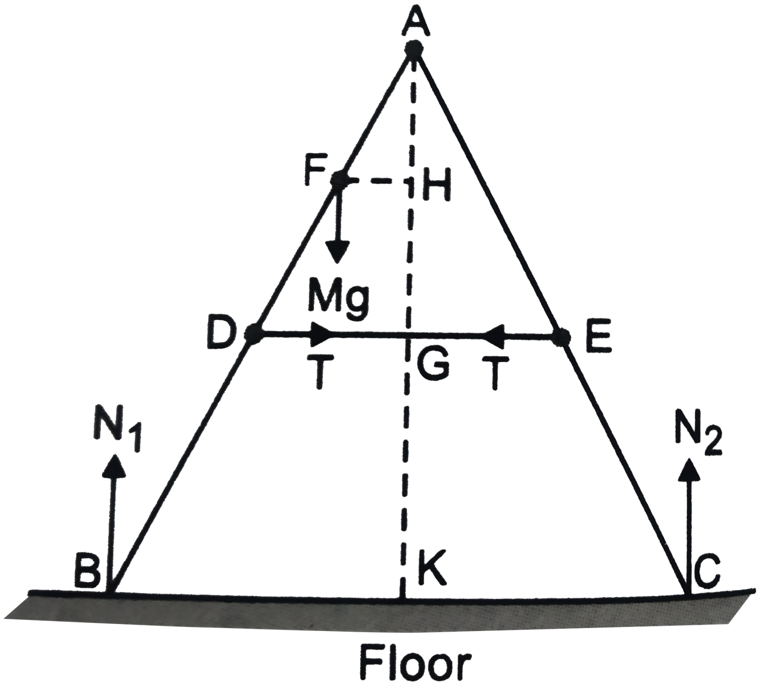
ADDITIONAL EXERCISES

1. As shown in Fig. the two sides of a step ladder BA and CA are $1.6m$ long and hinged at A. A rope $DE, 0.5m$ is tied half way up. A weight $40kg$ is suspended from a point $F, 1.2m$ from B along the ladderBA. Assuming the floor to be fricionless and neglecting the weight of the ladder, find the tension in the rope and forces exerted by the floor on the ladder. (Take $g = 9.8m/s^2$)

(Hint. Consider the eqilibrium of each side of the ladder separately.)



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2. A man stands on a rotating platform, with his arms stretched horizontal holding a $5kg$

weight in each hand. The angular speed of the platform is 30 revolutions per minute. The man then brings his arms close to his body with the distance of each weight from the axis changing from $90cm$ to $20cm$. moment of inertia of the man together with the platform may be taken to be constant and equal t $7.6kgm^2$. (a) What is the his new angular speed ? (Neglect friction.)

(b) Is kinetic energy conserved in the process ? If not, from where does the change come about ?

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3. A bullet of mass $10g$ and speed $500m/s$ is fired into a door and gets embedded exactly at the centre of the door. The door is $1.0m$ wide and weight $12kg$. It is hinged at one end and rotates about a vertical axis practically without friction. Find the angular speed of the door just after the bullet embeds into it.(Hint. The moment of inertia of the door about the vertical axis at one end is $ML^2/3$)

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

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

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

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

(d) Account for this loss.

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5. (a) Prove the theorem of perpendicular axes.

(Hint : Square of the distance of a point (x, y) in the x-y plane from an axis through the origin and perpendicular to the plane is $(x^2 + y^2)$.

(b) Prove the theorem of parallel axes.

(Hint : If the centre of mass of a system of n particles is chosen to be the origin $\sum m_i r_i = 0$).

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6. Prove the result that the velocity v of translation of a rolling body (like a ring, disc, cylinder or sphere) at the bottom of an inclied plane of a hight h is given by $v^2 = \frac{2gh}{(1 + k^2 / R^2)}$ using dynamical consideration (i.e. by consideration of forces and torque). Note k i sthe radius of gyration of the body about its symmentry axis, and R is the radius of the body. The body starts from rest at the top of the plane.

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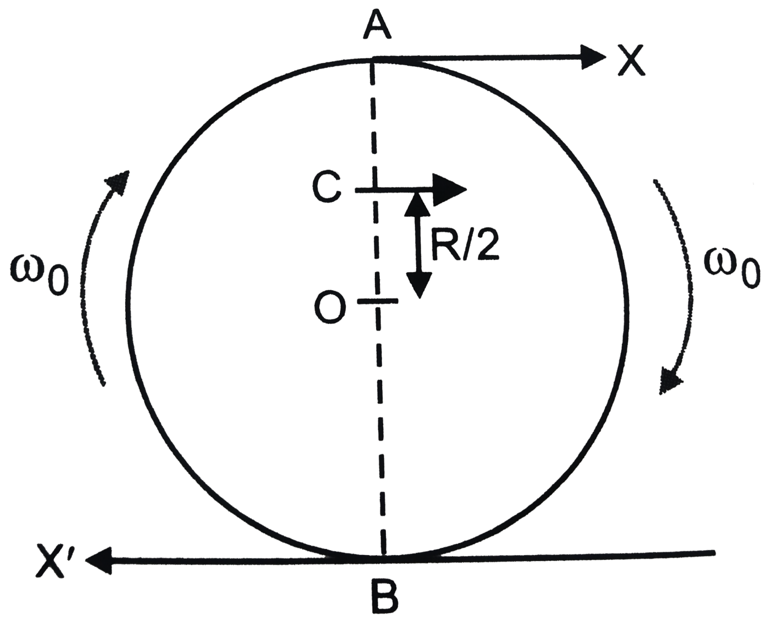
7. A disc roating about its axis with angular speed ω_0 is placed lightly (without any translational pull) on a perfectly frictionless table. The radius of the disc is R. What are the linear velocities of the points A, B and C on the disc shown in Fig. Will the disc roll in the

direction indicated ?



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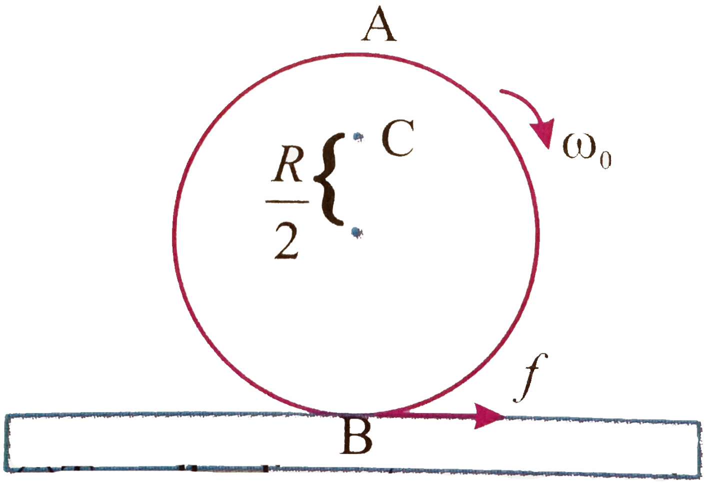
8. (i) Explain why friction is necessary to make the disc to roll in the direction indicated. (ii) Give the direction of frictional force at B, and the sense of frictional torque, before perfect rolling begins. (iii) What is the force of friction after perfect rolling begins?



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9. A solid disc and a ring, both of radius $10cm$ are placed on a horizontal table simultaneously, with initial angular speed equal to $10\pi rad / s$. Which of the two will start to roll earlier ? The coefficient of kinetic friction is $\mu_k = 0.2$.

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10. A cylinder of mass $10kg$ and radius $15cm$ is rolling perfectly on a plane of inclination 30°. The coefficient of static friction is $\mu_s = 0.25$.

(a) How much is the force of friction acting on the cylinder ?

(b) What is the work done against friction during rolling ?

(c) If the inclination θ of plane is increased, at what value of θ does the cylinder begin to skid and not roll perfectly ?

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11. Read each statement below carefully and state with reasons, if it is true ot false. (a) During rolling the force of friction acts in the same direction as the direction of motion of c.m of the body. (b) The instantaneous speed of the point of contact during rolling is zero. (c) The instantaneous acceleration of the point of contact during rolling is zero. (d) For perfect rolling motion, work done against friction is zero. (e) A wheel moving down a perfectly frictionless inclined plane will undergo slipping (not rolling motion).

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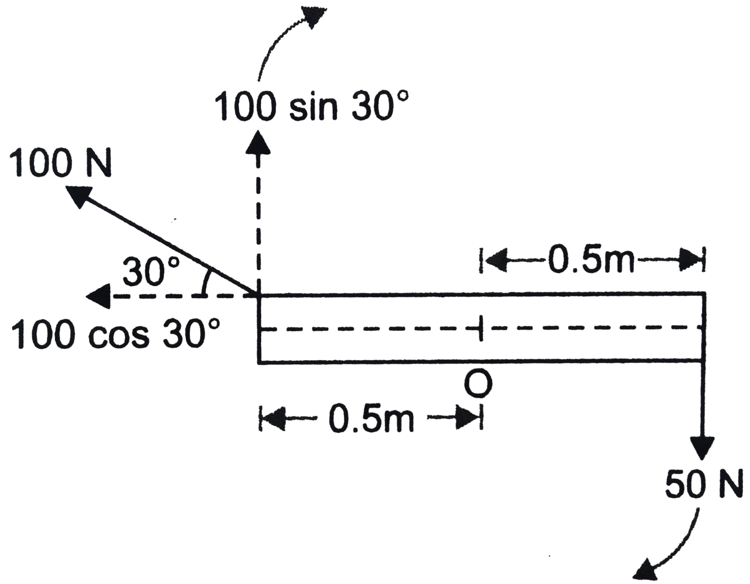
QUESTIONS

1. Two forces $50N$ and $100N$ are acting on a rod capable of rotating it about O as shown in Fig. What is the net torque acting on the rod ?



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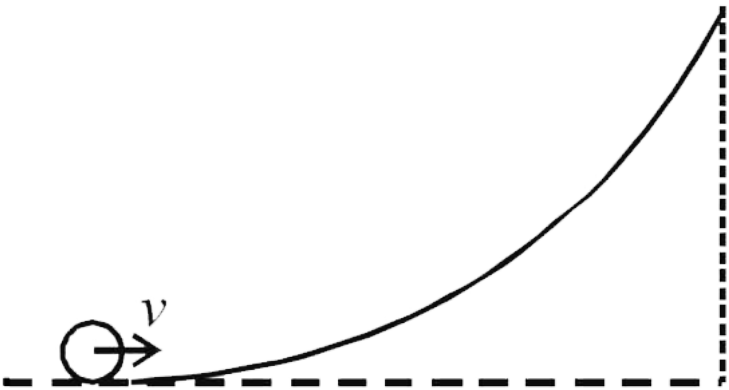
2. A small object of uniform density rolls up a curved surface with an initial velocity v. it reaches up to a maximum height of `(3v^2)/(4g)



with respect to the initial position. The object is

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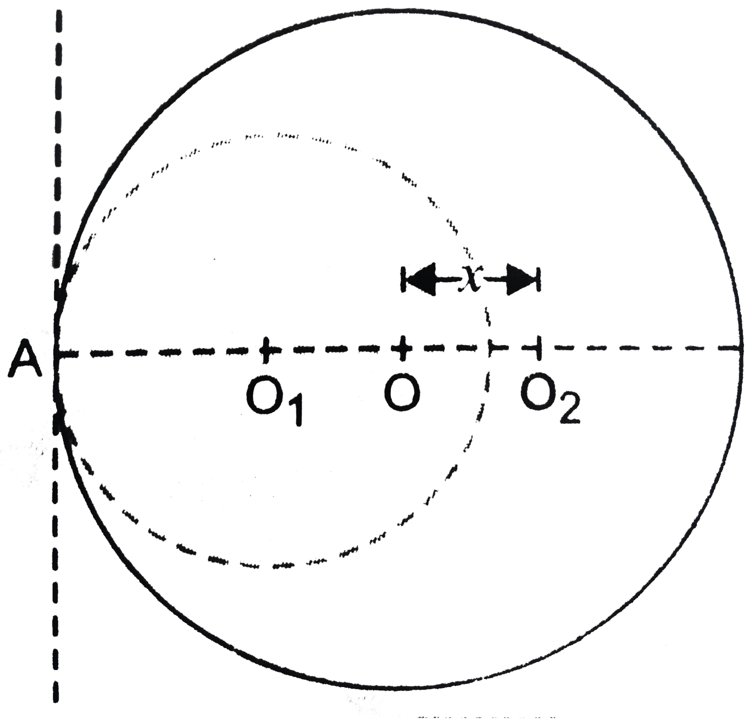
3. A circular plate of unifrom thickness has a diameter of $56 cm$. A circular portion of diameter $42 cm$ is removed from the edge of the plate as shown in Fig. Find the position of centre of mass of the remaining portion.



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4. A stone of mass m tied to the end of a string is whirled around in a horizontal circle (neglect force du eto grvaity). The length of the string is reduced gradually keeping the angular momentum of the stone about the centre of the circle constant. Then the tension in the given by $T = Ar^n$, where A is a constant and r is instantaneous radius of the circle. Show that $n = -3$.

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5. A threaded rod with $12 turns / cm$ and diameter $1.18 cm$ is mounted horizontal. A bar with a threaded hole to match the rod is screwed onto the rod. The bar spins at $216 rev / \min$. How long will it take for the bar to move $1.50 cm$ along the rod ?

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6. Find the centre of mass of a unifrom disc of radius a from which a circulr section of radius b has been removed. The centre of hole is at a distance c from the centre of the disc.

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7. A solid cylinder of mass $20kg$ and radius $0.12m$ rotating wit initial angula speed of $125rad/s$ is placed lightly (i.e. without any translational push) on a horizontal table with

coefficient of kinetic friction $\mu_k = 0.15$ between the cylinder and the table.

(a) After how long does the cylinder start rolling ?

(b) What is the initial translational energy, rotational energy and total energy of the cylinder ?

(c) What is the final (i.e. after rolling begins) translational energy, rotational energy and total energy of the cylinder ? (d) Is the finl total enrgy equal to the initial total energy of motion of the cylinder ? If not, where does the difference of energy disappear ?

(e) Account for the loss of total energy of motion in the following way : find the work done by friction on the body its translational motion. Show that net work done by friction on the body is negative, equal in magnitude to the loss of total energy calculated in (d) above.

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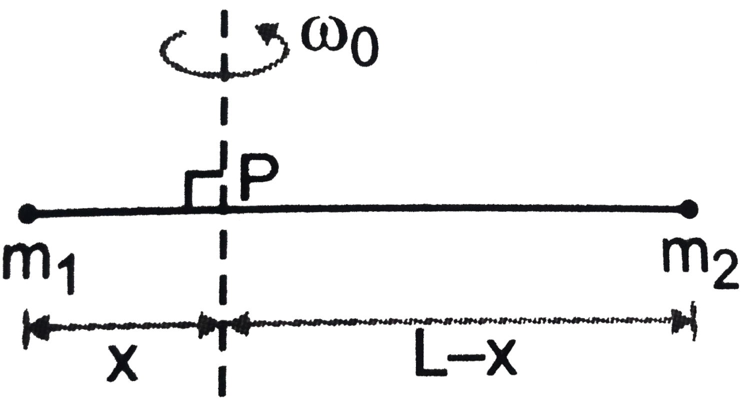
8. Point masses m_1 and m_2 are placed at the opposite ends of a rigid rod of length L, and negligible mass. The rod is to be set rotating about an axis perpendicualr to it. The position of point P on this rod through which the axis should pass so that the work required to set the rod rotating with angular velocity ω_0 is minimum, is given by :



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9. A ball of mass $10^{-2} kg$ and having charge $+3 \times 10^{-6} C$ is tied at one end of a $1m$ along thread. The other end of the thread is fixed and a charge $-3 \times 10^{-6} C$ is placed at this end. The ball can move in the circulr orbit of radius $1m$ in the vertical plane. Initially, the ball is at the bottom. Find the monimum initial horizontal velocity of the ball, so that it will be able to complete the full circle.

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10. Three particles, each of the mass m are situated at the vertices of an equilateral triangle of side a. The only forces acting on the particles are their mutual gravitational forces. It is desired that each particle moves in a circle while maintaining the original mutual separation a. Find the initial velocity that should be given to each particle and also the time period of the circular motion. $\left(F = \frac{Gm_1m_2}{r^2}\right)$

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11. From a uniform circular disc of diameter d, a circular disc of diameter $d/6$ and having centre at a distance $d/4$ from the centre of the disc is scooped out. Determine the centre of mass of remaining portion.

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12. A spot light S rotates in a horizontal plane with a constant angular velocity of $0.1 rad/s$. The spot of light P move along the wall at a disatnce $3m$. What is the velocity of the spot P when $\theta = 45^\circ$?

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13. A nail is located at a certain distance vertically below the point of suspension of a simple pendulum. The pendulum bob is released from a position where the string makes an angle of 60° with the vertical. Calculate the distance of nail from the point of suspension such that the bob will just perform revolutions with the nail as centre. Assume the length of the pendulum to be one meter.

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14. A uniform sphere of mass m and radius R is placed on a rough horizontal surface. The spher is struck horizontally at a height h from the floor. Show that the sphere rolls without slipping with a constant velocity, when $h = 7R/5$.

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

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VALUE BASED QUESTIONS

1. The mechanical energy (E) of a body is the sum of kinetic energy (K) and potential energy (V) of the body i.e., $E = K + V$. Whereas K is always positive, V can be positive or negative. For a system to axis, $K = (E - V) \geq 0$

Negative value of E indicates a bound state. For example, all planets revolving around the sum have negative mechanical energy.

Read the above passage and answer the

following questions :

(i) When mechanical energy $E = 0$, does it mean $K = 0$ and $V = 0$?

(ii) What is the implication of this study in day to day life ?

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2. The torque (τ) due to a force gives us the turning effect of the force about a fixed point/axis. It is measured by the product of magnitude of force (F) and perpendicular distance (r) of the line of action of force form the axis of rotation.

$$\overrightarrow{\tau} = \overrightarrow{r} \times \overrightarrow{F} = rF \sin \theta \widehat{n}$$

where $thete$ is smaller angle between $\overrightarrow{r}$ and $\widehat{n}$ is unit vector along $\overrightarrow{\tau}$.

Read the above passage and answer the following questions :

(i) What is the significance of torque ?

(ii) How do you determine the direction of torque ?

(ii) What is the implication of this concept in day to day life ?

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3. A rigid body is said to be in translational equilibrium, if it remains at rest or moving with a constant velocity in a particular direction. For this, the net external force or vector sum of all the external forces acting on the body must be zero, i.e.,

$$\overrightarrow{F} = 0 \text{ or } \overrightarrow{F} = \sum \overrightarrow{F_i} = 0$$

If U is potential energy of the body, then

$F = -\dfrac{dU}{dr} = 0$ or $U =$ constant (max. or min.)

When $U =$ minimum, equilibrium of body is stable,

When U tends to increase, equilibrium is unstable,

When U remains constant, equilibrium is neutral.

Read the above passage and answer the following questions :

(i) When can a body moving uniformly along a straight line be in equilibrium ? What is this equlilbrium called ?

(ii) What is the significance of $U =$ minimum in day to day life ?

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4. When a compass needle is held arbitrarily in any direction in earth's magnetic field, a couple acts on the needle. The force on north pole of needle is towards the north and force on south pole of the needle is towards south. These forces are equal in magnitude and opposite in direction. They from a couple, which rotates the compass needle and aligns it along north south direction. Once the alignment is complete, net force and net torque on the compass needle reduce to zero.

Read the above passage and answer the following :

(i) What is the origin of force and torque on the compass needle ?

(ii) What values of life do you learn from this study ?

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5. The concept of centre of mass proves that laws of mechanics which are true for a point mass, are equally valid for all macroscopic bodies of any shape, size, mass, etc. For example, when vector sum of external forces acting on a system of particles is zero, the velocity of centre of mass of the system will remain constant.

Read the above passage and answer the following questions :

(i) Is centre of mass of a body a real point ?

(ii) Does centre of mass lie within the body always ?

(iii) How do you justify that $\overrightarrow{v_{cm}} =$ constant ?

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CURIOSITY QUESTIONS

1. How do you account for the motion of your arms and legs ?

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2. What do you know artificial joints ?

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3. The plane of the orbit of a planet can never change on its own. Why ?

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4. When no external torque acts on a system, its angular momentum remains constant. Is the statement true ? Should kinetic energ of rotation of the system remain constant ? If yes, why , and if no, why not?

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MULTIPLE CHOICE QUESTIONS

1. The centre of mass of a body is moving with a uniform velocity of $10cm / s$. Three forces are applied on the body, which are in equilibrium. The velocity of centre of mass would become

A. Zero

B. $> 10cm / s$

C. $< 10cm / s$

D. $10cm / s$

Answer: D

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2. A fire cracker following a parabolic path explodes in mid air. The centre of mass of all the fragments will follow a path

A. along horizontal

B. along vertical

C. along same parabola

D. along circulae

Answer: C

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3. The correct relation between linear velocity $\overrightarrow{v}$ and angular velocity $\overrightarrow{\omega}$ of a particle is

A. $\overrightarrow{v} = \overrightarrow{\omega} \times \overrightarrow{r}$

B. $\overrightarrow{\omega} = \overrightarrow{v} \times \overrightarrow{r}$

C. $\overrightarrow{\omega} = \overrightarrow{r} \times \overrightarrow{v}$

D. $\overrightarrow{v} = \overrightarrow{r} \times \overrightarrow{\omega}$

Answer: A

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4. Obtain a expression for torque in polar co-ordinates.

A. $\tau = rF\sin\phi$

B. $\tau = rF\cos\phi$

C. $\tau = rF\tan\phi$

D. $\tau = \dfrac{F\sin\phi}{r}$

Answer: A

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5. The moment of linear momentum is called

A. torque

B. couple

C. angular momentum

D. none of the above

Answer: C

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6. To maintain a rotor at a uniform angular speed of $100s^{-1}$, an engine needs to transmit a torque of $90N - m$. The power of engine must be

A. $9kW$

B. $90kW$

C. $9MW$

D. $90MW$

Answer: A

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7. The correct relation between torwue τ and angular momentum L is

A. $\tau = \frac{dL}{dt}$

B. $L = \frac{d\tau}{dt}$

C. $\tau = L \times t$

D. $L = \tau \times t$

Answer: A

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8. A rigid body is said to be in translational equilibrium, when its velocity $\vec{v}$ is

A. Zero

B. constant

C. constant or zero

D. neither constant nor zero

Answer: C

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9. A rigid body is said to be in partial equilibrium, when it is in

A. translational equilibrium only

B. rotational equilibrium only

C. either (a) or (b)

D. neither (a)nor(b)

Answer: C

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10. Calculate the angular velcity of the minute`s hand of a clock.

A. $\pi / 30$

B. $\pi / 1800$

C. $2\pi / 30$

D. $\frac{2\pi}{1800}$

Answer: B

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11. Moment of inertia of a body depends upon

A. mass of body

B. shape and size of body

C. position and orientation of axis of rotation

D. all the above

Answer: D

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12. Formation of a neutron star is explained on the basis of

A. conservation of linear momentum

B. conservation of energy

C. conservation of angular momentum

D. none of these

Answer: C

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13. Moment of inertia of a uniform circular ring of mass $2kg$ and diameter $1m$ about its diameter is

A. $0.25kgm^2$

B. $0.5kgm^2$

C. $1kgm^2$

D. $2kgm^2$

Answer: A

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14. The radius of gyration of a uniform circular disc of radius R, about any diameter of the disc is

A. $K = R$

B. $K = R/2$

C. $K = 2R$

D. none of these

Answer: B

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15. Moment of inertia of a hollow cylinder of mass M and radius R, about the axis of cylinder is

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

B. MR^2

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

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

Answer: B

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16. Kinetic energy of a body rolling without slipping is

A. $K = \frac{1}{2}mv^2$

B. $K = \frac{1}{2}I\omega^2$

C. $K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

D. $K = \frac{1}{2}mv^2 - \frac{1}{2}I\omega^2$

Answer: C

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17. Acceleration of a solid cylinder rolling without slipping down an incline of inclination θ is

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

B. $\frac{2}{3}g\cos\theta$

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

D. $\frac{2}{3}g\tan\theta$

Answer: A

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18. The rotational analgue of force is

A. momentum

B. angular momentum

C. torque

D. none of these

Answer: C

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19. A grindstone of moment of inertia $6kgm^2$ is found to have a speed of 150 rpm, $10\,\text{sec}$. After starting from rest. Torque applied is

A. $6\pi Ns$

B. $3\pi Ns$

C. $9\pi Ns$

D. $12\pi Ns$

Answer: B

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20. What would be the length of the day, if earth were to shrink suddenly to $1/64th$ of its original volume ?

A. $24h$

B. $12h$

C. $6h$

D. $1.5h$

Answer: D

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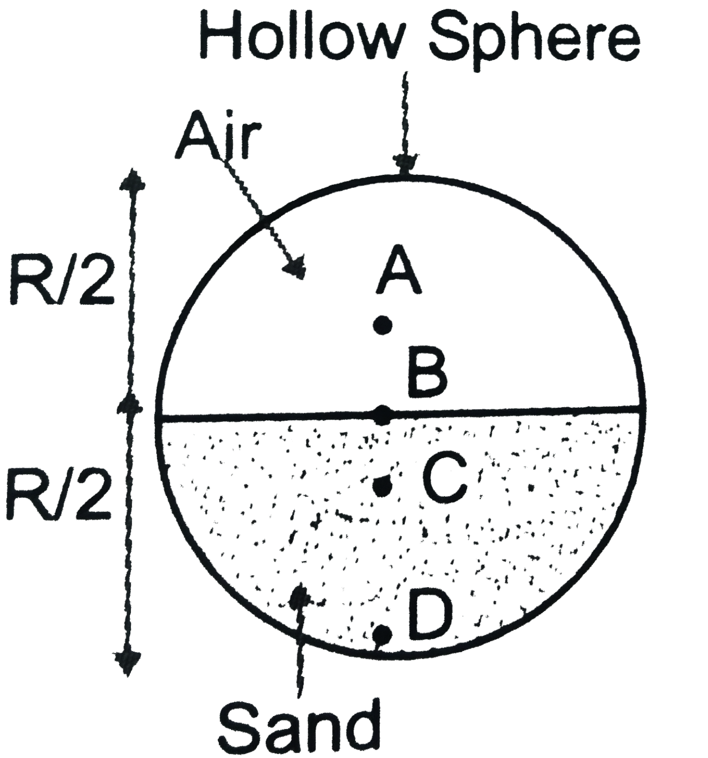
21. Which of the following points is the likely position of the centre of mass of the system shown in Fig.



A. A

B. B

C. C

D. D

Answer: C

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22. A particle of mass m is moving in yz-plane with a unifrom velocity v with its trajectory running parallel to +ve y-axis and intersecting z-axis at $z = a$ Fig. The change in its angular momentum about the origin as it bounces elastically from a wall at y = constant is :

A. $mva\hat{e}_x$

B. $2mva\hat{e}_x$

C. $ymva\hat{e}_x$

D. $2ymva\hat{e}_x$

Answer: B

23. When a disc rotates with uniform angular velocity, which of the following is not true ?

A. The sense of rotation remains same.

B. The orientation of the axis of rotation remains same.

C. The speed of rotation is non-zero and remains same.

D. The angular acceleration is non-zero and remains same.

Answer: D

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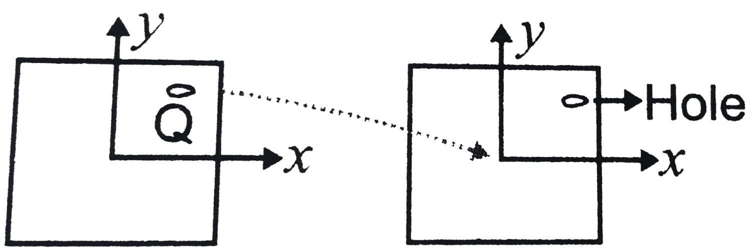
24. A unifrom square plate has a small piece Q of an irregular shape removed and glued to the centre of the plate leaving a hole behind [Fig.] The moment of inertia about the z-axis is than



A. increased

B. decreased

C. the same

D. changed in unpredicted manner.

Answer: B

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25. In problem $5, the CM$ of the plate is now in the following quadrant of $x - y$ plane.

A. I

B. II

C. III

D. IV

Answer: C

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26. The density of a non-uniform rod of length $1m$ is given by $\rho(x) = a(1 + bx^2)$

where a and b are constants and $0 \leq x \leq 1$.

The centre of mass of the rod will be at

A. $\dfrac{3(2+b)}{4(3+b)}$

B. $\dfrac{4(2+b)}{3(3+b)}$

C. $\dfrac{3(3+b)}{4(2+b)}$

D. $\dfrac{4(3+b)}{3(2+b)}$

Answer: A

Watch Video Solution

27. A Meery -go-round, made of a ring-like plarfrom of radius R and $mass M$, is revolving with angular speed ω. A person of mass M is standing on it. At one instant, the person jumps off the round, radially awaay from the centre of the round (as see from the round). The speed of the round after wards is

A. 2ω

B. ω

C. $\omega / 2$

D. 0

Answer: A

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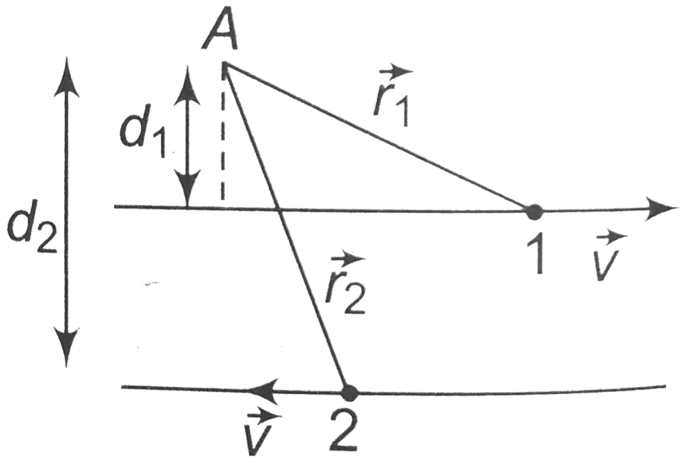
28. Figure shows two identical particles 1 and 2, each of mass m, moving in opposite directions with same speed $\vec{V}$ along parallel lines. At a particular instant, $\vec{r}_1$ and $\vec{r}_2$ are their respective position vectors drawn from point A which is in the plane of the parallel lines. Which of the following is the correct statement ?

,



A. Angular momentum $\overrightarrow{L_1}$ of particle 1 about A is $\overrightarrow{L_1} = mv(d_1) \odot$

B. Angular momentum $\overrightarrow{L_2}$ of particle 2 about A is $\overrightarrow{L_1} = mvr_2 \odot$

C. Total angular momentum of the system about A is $\overrightarrow{L} = mv(r_1 + r_2) \odot$

D. Total angular momentum of the system about A is $\overrightarrow{L} = mv(d_2 - d_1) \otimes$

$\odot$ respresents a unit vector coming out of the page.

ox represents a unit vector going into the page.

Answer: A::D

Watch Video Solution

29. The net external torque on a system of particles about an axis is zero. Which of the following are compatible with it ?

A. The forces may be acting radially from a point on the axis.

B. The forces amay be acting on the axis of rotation.

C. the forces may be acting parallel to the axis of rotation.

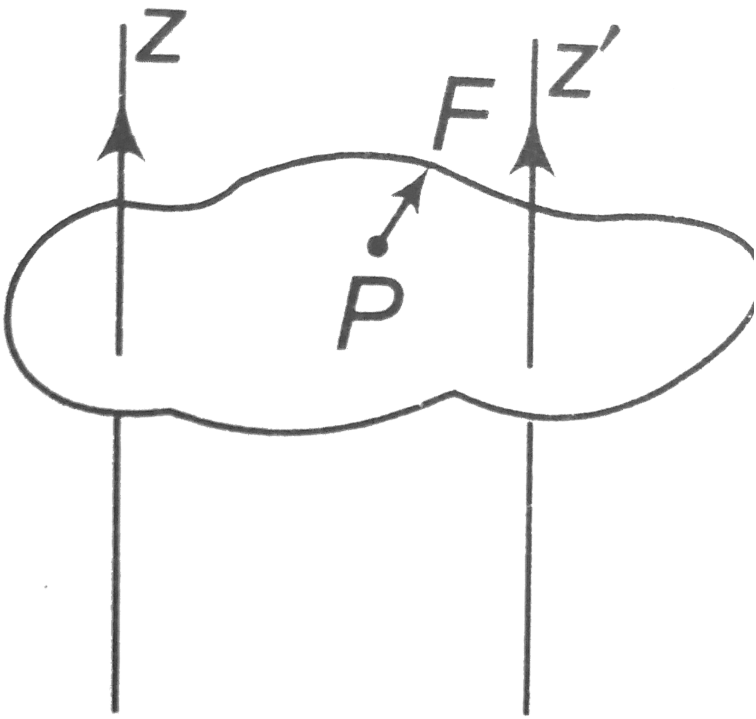
D. The torque caused by some forces may be equal and opposite to that caused by other forces.

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

Watch Video Solution

30. Figure shows a lamina in $x-y$ plane. Two axes z and z' pass perpendicular to its plane. A force F acts in the plane of lamina at point P as shown. Which of the following statements is incorrect ?

(The point P is closer to z' $- a\xi s$ than the z-axis).



A. Torque τ caused by F about z-axis is along -$\hat{k}$

B. Torque τ' caused by F about z' axis is along -$\hat{k}$.

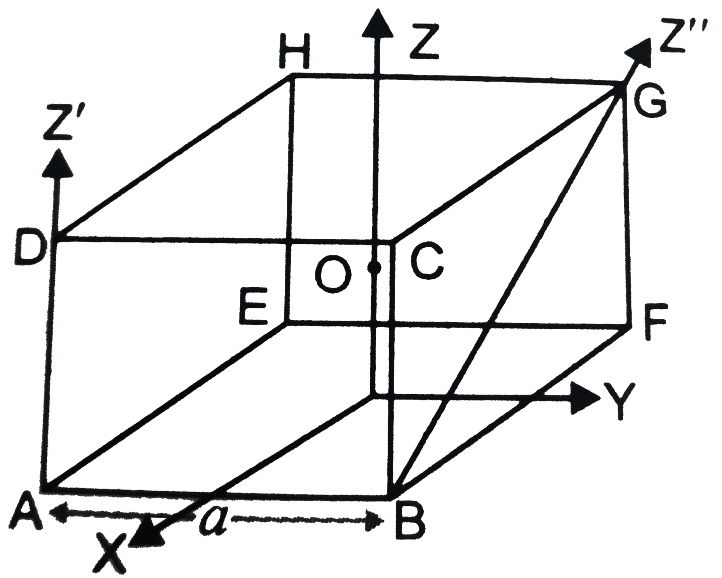
C. Torque τ caused by F about z-axis is greater in magnitude than that about z-axis.

D. Total torque is given be $\tau = \tau + \tau$'.

Answer: B::C

Watch Video Solution

31. With reference to Fig. of a cube of edge a and mass m, state whether the following are true or false. (O is the centre of the cube.)



A. The moment of inertia of cube about x-axis is,

$$I_z = I_x + I_y$$

B. The moment of inertia of cube about z'

is, $I_{z'}$

$$= I_z + \frac{ma^2}{2}$$

C. The moment of inertia of the about z'' is

$$= I_z + \frac{ma^2}{2}$$

D. $I_x = I_y$

Answer: B::D

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32. A rod of weight w is supported by two parallel knife edges A and B and is in equilibrium in a horizontal position. The knives are at a distance d from each other. The centre of mass of the rod is at distance x from A. The normal reaction on A is.. And on B is......

A. $\frac{Wd}{x}$

B. $\frac{W(d-x)}{x}$

C. $\frac{W(d-x)}{d}$

D. $\frac{Wx}{d}$

Answer: C

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33. Three identicle particle each of mass $1kg$ are placed with their centres on a straight line. Their centres are marked A, B and C respectively. The distance of centre of mass of the system from A is.

A. $\dfrac{PQ + PR + QR}{3}$

B. $\dfrac{PQ + PR}{3}$

C. $\dfrac{PQ + QR}{3}$

D. $\dfrac{PQ + QR + PR}{3}$

Answer: B

Watch Video Solution

34. A circular disc of radius R is removed from a bigger circular disc of radius 2R such that the cirucmferences of the discs coincide. The centre of mass of the new disc is $\dfrac{\alpha}{R}$ from the center of the bigger disc. The value of α is

A. $\frac{1}{4}$

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

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

D. $\frac{1}{6}$

Answer: B

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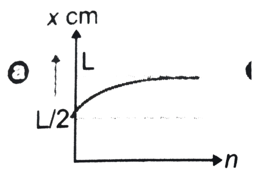
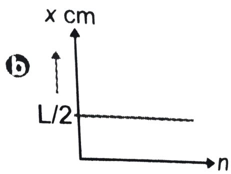
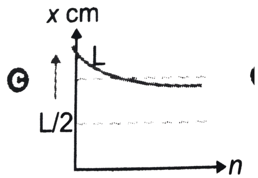
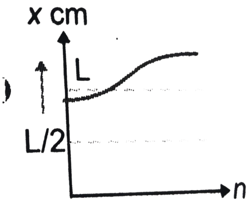
35. A thin rod of length 'L' is lying along the x-axis with its ends at $x = 0$ and $x = L$ its linear (mass/length) varies with x as $k\left(\frac{x}{L}\right)^n$, where n can be zero of any positive number. If to position x_{CM} of the centre of mass of the rod is plotted against 'n', which of the following graphs best apporximates the dependence of x_{CM} on n?

A. 

B. 

C. 

D. 

Answer: A

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36. A thin uniform rod of length l and mass m is swinging freely about a horizontal axis passing through its end. Its maximum angular speed is ω. Its cenre of mass rises to a maximum height of :

A. $\frac{I\omega}{6g}$

B. $\frac{l^2\omega^2}{2g}$

C. $\frac{l^2\omega^2}{6g}$

D. $\frac{l^2\omega^2}{3g}$

Answer: C

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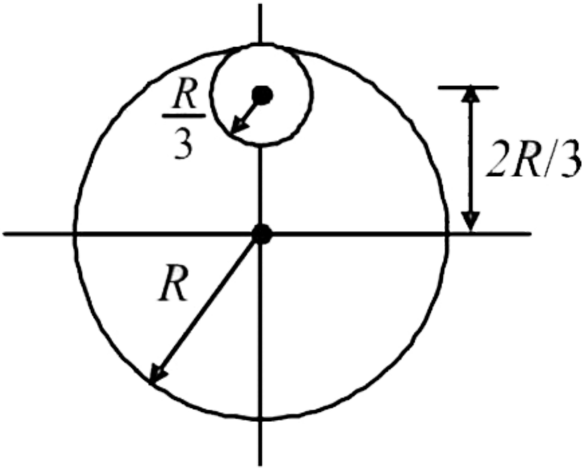
37. From a circular disc of radius R and mass 9 M , a small disc of radius R/3 is removed from the disc. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through O is



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

B. MR^2

C. $4MR^2$

D. $\frac{4}{9}MR^2$

Answer: A

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38. (1) Centre of gravity (C.G.) of a body is the point at which the weight of the body acts,

(2) Centre of mass coincides with the centre of gravity if the earth is assumed to have infinitely large radius,

(3) To evaluate the gravitational field intensity due to any body at an external point, the entire mass of the body can be cosidered to

be concentrated at its C.G..,

(4) The radius of gyration of any body rotating about ab axis is the length of the perpendicular dropped from thr C.G. the body to the axis. which one of the following paires of statements is correct ?

A. (4) and (1)

B. (1) and (2)

C. (2) and (3)

D. (3) and (4)

Answer: A

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39. Consider a two particle system with particles having masses m_1 and m_2 if the first particle is pushed towards the centre of mass through a distance d, by what distance should the second particle is moved, so as to keep the center of mass at the same position?

A. d

B. $(m_2 / m_1)d$

C. $[m_1 / (m_1 + m_2)]d$

D. $(m_1 / m_2)d$

Answer: D

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40. From a disc of radius R and $mass M$, a circular hole of diameter R, whose rim passes through the centre is cut. What is the moment of inertia of remaining part of the disc about a perependicular axis, passing through the centre ?

A. $\frac{13}{32}MR^2$

B. $\frac{11}{32}MR^2$

C. $\frac{9}{32}MR^2$

D. $\frac{15}{32}MR^2$

Answer: A

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41. A disc and a solid sphere of same radius but different masses roll off on two inclined planes of the same altitude and length. Which one of the two objects gets to the bottom of the plane first ?

A. solid sphere

B. both reach at the same time

C. depends on their masses

D. disc

Answer: A

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42. From a disc of radius R and mass M, a circular hole of diameter R, whose rim passes through the centre is cut. What is the moment of inertia of remaining part of the disc about a perependicular axis, passing through the centre ?

A. $\frac{13}{32} MR^2$

B. $\frac{11}{32} MR^2$

C. $\frac{9}{32} MR^2$

D. $\frac{15}{32} MR^2$

Answer: A

Watch Video Solution

43. The densities of two solid spheres A and B of the same radii R very with radial distance $rasp_A(r) = k\left(\frac{r}{R}\right)$ and $p_B(r) = k\left(\frac{r}{(R)^5}\right.$, respectively, where k is a constant . The moments of inertia of the inividual spheres about axes passing throgh their centres are I_A and I_B respectively. if $\frac{I_B}{I_A} = \frac{n}{10}$, the value of n is

A. 6

B. 10

C. 16

D. 7

Answer: A

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44. From a solid sphere of M and radius R a cube of maximum possible volume is cut. Moment of inertia of cube about an axis passing through its centre and perpendiular to one of its faces is:

A. $\dfrac{MR^2}{32\sqrt{2}\pi}$

B. $\dfrac{MR^2}{16\sqrt{2}\pi}$

C. $\dfrac{4MR^2}{9\sqrt{3}\pi}$

D. $\dfrac{4MR^2}{3\sqrt{3}\pi}$

Answer: C

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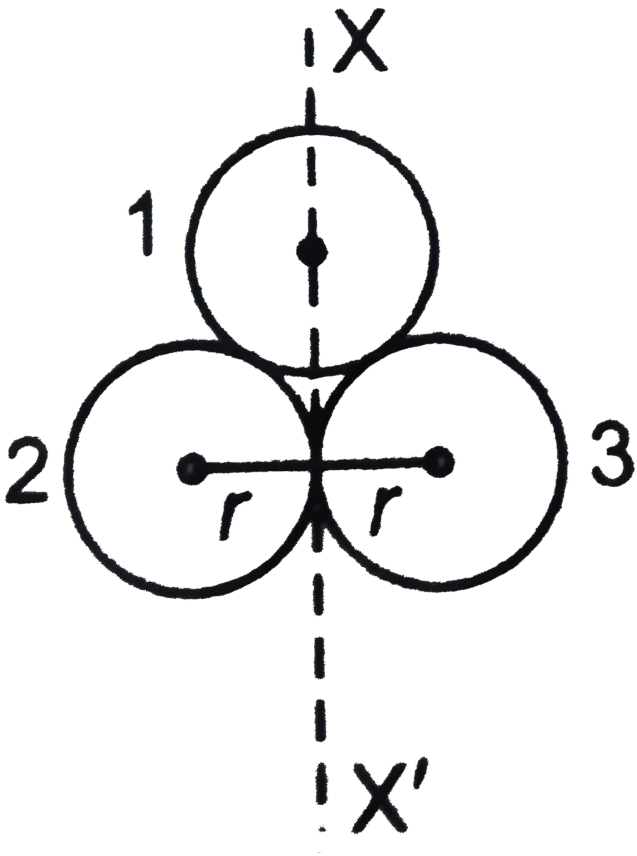
45. Three idential spherical shells each of mass m and radius r are placed as shown in Fig. Consider an axis XX' which is touching the two shells and passing through diameter of third shell. Moment of Inertia of the system consisting of these three spherical shells about XX' as axis is :



A. $3mr^2$

B. $\frac{16}{5}mr^2$

C. $4mr^2$

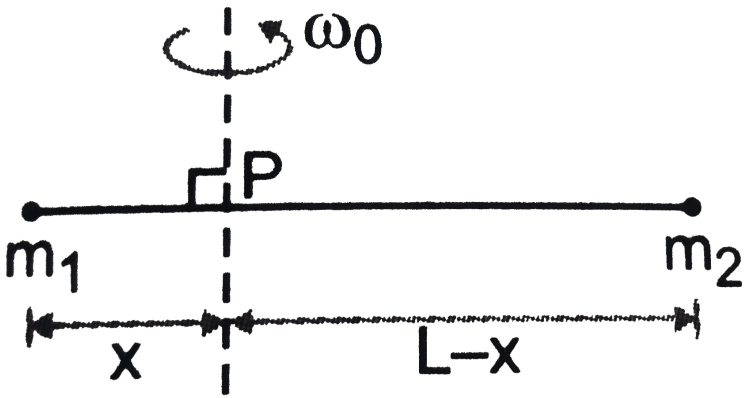
D. $\frac{11}{5}mr^2$

Answer: C

Watch Video Solution

46. Point masses m_1 and m_2 are placed at the opposite ends of a rigid rod of length L, and negligible mass. The rod is to be set rotating about an axis perpendicualr to it. The position of point P on this rod through which the axis should pass so that the work required to set the rod rotating with angular velocity

ω_0 is minimum, is given by :



A. $x = \dfrac{m_2 L}{m_1 + m_2}$

B. $x = \dfrac{m_1 L}{m_1 + m_2}$

C. $x = \dfrac{m_1}{m_2} L$

D. $x = \dfrac{m_2}{m_1} L$

Answer: A

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47. If l_1 is the moment of inertia of a thin rod about an axis perpendicular to its length and passing thorugh its centre of mass and l_2 the 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 to the plane of the ring. then find the ratio $\frac{l_1}{l_2}$.

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

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

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

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

Answer: A

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48. A raw egg and a hard boiled egg are made to spin on a table with the same angular speed about the same axis. The ration of the time taken by the two to stop is

A. $= 1$

B. < 1

C. > 1

D. none of the above

Answer: B

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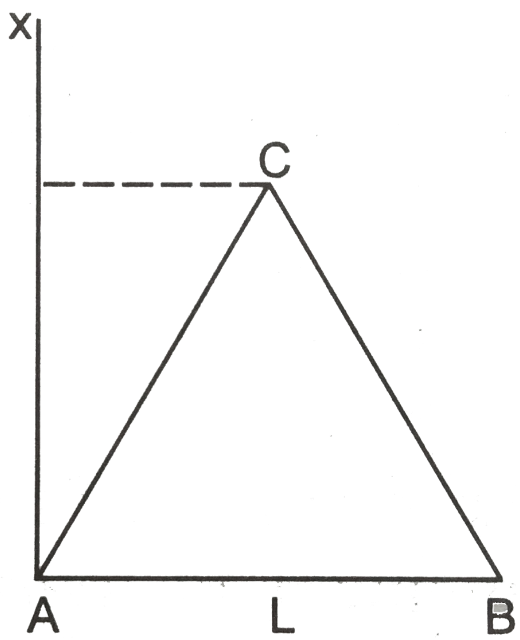
49. Three particles, each of mass m are situated at the vertices of an equilateral triangle ABC of side L figure. Find thee moment of inertia of the system about the line AX perpendicular to AB in the plane of ABC



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

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

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

D. $2ml^2$

Answer: A

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

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

B. $1:\sqrt{2}$

C. $2:3$

D. $2:1$

Answer: A

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

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

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

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

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

Answer: A

Watch Video Solution

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

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

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

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

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

Answer: D

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53. Four identical thin rods each of mass M and length l, from a square frame. Moment of inertia of this frame about an axis through the centre of the square and perpendicular to its plane is

A. $\frac{1}{3}Ml^2$

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

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

D. $\frac{13}{3}Ml^2$

Answer: B

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54. A circular disc of moment of inertia I_t is rotating in a horizontal plane about its symmetry axis with a constant angular velocity ω_i. Another disc of moment of inertia I_b is dropped co-axially onto the rotating disc. Initially, the second disc has zero angular speed. Eventually, both the discs rotate with a constant angular speed ω_f. Calculate the energy lost by the initially rotating disc due to friction.

A. $\frac{1}{2}\frac{I_t I_b}{(I_t + I_b)}(i)_i^2$

B. $\frac{1}{2}\frac{I_t^2}{(I_t + I_b)}(i)_i^2$

C. $\frac{I_b - I_t}{(I_t + I_b)}(i)_i^2$

D. $\frac{1}{2}\frac{I_b - I_t}{(I_t + I_b)}(i)_i^2$

Answer: A

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55. Four solid spheres each of diameter $sqart5$ cm and mass 0.5 kg are placed with their centers at the corners of a square of side 4cm. The moment is $N \times 10^{-4} kg - m^2$, then N is .

A. 7

B. 8

C. 9

D. 6

Answer: C

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

A. more than 3 but less than 6

B. more than 6 but less than 9

C. more than 9

D. less than 3

Answer: A

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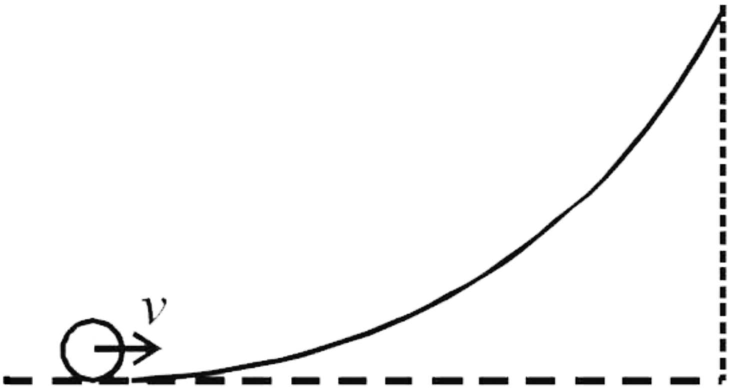
57. A small object of uniform density rolls up a curved surface with an initial velocity v. it reaches up to a maximum height of $\frac{3v^2}{4g}$ with respect to the initial position. The object is



A. Circular Disc

B. Ring

C. Solid sphere

D. Hollow sphere

Answer: A

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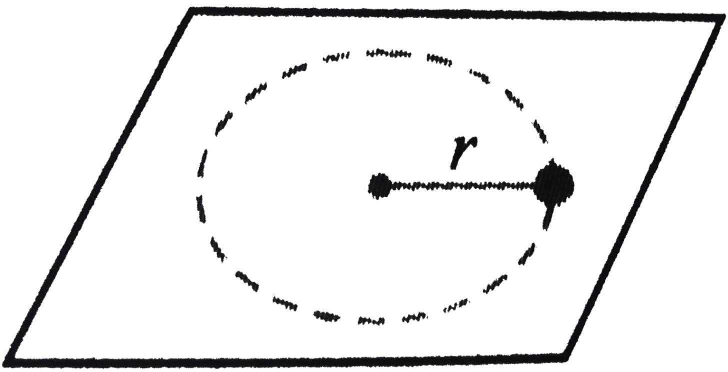
58. A small mass attached to a string rotates on a frictionless table top as shown in Fig. If the tension in the string is increased by pulling the string causing the radius of the circular motion to decrease by a factor of 2, the kinetic energy of the mass will



A. $\frac{1}{4}mv_0^2$

B. $2mv_0^2$

C. $\frac{1}{2}mv_0^2$

D. mv_0^2

Answer: B

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59. An autmobile moves on road with a speed of $54km/h$. The radius of its wheel is $0.45m$ and the moment of inertia of the wheel about its axis of rotation is $3kgm^2$. If the vehicle is brought to rest in $15s$, the magnitude of average torque tansmitted by its brakes to the wheel is :

A. $2.86kgm^2s^{-2}$

B. $6.66kgm^2s^{-2}$

C. $8.58kgm^2s^{-2}$

D. $10.86kgm^2s^{-2}$

Answer: B

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60. The moment of inertia of a uniform cylinder of length l and $radius R$ about its perpendicular bisector is I. What is the ratio l/R such that the moment of inertia is minimum ?

A. 1

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

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

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

Answer: C

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

A. 24

B. 36

C. 18

D. 12

Answer: D

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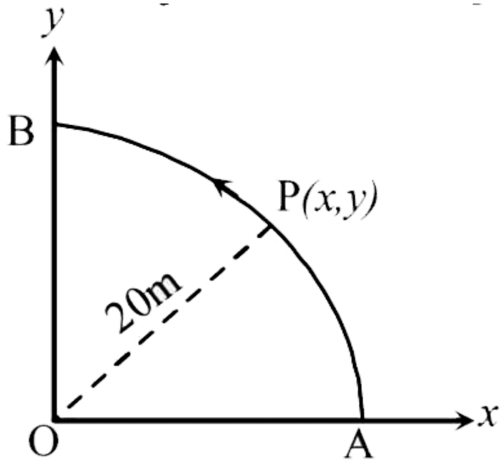
62. A point P moves in counter - clockwise direction on a circular path as shown in the figure . The movement of P is such that it sweeps out a length $s = t^3 + 5$, where s is in metres and t is in seconds . The radius of the path is $20m$. The acceleration of P when

$t = 2s$ is nearly .



A. $14m / s^2$

B. $13m / s^2$

C. $12m / s^2$

D. $7.2m / s^2$

Answer: A

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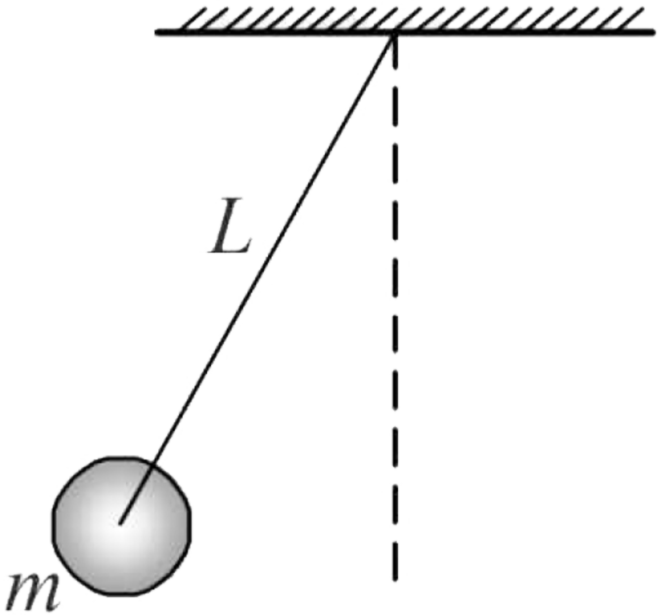
63. A ball of mass (m) 0.5g is attached to the end of a string having length (L) 0.5m. The ball is rotated on a horizontal circular path about vertical axis. The maximum tension that the string can bear is 324N. The maximum possible value of anguar velocity of ball(in radian/s) is



A. 9

B. 18

C. 27

D. 36

Answer: D

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

A. 1

B. 2

C. 3

D. 5

Answer: C

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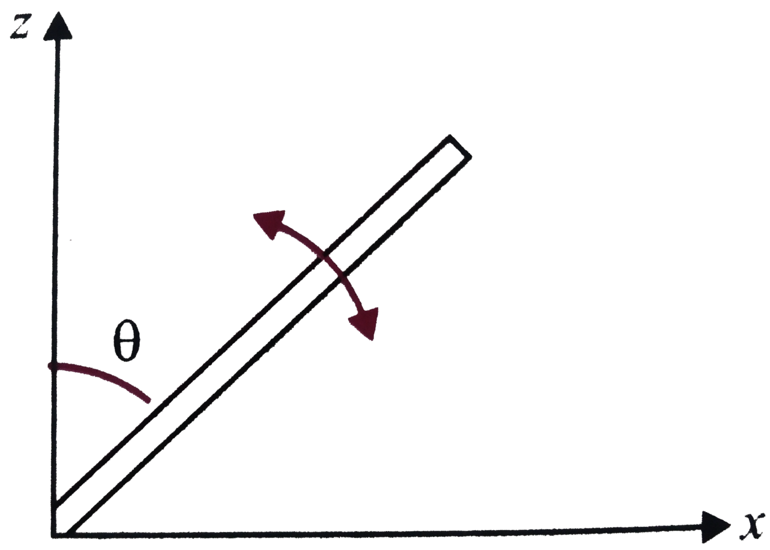
65. A slender uniform rod of mass M and length l is pivoted at one ens so that it can rotate in a vertical plane, Fig. There is negligible friction at the pivot. The free end is held vertically above the pivot and then released. The angular acceleration of the rod when it makes an angle θ with the vertical is



A. $\frac{3g}{2l}\cos\theta$

B. $\frac{2g}{3l}\cos\theta$

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

D. $\frac{2g}{3l}\sin\theta$

Answer: C

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

A. $5:7$

B. $2:3$

C. $2:5$

D. $7:5$

Answer: A

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67. A rod of length L is hinged from one end. It is brought to a horizontal position and released. The angular velocity of the rod, When it is in verticle position is

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

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

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

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

Answer: B

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68. A force $\overrightarrow{F} = \alpha\hat{i} + 3\hat{j} + 6\hat{k}$ is acting at a point $\overrightarrow{r} = 2\hat{i} - 6\hat{j} - 12\hat{k}$. The value of α for which angular momentum about origin is conserved is

A. 1

B. -1

C. 2

D. zero

Answer: B

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69. Two stone of masses m and $2m$ are whirled in horizontal circles, the heavier one in a radius $r/2$ and the lighter one in radius r. The tangential speed of lighter stone is n times that of the value of heavier stone when thy experience same centripetal forces. the value of n is

A. 1

B. 2

C. 3

D. 4

Answer: B

Watch Video Solution

70. A uniform metallic rod rotates about its perpendicular bisector with constant angualr speed. If it is heated uniformly to raise its temperature slightly, then

A. its speed of rotation increases

B. its speed of rotation decreases

C. its speed of rotation remains same

D. its speed increases because its moment of inertia increases

Answer: B

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71. A unifrom disc is acted by two equal forces of magnitude F. One of them, acts tangentially to the disc, while other one is acting at the central point of the disc. The friction between disc surface and ground surface in nF. If r be the radius of the disc, then the value of n would be (in N)

A. 0

B. 1.2

C. 2.0

D. 3.2

Answer: A

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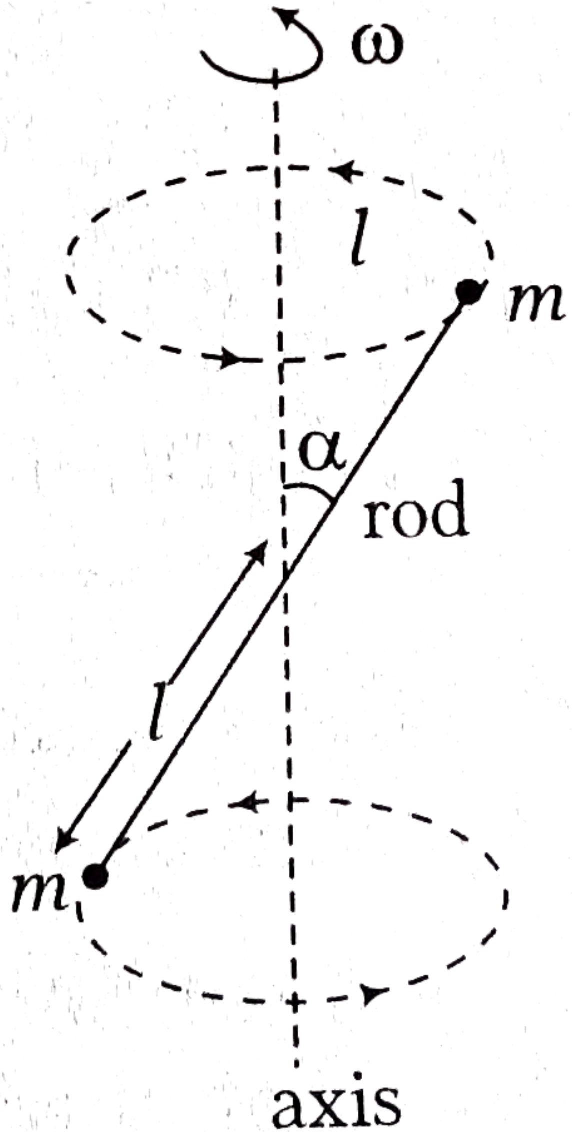
72. A massless rod S having length $2l$ has equal point masses attached to its two ends as shown in figure. The rod is rotating about an axis passing through its centre and making angle α with the axis. The magnitude of change of momentum of rod i.e., $\left|\frac{dL}{dt}\right|$ equals



A. $2ml^3\omega^2 \sin\alpha . \cos\alpha$

B. $ml^2\omega^2 \sin 2\alpha$

C. $ml^2 \sin 2\alpha$

D. $m^{1/2}l^{1/2}\omega \sin\alpha . \cos\alpha$

Answer: B

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73. A hemispherical bowl of radius R si set rotating abouv its axis of symmetry whichis kept vertical. A small blcok kept in the bowl rotates with the bowl without slippingn on its surface. If the surfaces of the bowl is mooth, and the abgel made by the radius through the block with the vertical is θ, find the angular speed at which the bowl is rotating.

A. $\omega = \sqrt{rg \sin \theta}$

B. $\omega = \sqrt{g / r \cos \theta}$

C. $\omega = \sqrt{\dfrac{gr}{\cos \theta}}$

D. $\omega = \sqrt{\dfrac{gr}{\tan \theta}}$

Answer: B

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74. A uniform circular disc of radius $50cm$ at rest is free to turn about an axis, which is perpendicular to the plane and passes through its centre. It is subjected to a torque which produces a constant angular acceleration of $2.0rad/s^2$. Its net acceleration in m/s^2 at the end of $2.0s$ is approximately

A. 7.0

B. 6.0

C. 3.0

D. 8.0

Answer: D

Watch Video Solution

75. A uniform sphere of mass $500g$ rolls without slipping on a plane surface so that its centre moves at a speed of $0.02m/s$.

The total kinetic energy of rolling sphere would be (in J)

A. $1.4 \times 10^{-4} J$

B. $0.75 \times 10^{-3} J$

C. $5.75 \times 10^{-3} J$

D. $4.9 \times 10^{-5} J$

Answer: A

Watch Video Solution

76. A bob of mass m attached to an inextensible string of length l is suspended from a vertical support. The bob rotates in a horizontal circle with an angular speed ω red/s about the vertical. About the point of suspension:

A. angular momentum changes in direction but not in magnitude,

B. angular momentum changes both in magnitude and direction,

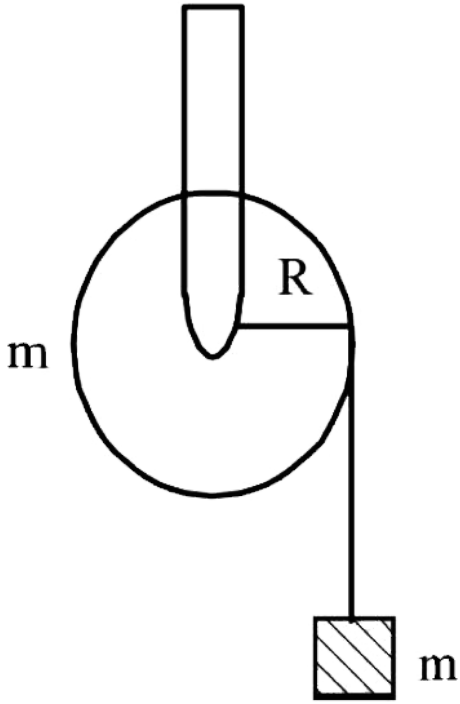
C. angular momenrum is conserved,

D. angular momentum changes in magnitude, but not in direction.

Answer: A

Watch Video Solution

77. A mass 'm' is supported by a massless string wound around a uniform hollow cylinder of mass m and radius R. If the string does not slip on the cylinder, with what acceleration will the mass fall or release?



A. $5g/6$

B. g

C. $2g/3$

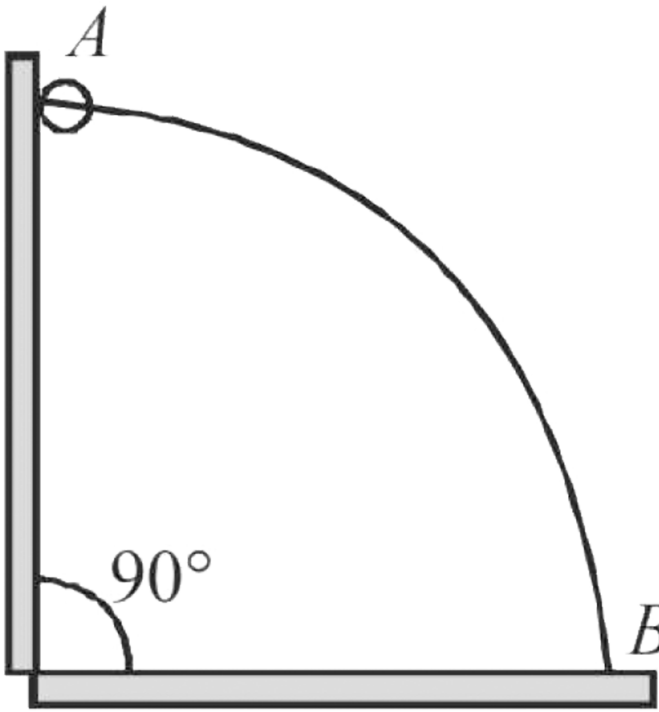
D. $g/2$

Answer: D

Watch Video Solution

78. A wire, which passes through the hole in a small bead, is bent in the form of quarter of a circle. The wire is fixed vertically on ground as shown in the figure. The bead is released from near the top of the wire and it slides along the wire without friction. As the bead moves from

A to B, the force it applies on the wire is



A. always radially outwards

B. always radially inwards

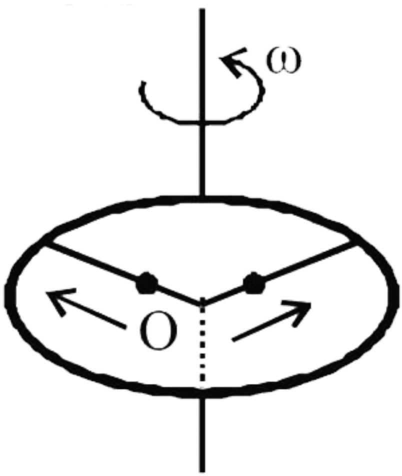
C. radially outwards initially and radially inwards later

D. radially inwards initially and radially outwards later.

Answer: D

Watch Video Solution

79. A ring of mass M and radius R is rotating with angular speed ω about a fixed vertical axis passing through its centre O with two point masses each of mass $\frac{M}{8}$ at rest at O. These masses can move radially outwards along two massless rods fixed on the ring as shown in the figure. At some instant the angular speed of the system is $\frac{8}{9}\omega$ and one fo the masses is at a distance of $\frac{3}{5}R$ from O. At this instant the distance of the other mass from O is



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

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

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

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

Answer: D

Watch Video Solution

80. A unifrom circular disc of radius $50cm$ at rest is free to turn about an axis, which is perependicular to the plane and passes through its centre. It is subjected to a torque which produces a constant angualr acceleration of $2.0 rad / s^2$. Its net acceleration in m / s^2 at the end of $2.0 s$ is approximately

A. 7.0

B. 6.0

C. 3.0

D. 8.0

Answer: D

Watch Video Solution

81. A paritcal of mass $10g$ moves along a circle of radius $6.4cm$ with a constant tangennitial acceleration. What is the magnitude of this acceleration . What is the magnitude of this acceleration if the kinetic energy of the partical becomes equal to $8 \times 10^{-4} J$ by the end of the second revolution after the beginning of the motion?

A. $0.15m/s^2$

B. $0.18m/s^2$

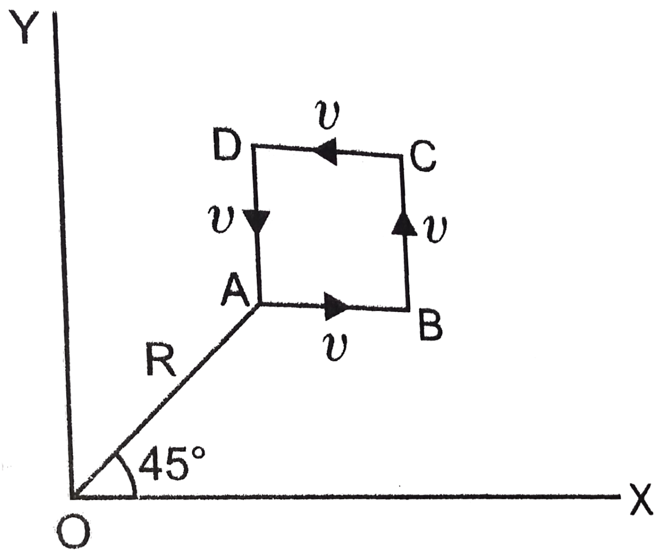
C. $0.20m / s^2$

D. $0.10m / s^2$

Answer: D

Watch Video Solution

82. A particle of mass m is moving along the side of a square of side a, with a unifrom speed v in XY palne as shown in Fig. Which of the followig statements is false for the angualr momentum $\vec{L}$ about the origin?



A. $\vec{L} = -\frac{mv}{\sqrt{2}} R\hat{k}$, when particle is moving from $A \rightarrow B$

B. $\vec{L} = -(mv)\left(\frac{R}{\sqrt{2}} - a\right)\hat{k}$, when particle is moving from $C \rightarrow D$

C. $\overrightarrow{L} = -(mv)\left(\frac{R}{\sqrt{2}} + a\right)\hat{k}$, when particle is moving from $B \to C$

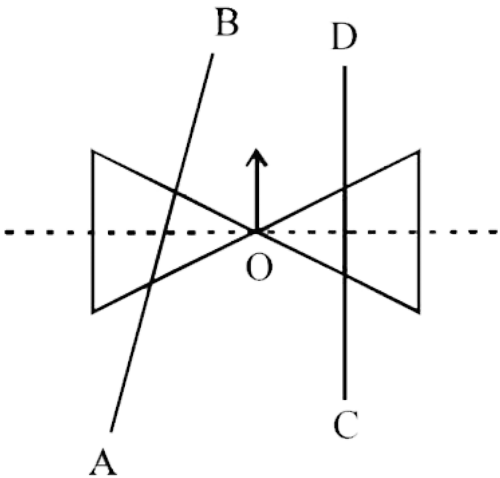
D. $\overrightarrow{L} = -\frac{mv}{\sqrt{2}}R\hat{k}$, when particle is moving from $D \to A$

Answer: B::D

Watch Video Solution

83. A roller is made by joining together two cones at their vertices O, ti is kept on two rails

AB and CD, which are placed asymmetrically with its axis perpendiuclar to CD and its center O at the centre of line joining AB and Cd it is given a light push so that it starts rolling with its centre O moving parallel to CD in the direction shown As it moves, the roller wil tand to:



A. turn left

B. turn right

C. go straight

D. turn left and right alternately

Answer: A

Watch Video Solution

84. A satellite is revolving in a circular orbit at a height 'h' from the earth's surface (radius of earth R, h ltltR). The minimum increase in its orbital velocity required, So that the satellite could escape from the erth's gravitational field, is close to :(Neglect the effect of atomsphere.)

A. $\sqrt{2gR}$

B. $\sqrt{gR}$

C. $\sqrt{gR/2}$

D. $\sqrt{gR}(\sqrt{2}-1)$

Answer: D

Watch Video Solution

85. A particle of mass $2kg$ located at the position $\left(\hat{i}+\hat{j}\right)m$ has velocity $2\left(\hat{i}-\hat{j}+\hat{k}\right)m/s$. Its angualr momentum about Z-axis in kgm^2/s is

A. $+4$

B. -8

C. $+8$

D. -4

Answer: B

Watch Video Solution

86. A wheel of radius R rolls on the ground with a unifrom velocity v. The velocity of topmost point releative to bottom must point is

A. zero

B. $2v$

C. v

D. $v/2$

Answer: B

Watch Video Solution

87. The centre of a wheel rolling on a plaen surface moves with a speed v_0. A particle on the rim of the wheel at the same level as the centre will be moving at speed

A. $\sqrt{2}v_0$

B. $2v_0$

C. v_0

D. zero

Answer: A

Watch Video Solution

88. A disc and a solid sphere of same radius but different masses roll off on two inclined planes of the same altitude and length. Which one of the two objects gets to the bottom of the plane first ?

A. solid sphere

B. both reach at the same time

C. depends on their masses

D. disc

Answer: A

Watch Video Solution

89. A particle moves so that its position vertor is given by $\vec{r} = \cos \omega t \hat{x} + \sin \omega t \hat{y}$, where ω is a constant. Which of the following is true?

A. velocity and acceleration both are perpendicular to $\overrightarrow{r}$

B. velocity and acceleration both are parallel to $\overrightarrow{r}$

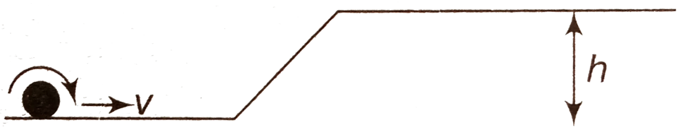
C. velocity is perpendicular to $\overrightarrow{r}$ and acceleeration is directed towards the origin

D. velocity is perpendicular to $\overrightarrow{r}$ and acceleeration is directed away from the origin

Answer: C

Watch Video Solution

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



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

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

C. $2gh$

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

Answer: A

Watch Video Solution

91. A particle of mass $m = 5$ unit is moving with a uniform speed $v = 3\sqrt{2}$ unit XY plane aong the line $Y = X + 4$. The magnitude of the angular momentum about origin is

A. $40\sqrt{2}unit$

B. $7.5unit$

C. zero

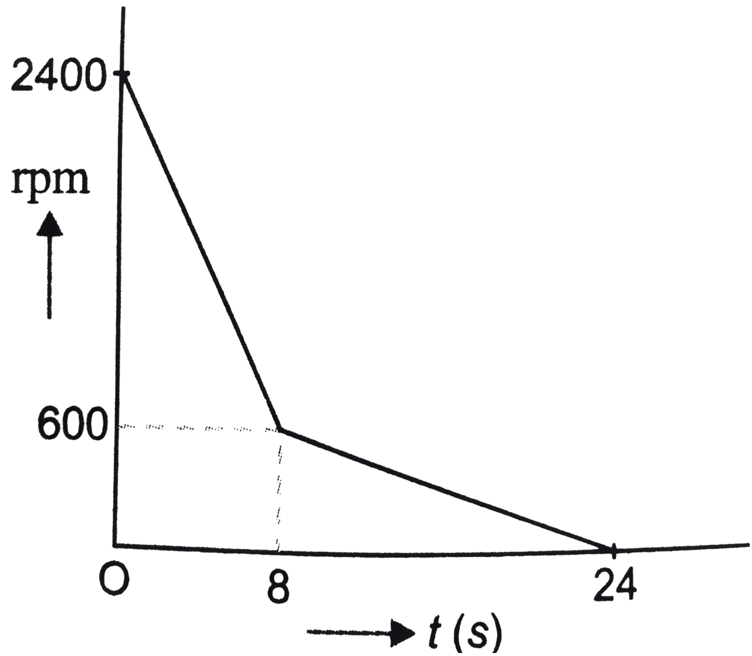
D. $60unit$

Answer: D

Watch Video Solution

92. A table fan rotating at a speed of 2400 rpm is switched off and the resulating variation of the revolution/minute time is shown in Fig.

The total number of revolutions of the fan before it comes to rest is



A. 280

B. 380

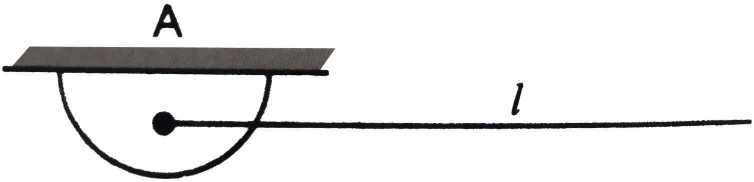
C. 420

D. 160

Answer: A

Watch Video Solution

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



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

B. $\frac{3g}{l}$

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

D. $\frac{2g}{l}$

Answer: A

Watch Video Solution

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

A. 1

B. 2

C. 3

D. 5

Answer: C

Watch Video Solution

95. A sphere can roll on a surface inclined at an angle θ if the friction coefficient is more than $\frac{2}{7} g \sin \theta$. Suppose the friction coefficient is $\frac{1}{7} g \sin \theta$, and a sphere is released from rest on the incline,

A. it will stay at rest

B. it will translate and rotate about the centre

C. it will make pure translational motion

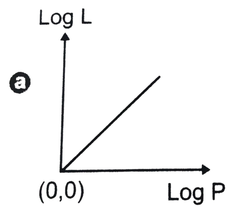
D. the angular momentum of the sphere about its centre will remian constant.

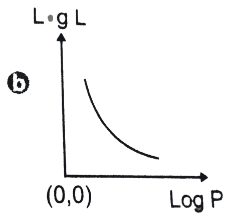
Answer: B

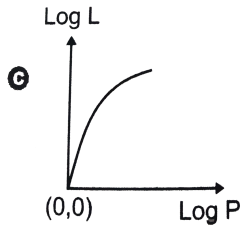
Watch Video Solution

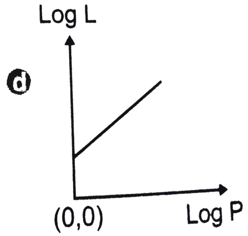
96. Angular momentum L is given by $L = Pr$

The variation of log L and $\log P$ is correctly shown in Fig.

A. 

B. 

C. 



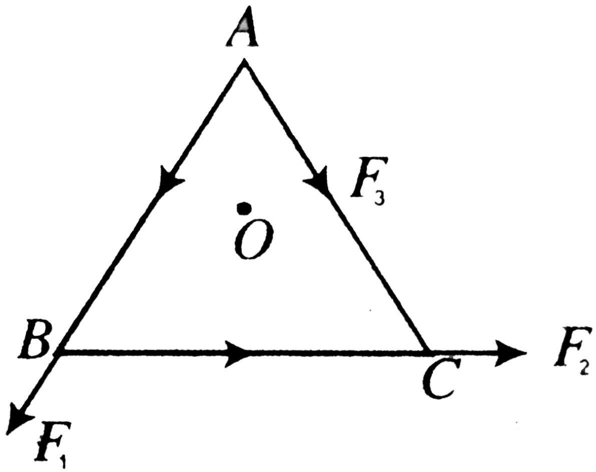
D.

Answer: D

Watch Video Solution

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

so that the total torque about O is zero?



A. $\dfrac{F_1 + F_2}{2}$

B. $2(F_1 + F_2)$

C. $(F_1 + F_2)$

D. $(F_1 - F_2)$

Answer: C

Watch Video Solution

98. A solid cylinder and a hollow cylinder, both of the same mass and same external fiameter are released from the same height at the same time on an inclined plane. Both roll down without slipping. Which one will reach the bottom first ?

A. Solid cylinder

B. Both together

C. One with higher density

D. Hollow cylinder

Answer: A

Watch Video Solution

99. A wheel has moment of inertia $5 \times 10^{-3} kgm^2$ and is making $20\text{rev}s^{-1}$. The torque needed to stop it in $10s$ is..... $\times 10^{-2} N - m$

A. 2π

B. 2.5π

C. 4π

D. 4.5π

Answer: A

Watch Video Solution

100. A wheel having moment of inertia $2kgm^2$ about its vertical axis, rotates at the rate of $60rom$ about this axis. The torque which can stop the wheel's rotation in one minuted woould be

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

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

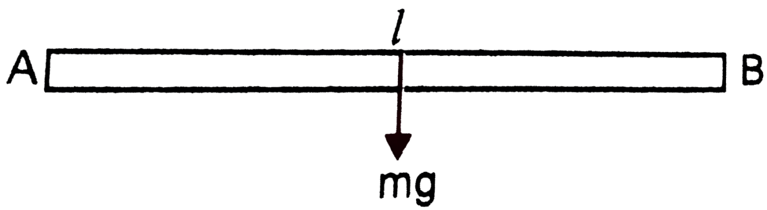
C. $\frac{2\pi}{15}N-m$

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

Answer: A

Watch Video Solution

101. A unifrom rod of length l and mass m is free to rotate in a vertical plane about A, Fig. The rod initially in horizontal position is released. The initial angular acceleration of the rod is $\left(MI \text{of rod about} A \text{is} \frac{ml^2}{3}\right)$



A. $mgl / 2$

B. $3g / 2l$

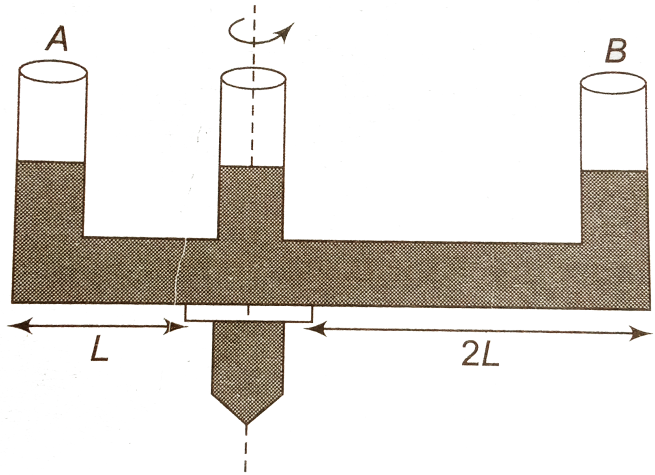
C. $2l / 3g$

D. $3g / 2l^2$

Answer: B

Watch Video Solution

102. A given shaped glass tube having uniform cross-section is filled with water and is mounted on a rotatable shaft as shown in figure. If the tube is rotated with a constant angular velocity ω then :



A. water levels in both sections A and B go up

B. water level in section A goes up and that in sectioon B comes down

C. water level in section A comes dowm andthat in B goes up

D. water level remains the same in both the sections

Answer: A

Watch Video Solution

103. A rod of length l whose lower end is fixed on a horizontal plane, starts toppling from the vertical position. The velocity of the upper end when it hits the ground is.

A. $\sqrt{3gl}$

B. $\sqrt{2gl}$

C. $2\sqrt{gl}$

D. $\sqrt{gl}$

Answer: A

Watch Video Solution

104. A cylinder of radius R and mass M rolls without slipping down a plane inclined at an angle θ. Coeff. of friction between the cylinder and the plane is μ. For what maximum inclination θ, the cylinder rolls without slipping ?

A. $\tan^{-1} \mu$

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

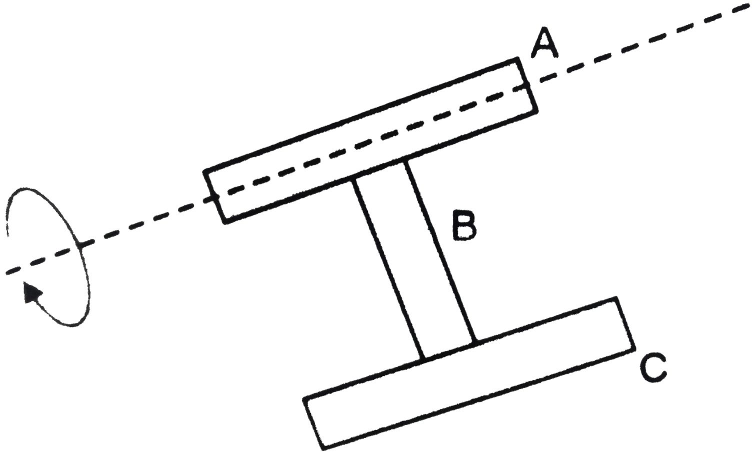
C. $\tan^{-1} 2\mu$

D. $\tan^{-1}. \frac{3}{2}\mu$

Answer: B

Watch Video Solution

105. A rigid body is made of three indentical thin rods, each of length L, fastened together in the form of letter H, Fig. The body is free to rotate about a horizontal axis that tuns along the length of one of legs of H. The body is allowed to fall from rest from a position in which plane of H is horizontal. the angular speed of body when plane of H is vertical is



A. $\sqrt{g/L}$

B. $\frac{1}{2}\sqrt{g/L}$

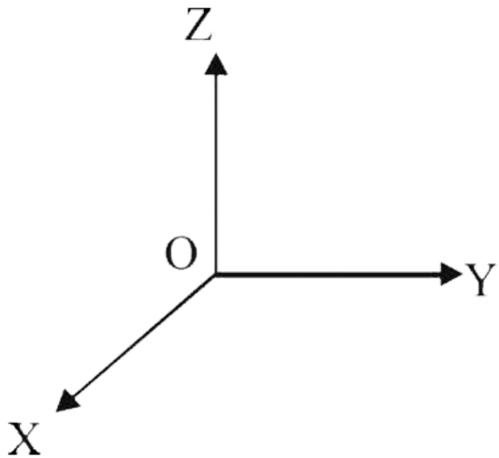
C. $2\sqrt{g/L}$

D. $\frac{2}{3}\sqrt{g/L}$s

Answer: D

Watch Video Solution

106. A force of $-F\hat{k}$ acts on O, the origin of the coodinate system. The torque about the point (1,-1) is



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

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

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

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

Answer: B

Watch Video Solution

107. If a solid sphere of mass $1kg$ and radius $0.1m$ rolls without slipping at a unifrom velocity of $1ms^{-1}$ along a stright line on a horizontal floor, the kinetic energy of the sphere is

A. $\frac{2}{5}J$

B. $1J$

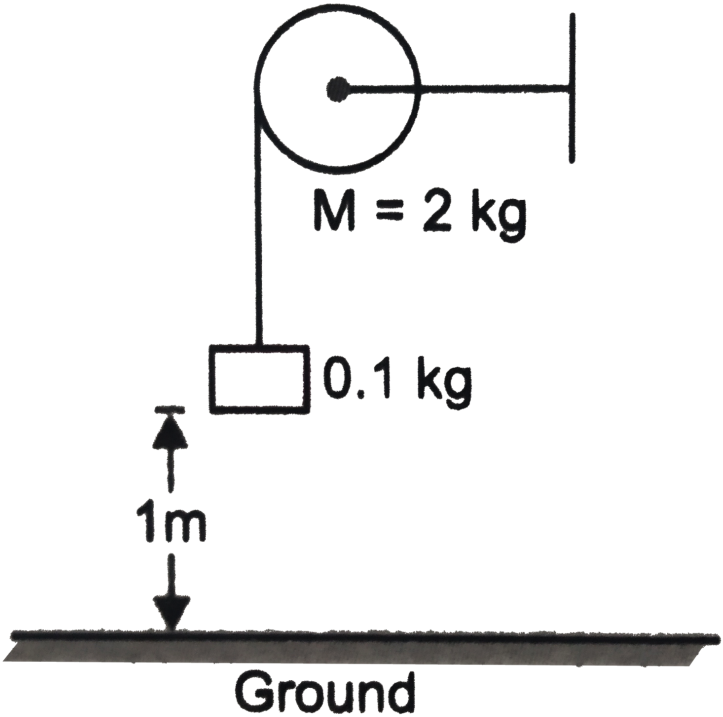
C. $\frac{7}{10}J$

D. $\frac{7}{5}J$

Answer: C

Watch Video Solution

108. A body of mass $0.1kg$ is suspended at a height of $1m$ about the ground by a weightless string which passes over a frictionless pulled, Fig. The velocity with which the body strikes the ground is



A. $\frac{11}{20}ms^{-1}$

B. $\frac{20}{11}m/s$

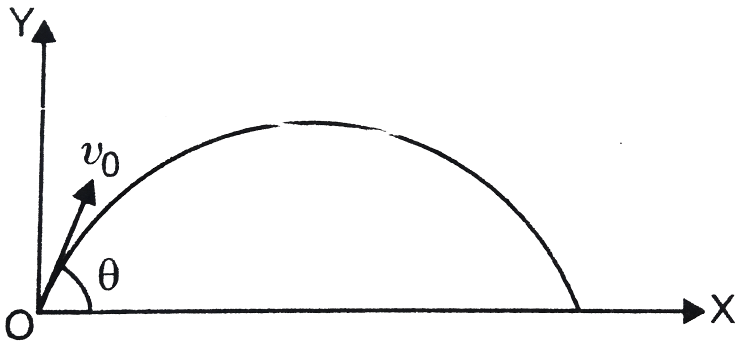
C. $\frac{10}{11}ms^{-1}$

D. $\frac{11}{10} m s^{-1}$

Answer: B

Watch Video Solution

109. A small particle of mass m is projected at an angle θ with x-axis with initial velocity v_0 in x-y plane as shown in Fig. Calculate the angular momentum of the particle at $t < \dfrac{v_0 \sin\theta}{g}$.



A. $mgv_0 t \cos\theta \hat{k}$

B. $-\dfrac{1}{2} mgv_0 t^2 \cos\theta \hat{k}$

C. $\dfrac{1}{2} mgv_0 t^2 \cos\theta \hat{i}$

D. $-mgv_0 t^2 \cos\theta \hat{j}$

Answer: B

Watch Video Solution

110. A flywheel of moment of inertia $3 \times 10^2 kgm^2$ is rotating with uniform angular speed of $4.6 rads^{-1}$. If a torque of $6.9 \times 10^2 Nm$ retards the wheel, then the time in which the wheel comes to rest is

A. $1.5s$

B. $2s$

C. $0.5s$

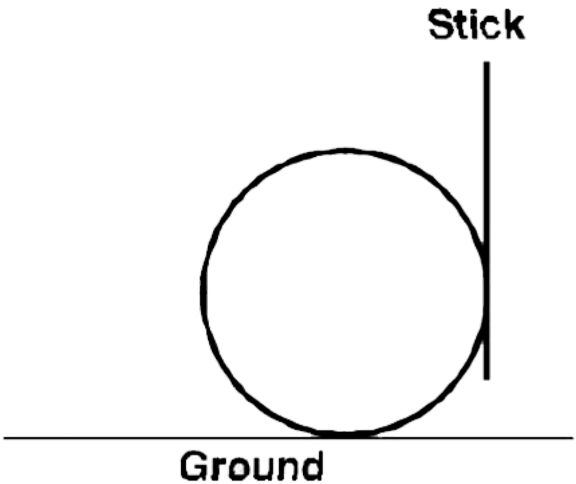
D. $1s$

Answer: B

Watch Video Solution

111. A boy is pushng a ring of mass 2kg and radius 0.5 m with a stick as shwon in figure. The stick applies a force of 2N on the ring and rolls it without slipping with an accelertaion of $0.3\frac{m}{s^2}$. The coefficinet of friction between the ground and the ring is large enough that rolling always occurs and the coefficient of friction between the stick and the ring of

(P/10). The value of P is



A. 3

B. 4

C. 5

D. 6

Answer: B

Watch Video Solution

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

A. continuously decreases

B. continuously increases

C. first increases and then decreases

D. remain unchanged

Answer: C

Watch Video Solution

113. A particle of mass 'm' is projected with a velocity v making an angle of 30° with the horizontal. The magnitude of angular moment of the projectile about the point of projection when the particle is at its maximum height 'h' is

A. $\frac{\sqrt{3}}{2}\frac{mv^2}{g}$

B. zero

C. $\frac{mv^3}{\sqrt{2}g}$

D. $\frac{\sqrt{3}}{2}\frac{mv^2}{g}$

Answer: D

Watch Video Solution

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

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

The torque on the wheel becomes zero at

A. $t = 1s$

B. $t = 0.5s$

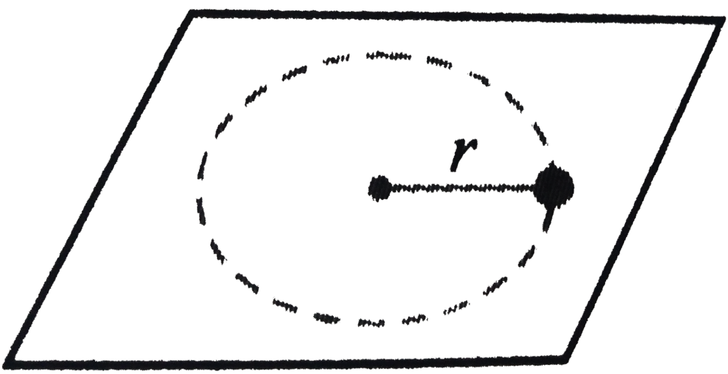
C. $t = 0.25s$

D. $t = 2s$

Answer: A

Watch Video Solution

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



A. remain constant

B. increase by a factor of 2

C. increase by a factor of 4

D. decrease by a foctor of 2

Answer: C

Watch Video Solution

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

A. $25N$

B. $50N$

C. $78.5N$

D. $157N$

Answer: D

Watch Video Solution

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

A. $5:7$

B. $2:3$

C. $2:5$

D. $7:5$

Answer: A

Watch Video Solution

118. A bob of mass m attached to an inextensible string of length l is suspended from a vertical support. The bob rotates in a horizontal circle with an angular speed ω red/s about the vertical. About the point of suspension:

A. angualr momentum changes in direction but not in magnitude,

B. angular momentum changes both in magnitude and direction,

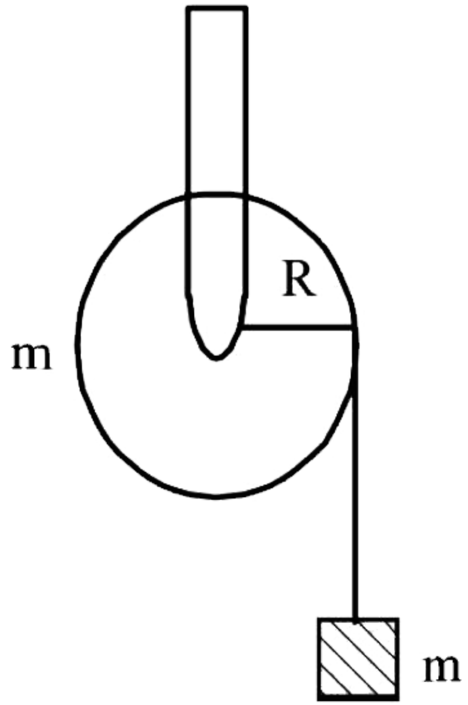
C. angular momentum is conserved,

D. angular momentum changes in magnitude, but not in direction.

Answer: A

Watch Video Solution

119. A mass 'm' is supported by a massless string wound around a uniform hollow cylinder of mass m and radius R. If the string does not slip on the cylinder, with what acceleration will the mass fall or release?



A. $5g/6$

B. g

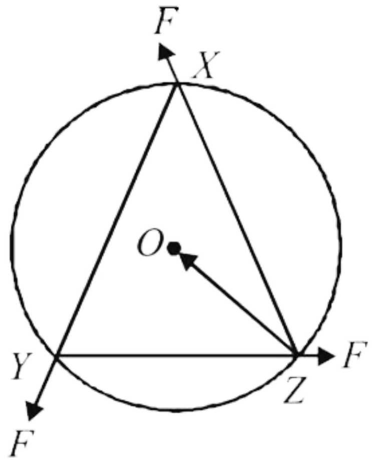
C. $2g/3$

D. $g/2$

Answer: D

Watch Video Solution

120. A uniform circular disc of mass 1.5 kg and raius 0.5 m is initially ar rest on a horiozntal frictonless surface. Three forces of equal matgnitude F = 0.5 N are applied simultaneously along the three sides of an equilateral triangle XYZ with its vertices on the perimeter of the disc (see figure). One second after applying the forces the angular speed of the disc in $rads^{-1}$ is



A. 1

B. 2

C. 3

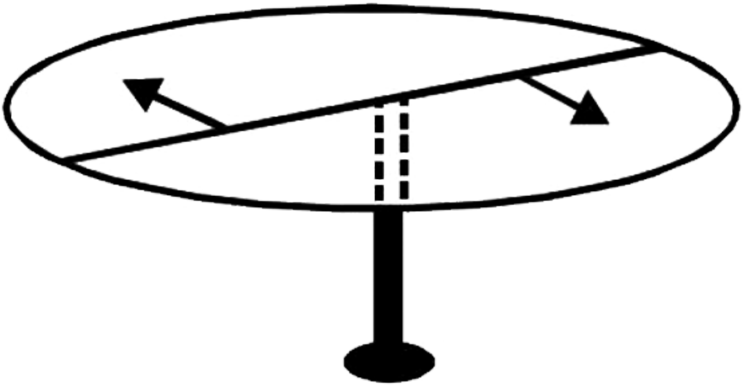
D. 4

Answer: B

Watch Video Solution

121. A horizontal circular platform of radius 0.5 m and mass axis. Two massless spring toy-guns, each carrying a steel ball of mass 0.05 kg are attached to the platform at a distance

0.25m from the centre on its either sides along its diameter (see figure). Each gun simultaneously fires the balls horizontally and perpendicular to the diameter in opposite directions. After leaving the platform, the balls have horizontal speed of $9ms^{-1}$ with respect to the ground. The rotational speed of the platform in $rads^{-1}$ after the balls leace the platform is



A. 4

B. 3

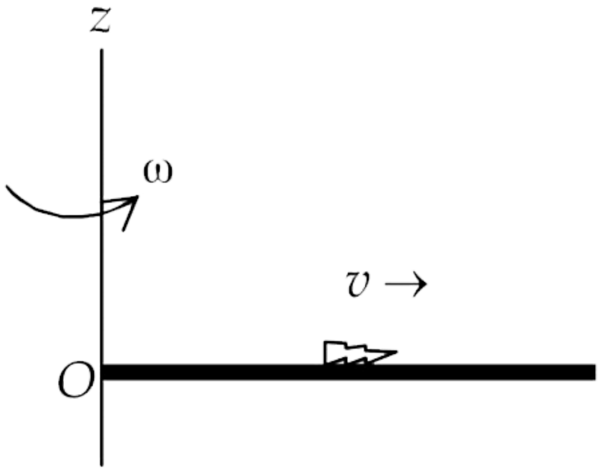
C. 2

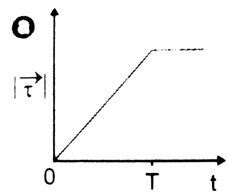
D. 1

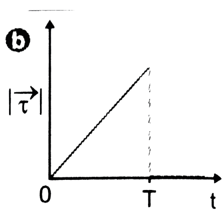
Answer: A

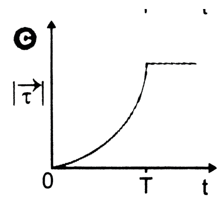
Watch Video Solution

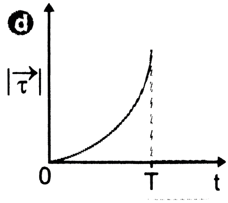
122. A thin uniform rod, pivoted at O, is rotating in the horizontal plane with constatn angular speed ω, as shown in the figure. At time t = 0, a small insect starts from O and moves with constant sped v, with respect to the rod towards the other end. It reaches the end of the rod at t =T and stops. The angular speed of the system remains ω throughout. The magnitude of the torque $\left(\left|\overrightarrow{\pi}\right|\right)$ about O, as a function of time is best represented by which plot?



A. 

B. 

C. 

D. 

Answer: B

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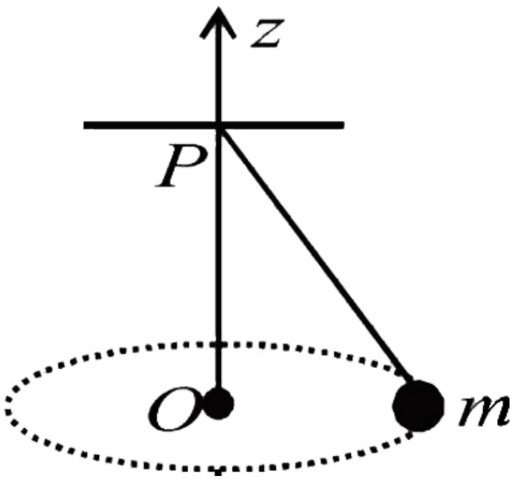
123. A small mass m is attached to a massless string whose other end is fixed at P as shown in the figure. The mass is undergoing circular motion in the x-y plane with centre at O and constant angular speed ω. If the angular momentum of the system. calculated about O and P are denoted. by $\overrightarrow{L}_O$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



A. $\overrightarrow{L_0}$ and $\overrightarrow{L_P}$ do not vary wit time

B. $\overrightarrow{L_0}$ varies wit time while $\overrightarrow{L_P}$ remains constant

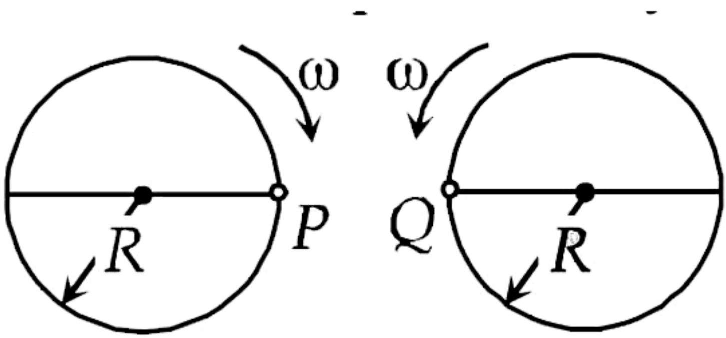
C. $\overrightarrow{L_0}$ remains consatnt, while $\overrightarrow{L_P}$ varies with time

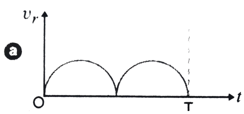
D. $\overrightarrow{L_0}$ and $\overrightarrow{L_P}$ both vary with time

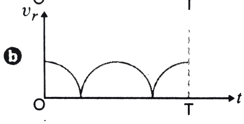
Answer: C

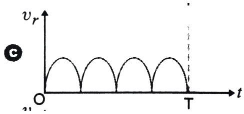
Watch Video Solution

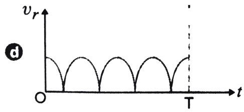
124. Two identical discs of same radius R are rotating about their axes in opposite directions with the same constant angular speed ω . The discs are in the same horizontal plane. At time $t = 0$, the points P and Q are facing each other as shown in the figure. The relative speed between the two points P and Q is v_r. In one time period (T) of rotation of the discs , v_r as a function of time is best represented by



A. 

B. 

C. 

D. 

Answer: A

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125. A circular platform is mounted on a frictionless vertical axle. Its radius $R = 2m$ and its moment of inertia about the axle is

$200 kgm^2$. It is initially at rest. A $50 kg$ man stands on the edge at the platform and begins to walk along the edge at the speed of $1 ms^{-1}$ relative to the ground. Time taken by the man to complete one revolution is :

A. πs

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

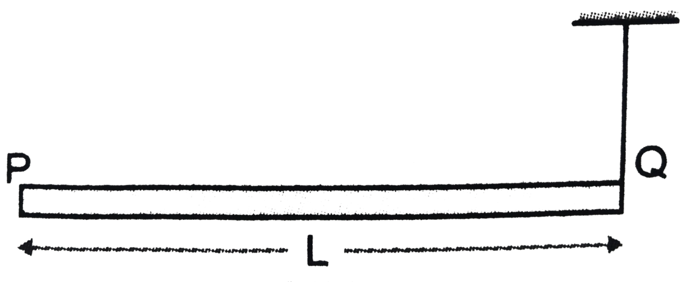
C. $2\pi s$

D. $\frac{\pi}{2} s$

Answer: C

Watch Video Solution

126. A rod PQ of mass M and length L is hinged at end P. The rod is kept horizontal by a masseless string tied to point Q as shown in Fig. When string is cut, the initial angular acceleration of the rod is :



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127. An explosion blows a rock into three parts. Two parts go off at right angles to each other . These two are $1kg$ first part moving with a velocity of $12ms^{-1}$ and $2kg$ second part moving with a velocity of $8ms^{-1}$. If the third part flies off with a velocity of $4ms^{-1}$. Its mass would be

A. $17kg$

B. $3kg$

C. $5kg$

D. $7kg$

Answer: C

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128. A hoop of radius r and mass m rotating with an angular velocity ω_0 is placed on a rough horizontal surface. The initial velocity of the centre of the hoop is zero. What will be the velocity of the centre of the hoop when it ceases ot slip?

A. $\frac{r\omega_0}{4}$

B. $\frac{r\omega_0}{3}$

C. $\frac{r\omega_0}{2}$

D. $r\omega_0$

Answer: C

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129. In circular motion, which of the following relations are valid ?

A. $\overrightarrow{v} = \overrightarrow{\omega} \times \overrightarrow{r}$

B. $\overrightarrow{a_t} = \overrightarrow{\alpha} \times \overrightarrow{r}$

C. $\overrightarrow{a_t} = \overrightarrow{\omega} \times \overrightarrow{r}$

D. $\overrightarrow{a} = \overrightarrow{\omega} \times \overrightarrow{a_t}$

Answer: A::B::C

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130. For a particle of a rotating rigid body, $v = r\omega$, which of the following are correct ?

A. $\omega \propto \dfrac{1}{r}$

B. $\omega \propto v$

C. $v \propto r$

D. ω is indepenedent of r

Answer: C::D

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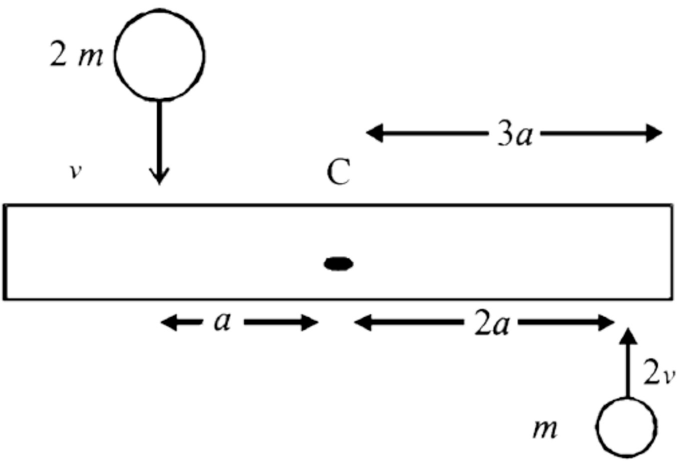
131. A uniform bar of length 6a and mass 8m lies on a smooth horizontal table. Two point masses m and 2m moving in the same horizontal plane with speed 2v and v, respectively, strike the bar [as shown in the fig.] and stick to the bar after collision. Denoting angular velocity (about the centre of mass),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



A. $v_0 = 0$

B. $\omega = (3v/5a)$

C. $\omega = (v/5a)$

D. $E = \left(3mv^2/5\right)$

Answer: A::C::D

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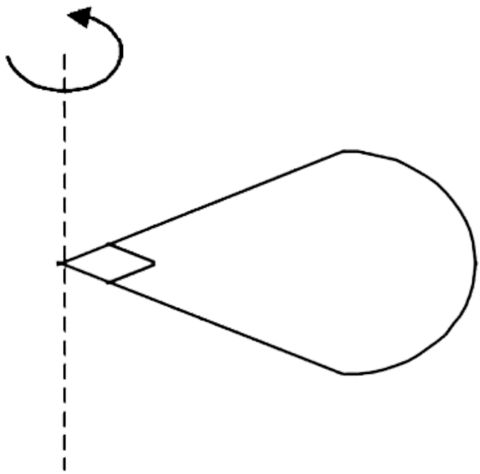
132. One quarter sector is cut from a uniform circular disc of radius R. This sector has mass M. it is made to rotate about a line perpendicular to its plane and passing through the center of the original disc. Its moment of inertia about the axis of rotation is



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

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

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

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

Answer: C

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133. If a_r and a_t respresent radial and tangential acceleration, the motion of a particle will be circualr is

A. $a_r = 0$ and $a_t = 0$

B. $a_r = 0$ but $a_t \neq 0$

C. $a_r \neq 0$ and $a_t = 0$

D. $a_r \neq 0$ and $a_t \neq 0$

Answer: C::D

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134. A simple pendulum of length L and mass (bob) M is oscillating in a plane about a vertical line between angular limit $-\phi$ and $+\phi$. For an angular displacement $\theta(|\theta| < \phi)$, the tension in the string and the velocity of the bob are T and V respectively. The following relations hold good under the above conditions:

A. $T\cos\theta = Mg$

B. $T - Mg\cos\theta = \frac{Mv^2}{L}$

C. Tangential acceleration $= g\sin\theta$

D. $T = Mg\cos\theta$

Answer: B::C

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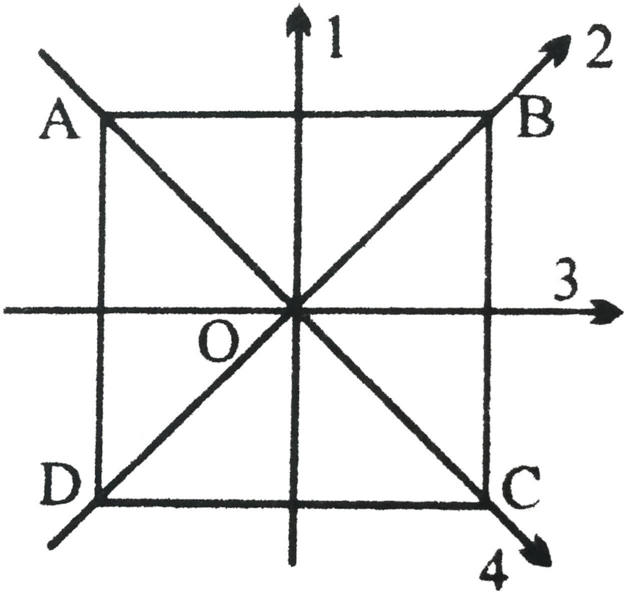
135. $ABCD$ is a square plate with centre O. The moments of inertia of the plate about the perpendicular axis through O is I and about the axes $1, 2, 3, \& 4$ are $I_1, I_2, I_3 \& I_4$

respectively. It follows that :



.

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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136. A circular disc X of radius R is made from an iron plate of thickness t, and another plate Y of radius $4R$ is made from an iron plate of thickness $t/4$. The ratio between moment of inertia I_Y/I_X is

A. 32

B. 16

C. 1

D. 64

Answer: D

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137. Two spherical bodies of mass M and 5M & radii R & 2R respectively are released in free space with initial separation between their centres equal to 12R. If they attract each other due to gravitational force only, then the distance covered by the smallar body just before collision is

A. $2.5R$

B. $4.5R$

C. $7.5R$

D. $1.5R$

Answer: C

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138. A particle moves on a straight line with a uniform velocity. The angular momentum of the particles is

A. Always zero

B. zero about a point on the stright line

C. zero about a point away from the straight line

D. constant always about a given point not on the line

Answer: B::D

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

A. zero

B. $mv^3 / (4\sqrt{2})g$

C. $mv^3 / (\sqrt{2})g$

D. $m\sqrt{2gh^3}$

Answer: B::D

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140. A nonzero external force on a system of particles. The velocity and the acceleration of the cente of mass are found to be v_0 and a_0 at an instant t. It is possible that

A. $v(0) = 0, a_0 = 0$

B. $v(0) \neq 0, a_0 = 0$

C. $v(0) = 0, a_0 \neq 0$

D. $v(0) \neq 0, a_0 \neq 0$

Answer: C::D

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141. A body A of mass M while falling wertically downwards under gravity brakes into two parts, a body B of mass $\frac{1}{3}$ M and a body C of mass $\frac{2}{3}$ M. The center of mass of bodies B and

C taken together shifts compared to that of body A towards

A. body B

B. body C

C. does not shift

D. depends on height of breaking

Answer: C

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142. A sphere is rolled on a rough horizontal surface. It gradually slows down and stops. The force of friction tries to

A. increase the angualr velocity

B. decrease the angualr velocity

C. increase the linear momentum

D. decrease the linear velocity

Answer: A::D

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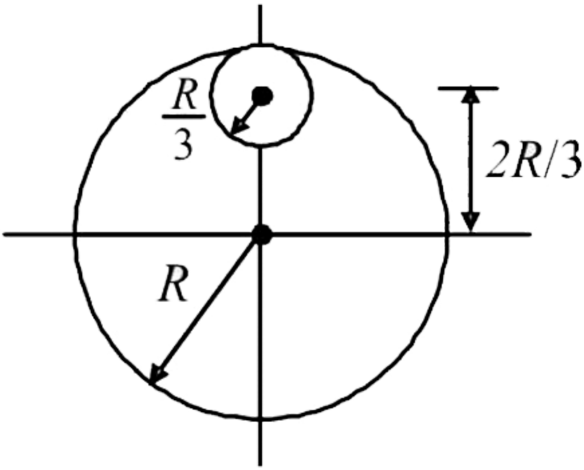
143. From a circular disc of radius R and mass 9 M , a small disc of radius R/3 is removed from the disc. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through O is



A. $4MR^2$

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

C. $10MR^2$

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

Answer: A

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144. If there is no external force acting on a nonrigid body, which of the followhng quantities must remain constant?

A. linear momentum

B. moment of inertia

C. angular momentum

D. kinetic energy

Answer: A::C

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

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

B. Cylinder P has larger linear acceleration than cylinder Q

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

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

Answer: D

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146. The centre of mass of a body is a point at which the entire mass of the body is supposed to be concentrated. The position vector $\overrightarrow{r}$ of c.m of the system of tow particles of masses m_1 and m_2 with position vectors $\overrightarrow{r_1}$ and $\overrightarrow{r_2}$ is given by

$$\vec{r} = \frac{m_1\vec{r_1} + m_2\vec{r_2}}{m_1 + m_2}$$

For an isolated system, where no external force is acting, $\overrightarrow{v_{cm}} =$ constant

Under no circumstances, the velocity of centre of mass of an isolated system can undergo a change

With the help of the comprehension given above, choose the most appropriate alternative for each of the following questions :

Two bocls of masses $5kg$ and $2kg$ are placed on a frictionless surface and connected by a spring. an external kick gives a velocity of $14m/s$ to heavier block in the direction of lengter one. the velocity gained by the centre of mass is

A. $14m/s$

B. $7m/s$

C. $12m/s$

D. $10m/s$

Answer: D

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147. The centre of mass of a body is a point at which the entire mass of the body is supposed to be concentrated. The position vector $\overrightarrow{r}$ of c.m of the system of tow particles of masses m_1 and m_2 with position vectors $\overrightarrow{r_1}$ and $\overrightarrow{r_2}$ is given by

$$\overrightarrow{r} = \frac{m_1 \overrightarrow{r_1} + m_2 \overrightarrow{r_2}}{m_1 + m_2}$$

For an isolated system, where no external force is acting, $\overrightarrow{v_{cm}} =$ constant

Under no circumstances, the velocity of centre of mass of an isolated system can undergo a change

With the help of the comprehension given above, choose the most appropriate alternative for each of the following questions :

An electron and a proton move towards eachother with velocities v_1 and v_2 respectively. the velocity of their centre of mass is

A. zero

B. v_1

C. v_2

D. $\frac{v_1 + v_2}{2}$

Answer: A

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148. The centre of mass of a body is a point at which the entire mass of the body is supposed to be concentrated. The position vector $\overrightarrow{r}$ of c.m of the system of tow particles of masses m_1 and m_2 with position vectors $\overrightarrow{r_1}$ and $\overrightarrow{r_2}$ is given by

$$\vec{r} = \frac{m_1\vec{r_1} + m_2\vec{r_2}}{m_1 + m_2}$$

For an isolated system, where no external force is acting, $\overrightarrow{v_{cm}} =$ constant

Under no circumstances, the velocity of centre of mass of an isolated system can undergo a change

With the help of the comprehension given above, choose the most appropriate alternative for each of the following questions :

A bomb dropped from an aeroplane in level flight explodes in the middle. the centre of mass of the fragments

A. is a rest

B. moves vertically downwards

C. moves vertically upwards

D. continues to follow the same parabolic path which it would have followed if there was no exposion.

Answer: D

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149. Moment of inertia of a body about a given axis is the rotational inertia of the body about that axis. It is respresented by $I = MK^2$, where M is mass of body and K is radius of gyration of the body about that axis. It is a scalar quantity, which is measured in kgm^2. when a body rotates about a given axis, and teh axis of rotates also moves, then total $K.E.$ of body $= K.E.$ of translation $+K.E.$ of rotation

$$E = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Which the help of the compreshension given above, choose the most apporpriate altermative for each of the following questions :

A circular disc and a circular ring of same mass and same diameter have, about a given axis,

A. same moment of inertia

B. unequal moments of inertia

C. cannot say

D. sometimes equal sometimes not

Answer: B

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150. Moment of inertia of a body about a given axis is the rotational inertia of the body about that axis. It is respresented by $I = MK^2$, where M is mass of body and K is radius of gyration of the body about that axis. It is a scalar quantity, which is measured in kgm^2. when a body rotates about a given axis, and teh axis of rotates also moves, then total $K.E.$ of body $= K.E.$ of translation $+K.E.$ of rotation

$$E = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Which the help of the compreshension given above, choose the most apporpriate altermative for each of the following questions :

A $40kg$ flywheel in the from of a unifrom circular disc of diameter $1m$ is making $120r \pm$. Its moment of inertia about a transverse axis through its centre is

A. $40kgm^2$

B. $5kgm^2$

C. $10kgm^2$

D. $20kgm^2$

Answer: B

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151. Moment of inertia of a body about a given axis is the rotational inertia of the body about that axis. It is respresented by $I = MK^2$, where M is mass of body and K is radius of gyration of the body about that axis. It is a scalar quantity, which is measured in kgm^2.

when a body rotates about a given axis, and teh axis of rotates also moves, then total $K.E.$ of body $= K.E.$ of translation $+K.E.$ of rotation

$$E = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Which the help of the compreshension given above, choose the most apporpriate altermative for each of the following questions :

Kinetic energy of rotation of the flywheel in the above case is

A. $20J$

B. $20J$

C. $395J$

D. $80J$

Answer: C

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FILL IN THE BLANKS

1. Centre of mass of a body is .... at which.............is............ .

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2. In certain cases, there may............at the............ .

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3. Total linear momentum of a system of particles is equal to ....of the system and velocity of ....

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4. The vector product of two vectors $\vec{A}$ and $\vec{B}$ is another..........whose magnitude is equal to.............and............between them.

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5. By convention, anticlockwise moments are ....and...........are taken as............ .

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6. Torque due to a force is the product of............and................of line of action............ .

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7. Torque due to a force is the product of............and................of line of action............ .

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8. Angular momentum of a particle..............is.................of the particle............. .

Watch Video Solution

9. Angular momentum of a particle about a given axis is ....of ....and.............of position vector of the particle.

Watch Video Solution

10. The centre of gravity of a body is a point where...........and............on the body is............... .

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11. Mass of a body is..........of..................of the body.................

Watch Video Solution

12. A quantity that measures..........of the body is called...........of the body.

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13. Radius of ....of a body about a given axis is equal to............of the constituent particles of the body............... .

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14. When.............acts on a system of particles, then............of the system remains.............. .

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15. When..............is conserved,................ may............... .

Watch Video Solution

16. Moment of inertia of a uniform circular ring of mass M and radius R about a diameter of ring is................... .

Watch Video Solution

17. Moment of inertia of a circular ring about a given axis is.............moment of inertia of.......... of............and..................about the same axis.

Watch Video Solution

18. The rate of ....of a body about a given axis is................to................applied on the body.

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19. Rotational analogue of..............is................ .

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20. Angle traced by a rotating body in nth seconds is $\theta_{nth} =$ ....where symbols have their usual meaning.

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PROBLEMS FOR PRACTICE TYPE A

1. Three blocks of uniform thickness and masses m, m and $2m$ are placed at the corners of a triangle having co-ordinates $(2.5, 1.5), (3.5, 1.5)$ and $(3, 3)$ respectively. Find the co-ordinates of the centre of mass of the system.

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2. A wheel is rotating at a speed of 1000 rpm and its $KEis10^6 J$. What is moment of inertia of the wheel about its axis of rotation ?

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PROBLEMS FOR PRACTICE

1. The centre of mass of three particles of masses $1kg, 2kg$ and $3kg$ lies at the point $(3m, 3m, 3m)$ where should a fourth particles of mass $4kg$ be positioned so that centre of mass of the four particle system at $(1m, 1m, 1m)$?

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2. Three point masses of $1kg, 2kg$ and $3kg$ lie at $(1, 2), (0, -1)$ and $(2, -3)$ respectively.

Calculate the co-ordinates of the centre of mass of the system.

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3. Two particle of mass $2kg$ and $1kg$ are moving along the same straight line with speeds $2m/s$ and $5m/s$ respectively. What is the speed of the centre of mass of the system if both the particles are moving (a) in same direction (b) in opposite direction ?

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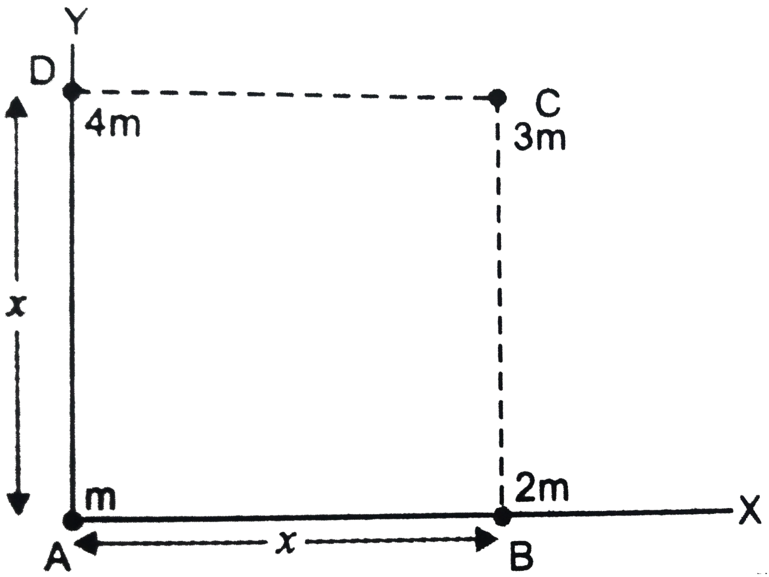
4. Four particles A, B, C and D of masses $m, 2m, 3m$ and $4m$ respectively are placed at corners of a square of side x as shown in Fig.



Locate the centre of mass.

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5. If a man of mass M jumps to the ground from a height h and centre of mass moves a distance x in time taken by him to hit the ground, show that the average force acting on him is Mgh / x.

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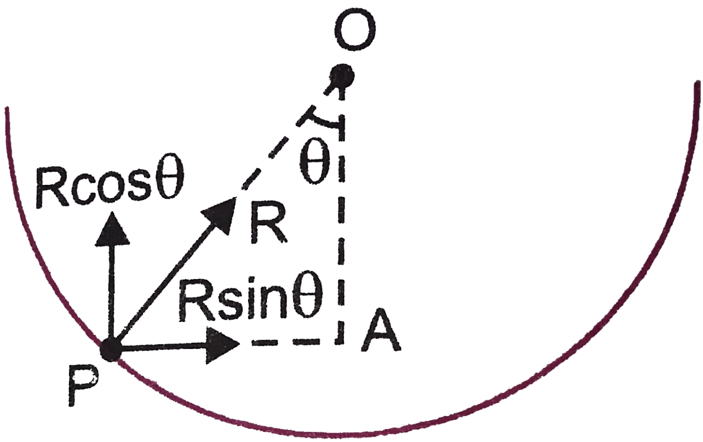
6. Four particles of masses $m_1 = 1kg, m_2 = 2kg, m_3 = 3kg$ and $m_4 = 4kg$ are located at the corners of a rectangle as shown in Fig. Locate the position of centre of mass.



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7. Two bodies of masses $10kg$ and $2kg$ are moving with velocities $\left(2\hat{i} - 7\hat{j} + 3\hat{k}\right)$ and $\left(-10\hat{i} + 35\hat{j} - 3\hat{k}\right)m/s$

respectively. Calculate the velocity of their centre of mass.

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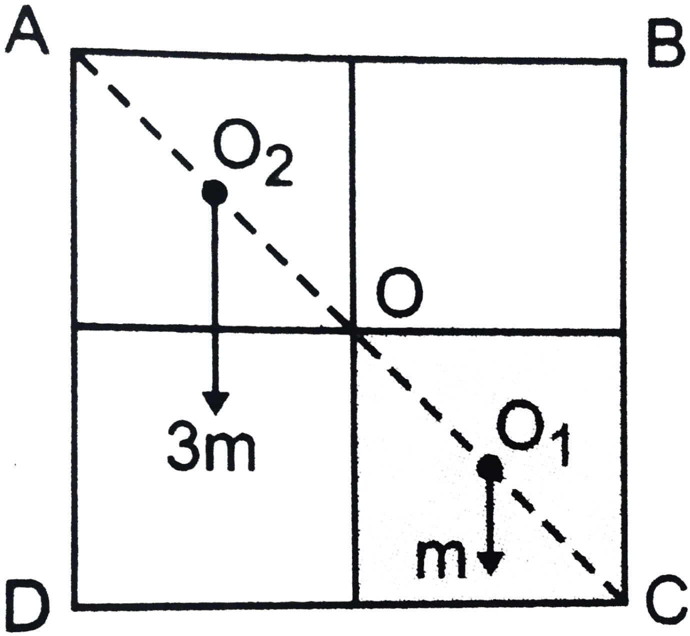
8. A square of side $4m$ having uniform thickness is divided into four equal squares as shown in Fig. If one of the squares is cut off, find



the position of centre of mass of the remaining portion from the centre O.

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9. From a uniform circular disc of diameter d, a circular disc of diameter $d/6$ and having centre at a distance $d/4$ from the centre of the disc is scooped out. Determine the centre of mass of remaining portion.

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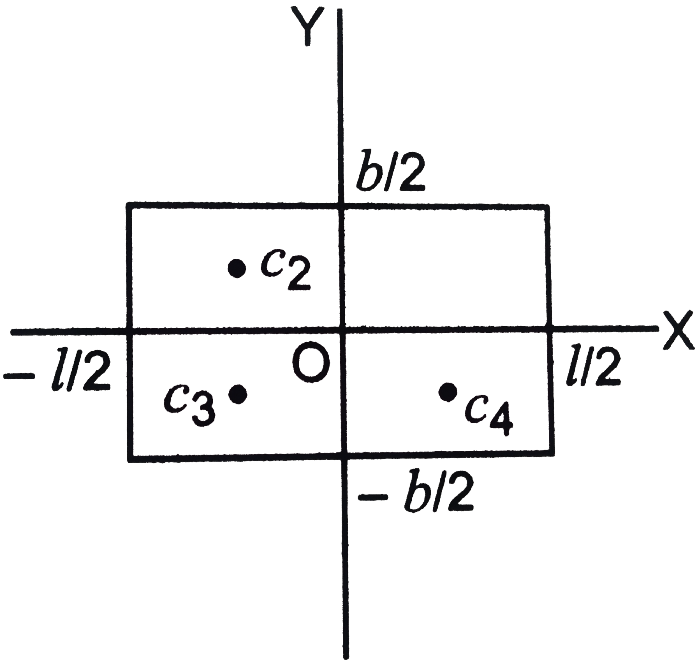
10. A rectangular plate of dimensions $l \times b$ is in $x-y$ plane as shown in Fig. If the portion of this plate lying in quadrant I is removed, find the position of centre of mass of remaining part of plate.



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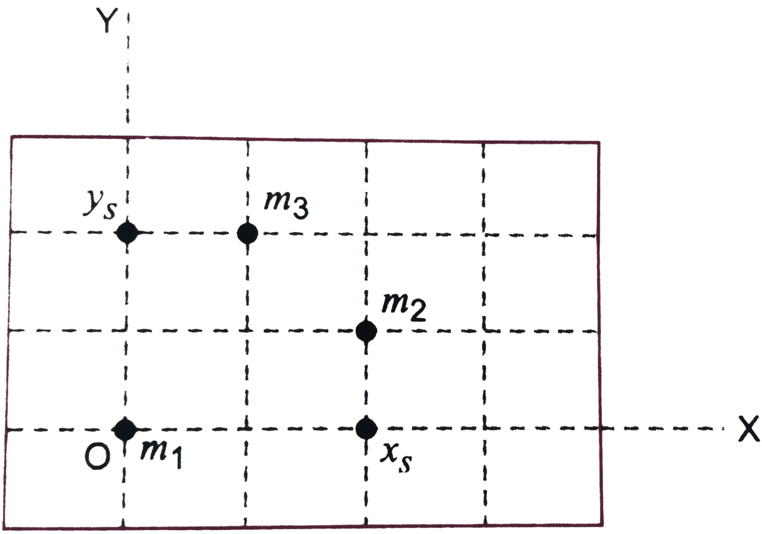
11. Fig. shown a three particle system with masses $m_1 = 3.0kg, m_2 = 4.0kg$ and $m_3 = 8.0kg$. The scales on the axes are set by $x_s = 2.0m$ and $y_s = 2.0m$. What are the co-ordinates of centre if mass ? If m_3 is gradually increased, does the centre of mass of the system shift towards or away from that particle or does it remain stationary ?



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12. A flywheel of mass $25kg$ has a radius of $0.2m$. It is making 240 rpm. What is the torque necessary to bring it to rest in $20s$? If the

torque is due to a force applies tangentially on the rim of the wheel, what is the magnitude of the force ? Assume that mass of flywheel is concentrated at its rim.

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13. A rope is wound round a hollow cylinder of mass $3kg$ and $radius 40cm$. If the rope is pulled with a force of $30N$, what is the angualr acceleration of the cylinder ?

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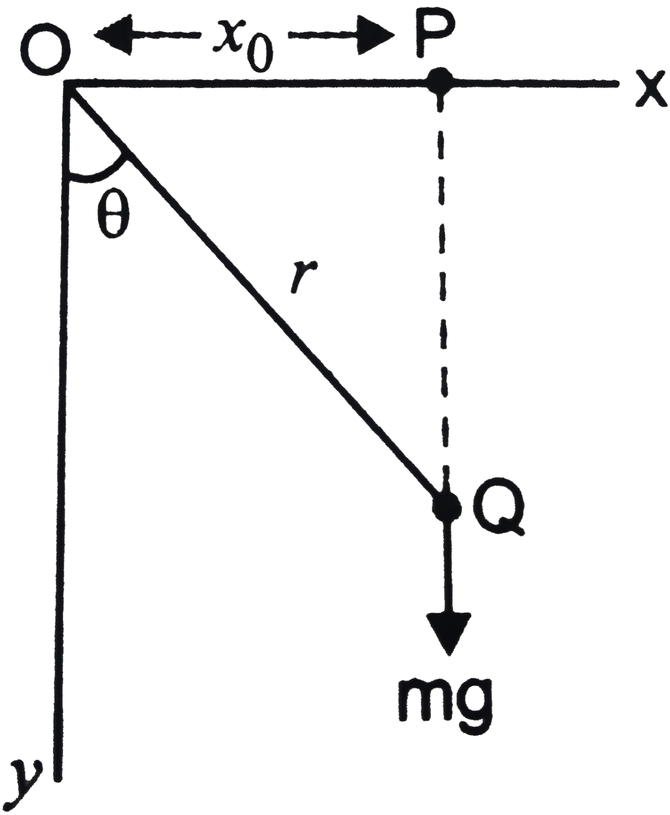
14. A particle of mass m is released from rest from point P at $x = x_0$ on X-axis from origin O and falls vertically along y-axis as shown in Fig. What is the magnitude of the torque acting on the particle at time t, when it is at the point $Q w.r.t. O$?



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15. A unifrom circular disc of mass $200g$ and radius $4cm$ is rotated about one of its diameters at an angular speed of $10rad/s$. Find its abgular momentum about the axis of rotation ?

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16. Determine the angular momentum of a car of mass $200kg$ moving in a circular track of diameter $100m$ with a speed of $40m/s$.

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17. An electron revolves around the nucleus of an atom in a circular orbit of radius 4Å with a speed of $6.0 \times 10^6 m/s$. If mass of electron is $9.0 \times 10^{-31} kg$, what is its angular momentum ?

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18. Suppose earth is a point mass of $6 \times 10^{24} kg$ revolving around the sun in a

circular orbit of diameter $3 \times 10^8 km$ in time $3.14 \times 10^7 s$. What is the angular momentum of the eart around the sun ?

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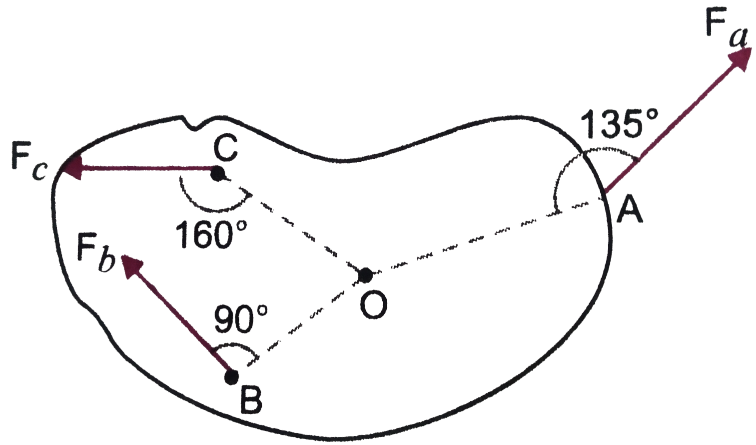
19. The body shown in Fig. is pivoted at point O. Three forces act on it $F_a = 10N$ at point A, $8.0m$ from O, $F_b = 16N$ at B, $4.0m$ from O, and $F_c = 19N$ at C, $3.0m$ from O. What is the net torque about O.



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20. The speed of a wheel increases from 600 rpm to 1200 rpm in $20s$. What is its angular acceleration ? How many revolutions will it make during this time ?

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21. A flywheel rotating at 420 rpm slows sown at a constant rate $2rads^{-2}$. What time is required to stop the flywheel ?

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22. The spin drier of a washing machine revolving at$15rps$ slows down to $5rps$, while making 50 revolutions. Find (a) angular acceleration and (b) time taken.

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23. On applying a consatnt torque, a wheel at rest, turns through 400 radian in $10s$. Find angular acceleration. If same torque continues to act, what will be angular veclocity of the wheel after $20s$ from stars ?

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24. A cord is wound around the circumference of a bicycle wheel (without tyre) of diameter $1m$. A mass of $2kg$ is tied at the end of the cord and it is allowed to fall from rest. The weight falls $2m$ in $4s$. The axle of the wheel is horizontal and the wheel rotates which its plane vertical. if $g = 10ms^{-2}$, what is the angular acceleration of the wheel ?

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25. A car is moving at a speed of $72km/h$. The diamter of its whells is $0.5m$. If the wheels are stopped in 20 rotations by applying brakes, calcualte the angular retardation produced by the brakes.

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26. An autmobile travelling at $80km/h$ has tyres of $75.0cm$ diameter. What is the angualr speed of the tyres about their axles ? If the car is brought to stop uniformly in 30 complete turns of the tyres without skidding, what is the magnitude of angular acceleration of the wheels ? How far does the car move during the braking ?

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27. A wheel rotating at an angular speed of 20 rad/s ils brought to rest by a constant trouque in 4.0 secons. If the moiment of inertia of the wheel about the axis of rotation is 0.20 $kg - m^2$ find the work done by the torque in the first two seconds.

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28. The centre of gravity of a loaded texi is $1.5m$ above the ground, and the distance between the wheels is $2m$. What is the maximum speed with which it can go round an unbanked curve of radius $100m$ without being turned upside down. What minimum value of coefficient of friction is needed at this speed ?

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29. Calculate rotational $K.E.$ of earth about its own axis, taking it to be a sphere of mass $6 \times 10^{24} kg$ and radius $6400 km$.

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30. A wheel of mass $5kg$ and radius $0.40m$ is rolling on a road without sliding with angular velocity $10 rads^{-1}$. The moment of ineria of the wheel about the axis of rotation is

$0.65 kgm^2$. The percentage of kinetic energy of rotate in the total kinetic energy of the wheel is.

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31. A thin metal hoop of radius $0.25m$ and mass $2kg$ stars from rest and rolls down an inclined plane. If its linear velocity on reaching the foot of the plane is $2m/s$, what is its rotational KE at that instant ?

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32. A circular disc of mass M and radius r is set rolling on a table. If ω be its angular velocity, show that its total $K.E.$ is given by $(3/4)Mv^2, wherev$ is its linear velocity $M.I.$ of circular disc $= (1/2)mass \times (radius)^2$.

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33. A spherical ball rolls on a table without slipping. Determine the percentage of its

$K.E.$ which is rotational. Moment of inertia of sphere $= (2/5) \times mass \times (\text{radius})^2$.

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34. A solid cylinder rolls down an inclined plane. Its mass is $2kg$ and $radius 0.1m$. It the height of the inclined plane is $4m$, what is its rotational $K.E.$ when it reaches foot of the plane ? Assume that the surfaces are smooth. Take $M.I.$ of solid cylinder about its axis = $mr^2/2$.

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35. The earth has a mass of $6 \times 10^{24} kg$ and a radius of $6.4 \times 10^{6} m$. Calculate the amount of work that must be done to slow down its rotation so that duration of day becomes 30 hrs instead of 24 hours.

Moment of inertia of earth $= \frac{2}{5} MR^{2}$.

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36. A bucket of mass $8kg$ is supported by a light rope wound around a solid wooden cylinder of mass $12kg$ and $radius 20cm$, free to rotate about its axis. A man holding the free end of the rope with the bucket and the cylinder at rest initially, lets go the bucket freely downward in a well $50m$ deep. Neglecting friction, obtain the speed of bucket and angualr speed of the cylinder just before the bucket enters water. Take $g = 10m/s^2$.

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37. A hoop of radius $2m$ weight $100kg$.It rolls along a horizontal floor so that its centre of mass has a speed of $20cms^{-1}$. How much work has to be done to stop it ?

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38. If a constant torque of $500N-m$ turns a wheel of moment of inertia $100kgm^2$ about an axis passing through its centre, find the gain in angular velocity in $2s$.

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39. A ring of diameter $0.4m$ and of mass $10kg$ is rotating about its axis at the rate of 2100 rpm. Calculate moment of inertia, angular momentum and rotational KE of the ring.

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40. A cylinder of length $20cm$ and radius $10cm$ is rotating about its central axis at an angular speed of $100rad/s$. What tangential force will stop the cylinder at a unifrom rate is $10s$?

Given moment of inertia of the cylinder about its axis of rotation is $8.0kgm^2$.

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41. A $40kg$ flywheel in the from of a unifrom circular disc $200cm$. in diameter is making 120 revolutions/minute. Calculate angular momentum. Moment of inertia of disc $= (1/2)mass \times (\text{radius})^2$.

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42. A circular ring of diameter $40cm$ and mass $1kg$ is rotating about an axis normal to its plane and passing through the centre with a frequency of $10rps$. Calculate the angular momentum about the axis of rotation.

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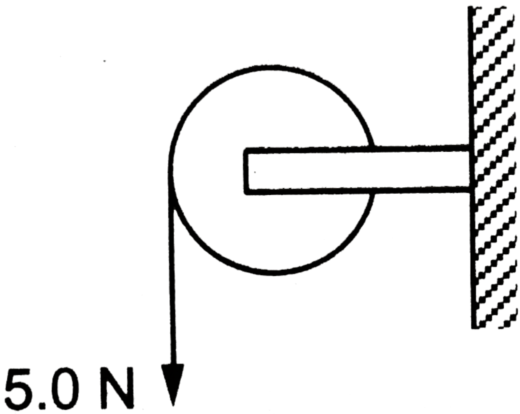
43. A wheel of radius 10 cm can rotate freely about its centre as shown in figure. A stirng is wrapped over its rim and is ulle dby a force of

5.0 N. It is found that the torque roduces an angular acceleration 2.0 $ra\frac{d}{s^2}$ in the wheel. Calculate the moment of inertia of the wheel.



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44. A force of $36N$ is applied to a particle located at $0.15m$ from the axis of rotation.

What is the magnitude of the torque about this axis, if the angle between the direction of the applied force and radius vector is (a) $120^\circ (b) 45^\circ$?

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45. A circular ring of diameter $40cm$ and mass $1kg$ is rotating about an axis normal to its plane and passing through the centre with a frequency of $10rps$. Calculate the angular momentum about the axis of rotation.

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46. A torque of 10^8 dyne - cm is applied to a fly wheel of mass $10kg$ and radius of gyration $50cm$. What is the resultant angular acceleration ?

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47. A sphere of mass $2kg$ and radius $5cm$ is rotating at the rate of 300 revolutions per minute. Calculate the torque required to stop it in 6.28 revolutions. [Moment of inertia of sphere about diameter $= 2/5 mass \times (\text{radius})^2$].

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48. A flywheel of moment of inertia 5.0 $kg-m^2$ is rotated at a speed of 60 rad/s. Because of the friction at the axle, it comes to rest in 5.0 minutes. Find a. The average torque of the friction. B. the total work done by the friction and c. the angular momentum of the wheel 1 minute before it stops rotating.

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49. How much tangential force will be needed to stop the earth in one year, if it is rotating with an angular velocity of $7.3 \times 10^{-5} rad / s$? Given moment of inertia of earth $= 9.3 \times 10^{37} kgm^2$ and radius of earth $= 6.4 \times 10^6 m.$

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50. A boy is seated in a revolving chair revolving at an angular speed of 120 rpm. By some arrangement, the boy decrease the moment of inertia of the system from $6kgm^2$ to $2kgm^2$. What will be the new angular speed ?

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51. If the earth expands suddenly to twice its diamteter, what would be the length of the day ?

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52. Prove that for an earth satellite, the ratio of its velocity at apogee (when farthest from earth) to its velocity at perigee (when closer to earth) is in the inverse ratio of its distance at apogee and perigee.

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53. A uniform disc rotating freely about a vertical axis makes 90 rpm. A small piece of wax of mass m gram falls vertically on the disc and sticks to it at a distance $r cm$ from the axis. If number of rotations per minute reduces to 60, find the moment of inertia of the disc.

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54. A circular disc of moment of inertia I_t is rotating in a horizontal plane about its symmetry axis with a constant angular velocity ω_i. Another disc of moment of inertia I_b is dropped co-axially onto the rotating disc. Initially, the second disc has zero angular speed. Eventually, both the discs rotate with a constant angular speed ω_f. Calculate the energy lost by the initially rotating disc due to friction.

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55. A disc of mass M and radius r is rotating with an angular velocity ω. If gently, two masses m each are placed at a distance $r/2$ on either side of the axis of rotation, what will be the new angular velocity ?

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56. Calculate moment of inertia of a uniform circular disc of mass $700g$ and diameter $20cm$ about

(i) an axis through the centre of disc and perpendicular to its plane, (ii) a diameter of disc, (iii) a tangent in the plane of the disc, (iv) a tangent perpendicular to the plane of the disc.

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57. What is the moment of inertia of a ring of mass $2kg$ and diameter $1m$ about a transverse axis passing through its centre. How is moment of inertia affected if axis passes through edge of the ring parallel to given axis

?

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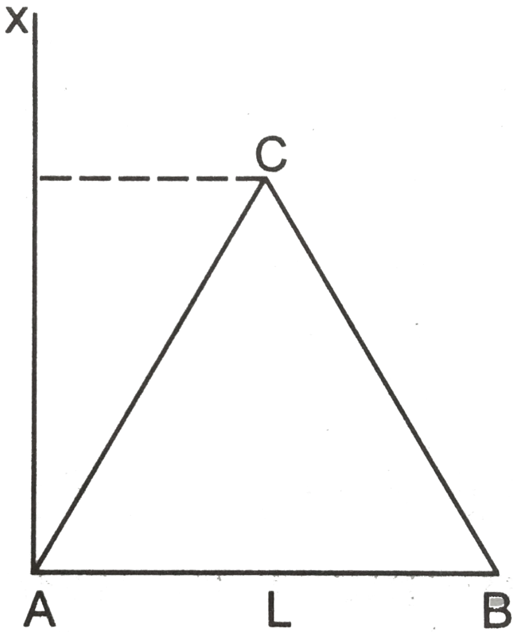
58. Three particles, each of mass m are situated at the vertices of an equilateral triangle ABC of side L figure. Find thee moment of inertia of the system about the line AX perpendicular to AB in the plane of

ABC



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59. Find the radius of gyrational and moment of inertia of a rod of mass $100g$ and length $1m$

about an axis passing through its centre and perpendicular to its length.

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60. Four particles of masses $4kg, 2kg, 3kg$ and $5kg$ are respectively located at the four corners A, B, C, D of a square of side $1m$. Calculate the moment of inertia of the system about

(i) the axis passing through point of intersection of the diagonals and perpendicualr to the plane of the square. (ii) side AB (ii) diagonal BD.

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61. Calculate the moment of inertia of a circular disc of radius $10cm$, thickness $5mm$ and uniform density $8gcm^{-3}$, about a transverse axis through the centre of the disc.

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62. The earth has a mass of $6 \times 10^{24} kg$ and a radius of $6.4 \times 10^{6} m$. Calcualte the amount of work that must be done to slow down its rotation so that duration of day becomes 30 hrs instead of 24 hours.

Moment of inertia of earth $= \frac{2}{5} MR^2$.

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63. A uniform rod of length 1 metre has a mass of $500 gram$. What is moment of inertia of the rod about an axis passing through the centre of the rod perpendicular to its length. How is moment of inertia changed when the same axis passes through one end of the rod ?

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64. The wheel of a motor, accelerated uniformly from rest, rotates through 2.5 radian during the first second. Find the angle rotated during the next second.

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65. A rod of length l whose lower end is fixed along the horizontal plane starts from the vertical position. The velocity of the upper end of the rod when it hits the ground is

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66. A uniform rod of length $1m$ having mass $1kg$ rests against a smooth wall at an angle of 30° with the ground. Calculate the force exerted by the ground on the rod. Take $g = 10 m s^{-2}$.

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67. Two small balls A and B each of mass m, are attched erighdly to the ends of a light rod of length d. The structure rotates about the perpendicular bisector of the rod at an angular speed ω. Calculate the angular momentum of the individual balls and of the system about the axis of rotation.

68. A cylinder of mass $5kg$ and radius $30cm$ is rolling down an inclined plane at an angle of 45° with the horizontal. Calculate (i) force of friction (ii) acceleration of cylinder (iii) minimum value of coeff. of static friction so that cylinder does not slip while rolling down the plane.

69. A wheel of radius $6cm$ is mounted so as to rotate about a horizontal axis through its centre. A string of negligibe mass wrapped round its circumference carries a mass of $0.2kg$ attracted to its free end. When let fall, the mass descends through $1m$ in $5s$. Calculate the angular acceleration of the wheel, its moment of inertia and tension in the cord.

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PROBLEMS FOR PRACTICE TYPE B

1. Find the torque of a force $\left(7\hat{i} + 3\hat{j} - 5\hat{k}\right)$ about the origin. The force acts on a particle whose position vector is $\left(\hat{i} - \hat{j} + \hat{k}\right)$.

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2. A $40kg$ flywheel in the from of a uniform circular disc of $1m$ radius is making 120 rpm. Calculate the angular momentum.

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PROBLEMS FOR PRACTICE TYPE C

1. A constant torque is acting on a wheel. If starting from rest, the wheel makes n rotations in t seconds, show that the angular acceleration is given by $\alpha = \frac{4\pi n}{t^2} rad s^{-2}$.

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2. The sun rotates around itself once in27 days. If it were to expand to twice its present diameter, what would be its new period of revolution ?

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PROBLEMS FOR PRACTICE TYPE D

1. Three identical spheres each of mass m and radius R are placed touching each other so that their centres A, B and C lie on a straight line. The position of their centre of mass from centre of A is

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2. Calculate moment of inertia of a circular disc about a transverse axis through the centre of the disc. Given, diameter of disc is $40cm$, thickness $= 7cm$ and density of material of disc $= 9gcm^{-3}$.

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PROBLEMS FOR PRACTICE TYPE E

1. A flywheel rotating at the rate of 120 rpm slows down at a constant rate of $2 rad s^{-2}$. What time is required to stop the flywheel and how many rations does it make in the process ?

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MULTIPLE CHOICE QUESTIONS-I

1. For which of the following does the centre of mass lie outside the body ?

A. A pencil

B. A shotput

C. A dice

D. A bangle

Answer: D

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MULTIPLE CHOICE QUESTIONS-II

1. Choose the correct alternatives :

A. For a general rotational motion, angular momentum L and angular velocity ω need not be parallel.

B. For a rotational motion about a fixed axis, angular momentum L and angualr velocity ω are always parallel.

C. For a general translational motion, mometum p and velocity v are always parallel.

D. For a general translational motion, acceleration a and velocity v are always parallel.

Answer: A,C

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Focus Multiple Choice Questions I.

1. Distance of the centre of mass of a solid uniform cone from its vertex is z_0. If the radius of its base is R and its height is h then z_0 is equal to:

A. $\frac{h^2}{4R}$

B. $\frac{3h}{4}$

C. $\frac{5h}{8}$

D. $\frac{3h^2}{8R}$

Answer: B

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Multiple Choice Questions II.

1. In a unifrom circular motion, which of the following remain constant

A. speed and ω

B. acceleration and angualr acc.

C. time period and ω

D. velocity and position vector

Answer: A::B::C

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Multiple Choice Questions III. Comprehension 1

1. The centre of mass of a body is a point at which the entire mass of the body is supposed to be concentrated. The position vector $\overrightarrow{r}$ of c.m of the system of tow particles of masses

m_1 and m_2 with position vectors $\overrightarrow{r_1}$ and $\overrightarrow{r_2}$ is given by

$$\overrightarrow{r} = \frac{m_1\overrightarrow{r_1} + m_2\overrightarrow{r_2}}{m_1 + m_2}$$

For an isolated system, where no external force is acting, $\overrightarrow{v_{cm}} =$ constant

Under no circumstances, the velocity of centre of mass of an isolated system can undergo a change

With the help of the comprehension given above, choose the most appropriate alternative for each of the following questions :

Two bodies of masses $1kg$ and $2kg$ are located at $(1, 2)$ and $(-1, 3)$ respectively. the co-ordinates of the cetre of mass are :

A. $(-1, 3)$

B. $(1, 2)$

C. $\left(-\frac{1}{3}, \frac{8}{3}\right)$

D. $\left(\frac{1}{3}, \frac{8}{3}\right)$

Answer: C

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Multiple Choice Questions Comprehension 2

1. Moment of inertia of a body about a given axis is the rotational inertia of the body about that axis. It is respresented by $I = MK^2$, where M is mass of body and K is radius of gyration of the body about that axis. It is a scalar quantity, which is measured in kgm^2. when a body rotates about a given axis, and teh axis of rotates also moves, then total $K.E.$ of body $= K.E.$ of translation $+K.E.$ of rotation

$$E = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

Which the help of the compreshension given above, choose the most apporpriate altermative for each of the following questions :

Moment of inertia of a body depends on (i) mass of body (ii) size and shape of body (iii) axis of rotation of body (iv) all the above

A. (i) and (ii)

B. (i) and (iii)

C. (ii) and (iii)

D. (iv)

Answer: D

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Integer Type Questions

1. Two homogeneous spheres A and B of masses m and $2m$ having radii $2a$ and a respectively are placed in contact. The ratio of distance of c.m from first sphere to the distance of c.m from second sphere is :

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2. A non-uniform thin rod of length L is palced along X-axis so that one of its ends is at the origin. The linear mass density of rod is $\lambda = \lambda_0 x$. The centre of mass of rod divides the length of the rod in the ratio:

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3. A sphere of mass $5kg$ and diameter $2m$ rotates about a tangent. What is its moment

of inertia in kgm^2 ?

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4. A uniform rod of length $1m$ and mass $0.5kg$ rotates at angular speed of $6rad/\sec$ about one of its ends. What is the KE (in joule) of the rod ?

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5. A particle performing uniform circular motion has angular momentum L. When its angular velocity is doubled and $K.E$ is also doubled, the new angualr momentum becomes x times. What is x ?

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6. A constant torque of $200Nm$ turns a wheel of moment of inertia $50kgm^2$ about an axis through its centre. The angualr velocity 2 sec after staring form rest (in rad/sec) would be :

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7. If k_1 is radius of gyration of a circular disc about a tangent perpendicular to plane of disc and k_2 is radius of gyration of a circular ring of same size as disc about any diameter, what is the value of K_1^2 / K_2^2 ?

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8. If earth were to shrink to $\frac{1}{8}th$ of its present volume, what would be the new length of the day in hour ?

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9. An angular ring wth inner and outer radii $R_1 = 1.2cm$ and $R_2 = 4.8cm$ is rolling without slipping with a unifrom angular speed. What is the ratio of the forces experienced by the two particles of same mass situted on the outher and inner parts of the annular ring ?

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10. A circular disc of radius r is rolling without slipping on a horizontal surface. What is the ratio of the translational KE and rotational KE of disc ?

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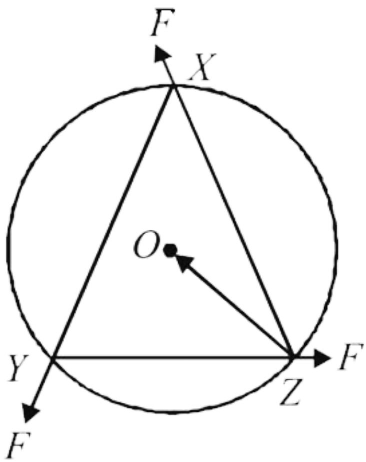
11. A uniform circular disc of mass 1.5 kg and raius 0.5 m is initially ar rest on a horiozntal frictonless surface. Three forces of equal matgnitude F = 0.5 N are applied simultaneously along the three sides of an equilateral triangle XYZ with its vertices on the perimeter of the disc (see figure). One second after applying the forces the angular speed of the disc in $rads^{-1}$ is



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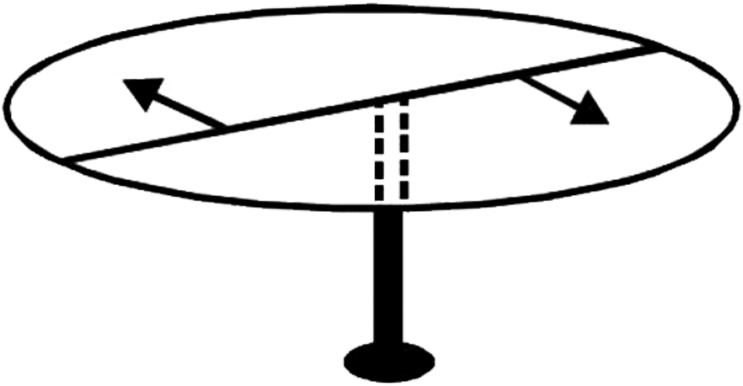
12. A horizontal circular platform of radius 0.5 m and mass axis. Two massless spring toy-guns, each carrying a steel ball of mass 0.05 kg are attached to the platform at a distance

0.25m from the centre on its either sides along its diameter (see figure). Each gun simultaneously fires the balls horizontally and perpendicular to the diameter in opposite directions. After leaving the platform, the balls have horizontal speed of $9ms^{-1}$ with respect to the ground. The rotational speed of the platform in $rads^{-1}$ after the balls leace the platform is



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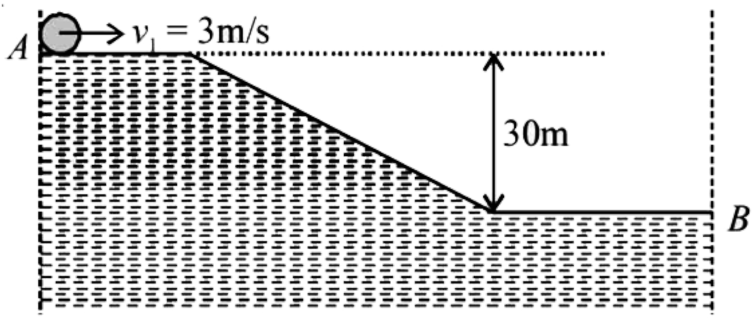
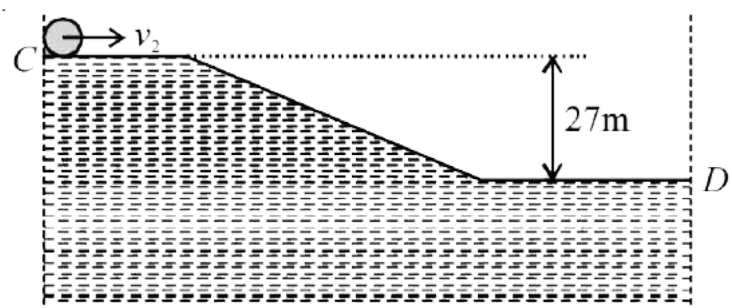
13. Two identical uniform discs roll without slipping on tow different sufaces AB and CD (see figure) starting at A and C with linear speeds v_1 and v_2 respectively, and always

remain in contact with the surfaces. If they reach B and D with the same linear speed $v_1 = 3m/s then v_2 \in m/s is (g = 10m/s^2)$





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Assertion- Reason Type questions

1. Assertion : In rolling, all points of a rigid body have the same linear velocity.

Reason : The rotational motion does not affect the linear velocity.

A. If both, Assertion and Reason are true and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: D

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2. Assertion : The speed of a whirl wind in a tornado is alarmigly high.

Reason : If no external torque acts on a body, its angualr velocity remains constant.

A. If both, Assertion and Reason are true and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: C

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3. Assertion : The velovity of a body at the bottom of an inclined plane of given height is more when it slides down the plane compared to when it is rolling down the same oplane.

Reason : In rolling down, a body acruires both kinetic energy of translation and rotation.

A. If both, Assertion and Reason are true and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: B

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4. Assertion : The moment of inertia of a rigid body reduces to its minimum value, when the axis of rotation passes through its centre of gravity.

Reason : The weight of a rigid body always acts through its centre of gravity.

A. If both, Assertion and Reason are true and the Reason is the correct explanation of the Assertion.
B. If both, Assertion and Reason are true but Reason is not a correct explanation of the Assertion.
C. If Assertion is true but the Reason is false.
D. If both, Assertion and Reason are false.

Answer: A

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5. Assertion : The centre of mass of an electron and proton, when released moves faster towards proton.

Reason : This is because proton is lighter than electron.

A. If both, Assertion and Reason are true and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: D

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6. Assertion : At the centre of earth, a body has centre of mass , but no centre of gravity.

Reason : This is because $g = 0$ at the centre of earth.

A. If both, Assertion and Reason are true and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: A

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7. Assertion : Torque is due to transverse componet is not perpendicular to radial component.

A. If both, Assertion and Reason are true and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: C

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8. Assertion : power associated with torque is product of torque and angualr speed of the body about the axis of rotation.

Reason : It is rotational analogue of power in translatory motion.

A. If both, Assertion and Reason are true and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: A

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9. Assertion : Torque is time rate of change of a parameter, called angualr momentum.

Reason : This is because in linear motion, force respresents time rate of change of linear momentum.

A. If both, Assertion and Reason are true and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: A

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10. Assertion : If earth were to shrink length of the day would increase.

Reason : Smaller object would take more time to complete one rotation around its axis.

A. If both, Assertion and Reason are true and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: D

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11. Assertion : There are two propellers in a helicopter.

Reason : Angular momentum is conserved.

A. If both, Assertion and Reason are true and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: B

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12. Assertion : If there is no external torque on a body about its centre of mass, then the velocity of the centre of mass remains constant.

Reason : The linear momentum of an isolated system remains constant.

A. If both, Assertion and Reason are true and the Reason is the correct explanation of the Assertion.

B. If both, Assertion and Reason are true but Reason is not a correct explanation of the Assertion.

C. If Assertion is true but the Reason is false.

D. If both, Assertion and Reason are false.

Answer: D

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13. Statement -1 : In the formation of a neutron star, spin angular velocity increases tremendously.

Statement-2 : Conservation of rotational kinetic energy

A. Statement-1 is true, Statement-2 is true , Statement-2 is correct explanation of Statement-1.

B. Statement-1 is true, Statement-2 is true but Statement-2 is not correct

explanation of Statement-1.

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: C

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14. Statement-1 : A wheel moving down a perfectly frictionless inclined plane shall undergo slipping (not rolling).

Statement-2 : For rolling, torque is required, which is provided by tangential froce.

A. Statement-1 is true, Statement-2 is true , Statement-2 is correct explanation of Statement-1.

B. Statement-1 is true, Statement-2 is true but Statement-2 is not correct

explanation of Statement-1.

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: A

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15. Statement-1 : Torque is a vector whose direction is along the applied froce.

Statement-2 : $\overrightarrow{\tau} = \overrightarrow{r} \times \overrightarrow{F}$

A. Statement-1 is true, Statement-2 is true , Statement-2 is correct explanation of Statement-1.

B. Statement-1 is true, Statement-2 is true but Statement-2 is not correct explanation of Statement-1.

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: D

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16. Statement-1 : The centre of mass of a body may lie where there is no mass.

Statement-2 : The centre of mass has nothing to do with the mass.

A. Statement-1 is true, Statement-2 is true , Statement-2 is correct explanation of Statement-1.

B. Statement-1 is true, Statement-2 is true but Statement-2 is not correct explanation of Statement-1.

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: C

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17. Statement-1 : Moment of inertia of a body is same, whatever be the axis of rotation.

Statement-2 : Moment of inertia depends on mass and size of rotation of the body.

A. Statement-1 is true, Statement-2 is true, Statement-2 is correct explanation of Statement-1.

B. Statement-1 is true, Statement-2 is true but Statement-2 is not correct explanation of Statement-1.

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: D

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18. Statement-1 : When ice on polar caps of earth melts, duration of the day increases.

Statement-2 : $L = I\omega = I\left(\frac{2\pi}{T}\right) = cons\tan t.$

A. Statement-1 is true, Statement-2 is true , Statement-2 is correct explanation of Statement-1.

B. Statement-1 is true, Statement-2 is true but Statement-2 is not correct explanation of Statement-1.

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: A

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19. Statement-1 : A hollow cylinder of diameter $0.5m$ has a mass of $10kg$. Its moment of inertia about its axis of symmetry is $0.625kgm^2$.

Statement-2 : $I = MR^2$

A. Statement-1 is true, Statement-2 is true , Statement-2 is correct explanation of Statement-1.

B. Statement-1 is true, Statement-2 is true but Statement-2 is not correct

explanation of Statement-1.

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: A

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20. Statement-1 : To unscrew a rusted nut, we need a wrench with longer arm.

Statement-2 : $\overrightarrow{\tau} = \overrightarrow{r} \times \overrightarrow{F}$.

A. Statement-1 is true, Statement-2 is true , Statement-2 is correct explanation of Statement-1.

B. Statement-1 is true, Statement-2 is true but Statement-2 is not correct explanation of Statement-1.

C. Statement-1 is true, but statement-2 is false.

D. Statement-1 is false, but statement-2 is true.

Answer: A

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