PHYSICS

BOOKS - S CHAND PHYSICS (ENGLISH)

CIRCULAR MOTION

Solved Examples

1. A race car negotiates a curve of radius 50.0 m on a flat road. What is its angular displacement when it covers a linear distance of 78.5 m?

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2. Earth completes one revolution round the sun in 365.25 days. What is the angular velocity ?

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3. A satellite moving in a circular orbit at an altitude of 1000 km completes one revolution round the earth in 105 minutes. What is (z) its angular velocity and speed? Radius of the earth $= 6.4 \times 10^6$m.

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4. A metal bob of mass 0.6 kg is attached to the end of a string of length 1 m and the bob is whirled in a horizontal circle with a uniform speed of 12 m/s. What is the centripetal force acting on the bob ? If the speed of the bob is 5 m/s calculate the tension in the string.

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5. A pilot of mass 70 kg in a jet aircraft moves in a vertical circle while executing the loop-the-loop at a constant speed of 200 m/s. If the radius of the circle is 2.5 km what is the force exerted by the seat on the pilot at (a) the top of the loop and (b) the bottom of the loop.

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6. What is the maximum speed with which a cylist can turn around curved path of radius 10.0 m, if the coefficient of friction between the tyre and the road is 0.5 ? If the cyclist wants to avoid overturning by what angle the cyclist must lean from the vertical ?

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7. A small toy car moves round a circular track of radius 4 m. The car makes one revolution in 10 s. Calculate (a) the speed of the car, (b) its centripetal acceleration, (c) the centripetal force exerted,by the track if the.mass of the car is 200 g, (d) the safe speed with which the car can move around without toppling, if the distance between the wheels is 4 cm and the height of the centre of gravity of the car from the horizontal is 2 cm.

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8. A pick up van negotiates an unbanked curve of radius 40 m with a crate of eggs in the middle of its flat bed. If the coefficient of static friction between the crate and the truck, is 0.55 what is the maximum speed the van can take, so that the crate does not slide ?

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9. The radius of the bump on a road is r. What force does the road exert on a car of mass m when the car passes the highest point on the bump ? Calculate the maximum speed with which the car can pass the highest point before losing contact wtih the road ?

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10. At what angle must a railway track with a level of 300 m radius be banked for safe running of trains at a speed of $90 kmh^{-1}$?

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11. A cyclist riding at a speed, of $24.25ms^{-1}$ takes a round a circular road of radius 34.64 m. What is his inclination to the vertical ?

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12. An aeroplane travelling at a speed of 500 km/hr tilts at an angle of 30^{o} as it makes a turn. What is the radius of the curve ?

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13. The distance between the inner and outer wheels of a car is 1.75 m and its centre of gravity is 0-50 m above the ground. What is the maximum speed with which the car can negotiate a curve of radius of 40 m without overturning ?

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14. A bend in a level road has a radius of 100 m. What is the maximum speed which a car turning this bend may have without skidding if the coefficient of friction between the road and the tyres in 0.3. If the centripetal force is provided by 'banking' what is the angle of banking?

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15. The bob of a pendulum is released from a horizontal position. If the lenght of the pendulum is 1.5 m what is the speed with which the bob arrives at the lowermost point, given that it dissipated $5\,\%$ of its initial energy against air resistance?

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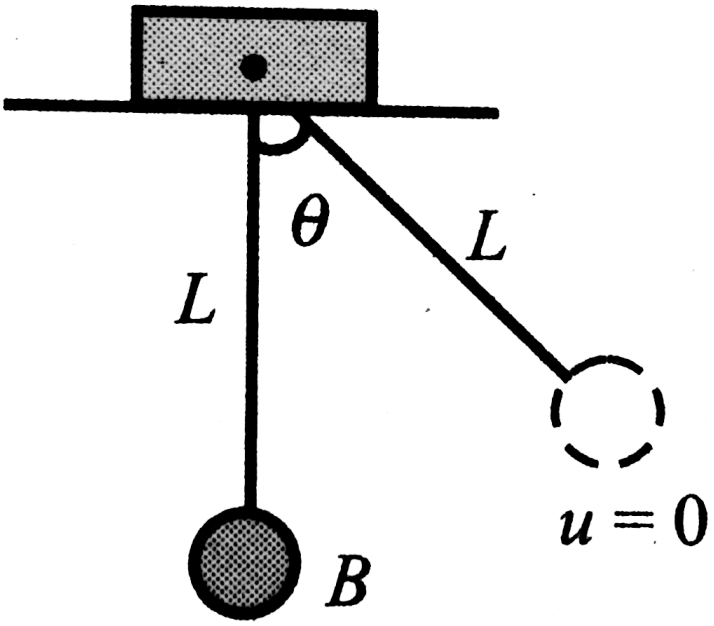
16. A small ball B of mass m is suspended with light inelastic string of length L from a block A of same mass in which can move on smooth horizontal surface as shown in the figure. The ball is displaced by angle θ from equilibrium position and then released.



The displacement of centre of mass of $A + B$ system till the string becomes vertical is

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17. One end of string of length 1.5 m is tied to a stone of mass 0.4 kg and the other end to a small pivot on a smooth vertical board. What is the minimum speed of the stone required at its lowermost.point so that the string does not slack at any point in its motion along the vertical circle ?

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18. A broad gauge train runs at a speed of 72 km/h on a curved track of radius of curvature 1 km. Find the elevation of the outer rail above the inner rail so that there may be side-pressure on the rails ? Distance between the rails is 1.7 m.

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19. A cylclist is riding with a speed of $27kmh^{-1}$. As he approaches a circular turn on the road of radius $80m$, he applies brakes and reduces his speed at the constant rate of $0.5ms^{-2}$. What is the magnitude and direction of the net acceleration of the cyclist on the circular turn ?

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20. A string 1 m long can just support a weight of 16 kg. A mass of 1 kg is attached to one of its ends. The body is revolved in a horizontal circle

about the other fixed end of the stringy Find the greatest number of revolutions made by the mass per seconds ? (Take $g = 10ms^{-2}$)

The maximum tension the string can withstand = weight of 16 kg.

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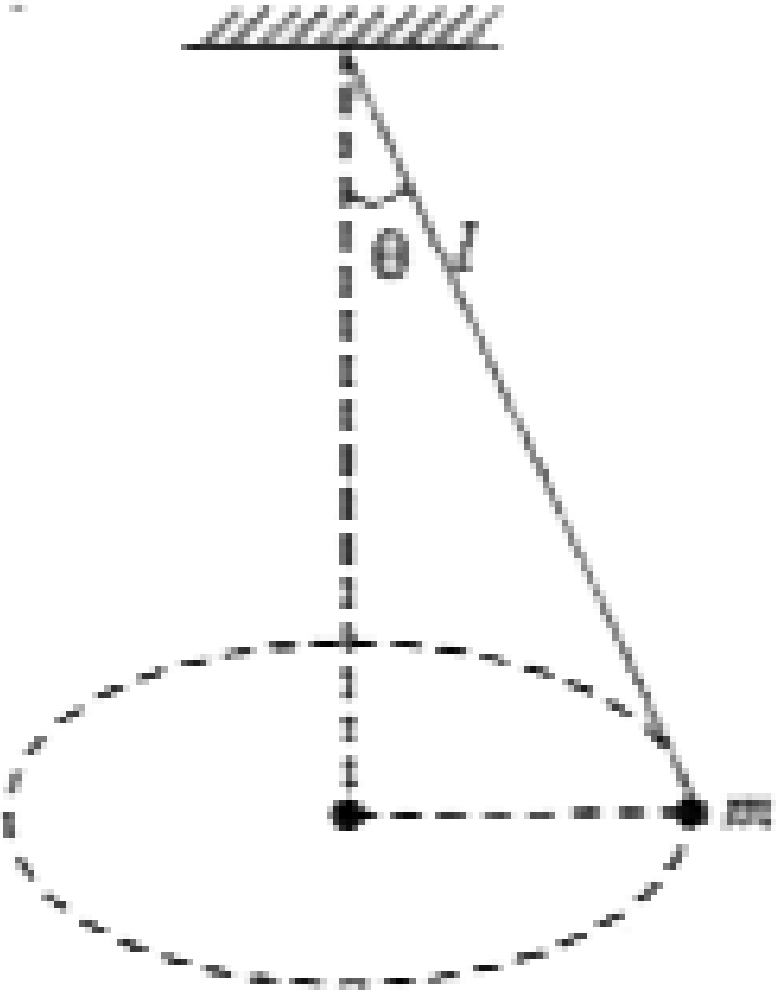
21. Fig. show a conical pendulum. If the length of the pendulum is l, mass of die bob is m and θ is the angle made by the string with the vertical show that the angular momentum of the pendulum about the point of support is:

$$L = \sqrt{\frac{m^2 g l^3 \sin^4 \theta}{\cos \theta}}$$



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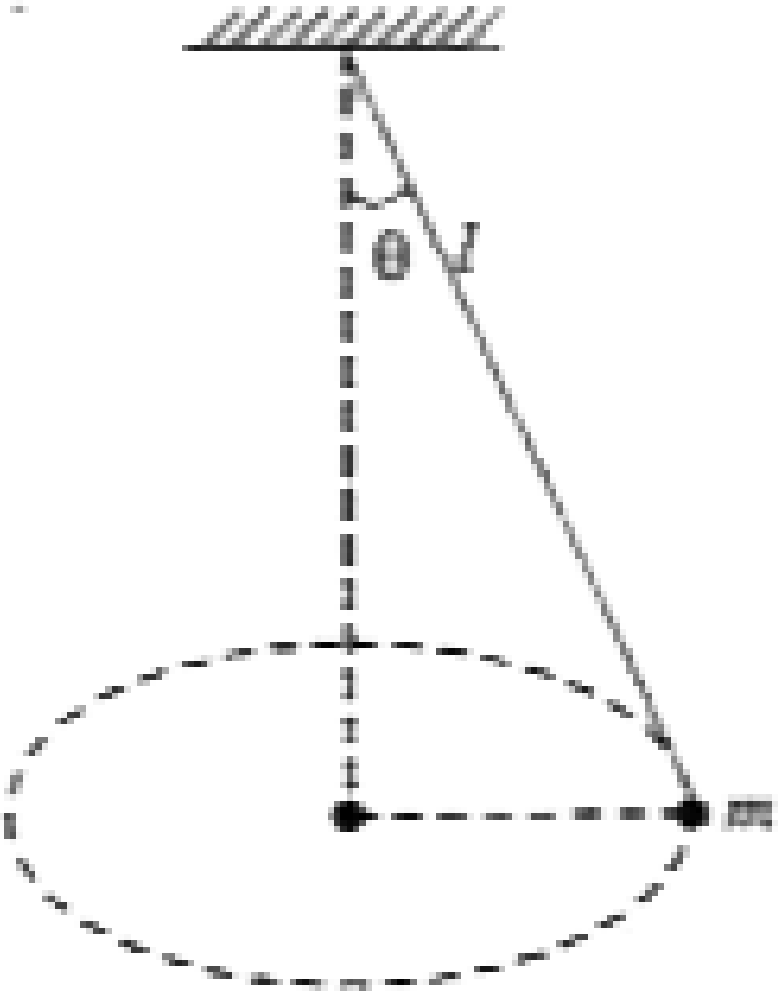
22. Fig. show a conical pendulum. If the length of the pendulum is l, mass of die bob is m and θ is the angle made by the string with the vertical show that the angular momentum of the pendulum about the point of support is:

$$L = \sqrt{\frac{m^2 g l^3 \sin^4 \theta}{\cos \theta}}$$



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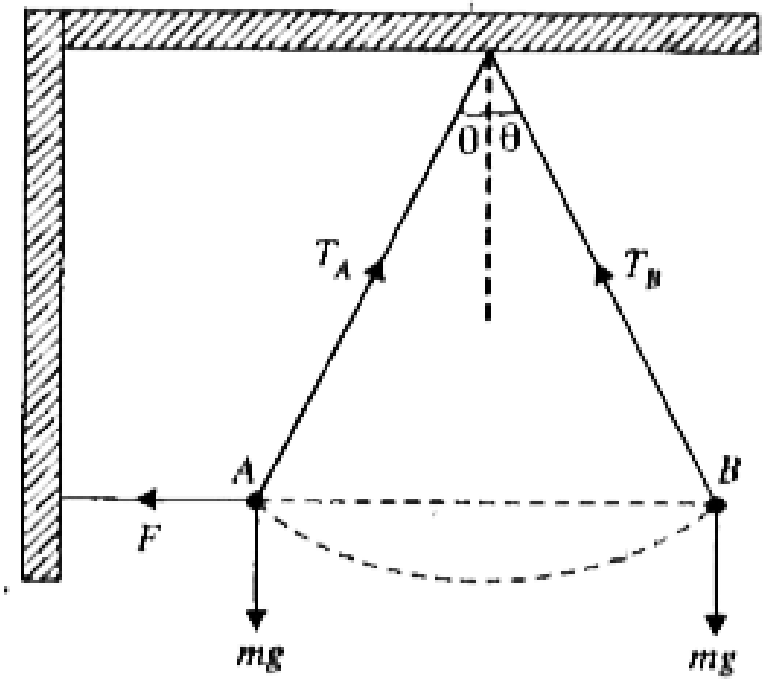
23. Using two light cords a bob is held in equilibrium at A. The horizontal cord is cut and the bob is allowed to swing as a pendulum. Calculate the ratio of the tension in the supporting cord in position B to that in position A.



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

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

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25. A sphere of radius $10cm$ and mass 25 kg is attached to the lower end of a steel wire of length $5m$ and diameter $4mm$ which is suspended from the ceiling of a room . The point of support is $521cm$ above the floor. When the sphere is set swinging as a simple pendulum, its lowest point just grazes the floor. Calculate the velocity of the ball at its lowest position $\left(Y_{steel} = 2 \times 10^{11} N/m^2\right)$.

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26. A racing car travelling at $35ms^{-1}$ along a circular path of radius 700 m, starts picking up speed at the rate of $2ms^{-2}$ What is its total acceleration ?

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27. What is the magnitude and direction of total linears acceleration of a particle moving in a circular path of radius 0.7 m having an instantaneous angular velocity of $3.5rads^{-1}$ and angular acceleration of $4.2rads^{-2}$.

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28. The shaft of a motor rotates at a constant speed of 1800 rpm. What is the angle in radians it has turned through in one second ?

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29. The blades of an aeroplane propeller are 2 m long and rotate at 300 rpm. Calculate (i) the frequency, (ii) period of rotation, (iii) the angular velocity, (iv) linear velocity of point 0.5 m from the top of the blades.

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30. A uniform round object of mass M, radius R and moment of inertia about its centre of mass I_{cm} has a light, thin string wrapped several times around its circumference. The free end of string is attaced to the celling and the object is released from rest. Find the acceleration of centre of the object and tension n the string. [Take $\frac{I_{cm}}{MR^2} = k$]

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31. A flywheel requires 3 s to rotate through 234 radian. If its angular velocity at 3 s is 108 rad/s, find the initial velocity and uniform acceleration.

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32. A flywheel starts rotating from rest when a torque is applied on it, with a uniform angular acceleration of $5\mathrm{rad}/s^2$. What is the angular displacement of the flywheel in the 5th Second ?

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33. A block is released from A on a frictionless track as shown in Fig. 7.2.6. What is the magnitude of radial acceleration and the total acceleration of the block at B ?

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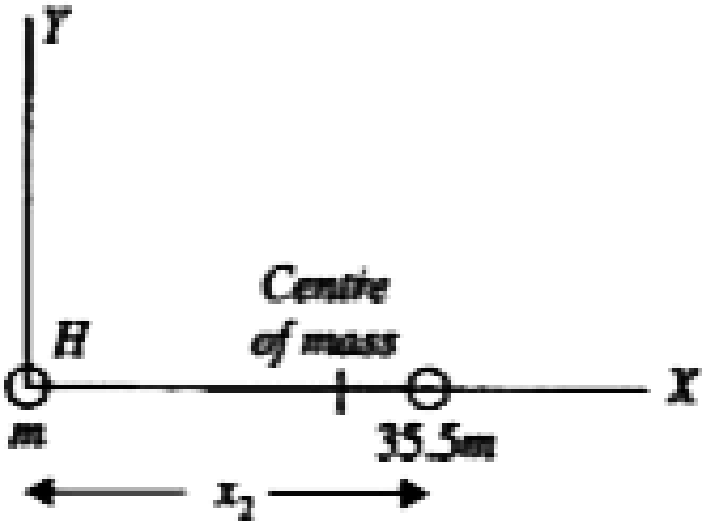
34. In the HCl molecule, the separation between the nuclei of two atoms is about 1.27 A ($1A = 10^{-10}$m). Find the approximate location of the CM. of the molecule, given that a chlorine atom is about 35.5 times as massive as a hydrogen atom and nearly all the mass of an atom is concentrated in

its nucleus.



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35. Three masses 3, 4 and 5 kg are placed at the centre of an equiliteral triangle of 1 m sides. Locate its centre of mass.

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36. Two particles of masses 100 gm and 300 gm have at a given time, position $2\hat{i}+5\hat{j}+13\hat{k}$ and $-6\hat{i}+4\hat{j}-2\hat{k}$ respectively and velocities

$10\hat{i} - 7\hat{j} - 3\hat{k}$ and $-7\hat{i} - 9\hat{j} - 6\hat{k}$ m/s respectively. Deduce the instantaneous position and velocity of the Centre of mass.

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37. A particle of mass 200g is attached to an ideal string of length 1.30 m whose upper end is fixed to ceiling. The particle is made to revolve in a horizontal circle of radius 50 cm. The tension in the string is $\left(g = 10\frac{m}{s^2}\right)$

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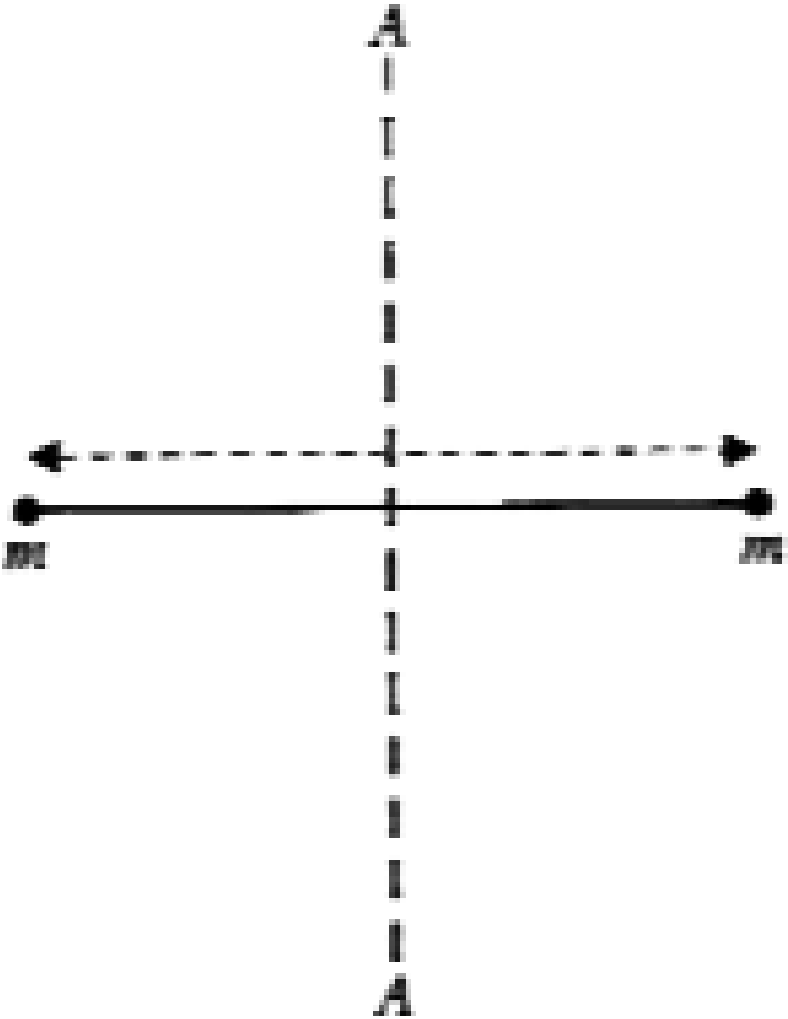
38. The distance between the two atoms in a diatomic molecule O_2 is 1.21×10^{-10} m. The mass of each oxygen atom is 2.66×10^{-26} kg. Treating the atoms as point masses find the m moment of inertia of the molecule about an axis passing perpendicular to the line joining the

centres of the atoms.



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39. The mass of a disc is 700 gm and its radius of gyration is 20 cm. What is its moment of inertia if it rotates about an axis passing through its centre and perpendicular to the face of the disc?

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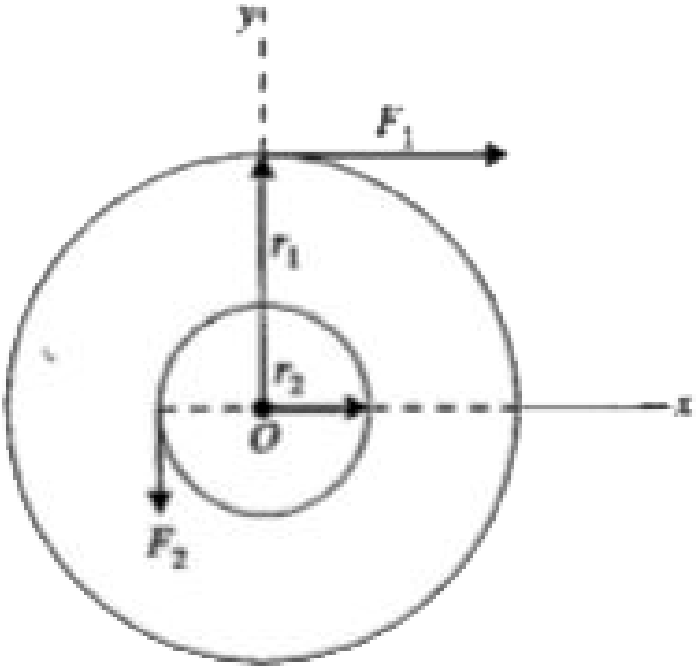
40. A cross-section of a solid cylinder is shown in Fig. 7.2.20, with the core section protruding from the larger drum. A rope wrapped around the drum of radius $r_1 = 80$ cm exerts a force 10.0 N to the right on the cylinder. The cylinder can rotate freely around the central axis. A rope wrapped around the core of radius $r_2 = 40cm$ exerts a force of 15.0 N downwards on the cylinder, (a) Calculate the net torque acting on the

cylinder about the axis of rotation ?



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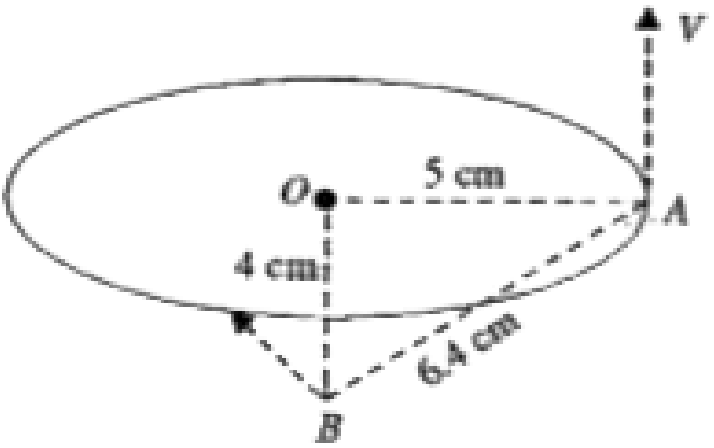
41. A particle of mass 50 gm moving in a circle at 5 cm radius with a constant speed of 10 cm/s. What is its angular momentum about (i) centre of the circle, (ii) a point on the axis of the circle at 4 cm distance from its centre ? Which of these will be always in the same direction ?

[Fig.]



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42. A bob of mass 200 gm is attached to a string of length 100 cm and is revolved at the rate of 2 revolutions per second. What is its angular momentum ? If after 10 s it makes only on revolutions per second calculate the mean torque.

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43. A torque of 10 Nm is applied to a flywheel of mass 5 kg and radius of gyration 0.6 m. What is the resultant angular acceleration ?

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44. The earth is rotating with an angular velocity of 7.3×10^{-5} rad/s. What is the tangential force needed to stop the earth in one year ? Given moment of inertia of the earth about the axis of rotation = $9.3 \times 10^{37} m^2$. Radius of the earth = 6.4×10^6 m

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45. A body weighs 64 N on the surface of the Earth. What is the gravitational force on it (in N) due to the Earth at a height equal to one-third of the radius of the Earth?

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

$(A)(\#\#VMC_PHY_XI_WOR_BOK_{01}_C04_E03_{050}_Q01\#\#)$Conical pendul

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$(D)(\#\#VMC_PHY_XI_WOR_BOK_{01}_C04_E03_{050}_Q04\#\#)$The car is mov

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47. A flywheel of mass 100 kg and radius 1 m is rotating at the rate of 420 rev/min. Find the constant retarding torque to stop the wheel in 14 revolutions, the mass is concentrated at the rim. M.I. of the flywheel about its axis of rotation $I = mr^2$.

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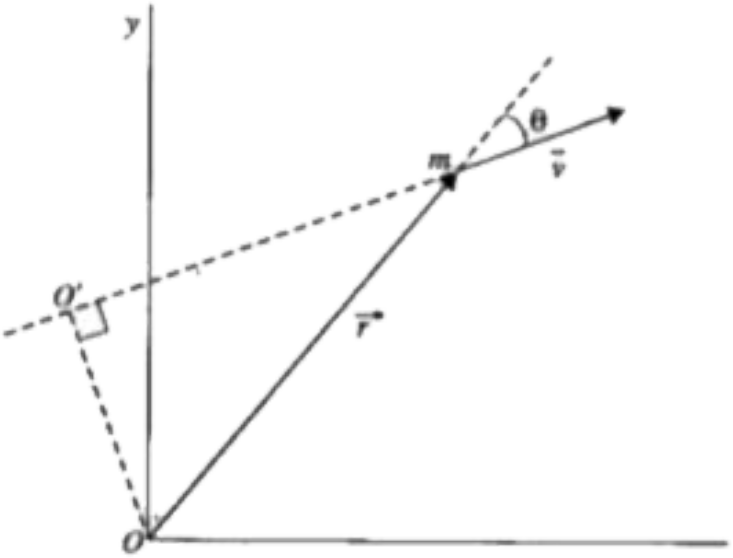
48. A point mass 10 g moves in the xy plane with a velocity $2ms^{-1}$ along a straight line. Find the magnitude and direction of its angular

momentum (i) with respect to the origin O and (ii) with respect to the origin O. The magnitude of the position vector $\vec{r}$ is 0.5 m and the angle $\theta = 30^\circ$.



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49. A particle is tied to the end of a string of length 20 cm and makes 5 rps. How many revolutions will it make in one second when the string is shortened to 10 cm ?

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50. A horizontal disc rotating freely about a vertical axis makes 100 rpm. A small piece of wax of mass 10 g falls vertically on the disc and adheres to it at a distance of 9 cm from the axis if the number of revolution per minute is thereby reduced to 90. Calculate the moment of inertia of disc.

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51. A circular disc of 49 kg and radius 50 cm is rotating at a speed of 120 rotations per minute. Calculate its kinetic energy if is moment of inertia about the axis of rotation is $\frac{1}{2}mr^2$.

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52. A sphere of mass 50 gm and diameter 2 cm rolls without slipping with a velocfty of 5 cm/s. Calculate the total energy.

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53. Calculate the work done in increasing the angular velocity of a wheel of moment of inertia 200 kg m_2 from 20 rev/s to 40 rev/s.

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54. The flywheel of an engine, acted upon by a constant torque at the rate of 3000 rev/ min and develops a power of 10 kW. Find the torque acting on the wheel.

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55. The rotational kinetic energy of a disc is 450 J and its moment of inertia is 100 kg m^2. What is its angular momentum ?

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56. One end of a massless string is wound around a cylinder of mass 5 kg and radius 16' cm. The cylinder' is mounted symmetrically on a horizontal axle so 5 that It can freely rotate about its axis, to the other end of the string a mass of 500 gm is attached. Calculate the acceleration of the mass when it is released from rest.

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57. Calculate'the final speed acquired by the softd cylinder shown in Fig.2.48 when it rolls down and reaches the bottom of the inclined plane' without slipping. Assume that the inclined plane is frictionless.

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58. A solid sphere of radius $2.45m$ is rotating with an angular speed of $10rad/s$. When this rotating sphere is placed on a rough horizontal surface then after sometime it starts pure rolling. Find the linear speed of the sphere after it starts pure rolling.

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59. A uniform circular disc of mass m is set rolling on a smooth horizontal table with a uniform linear velocity v. Find the total K.E. of the disc.

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60. A thin meter scale is kept vertical by placing its one end on floor, keeping the end in contact stationary, it is allowed to fall. Calculate the velocity of its upper end when it hit the floor.

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61. A rope of negligible mass is wound round a hollow cylinder of mass 3 kg and radius 40 cm. If the rope is pulled with a force of 30 N, then the angular acceleration produced in the cylinder is

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62. A flywheel of mass 140 kg and radius of gyration 3.5 m is rotated with a speed of 240 rpm. Find the torque required to stop it in 3.5 rotations ?

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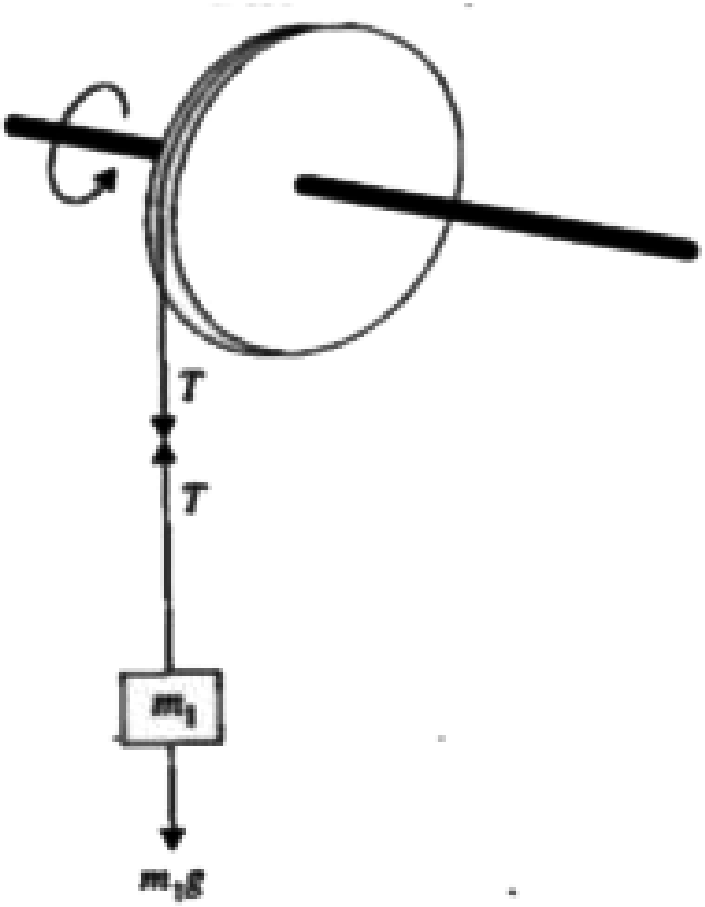
63. A wheel of mass 1.4 kg and radius 0.4 m is mounted on a frictionless, horizontal axle as shown in Fig. 7.2.50. Alight string wrapped around the rim supports a mass of 2 kg. What is the angular acceleration of the wheel and the tangential acceleration of a point on the rim ? Also find the

tension in the string.



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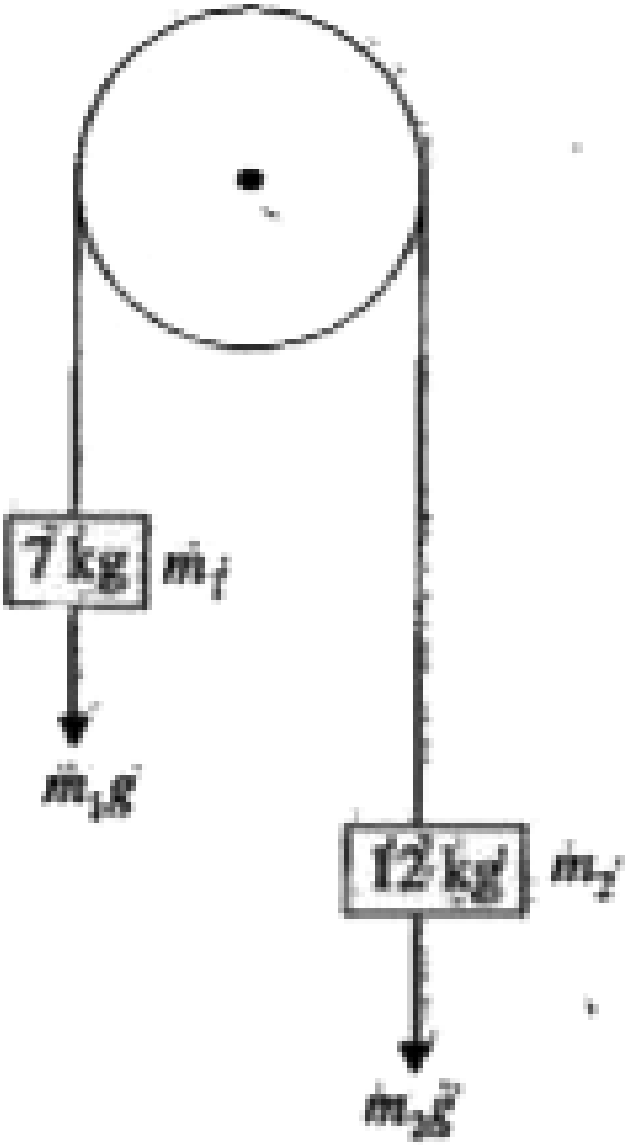
64. In the Atwood's machine shown in Fig. $m_1 = 7$ kg and $m_2 = 12$ kg are connected at the two ends of a light inextensible string that goes over a frictionless pulley of radius 5 cm. When the system is released from rest

the heavier mass is found to fall 1 m in 2 s. Calculate the moment of inertia of the pulley ?



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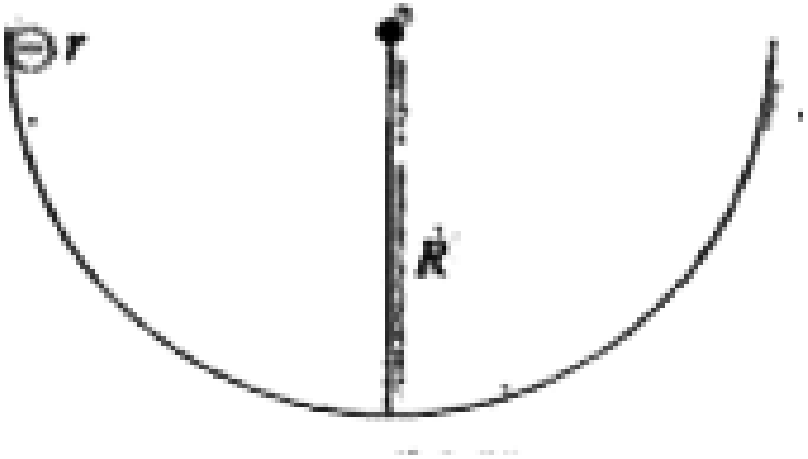
65. The radius of a large hemisphere whose" axis of symmetry is vertical is R = 50 cm. A small sphere of radius r= 5cm rolls without slipping with a speed of 2cm/s. The mass of the sphere is 100 gm. If it start's at the top from rest (i) what is the kinetic energy at the bottom? (ii) What fraction is rotational ? (iii) What fraction is translational?



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66. The mass of a spool of wire in the form of a uniform solid cylinder is m and its radius is r. The wire is unwound under a constant force F. Assume

that the cylinder does not slip, find (i) the acceleration of the centre of mass, (ii) the force of friction, (iii) what is the speed attained by the centre of mass after the cylinder has rolled through a distance, assume that the cylinder starts from rest and it rolls without slipping ?

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67. A uniform thin rod of mass m and length l is standing on a smooth horizontal suface. A slight disturbance causes the lower end to slip on the smooth surface and the rod starts falling. Find the velocity of centre of mass of the rod at the instant when it makes an angle θ with horizontal.

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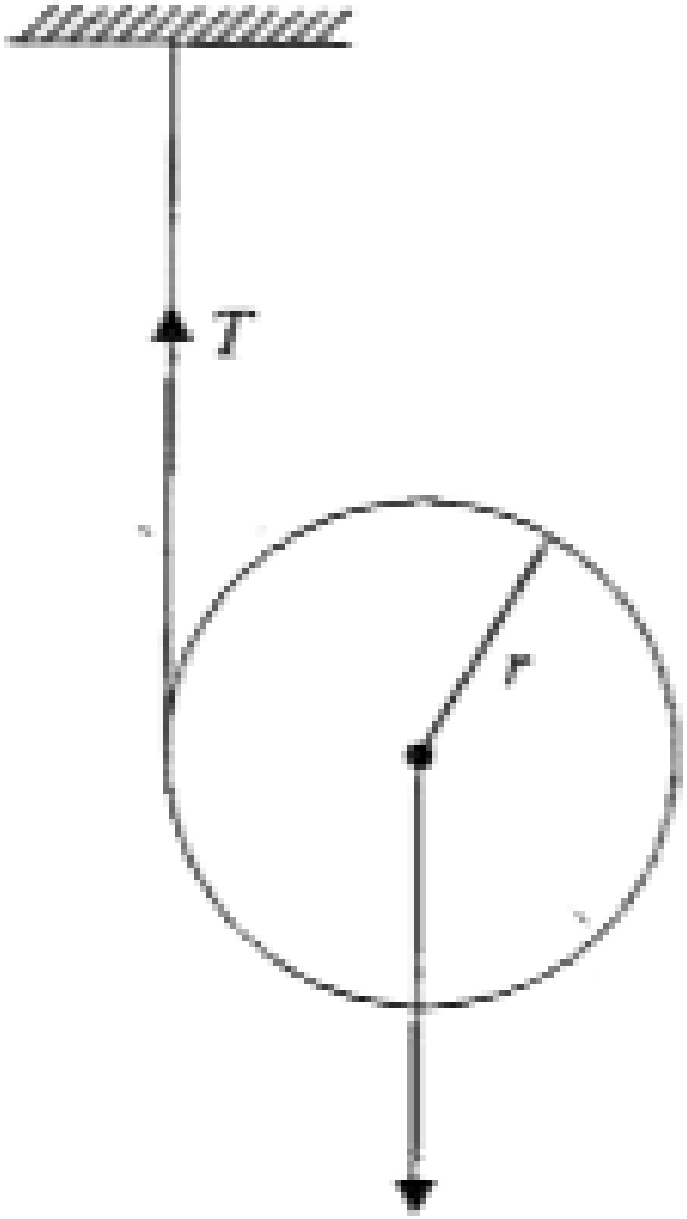
68. On the surface of a solid cylinder of mass 2 kg and radius 25 cm a string is wound several times and the end of the string is held stationary while the cylinder is released from rest. What is the acceleration of the

cylinder and the tension in the string ?



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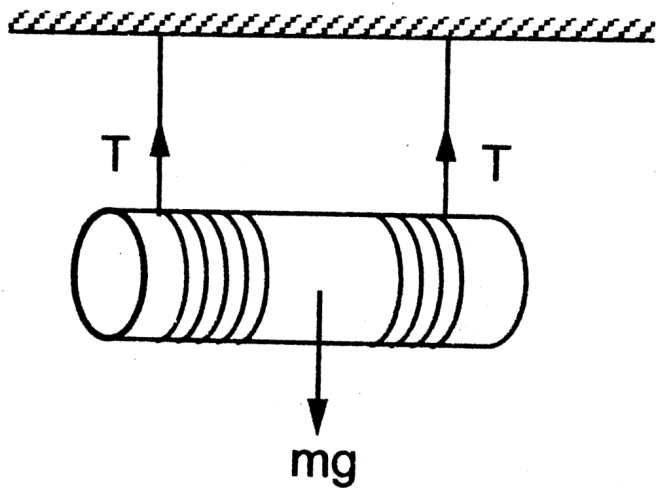
69. A cylinder of mass m is suspended through two strings wrapped around it as shwon in figure . Find (a). the tension T in the string and (b). the speed o the cylinder as it falls through a distance h.



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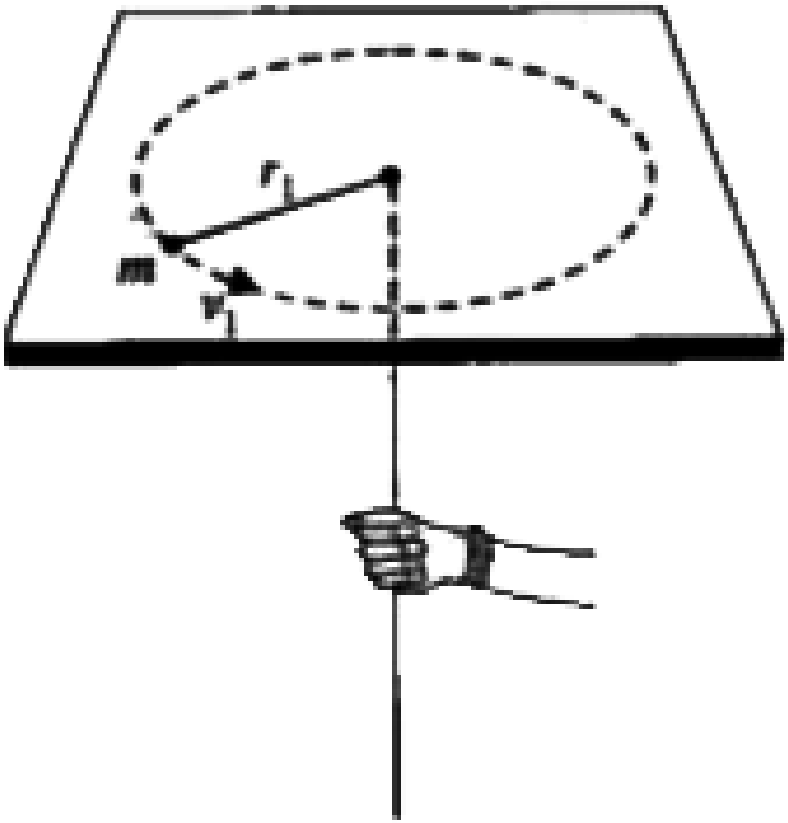
70. A mass m is attached to a string passing through a small hole in a frictionless, horizontal surface. The mass is initially orbiting with a velocity v_1 in a circle of radius r_1 The string is then slowly pulled from below, decreasing the radius of the circles to r_2 (i) What is the speed of the mass when the radius is r_2 ? (ii) What is the tension in the string ?

(iii) What is the work done in moving the mass m from r_1 to r_2?



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71. Derive an expression for the moment of inertia of a thin spherical shell about a diameter.

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72. Derive an expression for the moment of inertia of a thin spherical shell about a diameter.

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Module 1 Conceptual Short Answers Questions With Answers

1. When a car takes a round curve on a level raod at high speed, two of its wheels leave the ground. Which two remain on the ground ?

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2. If the acceleration of a particle remains constant in magnitude but not in direction, is its path necessarily a straight line or a circle ?

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3. When a car rounds a curve to which side of the car does a passenger inside it tend to slide ?

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4. A passenger in an aeroplane shall

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5. At stone is tied to the end of a string and is whirled in a horizontal aide with a constant speed. Suppose the string breaks suddenly. What happens to the stone ?

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6. In uniform circular motion

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7. Does the kinetic energy ofa\boay moving ipa vertical circular path also remain constant ?

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8. The speed of a body moving in uniform circular motion is doubled and the radius of the circular path is halved. What happens to the centripetal force?

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9. A stone is projected from level ground at $t = 0$ sec such that its horizontal and vertical components of initial velocity are $10\frac{m}{s}$ and $20\frac{m}{s}$ respectively. Then the instant of time at which tangential and normal components of acceleration of stone are same is: (neglect air resistance) $g = 10\frac{m}{s^2}$.

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10. A heavy mass is attached to a thin wire and is whirled in a vertical circle. The wire is most likely to break

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11. In uniform circular motion

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Module 1 Long Answer Questions

1. Show that a body moving along a circular path with uniform speed has an acceleration. Derive an expression for the centripetal acceleration.

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2. Define centripetal force. Derive an expression for it.

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3. To prevent overturning at a curved road what should a cyclist do ? By how much angle he should lean from the vertical ? Derive an expression for it.

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4. To prevent overturning at a curved road what should a cyclist do ? By how much angle he should lean from the vertical ? Derive an expression for it.

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5. What is meant by banking of rails ? What is its purpose ?

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6. Discuss the motion of a car on a banked road.

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7. Obtain an expression for the maximum speed with which a car can turn safely on a banked road.

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8. What is a conical pendulum ? Derive an expression for its time period ?

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Module 1 Short Answer Questions

1. Differentiate between uniform linear motion and uniform circular motion.

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2. A particle in a circular motion covers a distance of 0.5 πr where r is the radius of the circular path. What is the angular displacement ?

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3. Why do we need pure substances ?

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4. The direction of the angular velocity vector is along

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5. What is the relation connecting linear displacement and angular displacement ?

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6. In uniform circular motion

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7. Which of the following is the correct relation between linear velocity and angular velocity of a particle?

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8. The unit of angular acceleration in the SI system is

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9. What is the average velocity of a body in uniform circular motion ?

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10. Find the angular speed of the minute hand of a clock.

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11. A bus and a car move round a circular road with the same angular velocity. The car is closer to the centre of the curved road. Which has greater linear speed ?

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12. What is centripetal acceleration ? Why is it called so ?

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13. The dimensions of centripetal acceleration is

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14. What is a centripetal force?

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15. A passenger in a car moving round a curved road is thrown towards the outside of the curve. What force throws him in this direction ?

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16. Why does an aeroplane tilt while making.a curved flight ?

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17. Assertion When a car takes a circular turn on a horizontal road, then normal reaction on inner wheels is always less than the normal reaction on outer wheels.

Reason This is for rotational equilibrium of car.

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18. Find the acceleration of a particle placed on the surface of the earth at the equator, due to the earth rotation. The radius of earth is 6400 km and time period of revolution of the earth about its axis is 24 h.

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19. Why does mud fly off a rapidly turning wheel ?

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20. "A mass is attached to one end of a spring and by holding the other end in hand, the spring is whirled in a horizontal circle" What happens to the length of the spring ?

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21. At what point does a pilot in an aeroplane appear to be heaviest while performing a loop-the-loop in a vertical plane.

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22. An electric kettle has two coils. When one of these is switched on, thje water in the kettle boils in 6 minutes. When the other coil is switched on, the water boils in 3 minutes. If the two coils are connected in series, the time taken to boil the water in the kettle is

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23. Explain the reason of separation of cream from milk.

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24. A motor cyclist rides around the well with a round vertical wall and does not fall down while riding because

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25. What is meant 'banking of the road' ?

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26. On what values does the angle of banking depend ?

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27. What is meant by banking of rails ? What is its purpose ?

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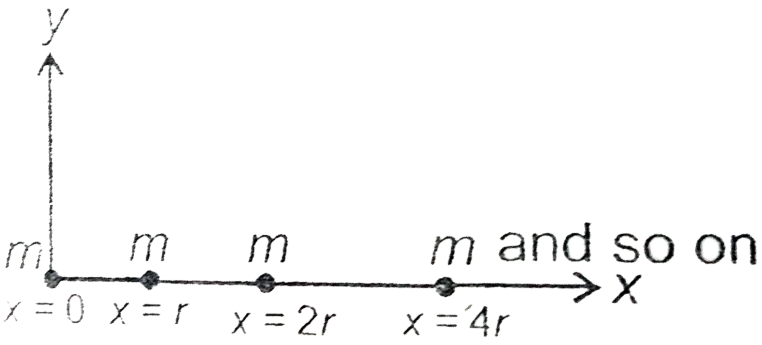
28. Consider an infinite distribution of point masses (each of mass m) placed on x-axis as shown in the diagram. What is the gravitational force acting on the point mass placed at the origin ?



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29. What is the conical, pendulum ? Why is it called so ?

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30. How are metals used as semiconductors refined ? What is the principle of the method used like germanium, silicon etc. ?

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31. Where does a body weigh more – at the surface of the earth or in a mine?

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32. Why it is more difficult to rotate a stone by tieing it to a longer string than shorter string ?

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33. A cyclist bends while taking turn to

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Module 1 Very Short Answer Questions

1. An object is projected vertically up from the earth's surface with velocity $\sqrt{Rg}$ where R is the radius of the earth and 'g' is the acceleration due to earth on the surface of earth. The maximum height reached by the object is nR. Find value of n.

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2. What provides the centripetal force (i) to satellite revolving round the earth and (ii) for the electrons going round the nucleus.

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3. What provides the centripetal force to a car taking a turn on a level road ?

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4. A pilot does not fall down when his aeroplane loops the loop. Why ?

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5. Which region of the earth experiences maximum centripetal force ?

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6. Which has greater angular velocity (i) rotation of the hour hand of watch (ii) rotation of earth around its axis ?

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7. What is the direction of the angular velocity of the minute hand of a clock ?

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Module 1 From Angular Velocity

1. What is the angular velocity of (a) a second hand and (b) minute hand of a clock ?

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2. What is the angular velocity of a body on'the surface of the earth at the equator ? Also find its linear velocity. Given radius of the earth is 6400 km. Period of rotation of the earth = 24 hours.

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3. The blades of an aeroplane propeller are 2m long and rotate at 300 rpm. Calculate (i) frequency (ii) period of rotation (iii) angular velocity (iv) linear velocity of a point 0.5 m from the top of the blades.

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4. The angular displacement of a body is given by $\theta = 2t^2 + 5t - 3$. Find the value of the angular velocity and angular acceleration when t = 2s.

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Module 1 From Centripetal Force

1. A stone is tied at the end of a string lm long and whirled round by holding the other end. The stone makes 120 revolution is 12 seconds. Calculate the angular velocity and linear velocity.

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2. An aircraft executes a hrorizontal loop of radius 1 km with a steady speed of $900 kmh^{-1}$ Compare its centripetal acceleration with the acceleration due to gravity ?

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3. A stone tied to the end of the string 100 cm long is whirled in a horizontal circle with a constant speed. If the stone makes 30 revolution in 15 s. Calculate the magnitude and direction of acceleration of the stone.

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4. An artificial satellite is orbiting around the earth with the speed of $4kms^{-1}$ at a distance of 10^4 km from the earth. Calculate its centripetal acceleration.

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5. A body of mass 0.5 kg is whirled with a velocity of $2ms^{-1}$ using 0.5 m length string which can be withstand a tension of 15 N, Neglecting the force of gravity on the body predict whether or not the string will break.

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6. A stone of mass 100 g tied to the end of a string 80 cm long is whirled in a horizontal circle with a constant speed.If the stone makes 14 revolutions in 25 s, calculate the centripetal force acting on the stone.

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7. A string 1 m long can just support a weight of 16 kg. Amass of 1 kg is attached to one of its ends. The body is revolved in a horizontal circle about the other fixed end of the string. Find the greatest number of revolutions made by the mass per second ? (Take g = $10ms^{-2}$)

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8. A car is moving with a velocity V. The car driver sees a truck at rest at a distance s. To avoid collision which is better, to apply brake or to turn sharply ?

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9. A long playing record revolves with a speed of $33\left(\frac{1}{4}\right)$ rev/min. and has a radius of 15 cm. Two coins are placed at 4 cm and 14 cm away from the centre of the record. If the coefficients of friction between the coin and the record is 0.15, which of the two coins will revolve with record ?

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10. A 70 kg man stands in contact against the wall of a cylindrical drum of radius 3 m rotating about its vertical axis with 200 rev/min. 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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11. You may have seen in a circus a motorcyclist driving in a vertical loop inside a 'death well' chamber with holes, so the spectators can watch from outside. Explain clearly why the motorcyclist does not drop down when he is at the uppermost point, with no support from below. What is the minimum speed required to perform a vertical loop if the radius of the chamber is 25 m ?

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12. A stone of mass 0.3 kg tied to the end of a string in a horizontal plane in whirled round in a circle of radius 1 m withp. speed of 40 rev/min. What is the tension in the string ? What is the maximum speed with which the stone can be whirled around if the string can withstand a maximum tension of 200 N ?

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13. What is the minimum velocity with which a body of mass m must enter a vertical loop of radius R so that it can complete the loop ?

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14. A small mass m starts from rest and slides down the surface of a frictionless solid sphere of radius R. Calculate the angle at which the mass flies off the sphere. If there is friction between the mass and the sphere, does the mass of fly off at a greater or lesser angle than the previous one ?

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15. A spring of force constant $1200Nm^{-1}$ is mounted on a horizontal table and a mass of 3.0 kg of attached to the free and of the spring. The mass is made to rotate with an angular velocity of 10 rad/s. What is the elongation produced in the spring if its unstretched length is 60 cm ?

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16. A particle describes a horizontal circle on the smooth surface of an inverted cone, the height of the plane of the circle above the vertex is 9.8 cm. Find the speed of the particle (g= $9.8m/s^2$) [See Fig.] (a) given in the answer section]

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17. A stone tied to the end of a string 80 cm long is whirled in a horizontal circle with a constant speed. If the centripetal acceleration of the stone is $9.91ms^{-2}$ how many revolutions does the stone make in 20 seconds.

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18. A mass is tied to a, string 1 m long and rotated in a horizontal circle at the rate of 600 rpm. If the tension inthe string is 3943.8 N, calculate the mass.

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19. A sphere of mass 20 g is whirled around in a horizontal circular path on the end of a string, the other end of which is stationary. If the tension in the string is 12.62 N, calculate the length of the string.

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20. A bridge over a canal is in the form of an arc of a circle of radius 20 m. Calculate the maximum speed at which a motor cycle can pass over the bridge without leaving the ground at the highest point ?.

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21. An earth satellite revolves in a circular orbit at a height of 300 km above the earth's surface with a period of 90 min. What is its speed ? Calculate the radial acceleration of the satellite ? Radius of the earth is 6.38×10^6m.

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22. In a children's park, using the park ride the visitors can be made to rotate in a vertical circle. At the top of the circle a rider has an effective weight of magnitude 1000 N. If his actual weight is 500 N

(i) What is his effective weight at the bottom of the cricle ?

(ii) What is the effective weight when the rider is halfway to the centre of the circle ?

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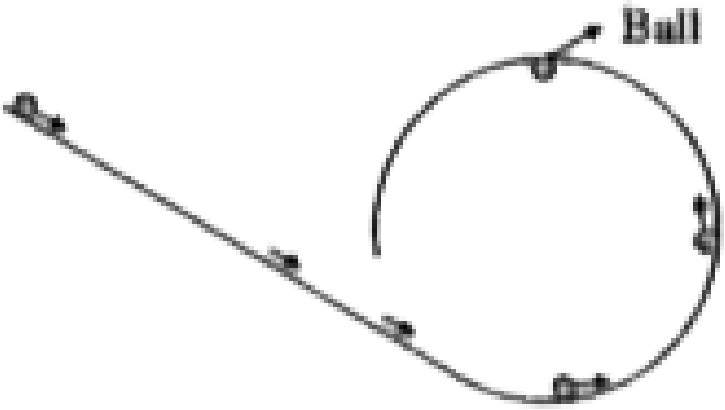
23. A ball of mass 100 g is made to loop-the-loop in a vertical circle as shown in Fig. 7.1.29. The radius of the circle is 0.5 m (i)-What is the critical velocity at the highest point of the track ? (ii) If the velocity of the ball at the highest point of the track is twice the critical velocity what is the

force exerted by the ball against track?



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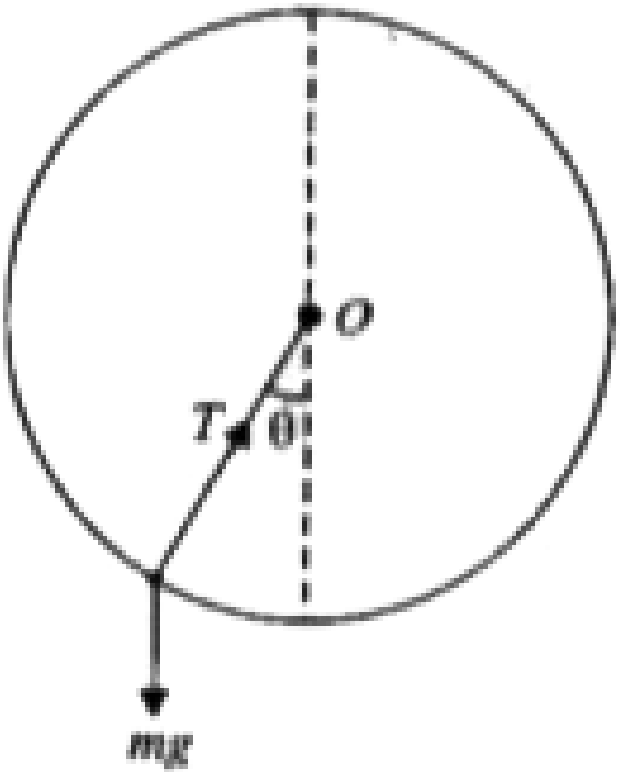
24. What is the tension Tin the cord (see Fig. 7.1.30) connected to the ball of mass 0.1 kg rotating in a vertical'circle of radius 1m, if the speed of the

ball is 0.2 m/s and $\theta = 30^\circ$.



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25. The speed of the electron in the hydrogen atom is approximately $2.2 \times 10^6 m/s$. What is the centripetal force acting on the electron ifthe

radius of the circular orbit is $0.53 \times 10^{-10} m$?Mass of the electron is $9.1 \times 10^{-31} kg$

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26. What is the centripetal acceleration of a space vehicle moving round the earth, assuming its orbit to be circular ? What is the apparent weight of an astronaut ?

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27. A small stone of mass 100 g in rotated I a verticlal circle of radius 40 cm. What is the minimum speed needed at the lowest point for looping the loop? Also find the tension in the string at this point $\left(g = 10 ms^{-2}\right)$.

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28. Suppose that the rotation of the earth was increased such that the centripetal acceleration was equal to the gravitational acceleration at the equator (i) Find the speed of a person standing at the equator and (ii) How long would a day be ?

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29. The kinetic energy K of a particle moving along a circle of radius R depends on the distance covered s as $K = as^2$. The force acting on the particle is

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30. A car is moving in a circular horizontal track of radius 10 m with a constant speed of $10ms^{-1}$. A plumb bob is suspended from the roof of the car by a light rigid rod of length 1 m. The angle made by the rod with track is

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31. If a body moves on the circumference of a circle with a speed equal to that which it would acquire by falling freely through half the radius of the circle, prove that its centripetal acceleration is equal to the acceleration of the free fall.

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Module 1 From Banking Or Rails And Roads

1. A train runs along an unbanked circular track of radius 30 m at a speed of 54 km/h . The mass of the train is 10 kg. What provides the centripetal force required for this purpose- The engine or the rails ? What is the angle of banking required to prevent wearing out of the rail ?

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2. An aircraft executes a horizontal loop at a speed of 200m/s with its wings banked at 15°. What is the radius of the loop ?

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3. A train has to negotiate a curve of 40 m radius. What is the super elevation of the outer rail required for a speed of $54kmh^{-1}$. The distance between the rails is one metre ?

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4. An electric bulb suspended from the roof of a train by a thread shifts through' an angle of 19.8° when the train goes round a curved path 100 m in radius. Find the speed of the train

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5. Calculate the safe speed with which a train can negotiate a curve of 50 m radius, where the superelevation of the outer rail above the inner rail is 0.6 m. Given that the distance between the rails is 1 m

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6. A train is moving with a speed of 20 m/s at a place where the radius of curvature of the railway line is 1500 m. Calculate the distance between the rails if the elevation of the outer rail above the inner rail is 0.042 m ?

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7. A uniform box of height $2m$ and having a square base of side $1m$, weight $150kg$, is kept on one end on the floor of a truck. The maximum speed with which the truck can round a curve of radius $20m$ without causing the block to tip over is (assume that friction is sufficient is no sliding).

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8. At what angle must a railway track with a bend of 250 m radius be banked for safe running of a train at a speed of $72 kmh^{-1}$.

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9. If a cyclist moving with a speed of 4.9 m/s on a level can take a sharp circular turn of radius 4 m, then coefficient between the cycle tyres and road is

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10. A cyclist goes around a circular track of circumference 410 m in 20 s. Find the angle that his cycle makes with the vertical.

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11. A motorcyclist goes round a circular race curve at $162 km h^{-1}$. To keep his balance he leans inward 40° from the vertical. What is the radius of the circular path ?

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12. What is the maximum speed with which a cyclist can move without skidding, in a circular path of radius 10 m, on a road where the coefficient of friction between the tyre and the road is 0.5 ?

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13. A cyclist wants to loop a loop inside a death globe of radius 5 m. Calculate the least velocity the cyclist should have at the lowest point and calculate the height from which he should start ?

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Module 2 Conceptual Short Answers Questions With Answers

1. A coin rolls on a horizontal plane. What fraction of its total kinetic energy is rotational ?

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2. "The mass of a flywheel is concentrated on the rim ". Why ?

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3. How is the swimmer jumping into water from a height be able to make loop in air ?

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4. There are two children in a family. Find the probability that at most one boy is there in the family.

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5. A metal ring is'melted and a solid sphere is made out of it. What happens to the M.I. about a vertical axis through the centre ?

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6. How will you distinguish between a note and its echo?

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7. Explain how a cat is able to-land on its feet when thrown into air ?

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8. If the ice at the poles melts and flows towards the equator, how will it affect the duration of day-night?

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9. (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 considered to be concentrated at its C.G..,

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

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10. A child is standing at one end of a long trolley moving with a speed v on a smooth horizontal floor. If the child starts running towards the

other end of the trolley with a speed u, the centre of mass of the system (trolley + child) will move with a speed

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11. When a mass is rotating in a plane about a fixed point, it angular momentum is directed along

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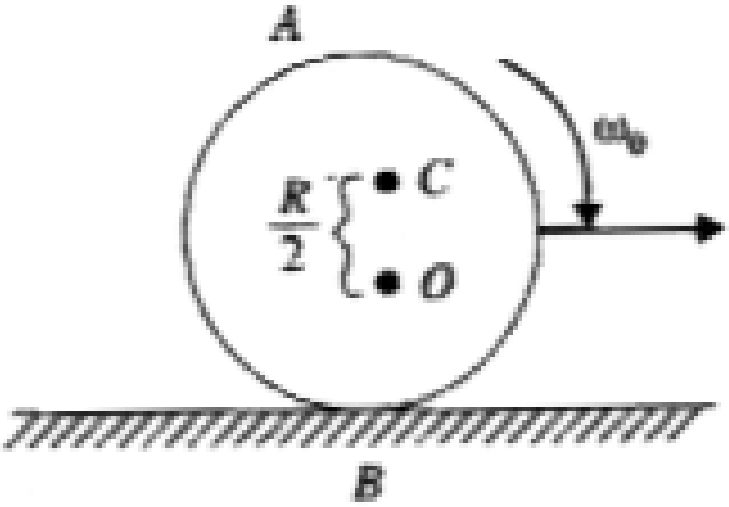
12. A disc rotating about its axis with angular speed is placed lightly {without any transnational push) on a perfectly friction-less table. The radius of the disc is R. What are the linear velocities of the point A, B and C on the disc shown in the Fig. B 7:2.60 ? Will the disc roll in the direction

indicated ?



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13. A ring, a disc and a sphere all of the same radius andmass roll down an inclined plane from the same height h. Which of the three reaches bottom (i) earliest (ii) latest ?

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

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Module 2 Long Answer Questions

1. Define angular velocity and angular acceleration.

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2. Derive the equations of rotational motion for a body moving with uniform angular acceleration,

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3. Define torque. Show that it is equal to the product of force and lever arm.

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4. Define angular momentum. What is its physical significance ?

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5. Define moment of inertia and radius of gyration

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6. State (i) parallel axes theorem and (ii) perpendicular axes theorem.

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7. Define angular momentum, write its unit and obtain relation for angular momentum in terms of moment of inertia and angular velocity.

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8. State and prove the law of conservation of angular momentum.

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9. Derive an expression for the rotational kinetic energy.

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10. Show that the work done to rotate a body is equal to the change in rotational kinetic energy,

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11. Derive an expression per the M.I. of a rectangular rod about an axis passing through its centre of mass and perpendicular to its length.

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12. Derive an expression for the MI. of a disc,

(i) about an axis passing through its centre and perpendicular to its plane. (ii) about its diameter.

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13. Derive an expression an expression for the MX of a sphere about its diameter.

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14. A cylinder is rolling without slipping on an inclined plane. Show that to prevent slipping the condition is $\mu_s \geq \frac{1}{3}\tan\theta$.

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Module 2 Short Answer Questions

1. The direction of the angular velocity vector is along

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2. Can we use the equations of rotational motion if θ is measured in degrees and not in radian ?

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3. If a disc starting from rest acquires an angular velocity of 240rev min^{-1} in 10 s, then its angular acceleration will be

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4. When the axis of rotation of a body changes does moment of inertia also change ? Why ?

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5. Two equal and opposite forces act on a rigid body at a certain distance. Then

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6. A : For a body to be in rotational equilibrium the net torque acting on the body about any point is zero.

R : For net torque to be zero, net force should also be zero.

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7. Using the S.I. units of torque and angular acceleration show that the S.I. unit of moment of inertia is kg m2

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8. "The rotational vectors are represented by straight lines lying along axis of rotation". Why ?

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9. Show on a diagram the vector that would represent the angular velocity of the earth rotating about its axis.

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10. For calculating the moment of inertia of a body can we assume the whole mass of the body to be concentrated at its centre of mass ?

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11. Derive an equation for the angle covered by, a rotating rigid body in the nth second.

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12. Define moment pf inertia. Name the factors on which the moment of inertia depend

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13. What is the physical significance of moment of inertia ?

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14. Radius of gyration has the unit

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15. Name a physical quantity which has the same dimensions as that of torque ? What is the difference between the two ?

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16. What is the torque exerted by the gravitational force of sun on the earth ? Explain.

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

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18. An electron moves round the nucleus of an atom, in a circular path. What is the direction of the angular momentum of the electron ?

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19. Show that the torque acting on a body is equal to the product of moment of inertia and the angular acceleration of the body.

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20. The angular momentum of a body with mass (m) moment of inertia (I) and angular velocity (ω) rad/s is equal to

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21. The dimensional formula for angular momentum is

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22. Write down the relation connecting torque and angular momentum ?

Watch Video Solution

23. State and prove the law of conservation of angular momentum.

Watch Video Solution

24. Write down the equation for the work done in rotatory motion.

Watch Video Solution

25. Derive an expression for the rotational kinetic energy.

Watch Video Solution

26. Name the factors on which the rotational kinetic energy depend.

Watch Video Solution

27. A hollow sphere and a solid sphere of the same dimensions rotate about the same axis with the same angular velocity. Which has greater kinetic energy ?

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28. The equatorial diameter of the earth is greater than the polar diameter. How would the moment of inertia of the earth change if some mass from near the equator were removed and transferred to the polar regions to make the earth a perfect sphere ?

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29. The torque acting on a particle about an arbitrary origin is zero, what can you say about its angular momentum' ?

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30. Can you calculate the torque acting on a rigid body without specifying a centre of rotation ?

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31. It is easier to keep your balance on a moving bicycle than on a bicycle at rest". Why ?

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32. A cat is at rest on a horizontal turn table mounted on a vertical axis. If the cat begins to walk around the perimeter, what happens to the turn

table ? Explain.

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33. A particle moves in a circular path with constant speed .Find out a point about which the angular momentum of the particle is constant and another point about which changes with time.

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34. State the laws of motion for rotating bodies.

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35. While walking across a narrow railroad track, suppose you start to lose your balance. If you start falling to the left which way do you turn your body to regain the balance ? Explain.

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Module 2 Very Short Answer Questions

1. What is meant by circular motion? Give one example.

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2. Which of following statements are correct ? l (a) Centre of mass of a body always coincides with the centre of gravity of the body

(b) Central of mass of a body is the point at which the total garvitational torque on the body is zero

(c) Couple on a body produces both trasnlational and rotation motion in a body

(d) Mechinical advantage greater than one means that small efforts can be used to lift a large load

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3. How will you explain temperature using kinetic theory?

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4. Give an example each for a body where the centre of mass lies inside the body and outside the body.

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5. The coordinates of the centre of mass of a system of three particles of masses 1 mg , 2 mg and 3mg are (2 ,2 ,2) . The coordinates of the fourth particle of mass 4 mg to be positioned so that the center of mass of the four particles system is at the origin of the three – dimensional rectangular coordinate system are

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

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7. Does moment of inertia depend upon the angular velocity of the body ?

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8. A handle is put near the circumference of the wheel of a hand driven grinding machine" why ?

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9. "The cap of a pen can easily be opened with the help of two fingers than with one finger". Explain Why?

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10. A ladder is kept at rest with is upper end against a wall and the lower end on the ground. The ladder is more like to slip when a mass stands on it at the top than at the bottom. Why ?

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11. Which physical quantities are expressed by the following ? (a) rate of change of angular momentum (b) moment of momentum

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12. "A wrench of longer arm as compared to a wrench of shorter arm is preferred." Why?

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13. When a tree is cut, the cutter makes a cut on the side facing the direction in which he wants it to fall. Why ? Explain.

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14. If the earth, were suddenly contracted to (l/n)th of its present radius without change in its mass, then what will be the effect on the duration of the day.

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Module 2 From Equations Of Rotational Motion

1. A particle starts rotating from rest according to the formula $\theta = \left(3t^3/20\right) - \left(t^2/3\right)$ .Find the angular velocity and the acceleration at the end of 5s.

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2. The initial angular velocity of a heavy flywheel rotating on its axis is w_0. Its angular velocity decreases due to friction. At the end of the first minute its angular velocity is $0.8\omega_0$. What is its angular velocity at the end of third minute, if the frictional force is constant ?

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3. A wheel starts rotating with an-angular velocity of 2 rad/s. If it rotates with a constant angular acceleration $4\mathrm{rad}/\mathrm{s}^2$ what angle does the wheel rotate through in 2.0 s ? What is the angular speed, after 2.0 s.

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4. A flywheel is rotating at the rate of 100 rpm and slows down at a constant rate of $1\ \mathrm{rad}/\mathrm{s}^2$. Calculate the time required to stop the flywheel and the number of rotations made by the flywheel before coming to rest?

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5. Calculate the magnitude and direction of total linear acceleration of a particle moving in a circle of radius 0.4 m having an instantaneous angular velocity of $2\text{rad}s^{-1}$ and angular acceleration 5"rad"s^(-2)

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6. The number of revolutions made by a flywheel change from 300 rpm to 1500 rpm in 10 s. Calculate angular acceleration assuming it to be uniform. Also calculate the number of revoluations made during the time.

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7. When a constant torque is applied, a wheel is turned from rest through 200 radians in 10 s. What is its angular acceleration. If the same torque continues to act what is the angular velocity of the wheel after 15 s from the start ?

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8. Starting from rest a centrifuge accelerates uniformly at the rate of $40\mathrm{rad}/s^2$. What is the number of revolutions made by it when its angular velocity becomes 1800 rev/min ?

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Module 2 From Centre Of Mass

1. Three point masses of 1 kg, 2kg and 3 kg lie at (0, 0), (1, 2), (3, -1), respectively. Calculate the coordinates of the centre of mass of the system.

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2. Two bodies of masses m_1 and $m_2(m_1 > m_2)$ respectively are tied to the ends j of a string which passes over a light frictionless pulley. The masses are intitially at rest and released. What is the acceleration of the centre of mass ?

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3. Find the centre of mass of the CO molecule. .Given that the atoms are 1.13×10^{-10} m apart and the ratio of the masses of the two atoms $m_0 / m_c = 1.33$

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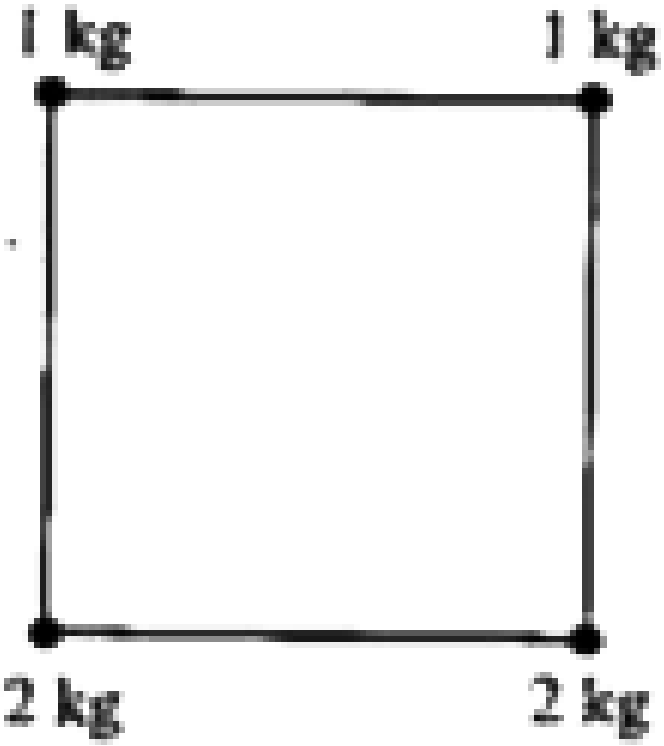
4. Four point masses 1 kg, 1 kg, 2 kg and 2 kg are placed at the corners of a square of side a m as shown in Fig. Find the centre of mass of the

system.



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5. Find the centre of mass of the water molecule. Given that the $m_0 = 16m_H$ the distance between the oxygen atoms and hydrogen atom is 1.02° A and (the angle made by .the two hydrogen atoms with the oxygen atom is 105°

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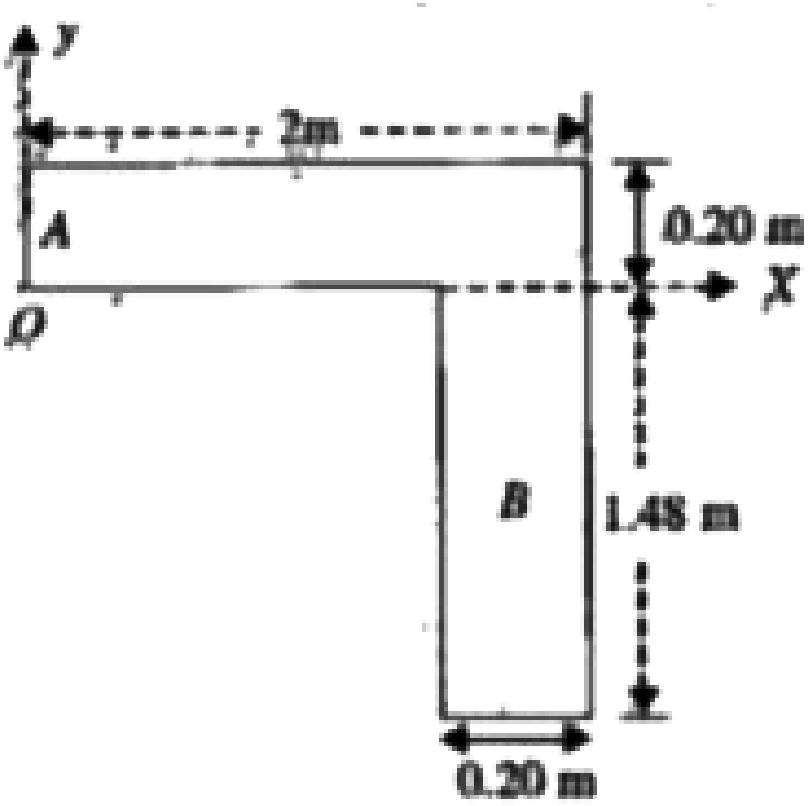
6. Locate ,the centre of mass of the uniform then L-shaped body as shown in Fig. Assume its thickness to be t and density ρ.



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7. A body falling vertically .downwards explodes into two equal fragments when it is at a height of 200 m and has a downward velocity of ,6 just after the explosion one pf the fragments is seen to move .downward with a velocity of $8ms^{-1}$ .Calculate the position of the centre of mass of the system 5 s after ,the explosion.

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8. Two particles A and B are initially separated by a distance of 1.0 m and are at rest. The mass of A is 100 gm and that of B is 30.0 gm and they move under a constant mutual attractive force of 0.02 N .At what distance from the A's original position do the particles collide.

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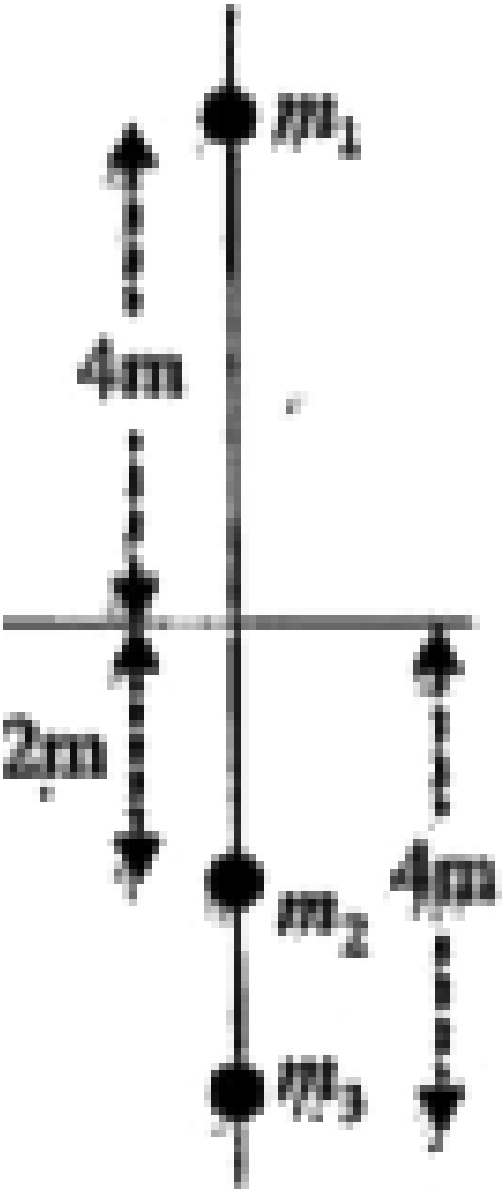
Module 2 From Moment Of Inertia Torque

1. Three point masses $m_1 = 4kg, m_2 = 3$ kg and $m_3 = 2$ kg,are placed along a straight line along the y-axis as shown in Fig. What is the moment

of inertia pf:the system about the x - axis ?



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2. Three masses of 2 kg, 3 kg and 4 kg are located at the three vertices of an equilateral triangle of side 1 m. What is the M.I. of the system about an axis along the altitude of the triangle and passing through the 3 kg mass?

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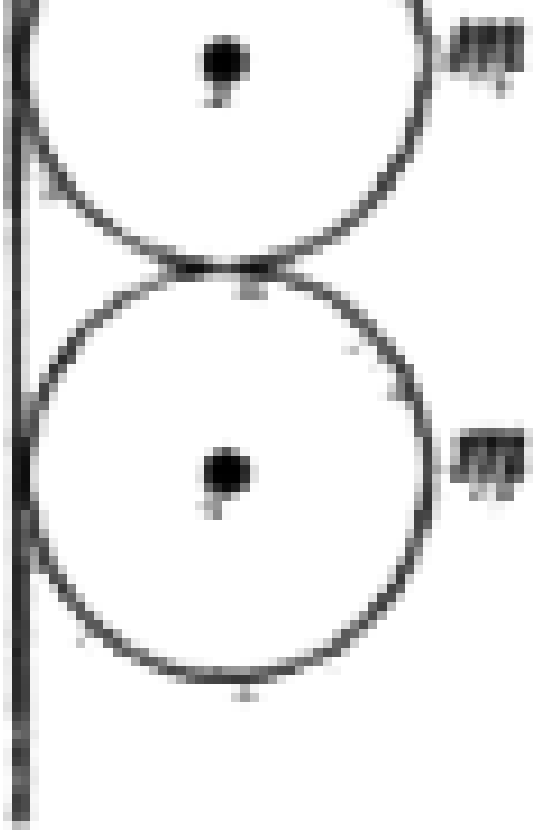
3. Three identical rings of masses m each and radius r are kept in contact as shown in Fig. Find the moment of inertia of the system about a common tangent.



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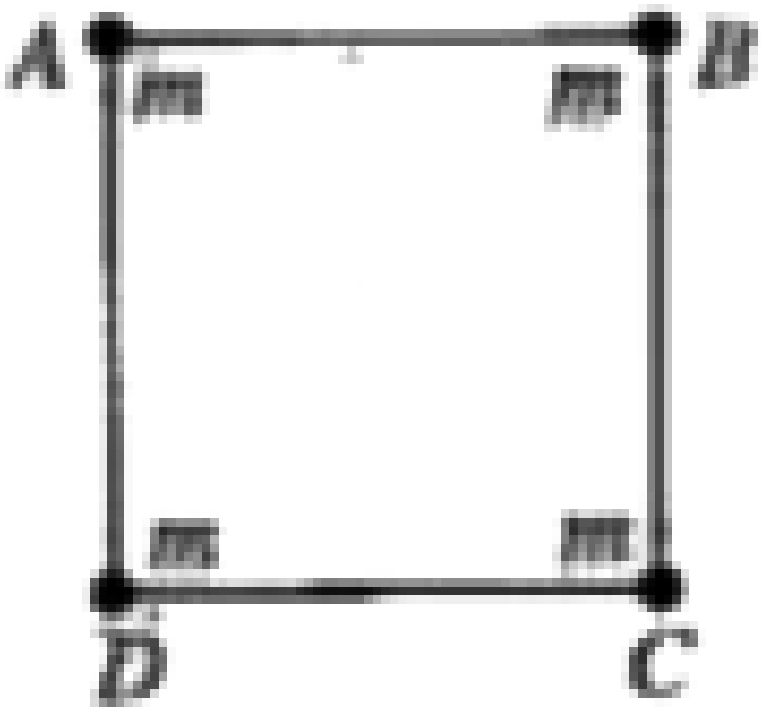
4. Four spheres A, B, C, D, each of mass m and diameter 2 a are placed with their centres at die four corners of a square of side b. What is the

moment of inertia of the system about any side of the square ?



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5. The mass of a unifprm rod is 0.4 kg and its length is 2 m. .Calculate the radius of gyration of the rod about an axis passing through its centre of mass and perpendicular to its length ?

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6. Calculate the moment of inertia of a.unifprm disc of mass 0.4 kg and radius 0.1m about an axis passing through its edge and perpendicular to the plane of die disc ?

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7. Calculate the moment of inertia of a cylinder of length 2 m, radius 5 cm and density $8 \times 10^3 kg/m^3$ about (i) the axis of the cylinder and (ii) and axis passing through the centre and perpendicular to its length.

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8. Calculate the percentage increase in the moment of inertia about the axis of symmetry of a flywheel when the diameter of the flywheel is increased by 2%.

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9. Find ratio of radius of gyration of a disk and ring of same radii at their tangential axis in plane

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10. When a constant torque is applied to a flywheel at rest it angular velocity increases by 10 rad/s in 2 s: Calculate the torque applied if the moment of inertia of the flywheel about the axis of rotation is $200kgm^2$.

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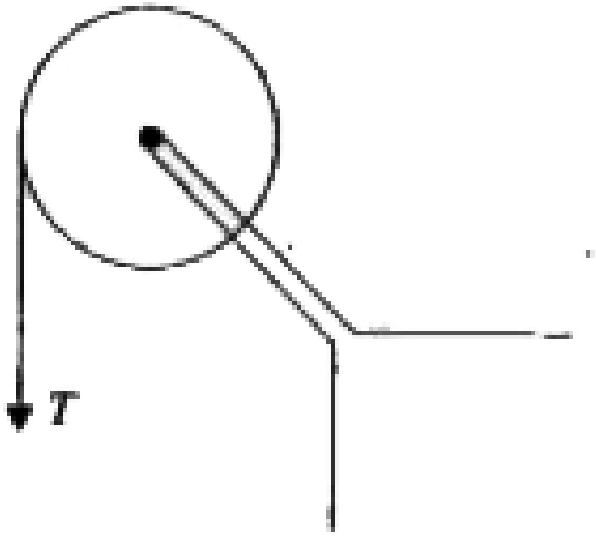
11. Fig. shows a uniform disc of mass 1 kg and radius 0.2 m mounted on an axle supported in fixed frictionless bearings. A light string is wrapped around the rim of the wheel. A constant downwards pull of 2 kg wt. is exerted on the string. What is the angular acceleration of the wheel and

the tangential acceleration of a point on the rim ?



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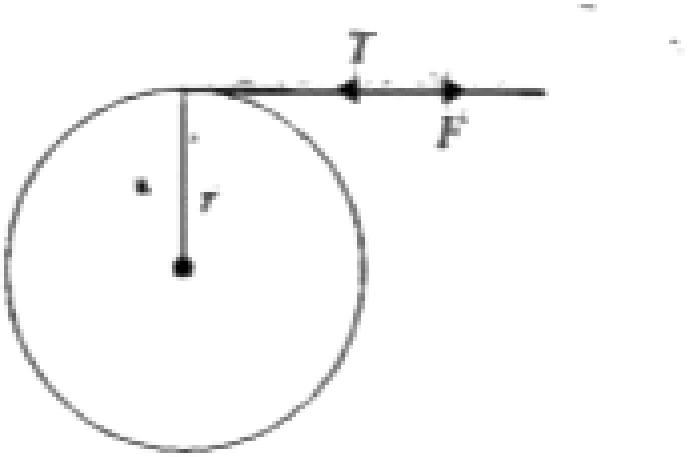
12. A uniform disc of mass of 0.50 kg and radius 0.20 m lies on one side initially at rest on a frictionless horizontal surface. A constant force of 3 N is then applied tangentially at its perimeter using a light weight cord wrapped aroutid its edge. What is the (i) angular acceleration (ii) angular

velocity and angular displacement after 2s ?



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13. A uniform disc of moment of inertia $1kgm^2$ rotates with a speed of 120 rpm, Calculate the torque required to stop the disc in 10 revolutions ?

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14. The power of a motor is 15 HP and its maximum angular speed is $150rads^{-1}$. What is the corresponding torque ?

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15. A constant torque of 20 Nm is exerted bri a pivoted wheel for 10 seconds during which" time' the angular velocity of the wheel changes from 0 to 100 rpm. When the external torque is removed'it is stopped by friction in 100 s. Find (i) the MX of the wheel and (ii) the fiictional torque ?

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16. A wheel of grindstone has applied at its axle 2 cm in radius a constant tangential force of 600 N. Find the change in angular momentum acquired after 8 s and also the torque acting

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17. A particle of mass m is projected with speed u at an angle θ with the horizontal. Find the torque of the weight of the particle about the point of projection when the particle is at the highest point.

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18. What is the torque acting on the bob of mass m of a simple pendulum Of length l, when the string of the pendulum makes an angle θ with the vertical ? When is the torque (i) zero and (ii) maximum.

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19. A torque of 10 Nm is applied to a flywheel of mass 10 kg and radius of gyration 50 cm. What is the resultant angular acceleration ?

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20. A flywheel of radiiis 10 cm mounted so as to rotate about a horizontal axis through its centre. A string of negligible mass wrapped round its' circumference carries' a mass of 200 gm attached to its free end, when let fall the mass descends through 100 cm is 5 s. Calculate the angular acceleration and the moment of inertia of the flywheel.

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21. A flywheel has a mass 200 kg and radius of gyration 0.6 m. It is given an angular speed of 150 rpm in 90 rotations starting from rest. Determine the torque assuming it to be constant that acted on the flywheel.

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22. A grindstone has a moment of inertia of $6kgm^2$. A constant torque is applied and the grindstone is found to have a speed of 150 rpm, 10 seconds after starting from rest. The torque is

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Module 2 From Angular Momentum Conservation

1. A car of mass 1000 kg moves on a circular track of radius 100 m with a speed of 40 m/s. Calculate the magnitude of its angular momentum

relative to the centre of the track.

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2. A uniform sphere of radius 0.25 m and mass 2 kg rotates about its diameter. What is the angular momentum when the angular speed is 5 rad/s ?

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3. The mean distance of the moon from the earth is 3.84×10^5 km and it rotates around the earth in 27.3 days. What is the angular momentum of the moon around the earth ? Mass of the moon = $7.3 \times 10^{22} kg$

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4. A particle of-mass m moves along a circular path of radius r with velocity v. What is its instantaneous angular momentum about a point on

the plane of the orbit at a distance x from the centre of the axis of rotation.

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5. Find the angular momentum of a satellite of mass m moving round the earth of mass m if its orbital radius is r, assuming it to be circular. Express it in terms of G, M, m and r, where G is the universal gravitational constant ?

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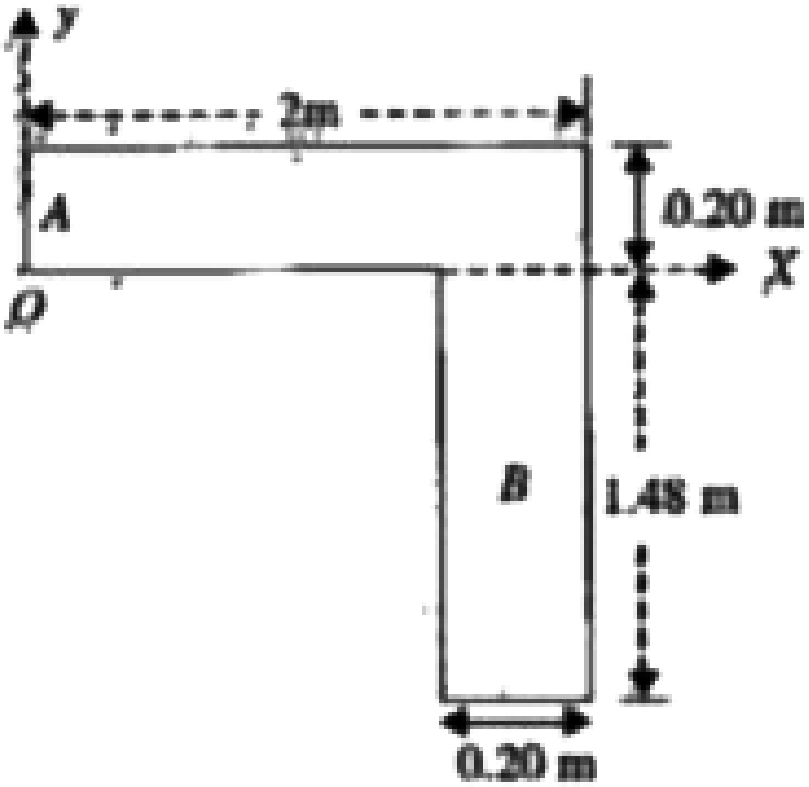
6. Locate ,the centre of mass of the uniform then L-shaped body as shown in Fig. Assume its thickness to be t and density ρ.



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7. Two particles of masses m_1 and m_2 are joined by a light rigid rod of length r. The system rotates at an angular speed ω about an axis through the centre of mass of the system and perpendicular to the rod. Show that the angular momentum of the system is $L = \mu r^2 \omega$ where μ is the reduced mass of the system defined as $\mu = \dfrac{m_1 m_2}{m_1 + m_2}$

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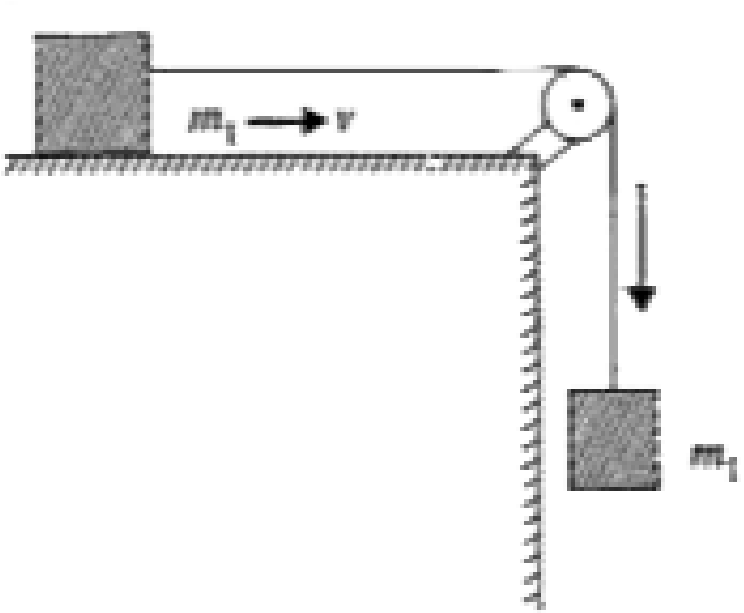
8. If $m_1 = 3$ kg and $m_2 = 1$ kg what is the angular momentum of the system about center of pulley ? The radius of the pulley is 0.3 m and its moment of inertia about its axle is 0.14 kg m^2. The system moves with a linear velocity of 2 m/s on a frictionless horizontal surface ?



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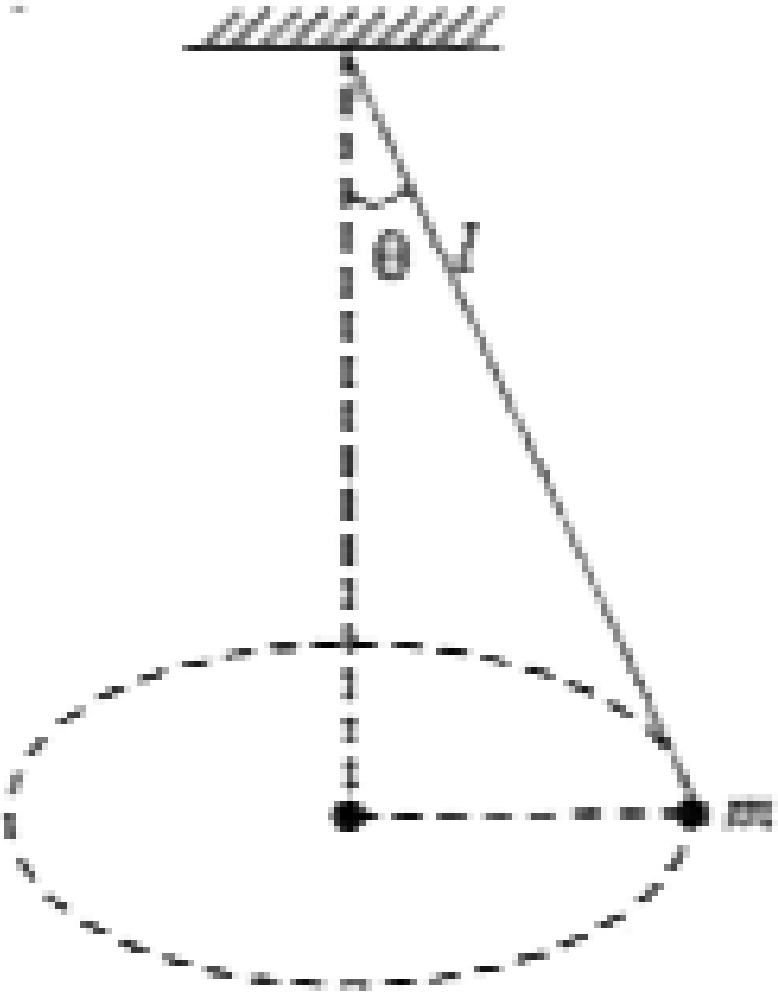
9. Fig. show a conical pendulum. If the length of the pendulum is l, mass of die bob is m and θ is the angle made by the string with the vertical show that the angular momentum of the pendulum about the point of support is:

$$L = \sqrt{\frac{m^2 g l^3 \sin^4 \theta}{\cos \theta}}$$



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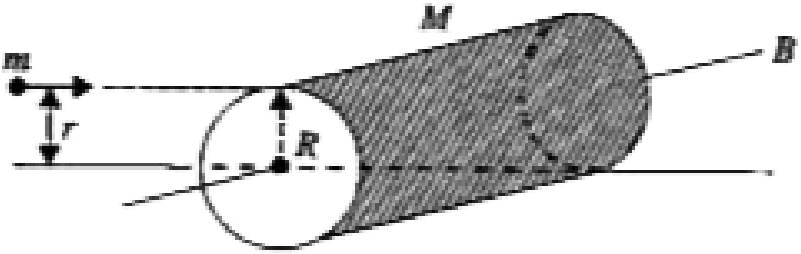
10. A small body of mass 100 g moving with a velocity 2 m/s is strikes a solid cylinder of mass 2 kg and radius 20 cm. The cylinder is initially at rest and is mounted on a fixed horizontal axle that passes through the centre of mass. The line of motion of the small body is at a perpendicular lar distance of 15 cm from the centre of the cylinder. The small body strikes the cylinder and adheres to its surface. What is the angular speed of the system just after the collision ? Assume there is no friction.



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11. The torque acting on a particle about an arbitrary origin is zero, what can you say about its angular momentum' ?

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12. If earth suddenly contracts by 1/2 of its present radius by how much would the day be decreased ?

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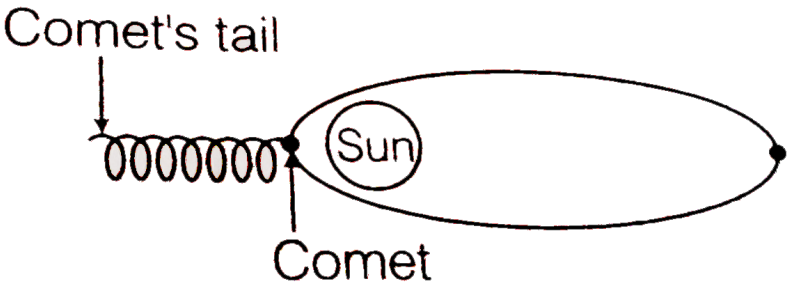
13. The maximum and minimum distances of a cornet form Sun are $1.4 \times 10^{12} m$ and $7 \times 10^{10} m$. If velocity nearest to Sun is $6 \times 10^{4} m s^{-1}$, what is velocity if cornet when it is farthest from the Sun ?



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14. The mass ofa star is 3.98×10^{30} kg and its radius is 106 km. It rotates.about its axis with an angular speed of 10^{-6} rad/s. Calculate the speed of the star when it collapses to a radius of 10^4 km ? Assume the moment of inertia of the star to be $\frac{2}{5}mr^2$.

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Module 2 From Rotational Kinetic Energy Work Power

1. A heavy circular disc is revolving in a horizontal plane about the centre which is fixed. An insect of mass $\frac{1}{n}th$ that of the disc walks from the centre along a radius and then flies away. Show that the final angular velocity is $\frac{n}{n+2}$ times the original angular velocity of the disc.

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2. Calculate the angular momentum and rotational kinetic energy of the earth about its own axis. Given mass of the earth is 6×10^{24} kg and its

radius $=6.4 \times 10^3$ km. [Moment of inertia of the earth about its axis of rotation is $\frac{2}{5}mr^2$]

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3. An oxygen molecule has a mass of 5.3×10^{-26} kg anda moment of inertia of $1.94 \times 10^{-46} kgm^2$ about an axis passing through the centre and perpendicular to the line joining the two oxygen atoms. The molecule is moving at a speed of 500 m/s and its rotational kinetic energy is two-thirds its translational K.E. Calculate its angular velocity.

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4. A flywheel of mass 400 kg and one metre radius makes 600 rev/minute. Assuming its mass to be concentrated at the rim, calculate the angular velocity, M.I. and energy of the flywheel.

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5. A bucket of mass 8 kg is supported by a light rope wound around a solid wooden cylinder of mass 12 kg and radius 20 cm 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 downwards in a well 50 m deep. Neglecting friction, obtain the speed of the bucket and the angular speed of the cylihder just before the bucket enters water.

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6. A metre scale of mass 100 gm is suspended freely at its end. It is pulled aside and swung about a horizontal axis with an angular velocity 5 rad/s. Calculate the height to which the centre of mass of the scale rises above its lowest position, assuming that there is no friction and air resistance. (given : length of meter scale used = 1m)

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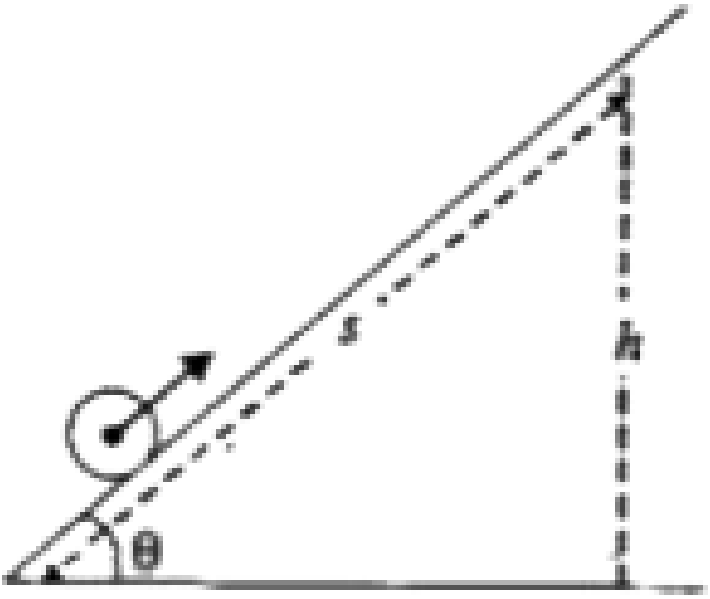
7. A disc rolls up an inclined plane of angle 45^{o}. The centre of mass of the sphere has a translational speed of 2 m/s at the bottom of the plane. What is the distance through which the disc travel up the plane ?



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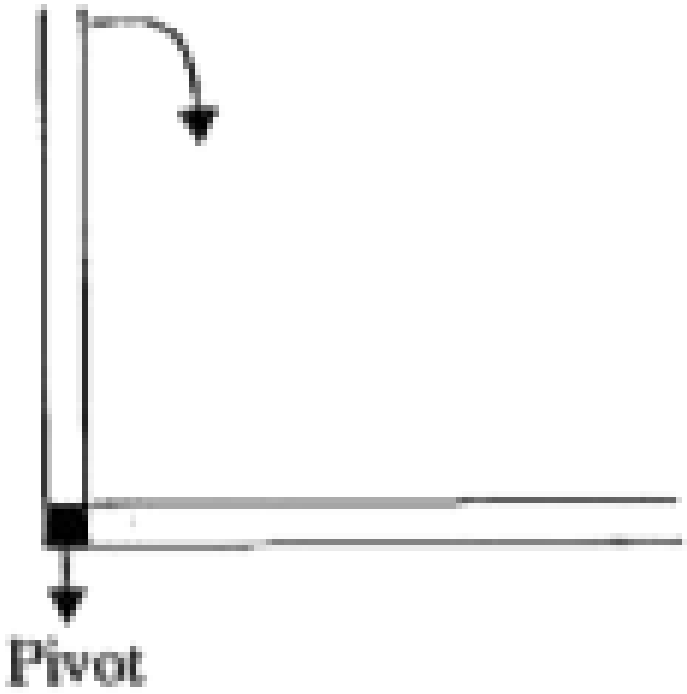
8. A half metre scale is pivoted about a horizontal fiictionless pin through one end as shown in Fig. The scale is released from rest in a vertical position. At the instant when the scale is horizontal what is (i) its angular speed and (ii) the magnitude of the angular acceleration.(Given length of

rod =1/2 m)



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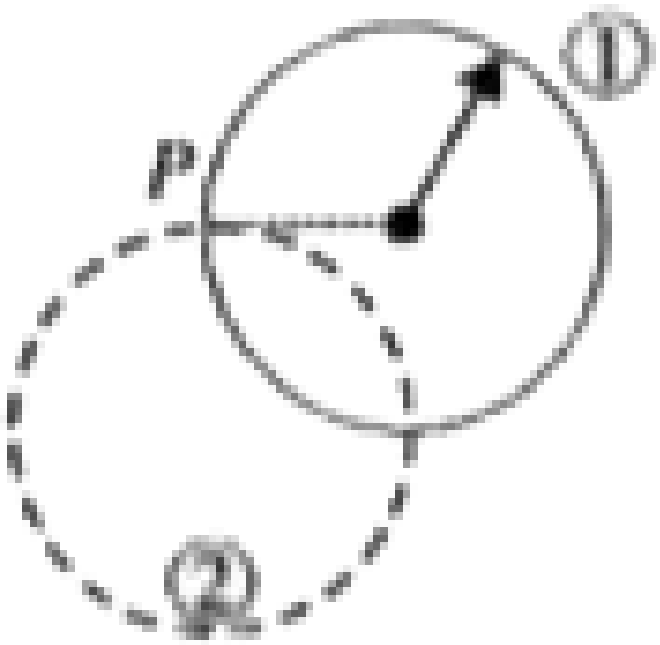
9. A uniform disc of radius r and mass m is free to rotate on a frictionless pivot through point P on its rim as shown in Fig. The disc is at rest and is released from the position (1). (i) What is the speed of the centre of mass when the disc reaches the position (2). (ii) Also rind the speed of the

lowest point on the disc in the dashed position.



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10. A circular disc of mass 100 g and radius 10 cm' is making 2 rps about an axis passing through its centre and perpendicular to its plane. Calculate its kinetic energy.

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11. Calculate the total K.E. of earth, assuming it to be a uniform spherical body moving around the sun with a speed of $30kms^{-1}$ and spinning about its own axis? Mass of earth = 6×10^{24} kg, Radius of earth = 6400 km ?

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12. A circular discof mass 4 kg and radius 1 m rolls on a smooth table with a uniform velocity of $0.5ms^{-1}$. Calculate its (a) rotating K.E. (b) translational K.E.

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13. Calculate the kinetic energy of a hollow metal sphere of mass 2 kg, which rolls over a horizontal surface with a linear velocity of 20 cm/s ?

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14. A uniform solid sphere rolls on a horizontal surface with a linear speed of 10 m/s. It then rolls up a.plane inclined at 30° to horizontal. What is the height upto wlrich the sphere rises ? (See Fig.) Assume that the surface is frictionless. Also calculate the distance travelled by the sphere on the inclined plane ?

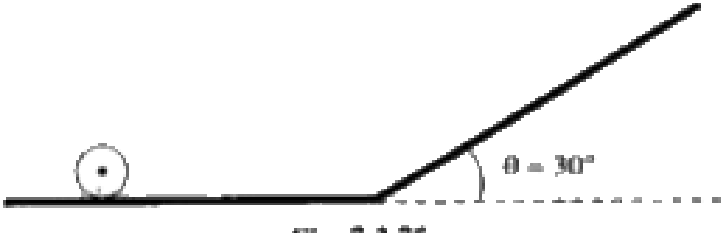

Fig. 7.2.75

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15. A thin uniform rod 0.75 m long and having a mass 1.5 kg rotates 7 times per second about an axis passing through its centre of gravity and perpendicular to its length. Find its kinetic energy ?

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16. A wheel of moment of inertia I_1 rotates about a vertical frictionless axle with an angular velocity ω_1. A second wheel of moment of inertia I_2 and initially at rest drops onto the first wheel. The two wheels attain a common angular velocity of ω_2 . (a) What is the value of ω_2 ? (b) What is the ratio of the initial to the final rotational energy ?

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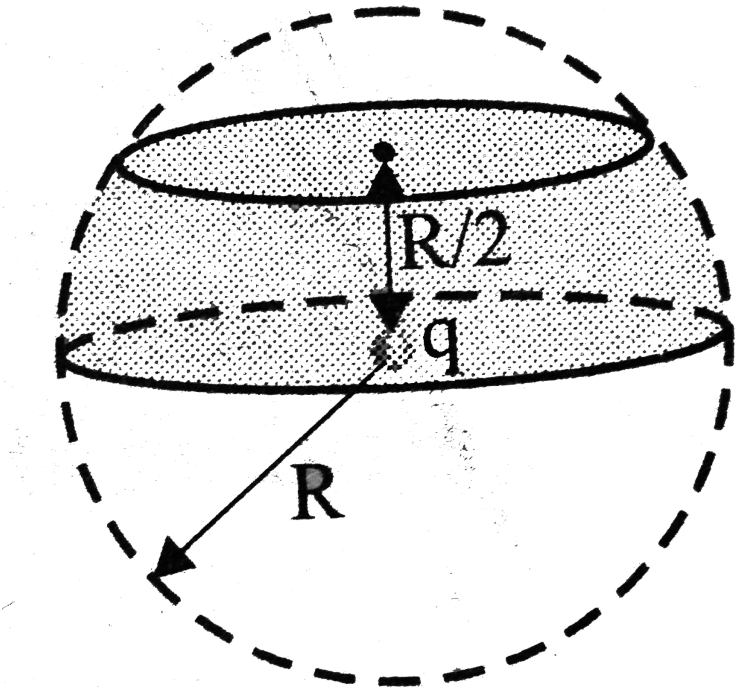
17. Flux passing through the shaded surface of a sphere when a point charge q is placed at the center is (radius of the sphere is R)



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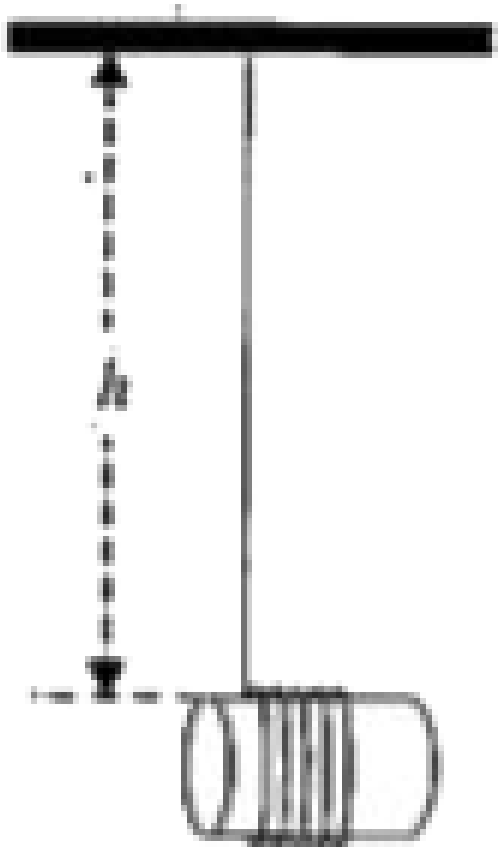
18. One end of a string is tied to a rigid support attached to roof and the other end is wound around a uniform wheel of radius r and mass m. The string is kept vertical and the wheel is released from rest. As the wheel descends show that (i) the tension in the string is one-third the weight of the wheel, (ii) the magnitude of the acceleration of the centre of mass is

2g/3 and (iii) the speed of the centre of mass is $(4gh/3)^{1/2}$



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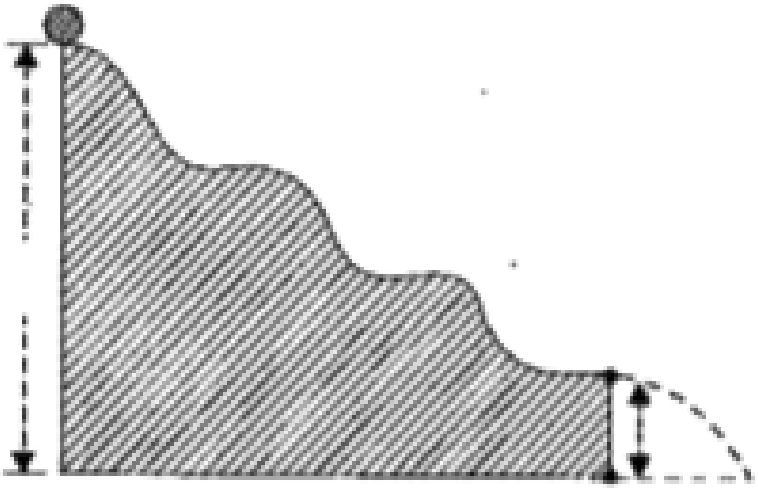
19. In Fig. 98 m and H=98 m. A rigid uniform sphere starts from the point A from rest and rolls down the track without slipping and reaches the horizontal right hand end B, What is the distance to the right of the point C at which the sphere strikes the horizontal base line ?(given

h=29.4)



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20. The mass of a hoop of radius 0.30 m is 2kg. It rolls along a horizontal floor so that its centre of mass has a speed of 2 m/s. What is the work done to stop it ?

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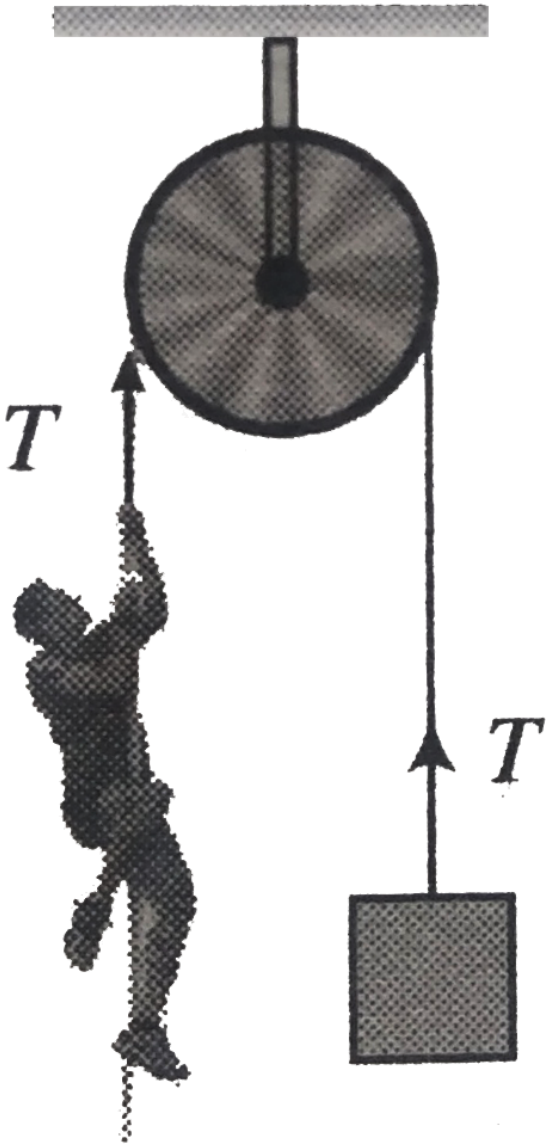
21. In order to raise a mass of 100 kg, a man of mass 60 kg fastens a rope to it and passes the rope over a smooth pulley. He climbs the rope with acceleration $5g/4$ relative to the rope. The tension in the rope is (take

$g = 10ms^{-2}$)



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22. If a constant torque of 500 Nm turns a wheel of moment of inertia $100kg - m^2$ about an axis through its centre, find the angular velocity and the kinetic energy gained in 2 seconds,

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23. The flywheel of an engine, acted upon by a constant torque at the rate of 3000 rev/ min and develops a power of 10 kW. Find the torque acting on the wheel.

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

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