# PHYSICS

# BOOKS - MBD

# MOTION OF SYSTEM OF PARTICLES AND RIGID BODY

## Example

**1.** Can centre of mas of a body be outside it ? If so, give example.

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**2.** Where does the centre of mass of a rectangle lie?

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**3.** Define centre of mass of a system of particles.

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**4.** What is an isolated system?

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**5.** Is it necessary that C.M. should always lie inside the body? Give one example.

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**6.** Is centre of mass a reality?

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

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**8.** Is it correct to say that C.M. of a system of n-particles is always given by the average position vectors of the consituent particles? If not, when is this statement true?

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

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**10.** Where does the centre of mass of a rectangle lie?

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**11.** If one of the particle is heavier than the other, to which side will their centre of mass shift?

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**12.** Is torque a scalar or a vector quantity?

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**13.** What is S.I. unit of torque?

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**14.** What is torque ? Give its S.I. unit.

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**15.** Which physical quantities are expressed by the following? Rate of change of angular moementum.

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**16.** Which physical quantities are expressed by the following? Moment of lineaer momentum.

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**17.** What is law of conservation of momentum ?

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**18.** A body is rotating, it is necessary being acted upon by an exteral torque?

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**19.** What is the difference between torque and work?

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**20.** What is physical meaning of angular momentum?

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**21.** What is lever arm?

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**22.** What is the relation between torque and power?

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**23.** How torque is related to angular momentum?

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**24.** How angular momentum related to areal velocity?

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**25.** Which rule is used for finding direction of torque?

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**26.** The cap of the pen can be easily opened with the help of tw fingers than with one finger. Explain why.

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**27.** Why do all helicopters have two properllers?

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**28.** Define moment of inertia

Watch Video Solution

**29.** On what factors the radius of gyration depend.

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**30.** On what factors does the moment of inertia depend?

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**31.** Draw a graph between moment of inertia and radius of gyration.

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**32.** Is there any difference between moment of inertia and rotational inertia?

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**33.** Does M.I. change with change of the axis of rotation?

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**34.** Why are spokes fitted in a cycle wheel?

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**35.** About which axis of a body is its moment of inertia the least?

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**36.** How does M.I. change with speed of rotation.

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**37.** Two satellites of equal masses are revolving around at different heights. Will their moment of inertia same or different?

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**38.** What is the moment of inertia of a ring

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**39.** What is the moment of inertia of a disc about their diameters?

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**40.** A disc is recast into hollow and thin cylinder of same radius, which will have larger moment of inertia.

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**41.** An electric drill comes to rest quicker than an electric grinder after the power is switched off. Why.

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**42.** Give the location of the centre of mass of a

:- sphere.

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**43.** Give the location of the centre of mass of a

:- cylinder.

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**44.** Give the location of the centre of mass of a

:- cylinder.

Watch Video Solution

**45.** Give the location of the centre of mass of a

:- ring.

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**46.** Give the location of the centre of mass of a

:- cube, each of uniform mass density. Does the centre of mass of a body necessarily lie inside the body ?

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**47.** In the HC1 molecule, the separation between the nuclei of the two atoms is about $1.27\overset{\circ}{A}$ $(1\overset{\circ}{A} = 10^{-10}m)$. 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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**48.** A child sits stationary at one end of a long trolley moving uniformly with a speed V on a smooth horizontal floor. If the child gets up and runs about on the trolley in any manner, what is the speed of the CM of the (trolley + child) system ?

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**49.** Show that the area of the triangle contained between the vectors $\overrightarrow{a}$ and $\overrightarrow{b}$ is one half of the magnitude of $\overrightarrow{a} \times \overrightarrow{b}$.

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**50.** Show that $a.\ (b \times c)$ is equal in magnitude to the volume of the parallelepiped formed on the three vectors , a, b and c.

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**51.** Find the components along the x, y, z axes of the angular momentum 1 of a particle, whose position vector is r with components x, y, z and momentum is 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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**52.** Two particles, each of mass mand speed v, travel in opposite directions along parallel lines separated by a distance d. Show that the vector angular momentum of the two particle system is the same whatever be the point about which the angular momentum is taken.

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**53.** A non-uniform bar of weight W is suspended at rest by two strings of negligible weight as shown in Fig.7.39. The angles made by the strings with the vertical are $36.9^\circ$ and $53.1^\circ$ respectively. The bar is 2 m long.

Calculate the distance d of the centre of gravity of the bar from its left end.

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

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**55.** 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.

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**56.** Given the moment of inertia of a disc of mass M and radius R about any of its diameters to be $MR^2/4$, find its moment of inertia about an axis normal to the disc and passing through a point on its edge.

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**57.** Torques of equal magnitude are applied to a hollow cylinder and a solid sphere, both having the same mass and radius. Hie cylinder is free to rotate about its standard axis of symmetry, and the sphere is free to rotate about an axis passing through its centre.

Which of the two will acquire a greater angular speed after a given time.

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**58.** A solid cylinder of mass 20 kg rotates about its axis with angular speed $100 rad s^{-1}$. The radius of the cylinder is 0.25 m. 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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**59.** A child stands at the centre of a turntable with his two arms outstretched. The turntable is set rotating with an angular speed of $40 rev / \min$. How much is the angular speed of the child if he folds his hands back and thereby reduces his moment of inertia to $2/5$ times the initial value ? Assume that the turntable rotates without friction.

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

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**61.** To maintain a rotor at a uniform angular speed of $200rads^{-l}$, an engine needs to transmit a torque of 180 N m. What is the power required by the engine ? (Note: uniform angular velocity in the absence of friction implies zero torque. In practice, applied torque is needed to counter frictional torque). Assume that the engine is 100% efficient.

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**62.** From a uniform disk of radius R, a circular hole of radius $R/2$ is cut out. The centre of the hole is at $R/2$ from the centre of the original disc. Locale the centre of gravity of the resulting flat body.

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**63.** A metre stick is balanced on a knife edge at its centre. When two coins, each of mass 5 g are put one on top of the other at the 12.0 cm mark, the stick is found to be balanced at 45.0 cm. What is the mass of the metre stick?

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**64.** A solid sphere rolls down two different inclined planes of the same heights but different angles of inclination:- Will it reach the bottom with the same speed in each case?

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**65.** A solid sphere rolls down two different inclined planes of the same heights but different angles of inclination:- Will it take longer to roll down one plane than the other?

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**66.** A solid sphere rolls down two different inclined planes of the same heights but different angles of inclination:- Will it take longer to roll down one plane than the other?

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**67.** A hoop of radius 2 m weighs 100 kg. It rolls along a horizontal floor so that its centre of mass has a speed of $20cm/s$. How much work has to be done to stop it?

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**68.** 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 lines joining the two atoms. Suppose the mean speed of such a molecule in a gas is $500m/s$ 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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**69.** A solid cylinder rolls up an inclined plane of angle of inclination $30^\circ$. At the bottom of the inclined plane the centre of mass of the cylinder has a speed of $5m/s$:- How far will the cylinder go up the plane?

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**70.** A solid cylinder rolls up an inclined plane of angle of inclination $30^{\circ}$. At the bottom of the inclined plane the centre of mass of the cylinder has a speed of $5m/s$:- How long will it take to return to the bottom?

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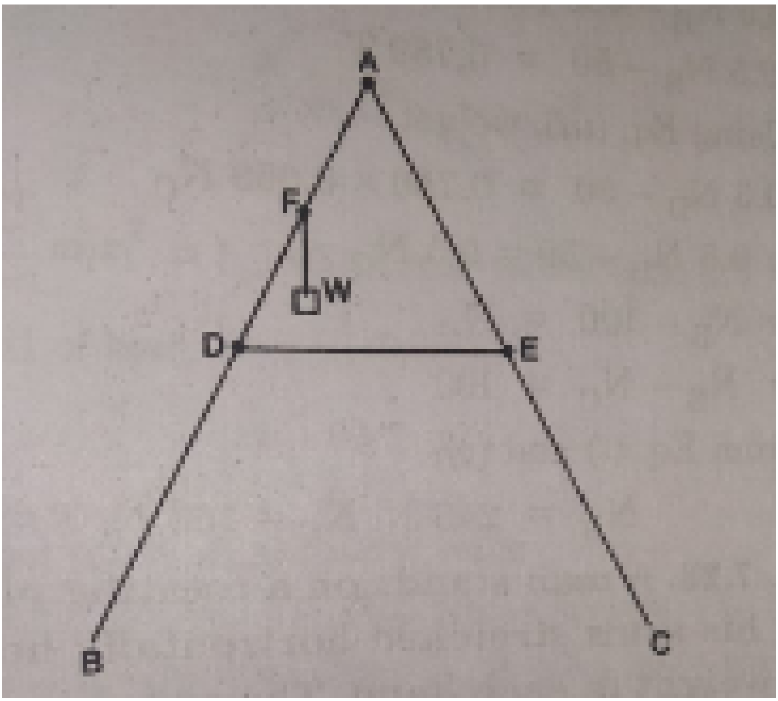
**71.** As shown in the given figure. the two sides of a step ladder BA and CA are 1.6 m long and hinged at A.A rope DE, 0.5 m is tied half way up. A weight 40 kg is suspended from a point

F, 1,2 m from B along the ladder BA. Assuming the floor to be frictionless and neglecting the weight of the ladder, find the tension in te rope and forces exerted by the floor on the ladder. (Take g = $9.8ms^{-2}$) (Hint: consider the equilibrium of each side of the ladder separately).



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**72.** A man stands on a rotating platform, with his arms stretched horizontally holding a 5 kg 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. The moment of inertia of the man together with the platform may be taken to be constant and equal to

$7.6 kgm^2$:- What is his new angular speed? (Neglect friction.)

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**73.** A man stands on a rotating platform, with his arms stretched horizontally holding a 5 kg 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. The moment of inertia of the man together with the platform may be taken to be constant and equal to $7.6 kgm^2$:- Is kinetic energy conserved in the process? If not, from where does the change come about?

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**74.** A bullet of mass 10 g and speed $500 m / s$ is fired into a door and gets embedded exactly at the centre of the door. The door is 1.0 m wide and weighs 12 kg. 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.

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**75.** Two dics 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 speed $\omega_1$ and $\omega_2$ are brought into contact face to face with their axes of

rotation coincident. Find the angular speed of the two-disc system.

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**76.** The discs of moments of inertia $I_1$ and $I_2$ about their respective axis (normal to the disc and passing through the centre), and rotating with agnular speeds $\omega_1$ and $\omega_2$ are brought into contact face to face with their axis of rotation coincident.

Show that the kinetic energy of the combined system is less than the sum of the initial kinetic energies of the two discs. How do you account for this loss in energy ? Take $\omega_1 \neq \omega_2$.

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**77.** Prove the theorem of perpendicular axes. (Hint: Square of the distance of a pint (x,y) in the x - y plane from an axis perpendicular to the plane through the origin is $x^2 + y^2$)

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**78.** Prove the theorem of parallel axes.

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**79.** 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 inclined plane of a height h is given by $v^2 = \frac{2gh}{1 + k^2 / R^2}$ using dynamical consideration (i.e. by consideration of forces and torques). Note k is the radius of gyration of the body about its symmetry axis, and R is the radius of the body. The body starts from rest at the top of the plane.

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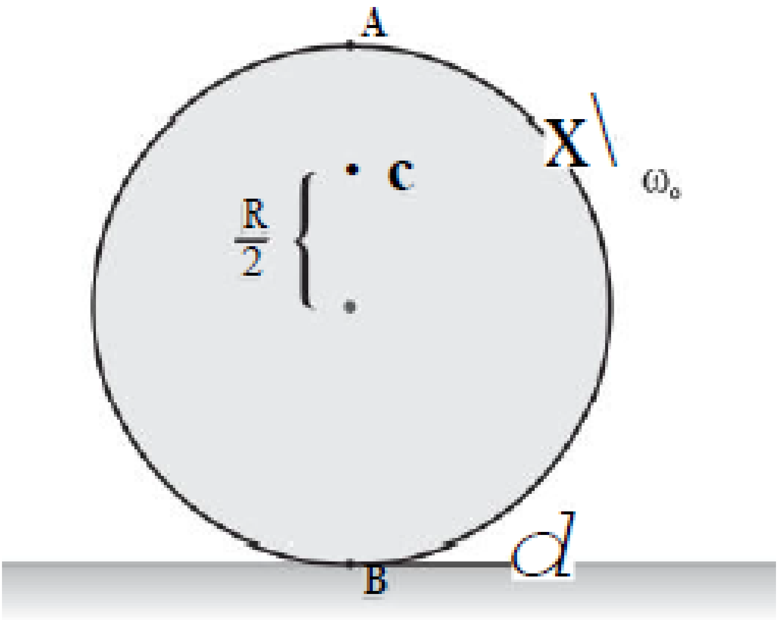
**80.** A disc rotating about its axis with angular speed $\omega_0$ is placed lightly (without any translational push) 011 a perfectly frictionless table. The radius of the disc is R. What are the linear velocities of the points A, B and C on the disc shown in Fig. 7.41? Will the disc roll in the direction indicated ?

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**81.** Explain why friction is necessary to make the disc roll in the direction indicated.

Given the direction of friction force at B, and the sense of frictional torque, before perfect rolling begins.

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**82.** Explain why friction is necessary to make the disc roll in the direction indicated.

Given the direction of friction force at B, and the sense of frictional torque, before perfect rolling begins.

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**83.** A solid disc and a ring, both of radius 10 cm are placed on a horizontal table simultaneously, with initial angular speed equal to $10\pi rads^{-1}$. Which of the two will start to roll earlier ? The co-efficient of kinetic friction is $\mu_k = 0.2$.

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**84.** A cylinder of mass 10 kg and radius 15 cm is rolling perfectly on a plane of inclination $30^\circ$. The co-efficient of static friction $\mu s = 0.25$:-

How much is the force of friction acting on the cylinder ?

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**85.** A cylinder of mass 10 kg and radius 15 cm is rolling perfectly on a plane of inclination $30^{\circ}$. The co-efficient of static friction $\mu s = 0.25$:-

What is the work done against friction during rolling ?

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**86.** A cylinder of mass 10 kg and radius 15 cm is rolling perfectly on a plane of inclination $30^{\circ}$. The co-efficient of static friction $\mu s = 0.25$:- If the inclination $\theta$ of the plane is increased, at what value of $\theta$ does the cylinder begin to skid, and not roll perfectly ?

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**87.** Read each statement below carefully, and state, with reasons, if it is true or false :-

During rolling, the force of friction acts in the same direction as the direction of motion of the CM of the body.

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**88.** Read each statement below carefully, and state, with reasons, if it is true or false :- The instantaneous speed of the point of contact during rolling is zero.

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**89.** Read each statement below carefully, and state, with reasons, if it is true or false :- The instantaneous acceleration of the point of contact during rolling is zero.

Watch Video Solution

**90.** Read each statement below carefully, and state, with reasons, if it is true or false :- For perfect rolling motion, work done against friction is zero.

Watch Video Solution

**91.** Read each statement below carefully, and state, with reasons, if it is true or false :- A wheel moving down a perfectly frictionless inclined plane will undergo slipping (not rolling) motion.

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**92.** Separation of mmotion of a systme of particles into motion of the centre of mass and motion about the centre of mass

Show $\overrightarrow{p} = \overrightarrow{p}_i + m_i\overrightarrow{V}$ where $\overrightarrow{p}_i$ is the momentum of the ith particle

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**93.** Separation of mmotion of a systme of particles into motion of the centre of mass and motion about the centre of mass

Show K = K + 1/2 $MV^2$, where k is the total kinetic energy of the system of particles, K is the total kinetic energy of the system when the particle velcoities are taken with respect to the centre of mass and $MV^2/2$ is the kinetic energy of the translation of the system as a whole (i,e of the centre of mass motion of the system).

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**94.** Separation of mmotion of a systme of particles into motion of the centre of mass and motion about the centre of mass

Show $\overrightarrow{L} = L = \overrightarrow{L} + \overrightarrow{M} R \times \overrightarrow{V}$ where

$\overrightarrow{L} = \Sigma \overrightarrow{r}_i \times \overrightarrow{p}_i$ is the angular momentum of the system about the centre of mass with velocities taken relative to the centre of mass. Remember $\overrightarrow{r}_i = \overrightarrow{r}_i - \overrightarrow{R}$, rest f the notation is the standard notation used in the chapter. Note $\overrightarrow{L}$ and $\overrightarrow{M} R \times \overrightarrow{V}$ can be said to be angular moemnta respectively about and of the centre of mass of the system of particles.

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**95.** Separation of Motion of a system of particles into motion of the centre of mass and motion about the centre of mass :- Show (dL')/(dt)=(sumr_i') xx (dp')/(dt)

$Further, show t\frac{\widehat{dL'}}{dt} =$ tau'_(ext)$where$

tau'_(ext)` is the sum of all external torques acting on the system about the centre of mass.

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**96.** 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:**

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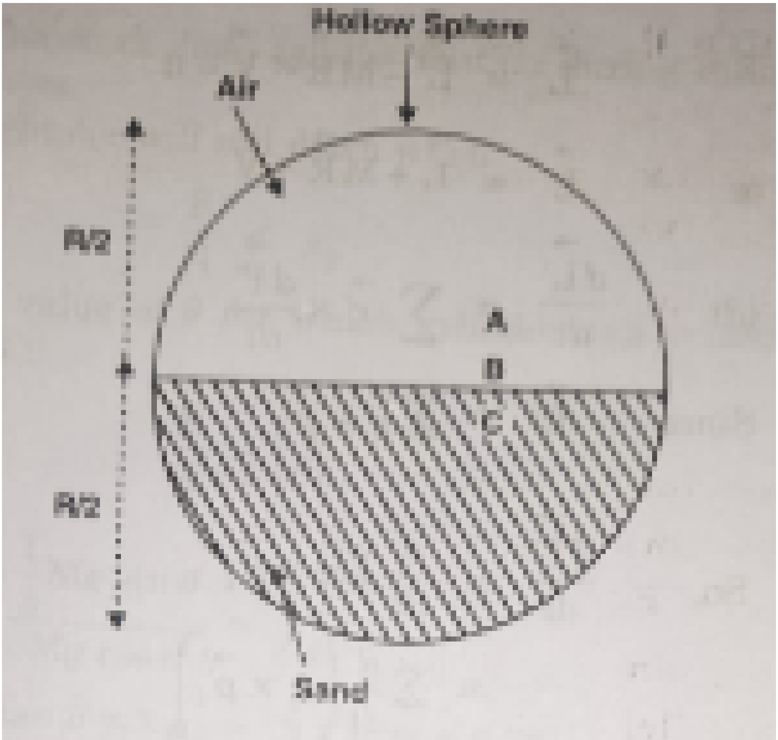
**97.** Which of the following points is the likely position of the centre of mass of the system shown in the figure.




A. A

B. B

C. C

D. D

**Answer:**

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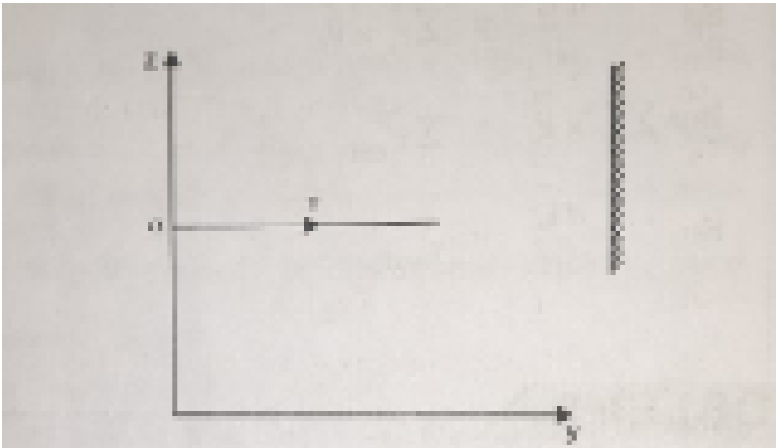
**98.** A particle of mass m is moving in yz-plane with a uniform velocit v with its trajectory running paralel to + ve y-axis and intersecting z-axis at z = a show in the figure. The change in its angular momentum about the origin as it bounces elastically from a wal at y = constant

is



A. $mva\hat{e}_x$

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

C. $ymv\hat{e}_x$

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

**Answer:**

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**99.** 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 ofrotation remains same.

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

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

**Answer:**

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**100.** The angular acceleration is non-zero and remains same.

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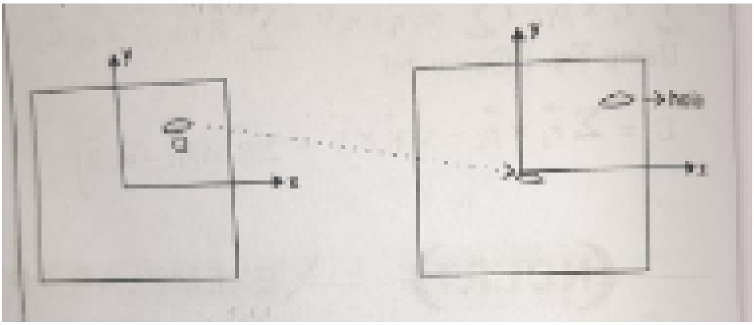
**101.** A uniform square plate has a small piece Q of an irregular shape removed and glued to the enre of the plate leaving a hole behind shown in the figure.



The moment of inretia about the z-axis is then

A. increased

B. decreased

C. the same

D. changed in unpredicted manner.

**Answer:**

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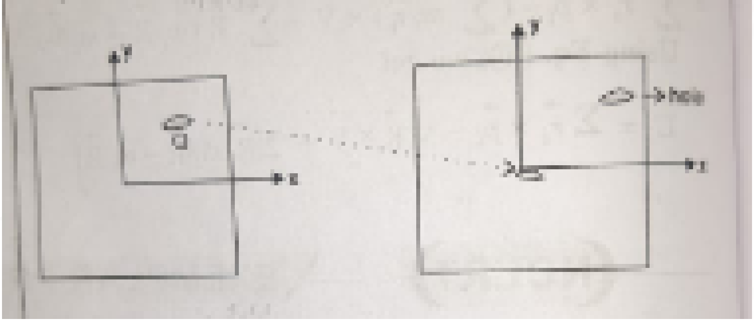
**102.** A uniform square plate has a small piece Q of an irregular shape removed and glued to the enre of the plate leaving a hole behind shown in the figure.



the CM of the late is now in the following quadrant of x-y plane.

A. I

B. II

C. III

D. IV

**Answer:**

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**103.** The density of a non-uniform rod of length 1 m is given by $\rho(x) = a(1 + bx^2)$ where a and b are constant and $0 \leq x \leq 1$. The center 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:**

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**104.** A Merry-go-round made of a ring-like platform of radius R and mass M is revolving with angular speed $\omega$. A person of mass M is standing on it. At one instant, the person jumps off the round radially away from the center of the round (as seen from the center of the round (as seen from the round). The speed of the round afterwards is

A. $2\omega$

B. $\omega$

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

D. 0

**Answer:**

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**105.** Choose the correct alternatives

A. For a general rotational motion, angular momentum $\vec{L}$ and angular velocity $\vec{\omega}$ need not be paralel.

B. For a rotational motion about a fixed axis angular momentum $\vec{L}$ and angular velocity $\vec{\omega}$ are always parallel.

C. For a general translational motion. momentum $\vec{P}$ and velocity $\vec{v}$ are always parallel.

D. For a general translational motion, acceleration $\vec{a}$ and velocity $\vec{v}$ are always parallel.

**Answer:**

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**106.** Two particles, each of mass mand speed v, travel in opposite directions along parallel lines separated by a distance d. Show that the vector angular momentum of the two particle system is the same whatever be the point about which the angular momentum is taken.

A. Angular momentum $\overrightarrow{l}_1$ of particle 1 about A is $\overrightarrow{l}_1 = m \vee ecd_1 \odot$

B. Angular momentum $l_2$ of particle 2 about A is $\overrightarrow{l}_2 = m \vee ecr_2 \odot$

C. Total angular momentm of the system about A is $\overrightarrow{l} = mv\left(\overrightarrow{r}_1 + \overrightarrow{r}_2\right) \otimes$ .

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

represents a unit vector coming out of the page. $\otimes$ represents a unit vector going into the page.

**Answer:**

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**107.** 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 may 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:**

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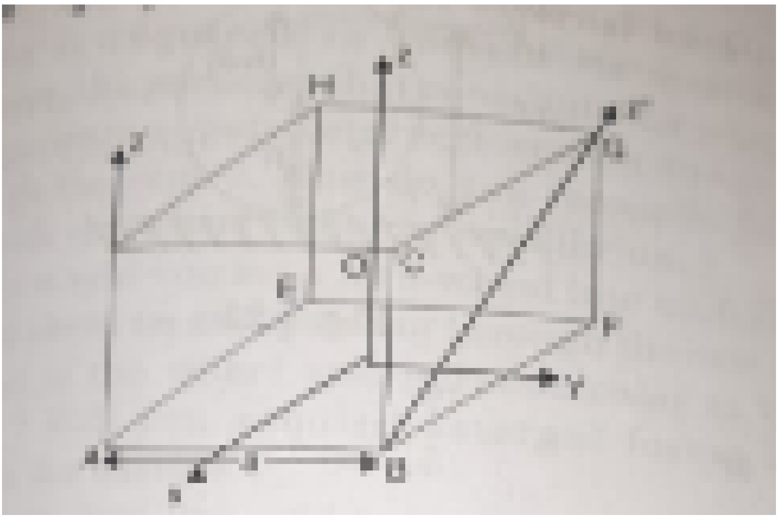
**108.** With reference to (show in the figure) of a cube of edge a and mass m, state whether the following are true or false. (O is the cetre of the cube).



A. The moment of inertia of cube about z-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 cube about z'' is $= I_z + \frac{ma^2}{2}$

D. $I_x = I_y$

**Answer:**

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**109.** 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 quantitative meaning of 'small' and 'extended' in this regard? For whicih of the following the two coincides? A building, a pond, a lake, a mountain??

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**110.** 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 symmetry?

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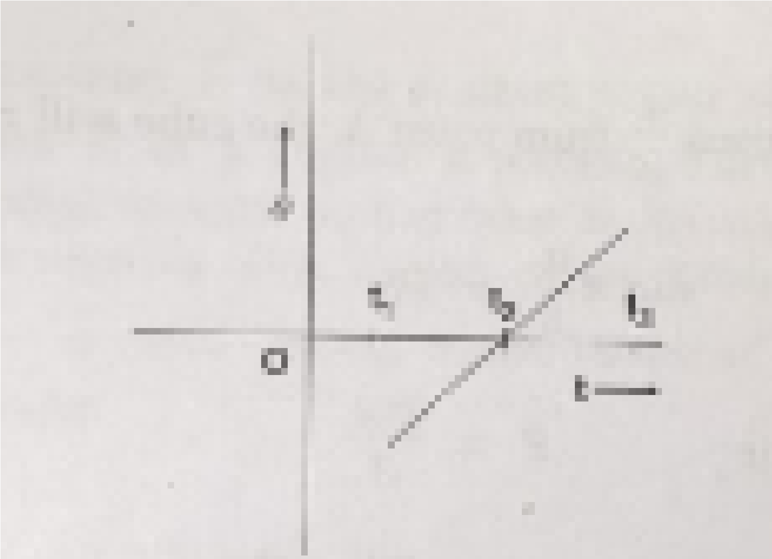
**111.** The variation of angular position $\theta$, of a point on a rotating rigid body, with time t is shown in the figure . Is the body rotating clockwise or anti-clockwise?

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

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**113.** A wheel in uniform motion about an axis passing through its centre and perpendicular to its plane is considered to be in mechanical (translational plus rotational equilibrium because no net external force or torque is required to sustain its motion. However, the particles that constitute the wheel do experience a centripetal acceleration directed towards the centre. How do you reconcile this fact with the wheel being in equilibrium?

How would you set a half - wheel into uniform motion about an axis passing through the centre of mass of the wheel and perpendicular to its plane? Wil you require external forces to sustain the motion?

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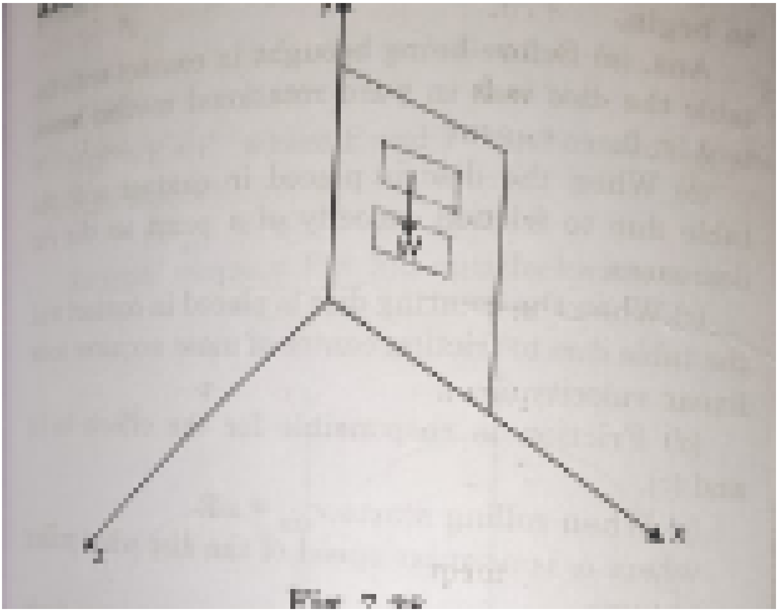
**114.** A door is hinged at one end and is free to rotate about a vertical axis. (show in the figure) Does its weight cause any torque about this axis ? Give reasons for your answer.



**115.** (n-1) equal point masses each of mass m are placed at the vertices of a regular n-polygon. The vacant vertex has a position vector $\vec{a}$ with respect to the center of the polygon. Find the position vector of centre of mass.

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**116.** Find the cente of mass of a uniform half-disc

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**117.** Find the centre of mass of a uniform quarter-disc.

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**118.** Two dics 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 speed $\omega_1$ and $\omega_2$ are brought into contact face to face with their axes of

rotation coincident. Does the law of conservation of angular momentum apply to the situation? Why?

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**119.** Two dics 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 speed $\omega_1$ and $\omega_2$ are brought into contact face to face with their axes of

rotation coincident. Find the angular speed of the two-disc system.

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**120.** Two dics 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 speed $\omega_1$ and $\omega_2$ are brought into contact face to face with their axes of rotation coincident. Calculate the loss in kinetic energy of the system in the process.

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**121.** Two dics 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 speed $\omega_1$ and $\omega_2$ are brought into contact face to face with their axes of rotation coincident. Account for this loss.

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**122.** A disc of radius R is rotating with an angular speed $\omega_0$ about a horizontal axis. it is placed on a horizontal table. The coefficient of kinetic friction is $\mu_k$. What was the velocity of its centre of mass before being brought in contact with the table?

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**123.** A disc of radius R is rotating with an angular speed $\omega_0$ about a horizontal axis. it is placed on a horizontal table. The coefficient of kinetic friction is $\mu_k$. What was the velocity of its centre of mass before being brought in contact with the table?

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**124.** A disc of radius R is rotating with an angular speed $\omega_0$ about a horizontal axis. it is placed on a horizontal table. The coefficient of kinetic friction is $\mu_k$. What was the velocity of its centre of mass before being brought in contact with the table?

Watch Video Solution

**125.** A disc of radius R is rotating with an angular speed $\omega_0$ about a horizontal axis. it is placed on a horizontal table. The coefficient of kinetic friction is $\mu_k$. Which force is responsible for the effects in what happens to the linear velocity of a point on its rim when placed in contact with the table? and What happens to the linear speed of the centre of mass when disc is placed in contact with the table?

Watch Video Solution

**126.** A disc of radius R is rotating with an angular speed $\omega_0$ about a horizontal axis. it is placed on a horizontal table. The coefficient of kinetic friction is $\mu_k$. What condition should be satisfied for rolling to begin?

Watch Video Solution

**127.** A disc of radius R is rotating with an angular speed $\omega_0$ about a horizontal axis. it is placed on a horizontal table. The coefficient of kinetic friction is $\mu_k$. Calculate the time taken for the rolling to begin.

Watch Video Solution

**128.** Two cylindrical hollow drums of radii and 2R, and of a common height h, are rotating with angular velocities $\omega$ (anticlockwise) and $\omega$

(clockwise), respectively, Their axes, fixed are parallel and in a horizontal plane separated by $(3R + \delta)$. They are now brought in contact $(\delta \to 0)$. Show the frictional forces just after contact.

Watch Video Solution

**129.** Two cylindrical hollow drums of radii and 2R, and of a common height h, are rotating with angular velocities $\omega$ (anticlockwise) and $\omega$ (clockwise), respectively, Their axes, fixed are parallel and in a horizontal plane separated by $(3R + \delta)$. They are now brought in contact $(\delta \to 0)$. Identify forces and torques external to the system just after contact.

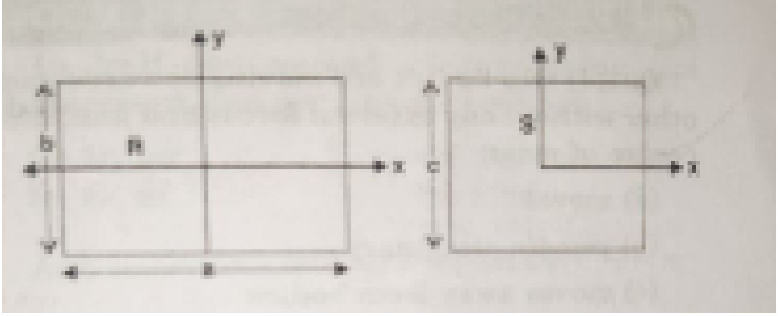
Watch Video Solution

**130.** Two cylindrical hollow drums of radii and 2R, and of a common height h, are rotating with angular velocities $\omega$ (anticlockwise) and $\omega$ (clockwise), respectively, Their axes, fixed are parallel and in a horizontal plane separated by

$(3R + \delta)$. They are now brought in contact $(\delta \to 0)$. What would be the ratio of final angular velocities when fiction ceases?

Watch Video Solution

**131.** A uniform square plate S (side c) and a uniform rectangular plate R (sides b,a) have identical areas and masses (show in the figure).

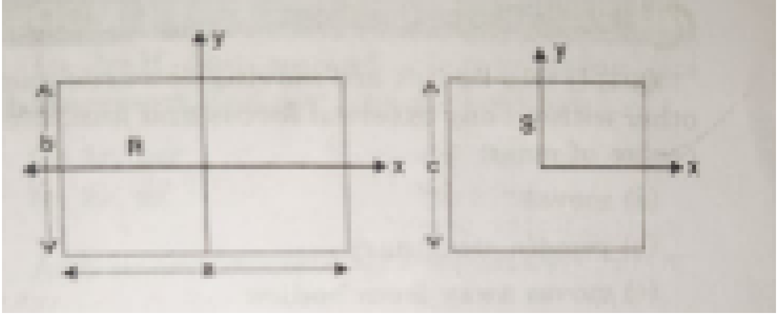



Show

that $I_{zR}$//I_(zS) > 1`

Watch Video Solution

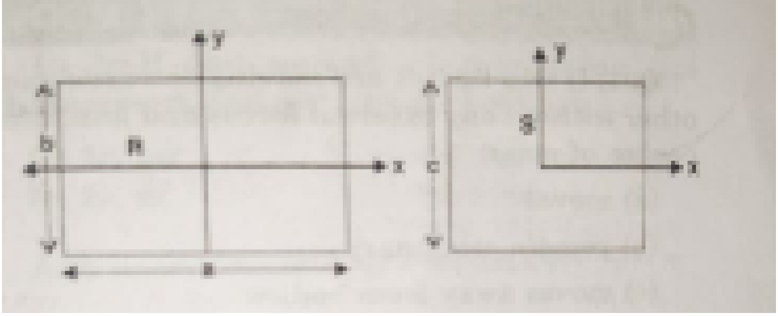
**132.** A uniform square plate S (side c) and a uniform rectangular plate R (sides b,a) have identical areas and masses (show in the figure).



Show that $I_{yR}$//I_(yS) < 1`

Watch Video Solution

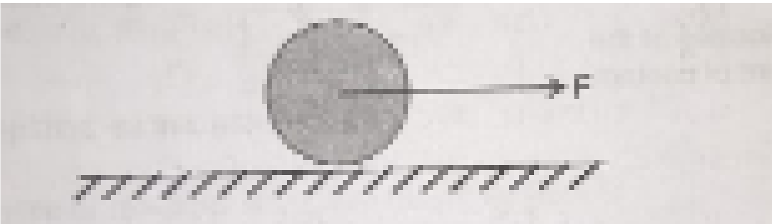
**133.** A uniform square plate S (side c) and a uniform rectangular plate R (sides b,a) have identical areas and masses (show in the figure).




Show that $I_{zR}$//I_(zS) > 1`

Watch Video Solution

**134.** A uniform disc of radius R, is resting on a table on its rim. The coeffcient of friction between disc and table is $\mu$(show in the figure). Now the disc is pulled with a force F . What is the maximum value of F for which the disc rolls without slipping?




Watch Video Solution

**135.** If two bodies are moving towards each other without any external forces and join, then centre of mass

A. moves

B. remains stationary

C. moves away from bodies

D. none of the above

**Answer:**

Watch Video Solution

**136.** Two bodies of different masses of 2 kg and 4 kg are moving with velocities $2ms^{-1}$ and $10ms^{-1}$ towards each other due to mutual gravitational attraction. What is velocity of their centre of mass?

A. $5ms^{-1}$

B. $6ms^{-1}$

C. $8ms^{-1}$

D. zero

**Answer:**

Watch Video Solution

**137.** A solid sphere is rotating in free space. If the radius of the sphere is increased keeping mass same, which one of the following will nt be affected?

A. Moment of intertia

B. rotational kinetic energy

C. Angular momentum

D. Angular velocity

**Answer: Rotational K.E.**

Watch Video Solution

**138.** Which of these statements is not correct?

A. Moment of inertia is dependent on shape and size of the body.

B. Moment of inertia depends on choice of axes.

C. Moment of inertia does not depend on mass of body.

D. none of the above

**Answer:**

Watch Video Solution

**139.** The mass of a flywheel is concentrated at its rim so as to have

A. a large moment of inertia

B. a small moment of inertia

C. a stable moment of inertia

D. an unstable equilibrium

**Answer:**

Watch Video Solution

**140.** If a body is moving in a circle of radius r centimetre at a constant speed of $vcms^{-1}$, then its angular velocity is

A. $\frac{v^2}{r}$

B. vr

C. $\frac{v}{r}$

D. $\frac{r}{v}$

**Answer:**

Watch Video Solution

**141.** A closed tube, partly filled with a liqyid and set horizontal, is rotated about a vertical axis passing through its centre. IN the process, the moment of inertia of the system about its axis would

A. always increase

B. always decrease

C. remain constant

D. increase if tube is less than half filled but otherwise decrease.

**Answer:**

Watch Video Solution

**142.** When a torque acting upon a system is zero, which of the following will be constant?

A. Force

B. Angular momentum

C. Linear impulse

D. None of these

**Answer:**

Watch Video Solution

**143.** A rigid body is rotating about an axis. To stop the rotation, we have to apply

A. pressure

B. force

C. momentum

D. torque

**Answer:**

Watch Video Solution

**144.** A couple produces a

A. pure linear motion

B. pure rotational motion

C. both linear and rotational motion no motion

D. no motion

**Answer:**

Watch Video Solution

**145.** Angular momentum is the vector product of

A. linear momentum and radius vector

B. moment of inertia and angular acceleration

C. linear momentum and angular velocity

D. linear velocity and radius vector.

**Answer:**

Watch Video Solution

**146.** A planet is revolving round the sun in elliptical orbit. The maximum and minimum distances of the planet from the sun are

$2 \times 10^2$ m and $2 \times 10^{10} m$ respectively. The speed of the planet when it is nearest to sun is $2 \times 10^{15} ms^{-1}$ What is the speed when it is farthest to the sun?

A. $1.33 \times 10^9 ms^{-1}$

B. $1.51 \times 10^7 ms^{-1}$

C. $1.33 \times 10^5 ms^{-1}$

D. $2 \times 10^7 ms^{-1}$

**Answer:**

Watch Video Solution

**147.** A particle moves in a circle of radius r. In half the period of revolution, its displacement and distance covered are

A. $2r, 2\pi r$

B. $r\sqrt{2}, \pi r$

C. $2r, \pi r$

D. $r, \pi r$

**Answer:**

Watch Video Solution

**148.** A car of mass 1000 kg moves on a circular road with a speed of $20 ms^{-1}$. Its direction changes by $90^{\circ}$ after travelling 628 m on the road. The centripetal force acting on the car is

A. 1000 N

B. 1500 N

C. 2000 N

D. 3000 N

**Answer:**

Watch Video Solution

**149.** A particle revolves round a circular path.The centripetal acceleration of the particle is inversely proportional to:

A. along circumference of the circle

B. along the tangent

C. along the radius

D. zero centripetal

**Answer:**

Watch Video Solution

**150.** Fill in the blanks:

When no external force acts on a system the total _____ of the system remains constant.

Watch Video Solution

**151.** Fill in the blanks:

Centre of mass can lie _ the body.

Watch Video Solution

**152.** Fill in the blanks:

Torque is the product of force and __ distance from the axis of rotation.

Watch Video Solution

**153.** Fill in the blanks:

Mass of a body is _________ of inertia of the body to _______ motion.

Watch Video Solution

**154.** Fill in the blanks:

When angular momentum is conserved _______-what does it mean?

Watch Video Solution

**155.** Fill in the blanks:

Radius of gyration of a body is ________ constant quantity.

Watch Video Solution

**156.** Fill in the blanks:

Unit of MI in SI = __________

Watch Video Solution

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

Watch Video Solution

**158.** What is an isolated system?

Watch Video Solution

**159.** What is dimensional formula of angular momentum ? What are its units? Is it scalar quantity?

Watch Video Solution

**160.** Why does cream collect in the middle when milk is churned up?

Watch Video Solution

**161.** Prove that

$$\left|\vec{A}\,.\,\vec{B}\right|^2+\left|\vec{A}\times\vec{B}\right|^2=A^2B^2$$

Watch Video Solution

**162.** A wrench with large arm is preferred. Why?

Watch Video Solution

**163.** On what factors does the moment of inertia depend?

Watch Video Solution

**164.** Define perpendicular axis theorem of moment of inertia.

Watch Video Solution

**165.** Define parallel axis theorem.

Watch Video Solution

**166.** Define radius of gyration.

Watch Video Solution

**167.** Under what conditions angular momentum of a moving body is zero?

Watch Video Solution

**168.** Give mathematical expression of centre of mass of N-particle system.

Watch Video Solution

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

Watch Video Solution

**170.** Torque and work are both defined as force times distance. How do they differ?

Watch Video Solution

**171.** In a flywheel most of mass is concentrated at the rim. Explain why?

Watch Video Solution

**172.** If the ice on the polar caps of the earth melts, how will it affect the duration of the day? Explain.

Watch Video Solution

**173.** Is there any difference between moment of inertia and rotational inertia?

Watch Video Solution

**174.** Why does a cyclist lean to one side while going along a curve? In which direction does he lean?

Watch Video Solution

**175.** Moment of inertia of the sphere about its diameter is $\frac{2}{5}Mr^2$. What is the moment of inertia about an axis $\perp$ to point of intersection of two diameters?

Watch Video Solution

**176.** Can centre of mas of a body be outside it ?

If so, give example.

Watch Video Solution

**177.** Center of mass of a body always lies at a point, where there is no mass?

Watch Video Solution

**178.** Can centre of mas of a body be outside it ? If so, give example.

Watch Video Solution

**179.** Two solid spheres of same mass are made of metals of different densities. Which one of them has a larger moment of inertia about a diameter?

Watch Video Solution

**180.** Two sphere are of same mass and same external radius, one is solid and the other is hollow. Which one of them has larger moment of inertia about its diameter?

Watch Video Solution

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

Watch Video Solution

**182.** A body is rotating, it is necessary being acted upon by an exteral torque?

Watch Video Solution

**183.** Moment of inertia of a sphere about its diameter is $\frac{2}{5}MR^2$. What is the radius of gyratin about that axis?

Watch Video Solution

**184.** A bucket containing water is rotated in a vertical circle. Explain why does not water fall down.

Watch Video Solution

**185.** During motion in the vertical circle, what is the difference in tension at the top and bottom of the circle?

Watch Video Solution

**186.** What is rotational analogue of mass?

Watch Video Solution

**187.** What happens when a spinning ballet-dancer draws her arms close to her chest?

Watch Video Solution

**188.** How a swimmer jumping from a height is able to increase the number of loops made in the air?

Watch Video Solution

**189.** Do the internal forces affect the location of the centre of mass?

Watch Video Solution

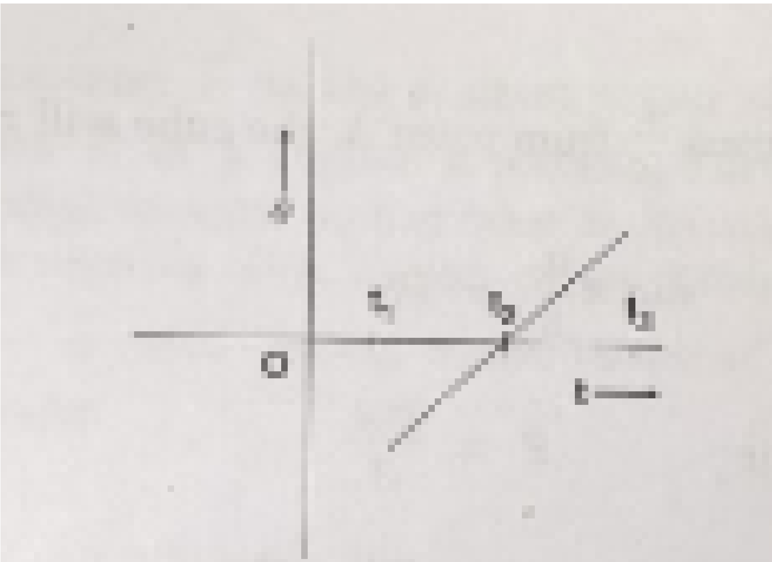
**190.** The centre of gravity of a body on the earth coincides with its centre of mass for a 'small' object whereas for an 'extended' object it may not. What is the quantitative meaning of 'small' and 'extended' in this regard? For whicih of the following the two coincides? A building, a pond, a lake, a mountain??

Watch Video Solution

**191.** 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 symmetry?

Watch Video Solution

**192.** The variation of angular position $\theta$, of a point on a rotating rigid body, with time t is shown in the figure . Is the body rotating clockwise or anti-clockwise?



Watch Video Solution

**193.** Center of mass of a body always lies at a point, where there is no mass?

Watch Video Solution

**194.** Can centripetal force produce rotation?

Watch Video Solution

**195.** What is S.I. unit of torque?

Watch Video Solution

**196.** Is radius of gyration of a body a constant quantity?

Watch Video Solution

**197.** Does M.I. change with change of the axis of rotation?

Watch Video Solution

**198.** Two sphere are of same mass and same external radius, one is solid and the other is hollow. Which one of them has larger moment of inertia about its diameter?

Watch Video Solution

**199.** What are the dimensions and unit of moment of inertia?

Watch Video Solution

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

Watch Video Solution

**201.** The centre of mass of a body___ on the distribution of mass inside it.

Watch Video Solution

**202.** _______ is a useful mathematical concept to simplify the study of the motion of a rigid body.

Watch Video Solution

**203.** The centre of mass of a system of particles moves as if all the ________ of the system was concentrated at the ________ of mass and all the external forces acting on the system were applied directly at this point.

Watch Video Solution

**204.** If $F\_(ext) = 0$, the c.m. of a system moves with _______ velocity.

Watch Video Solution

**205.** In fact, there is ________ at the location of centre of mass.

Watch Video Solution

**206.** A body is in mechanical equilibrium if _____ and ___________ don't change with time.

Watch Video Solution

**207.** Is centre of mass a reality?

Watch Video Solution

**208.** Define a rigid body.

Watch Video Solution

**209.** Prove that the time rate of change of the angular momentum of a particle is equal to the torque acting on it.

Watch Video Solution

**210.** Deduce an expression for rectangular components of torque in the three dimensions.

Watch Video Solution

**211.** Show that for an isolated system, centre of mass moves with a uniform velocity along a straight path.

Watch Video Solution

**212.** Show that torque is due to transverse component only and does not depend on the radial component.

Watch Video Solution

**213.** What is law of conservation of momentum

?

Watch Video Solution

**214.** Define moment of inertia

Watch Video Solution

**215.** Define moment of inertia

Watch Video Solution

**216.** On what factors the radius of gyration depend.

Watch Video Solution

**217.** Discuss general motion of a rigid body.

Watch Video Solution

**218.** What is law of conservation of momentum ?

Watch Video Solution

**219.** Prove the theorem of parallel axes.

Watch Video Solution

**220.** State Theorem of perpendicular axis.

Watch Video Solution

**221.** Show that the vector $\overrightarrow{A} = -6\hat{i} + 9\hat{j} - 12\hat{k}$ and $\overrightarrow{=}\ 2\hat{i} - 3\hat{j} + 4\hat{k}$ are parallel to each other.

Watch Video Solution

**222.** Given that $\overrightarrow{a} \cdot \overrightarrow{b} = 0$ and $\overrightarrow{a} \times \overrightarrow{b} = \overrightarrow{0}$.

What can you conclude about the vectors $\overrightarrow{a}$ and $\overrightarrow{b}$?

Watch Video Solution

**223.** If the angular momentum is conserved in a system whose MI is decreased, will its rotational KE be also conserved? Explain.

Watch Video Solution

**224.** Three identical spheres each of radius R are placed touching each oother on a horizontal table. Where is the centre of mass of the system located?

Watch Video Solution

**225.** Establish the relation L = $I\omega$

Watch Video Solution

**226.** What is law of conservation of momentum ?

Watch Video Solution

**227.** It is easier to balance a bicycle in motion. Why?

Watch Video Solution

**228.** Deduce the relation between torque and moment of inertia.

Watch Video Solution

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

Watch Video Solution

**230.** Determine the co-ordinates of centre of mass of a system of n particles.

Watch Video Solution

**231.** Illustrate with examples, the concept of centre of mass.

Watch Video Solution

**232.** Define a rigid body.

Watch Video Solution

**233.** Discuss general motion of a rigid body.

Watch Video Solution

**234.** Define torque. Discuss the rotational motion of a single particle in a plane.

Watch Video Solution

**235.** Derive expression for torque in cartesian co-ordinate system.

Watch Video Solution

**236.** Show that $T_z = xF_y - yF_x$

Watch Video Solution

**237.** Derive expression for torque in polar coordinates.

Watch Video Solution

238. Show that $\tau = F.d.$ where $\tau$ is torque, F is force applied and d is the $\perp$ distance of the particle from the axis of rotation called lever arm.

Watch Video Solution

239. Deduce an expression for rectangular components of torque in the three

dimensions.

Watch Video Solution

**240.** What is the significance of torque?

Watch Video Solution

**241.** How torque is related to angular momentum?

Watch Video Solution

**242.** Derive the expression for angular momentum of a particle in two dimensions for in a plane).

Watch Video Solution

**243.** Show that $L_z = xp_y - yp_x$, where letters have their usual meanings.

Watch Video Solution

**244.** Derive the expression for angular momentum in three dimensions.

Watch Video Solution

**245.** Find the relation between angular momentum and lever arm.

Watch Video Solution

**246.** Show that the angular momentum is the product of linear momentum and $\perp$ distance from the axis of rotation (lever arm) i.e. L = p.d

Watch Video Solution

**247.** Show that angular momentum is due to transverse component and does not depend on the radial component i.e. $L = rp_{\theta}$

Watch Video Solution

**248.** What is geometrical meaning of angular momentum in two dimensions?

Watch Video Solution

**249.** State Keplers' laws of planetary motion.

Watch Video Solution

**250.** How torque is related to angular momentum?

Watch Video Solution

**251.** Derive an expression for kinetic energy of rotation.

Watch Video Solution

**252.** Define moment of inertia

Watch Video Solution

**253.** Compare relations in linear motion and rotational motion.

Watch Video Solution

**254.** Find the moment of inertia of a thin circular ring

about an axis passing through the centre and perpendicular to the plane of the ring

Watch Video Solution

**255.** Derive the expression for moment of inertia of a circular disc

about the diameter of the disc.

Watch Video Solution

**256.** Given the moment of inertia of a disc of mass M and radius R about any of its diameters to be $MR^2/4$, find its moment of inertia about an axis normal to the disc and passing through a point on its edge.

Watch Video Solution

**257.** Find the moment of inertia of a thin circular ring

about a tangent $\perp$ to the plane of the ring.

Watch Video Solution

**258.** Derive the expression for moment of inertia of a circular disc

about an axis passing through its centre and perpendicular to its plane

Watch Video Solution

**259.** Derive the expression for moment of inertia of a circular disc

about the diameter of the disc.

Watch Video Solution

**260.** Derive the expression for moment of inertia of a circular disc

about an axis tangential to the plane of the disc.

Watch Video Solution

**261.** Derive the expression for moment of inertia of a circular disc

about an axis passing through its centre and perpendicular to its plane

Watch Video Solution

**262.** Find the expression for moment of inertia of a thin uniform rod about an axis passing through its centre and perpendicular to its length

Watch Video Solution

**263.** Find the expression for moment of inertia of a thin uniform rod

about an axis passing through its one end and perpendicular to its length.

Watch Video Solution

**264.** Discuss Motion of Mass point on a string wound on cylinder.

Watch Video Solution

**265.** Derive an expression for aceleration of a bdy moving down an inclined plane.

Watch Video Solution

**266.** A 2 kg body and a 3 kg body are moving along X-axis. At a particular instnat, the 2 kg body is 1 m from the origin and has a velocity of $3ms^{-1}$ and the 3 kg body is 2 m away from the origin has a velocity of $-1ms^{-1}$. Find the position and velocity of the centre of mass.

Watch Video Solution

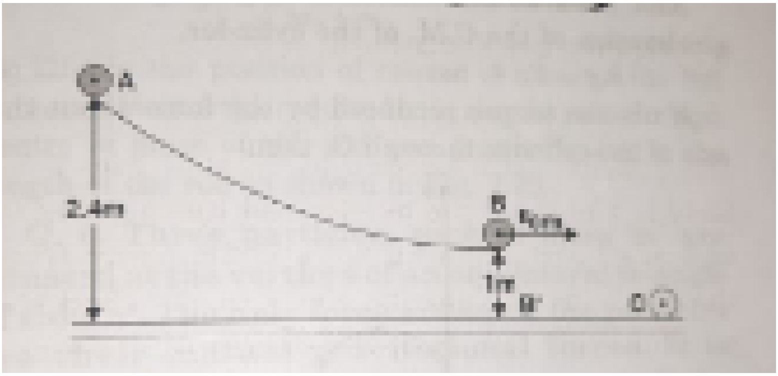
**267.** A particle moves in a circle of radius r with constant angular velocity $\omega$. What is the change in velocity when the particle describe an angle of $90^\circ$?

Watch Video Solution

**268.** A cyclist speeding at $18kmh^{-1}$ on a level road makes a sharp circular turn of radius 3 m without reducing the speed. The coefficient of static friction between the tyres and the road is 0.1 will the cyclist slip while taking the turn?

Watch Video Solution

**269.** A small sphere rolls down without slipping from the top of a track in a vertical plane. The track has an elevated section and a horizontal part is 1.0 m above the ground level and the top of the track is 2.4 m above the ground. Find the distance on the ground with respect to the point B (which is vertically ) below the end of the track as shown in figure. Where the sphere lands. During its flight as a projectile does the sphere continue to rotate about its centre of mass? Explain.

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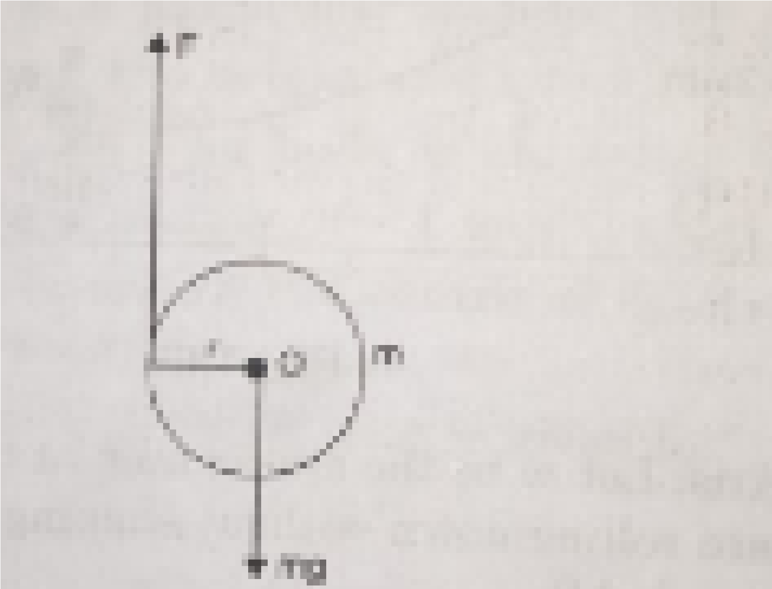
**270.** A circular cylinder has an inextensible string wrapped around it as shown in the figure.

What is the linear acceleration of the cylinder when released?

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**271.** Four sphere each of mass 10 kg and of radius 20 cm are placed at the four cornes of a square of side 100 cm. Calculate the moment of inertia of the system about an axis coinciding with side of the square (given moment of inertia of sphere $= \frac{2}{5}MR^2$)

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272. Four sphere each of mass 10 kg and of radius 20 cm are placed at the four cornes of a square of side 100 cm. Calculate the moment of inertia of the system about an axis coinciding with diagonal of the square. (given moment of inertia of sphere $= \frac{2}{5}MR^2$)

Watch Video Solution

**273.** A horizontal disc rotating about a vertical axis makes 100 revolutions per minute. 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 revolutions per minute is there by reduced to 90, calculate the moment of inertia of the disc.

Watch Video Solution

**274.** Point masses $m_1$ and $m_2$ are placed at the opposite ends of a rigid rod of length L, and nelgligible mass. The rod is to be set rotating about an axis perpendicular to it. Find the position on this rod through which the axis should pass in order that the work required to set the rod rotating with angular velocity $\omega_0$ should be minimum.

Watch Video Solution

**275.** Three particles, each of mass 'm' are situated at the vertices of an equilateral triangle of side 'a'. the only force acting on the particles are their mutual gravitatinoal foces. It is desired that each particle move on 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.

## Exercise

**1.** Define centre of mass.

Watch Video Solution

**2.** Under what conditions the centre of mass of two bodies lies midway between the two bodies?

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**3.** What is the relation between torque and power?

Watch Video Solution

**4.** On what factors does the moment of inertia depend?

Watch Video Solution

**5.** About which axis of a body is its moment of inertia the least?

Watch Video Solution

**6.** Why M.I. of called rotational inertia?

Watch Video Solution

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

Watch Video Solution

**8.** If the ice on the polar caps of the earth melts, how will it affect the duration of the day? Explain.

Watch Video Solution

**9.** Two satellites of equal masses are revolving around at different heights. Will their moment of inertia same or different?

Watch Video Solution

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

Watch Video Solution

**11.** Prove that:

$$\tau = I\alpha$$

Watch Video Solution

**12.** Prove that:

$$L = I\omega$$

Watch Video Solution

**13.** State the principle of conservation of angular momentum.

Watch Video Solution

**14.** Define centre of mass.

Watch Video Solution

**15.** A stone tied to one end of string is moved in a circle. How much work is done by the centripetal force in this circular motion ?

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