OBJECTIVE
MHT-CET
PHYSICS

Chapterwise - Topicwise
- Chapterwise Theory as per latest syllabus
- 3 Level Exercises with detailed solutions
- Previous 5 years' Questions of Competitive Exams
- MH-CET 2015 Solved Paper
- 3 Mock Test Papers for MHT-CET 2016
Introduction

For a rigid body, the distance between any two particles remains constant. When such a body performs rotational motion, the particles of the body move in circles. The centres of these circles lie on a straight line called the axis of rotation, which is fixed and perpendicular to the planes of circle. The ability of a force to produce rotational motion is called moment of force or torque. In rotational motion, the linear speeds of the particles of the rigid body moving in different circles at any instant are different.

3.1 Moment of Inertia

- A quantity that measures the inertia of rotational motion of the body is called rotational inertia or moment of inertia of the body.
- Moment of inertia of a rigid body about an axis of rotation is defined as the sum of product of the mass of each particle and the square of its perpendicular distance from the axis of rotation.

\[ I = \sum_{i=1}^{n} m_i r_i^2 \]

- Moment of inertia of a body depends upon the following factors
  - the mass, shape, and size of the body.
  - the distribution of mass in the body about an axis of rotation.
  - the position and orientation of the axis of rotation.

- If the rigid body is not considered to be made up of discrete particles but a continuous distribution of matter then the summation in equation is replaced by the integration. The mass \( m' \) of the particle is replaced by \( dm' \), which represent infinitesimally small part of the mass of the whole body, situated at a perpendicular distance \( r' \) from the axis of rotation. The moment of inertia of the body is given by

\[ I = \int r'^2 dm \]

- Dimensions of moment of inertia \( [I] = [L^2 M^1 T^0] \).

S.I. unit of moment of inertia is kg m².

3.2 Kinetic Energy of a Rotating Body

- If a rigid body of mass \( M \) rotating with constant angular velocity \( \omega \) about an axis passing through point \( O \) and perpendicular to the plane of the paper.
- If all the particles of the body are rotating with same angular velocity \( \omega \), they have different linear velocities.
Rotational Motion

- The linear velocities of particles are
  \[ v_1 = r_1 \omega, \quad v_2 = r_2 \omega, \quad v_3 = r_3 \omega, \ldots, \quad v_n = r_n \omega \]

Therefore, K.E. of particles are,
\[ E_1 = \frac{1}{2} m_1 v_1^2 = \frac{1}{2} m_1 (r_1 \omega)^2 = \frac{1}{2} m_1 r_1^2 \omega^2, \]
\[ E_2 = \frac{1}{2} m_2 v_2^2 = \frac{1}{2} m_2 (r_2 \omega)^2 \quad \ldots \ldots \quad E_n = \frac{1}{2} m_n v_n^2 = \frac{1}{2} m_n r_n^2 \omega^2 \]

- The total K.E. of the body is the sum of K.E. of all particles which is given by
  \[ E = E_1 + E_2 + E_3 + \ldots \ldots + E_n \]

\[ E = \frac{1}{2} \sum_{i=1}^{n} m_i r_i^2 \omega^2 \]

But \[ \sum_{i=1}^{n} m_i r_i^2 = I \quad \therefore \quad E = \frac{1}{2} I \omega^2 \]

3.3 Physical Significance of Moment of Inertia

- The moment of inertia plays same role in rotational motion as the mass of the body does in linear motion.
- To produce linear motion in a body the unbalanced force is applied to overcome its inertia. In this case inertia of a body is called the mass, which depends upon the amount of matter concentrated in the body. The relation between mass, force and linear acceleration is given by
  \[ F = Ma \]

- To produce rotational motion in a body an unbalanced torque is applied to overcome its inertia. In this case inertia of a body is called the rotational inertia or moment of inertia \((I)\). The relation between moment of inertia, torque and angular acceleration is given by
  \[ \tau = I \alpha \]

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Linear motion</th>
<th>Rotational motion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Distance covered (s)</td>
<td>Angle described (\theta)</td>
</tr>
<tr>
<td>2</td>
<td>Linear velocity (v)</td>
<td>Angular velocity (\omega)</td>
</tr>
<tr>
<td>3</td>
<td>Mass (M)</td>
<td>Moment of inertia (I)</td>
</tr>
<tr>
<td>4</td>
<td>Force (F = Ma)</td>
<td>Torque (\tau = I \alpha)</td>
</tr>
<tr>
<td>5</td>
<td>Work (dW = Fds)</td>
<td>Work (dW = \tau d\theta)</td>
</tr>
<tr>
<td>6</td>
<td>Kinetic energy of a translational motion (E_T = \frac{1}{2} \text{Mv}^2)</td>
<td>Kinetic energy of a rotational motion (E_R = \frac{1}{2} I \omega^2)</td>
</tr>
</tbody>
</table>

7. Power \(P = Fv\)  Power \(P = \tau \omega\)

8. Linear momentum \(p = Mv\)  Angular momentum \(L = I \omega\)

- In flywheel, the distribution of mass is more at the rim than the center region near the axis. Due to this moment of inertia increases and large diameter of the wheel makes moment of inertia larger.
- Similarly, grinding wheel has large mass and moderate diameter & hence has large moment of inertia.

3.4 Radius of Gyration

- It is defined as the distance from the axis of rotation at which, if whole mass of the body were concentrated, the moment of inertia of the body would be same as with the actual distribution of the mass of body. It is denoted by symbol \(K\).
- Radius of gyration of a body about an axis of rotation may also be defined as the root mean square distance of the particles from the axis of rotation.

\[ i.e., \quad K = \sqrt{\frac{r_1^2 + r_2^2 + \ldots + r_N^2}{N}} \]

- The moment of inertia of a body about a given axis is equal to the product of mass of the body and square of its radius of gyration about that axis.

\[ i.e., \quad I = MK^2 \]

- The SI unit of radius of gyration is metre and its dimensional formula is \([M^0L^2T^0]\).

Physical Significance of Radius of Gyration \((K)\)

- For a given body, mass always remains constant. If we change the axis of rotation, the distance of particles also changes. Due to this radius of gyration \((K)\) also changes. The radius of gyration depends upon shape and size of the body.
- Small value of radius of gyration shows that the mass of the body is distributed close to the axis of rotation so that moment of inertia is small. For large value of radius of gyration, the distribution of mass of the body is at large distance from the axis of rotation, so that moment of inertia is large.
- The following table shows different values of \(K\) for different type of bodies.
3.5 Torque acting on a Rotating Body

- Consider a rigid body of mass \( M \) rotating with a uniform (constant) angular acceleration \( \alpha \) about an axis passing through \( O \) and perpendicular to its plane of paper as shown in figure. The rigid body is acted upon by torque \( \tau \).

\begin{align*}
\tau &= rF \sin \theta \\
\text{For particles moving in circular path, } \theta &= 90^\circ \\
\therefore \quad \tau &= rF
\end{align*}

- Torque acting on the rigid body is the sum of the torque acting on each particle.

\begin{align*}
\tau &= \tau_1 + \tau_2 + \tau_3 + \ldots + \tau_n \\
\therefore \quad \tau &= \left( (m_1r_1^2)\alpha + (m_2r_2^2)\alpha + \ldots + (m_wr_w^2)\alpha \right) \\
\therefore \quad \tau &= \left( \sum_{i=1}^{n} m_ir_i^2 \right)\alpha \\
\tau &= I\alpha \\
\therefore \quad I &= \sum_{i=1}^{n} m_ir_i^2
\end{align*}

Both torque \( \tau \) and angular acceleration \( \alpha \) are directed parallel to the axis of rotation of the body.

\begin{align*}
\therefore \quad \tau &= I\alpha
\end{align*}

- Unit and dimensions of torque
In SI system, torque is expressed in Nm. Dimension of torque are same as work.

\[ [\tau] = [L^2M^I^T^{-2}] \]

3.6 Rolling Motion

- A motion is said to be rolling motion if a body possesses both linear motion (translational motion) and rotational motion.

- A rolling body possesses both K.E. of translational motion and K.E. of rotational motion.

- K.E. of the rolling body = translational K.E. + rotational K.E. 
  \[ E = \frac{1}{2} Mv^2 + \frac{1}{2} I\omega^2 \]

K.E. of the rolling body,

\[ E = \frac{1}{2} M\omega^2 (R^2 + K^2) \text{ (} \because I = MK^2 \text{ and } \omega = \frac{v}{R} \) \]

- When a body rolls down in an inclined plane of inclination \( \theta \) without slipping, its velocity at the bottom of inclined plane is given by

\[ v = \sqrt{\frac{2gh}{1 + \frac{K^2}{R^2}}} \]

where \( h \) is the height of the inclined plane.

- When a body rolls down on an inclined plane without slipping, its acceleration while rolling down the inclined plane is given by

\[ a = \frac{g \sin \theta}{1 + \frac{K^2}{R^2}} \]

- The position of rigid body is determined by the position of its center of mass.

- The center of mass of a rigid body is a point whose position is fixed with respect to the body as a whole.

- Two position of the center of mass of rigid body depends on -
  (i) Shape of the body.
  (ii) Distribution of mass in the body.

\[ \text{C.M.} = \frac{m_1r_1 + m_2r_2 + \ldots + m_wr_w}{M} \]

3.7 Theorem of Parallel and Perpendicular Axes

- Theorem of parallel axes: The moment of inertia of a body about any axis is equal to the sum of the moment of inertia of the body about a parallel axis passing through its centre of mass and the product of its mass and the square of the distance between the two parallel axes.
Consider a rigid body of mass $M$ rotating about an axis passing through a point $O$ and perpendicular to the plane of the figure.

Let $I_z$ be the moment of inertia of the body about an axis passing through point $O$. Take another parallel axis of rotation passing through point $C$, called the centre of mass of the body. Let $I_x$ be the moment of inertia of the body about point $C$. Take a small element of the body of mass $dm$ situated at a point $P$.

Consider a plane lamina of mass $M$. Let $OX$ and $OY$ be the two mutually perpendicular axes in the plane of lamina intersecting each other at point $O$.

Let $OZ$ be the axis perpendicular to the plane lamina and passing through point $O$ is shown in figure.

Let $I_x$, $I_y$, and $I_z$ be the moment of inertia of the lamina about $OX$, $OY$ and $OZ$ axes respectively. Then, the principle of perpendicular axes gives

$$I_z = I_x + I_y$$

Consider an infinitesimally small element of the lamina of mass $dm$, situated at point $P$.

Now from point $P$, draw $PD$ perpendicular to $OC$ produced. Let distance $CD = x$

From the figure

$$OP^2 = OD^2 + PD^2$$

\[ \therefore \quad OP^2 = (h + CD)^2 + PD^2 \]

\[ = h^2 + 2hCD + CD^2 + PD^2 \]

\[ \therefore \quad OP^2 = CP^2 + h^2 + 2bCD \]

\[ \therefore \quad r^2 = r_0^2 + h^2 + 2bx, \quad \ldots (i) \]

Multiplying the above equation (i) by $dm$ on both the sides and integrating, we get

\[ \int r^2 dm = \int r_0^2 dm + \int h^2 dm + \int 2bx dm \]

\[ \therefore \quad \int r^2 dm = \int r_0^2 dm + h^2 \int dm + 2b \int x dm \]

\[ x \cdot dm = 0 \quad \text{as} \quad C \quad \text{is centre of mass and algebraic sum of moments of all the particles about centre of mass is always zero, for body in equilibrium.} \]

\[ \therefore \quad \int r^2 dm = \int r_0^2 dm + h^2 \int dm + 0 \quad \ldots (ii) \]

But \[ \int dm = M \]

and \[ \int r^2 dm = I_0 \quad \text{and} \quad \int r_0^2 dm = I_z \]

\[ \therefore \quad \text{Equation (ii) becomes} \quad I_0 = I_z + Mh^2 \]

**Theorem of perpendicular axis**: The moment of inertia of a planar lamina about an axis perpendicular to its plane is equal to the sum of its moment of inertia about two perpendicular axes concurrent with perpendicular axis and lying in the plane of the body.

**Illustration**: Moment of inertia of a uniform circular disc about a diameter is $I$. Its moment of inertia about an axis perpendicular to its plane and passing through a point on its rim will be

(a) $5I$  \quad (b) $3I$  \quad (c) $6I$  \quad (d) $4I$

**Soln. (c)**: Moment of inertia of uniform circular disc about diameter = $I$

According to theorem of perpendicular axes

Moment of inertia of disc about axis $= 2I = \frac{1}{2}mr^2$

Applying theorem of parallel axes

Moment of inertia of disc about the given axis

$= 2I + mr^2 = 2I + 4I = 6I$. 
### 3.8 Applications - Rod, Ring, Disc, Solid Cylinder, Solid Sphere

Table: Moment of inertia and radius of gyration of some regular bodies about specific axis is given below.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Body</th>
<th>Axis of rotation</th>
<th>Moment of inertia ((I))</th>
<th>Radius of gyration ((K))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Uniform circular ring of mass (M) and radius (R)</td>
<td>(i) about an axis passing through its centre and perpendicular to its plane</td>
<td>(MR^2)</td>
<td>(R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) about a diameter</td>
<td>(\frac{1}{2} MR^2)</td>
<td>(\frac{R}{\sqrt{2}})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) about a tangent in its own plane</td>
<td>(\frac{3}{2} MR^2)</td>
<td>(\frac{3}{2} R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iv) about a tangent perpendicular to its plane</td>
<td>(2MR^2)</td>
<td>(R\sqrt{2})</td>
</tr>
<tr>
<td>2.</td>
<td>Uniform circular disc of mass (M) and radius (R)</td>
<td>(i) about an axis passing through its centre and perpendicular to its plane</td>
<td>(\frac{1}{2} MR^2)</td>
<td>(\frac{R}{\sqrt{2}})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) about a diameter</td>
<td>(\frac{1}{4} MR^2)</td>
<td>(\frac{R}{2})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) about a tangent in its own plane</td>
<td>(\frac{5}{4} MR^2)</td>
<td>(\frac{\sqrt{5}}{2} R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iv) about a tangent perpendicular to its plane</td>
<td>(\frac{3}{2} MR^2)</td>
<td>(\frac{3}{2} R)</td>
</tr>
<tr>
<td>3.</td>
<td>Solid sphere of radius (R) and mass (M)</td>
<td>(i) about its diameter</td>
<td>(\frac{2}{5} MR^2)</td>
<td>(\frac{\sqrt{5}}{5} R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) about a tangential axis</td>
<td>(\frac{7}{5} MR^2)</td>
<td>(\frac{\sqrt{7}}{5} R)</td>
</tr>
<tr>
<td>4.</td>
<td>Hollow sphere of radius (R) and mass (M)</td>
<td>(i) about its diameter</td>
<td>(\frac{2}{3} MR^2)</td>
<td>(\frac{\sqrt{3}}{3} R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) about a tangential axis</td>
<td>(\frac{5}{3} MR^2)</td>
<td>(\frac{\sqrt{5}}{3} R)</td>
</tr>
<tr>
<td>5.</td>
<td>Solid cylinder of length (l), radius (R) and mass (M)</td>
<td>(i) about its own axis</td>
<td>(\frac{1}{2} MR^2)</td>
<td>(\frac{R}{\sqrt{2}})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) about an axis passing through its centre and perpendicular to its own axis</td>
<td>(M \left[ \frac{R^2}{12} + \frac{l^2}{4} \right])</td>
<td>(\sqrt{\frac{R^2}{12} + \frac{l^2}{4}})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) about the diameter of one of the faces of cylinder</td>
<td>(M \left[ \frac{R^2}{3} + \frac{l^2}{4} \right])</td>
<td>(\sqrt{\frac{R^2}{3} + \frac{l^2}{4}})</td>
</tr>
<tr>
<td>6.</td>
<td>Hollow cylinder of mass (M), length (l) and radius (R)</td>
<td>(i) about its own axis</td>
<td>(MR^2)</td>
<td>(R)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) about an axis passing through its centre and perpendicular to its own axis</td>
<td>(M \left( \frac{R^2}{2} + \frac{l^2}{12} \right))</td>
<td>(\sqrt{\frac{R^2}{2} + \frac{l^2}{12}})</td>
</tr>
<tr>
<td>7.</td>
<td>Thin rod of length (L)</td>
<td>(i) about an axis through its centre and perpendicular to the rod</td>
<td>(\frac{ML^2}{12})</td>
<td>(\frac{L}{\sqrt{12}})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) about an axis through one end and perpendicular to the rod</td>
<td>(\frac{ML^2}{3})</td>
<td>(\frac{L}{\sqrt{3}})</td>
</tr>
</tbody>
</table>
### 3.9 Angular Momentum and Its Conservation

- Angular momentum of a body about a given axis is the moment of linear momentum of the body about that axis. It is denoted by symbol $\mathbf{L}$.

  \[ \mathbf{L} = \mathbf{r} \times \mathbf{p} \]

  In magnitude, $L = \mathbf{r} \mathbf{p} \sin \theta$, where $\theta$ is the angle between $\mathbf{r}$ and $\mathbf{p}$.

  Also, $\mathbf{L} = I \omega$

- Angular momentum is a vector quantity. Its SI unit is kg m$^2$ s$^{-1}$. Its dimensional formula is [ML$^2$T$^{-1}$].

- **Relationship between torque and angular momentum**: Rate of change of angular momentum of a body is equal to the external torque acting upon the body.

  \[ i.e., \quad \dot{\mathbf{L}} = \mathbf{\tau}_{ext} \]

- **Law of conservation of angular momentum**: If no external torque acts on a system then the total angular momentum is conserved,

  \[ i.e., \quad \mathbf{\tau}_{ext} = 0 \quad \text{then} \quad \frac{d\mathbf{L}}{dt} = 0 \quad \text{or} \quad \mathbf{L} = \text{constant} \]

- A rigid body is in mechanical equilibrium, if

  - it is in translational equilibrium i.e. the total external force on it is zero, i.e. $\sum F_i = 0$.
  - it is in rotational equilibrium, i.e., the total external torque on it is zero, i.e. $\sum \tau_i = 0$.

---

**Illustration**: A solid spherical ball rolls on a table. Ratio of its rotational kinetic energy to total kinetic energy is

- (a) $\frac{1}{2}$
- (b) $\frac{1}{6}$
- (c) $\frac{7}{10}$
- (d) $\frac{2}{7}$

**Soln. (d)**: Linear K.E. of ball = $\frac{1}{2}mv^2$ and rotational K.E. of ball = $\frac{1}{2}I \omega^2 = \frac{1}{2} \left( \frac{2}{5}mv^2 \right) \omega^2 = \frac{1}{5}mv^2$ [because $v = r \omega$]

Therefore total K.E. = $\frac{1}{2}mv^2 + \frac{1}{5}mv^2 = \frac{7}{10}mv^2$.

Ratio of rotational K.E. and total K.E.

\[ = \frac{(1/5)mv^2}{(7/10)mv^2} = \frac{2}{7} \]

**Illustration**: A solid homogenous sphere of mass $M$ and radius $r$ is moving on a rough horizontal surface, partly rolling and partly sliding. During this kind of motion of this sphere,

- (a) total kinetic energy is conserved
- (b) the angular momentum of the sphere about the point of contact with the plane is conserved
- (c) only the rotational kinetic energy about the centre of mass is conserved
- (d) angular momentum about the centre of mass is conserved

**Soln. (b)**: Angular momentum about the point of contact with the surface includes the angular momentum about the centre. Because of friction, linear momentum will not be conserved.
Moment of Inertia and Radius of Gyration:

- **Moment of inertia** ($I$) is the property of a body by virtue of which it opposes the torque tending to change its state of rest or of uniform motion about a given axis. $I = MR^2 = \sum m_i r_i^2$
- **Radius of gyration** ($K$) of a body about a given axis is the distance of a point from the axis of rotation where if the whole mass of the body were concentrated, it would have the same moment of inertia as it has with the actual distribution of mass of the body.

Dynamics of Rotational Motion about a Fixed Axis:

- **Torque** : The torque is the turning effect of the force about the axis of rotation. It is the product of force and perpendicular distance of line of action of force from the axis of rotation. $\tau = \vec{r} \times \vec{F}$ or $\tau = \alpha$
- **Angular momentum** : Angular momentum is the measure of the turning motion of the body. It is the product of linear momentum and the perpendicular distance of its line of action from the axis of rotation. $\vec{L} = \vec{r} \times \vec{p}$ or $L = I\omega$
- Work done by torque, $W = \int \tau \, d\theta$
- Rotational kinetic energy, $K = \frac{1}{2} I\omega^2$

Rolling Motion:

- For a body rolling without slipping, velocity of centre of mass $v_{cm} = R\omega$
- Kinetic energy = $K_{translational} + K_{Rotational}$
  \[
  K = \frac{1}{2} m v_{cm}^2 \left( 1 + \frac{K^2}{R^2} \right)
  \]
- On inclined plane, $v = \sqrt{\frac{2gb}{1 + K^2 / R^2}}$
- $a = \frac{g \sin \theta}{1 + K^2 / R^2}$
3.1 Moment of Inertia

1. A wheel of mass 4 kg and radius of gyration 0.4 m is making 300 rpm. Its moment of inertia is
   (a) 6.4 kg m² (b) 0.64 kg m² (c) 0.32 kg m² (d) 64 kg m²

2. Moment of inertia of a body does not depend upon its
   (a) mass (b) axis of rotation (c) shape (d) angular velocity.

3. Two masses of 500 gram and 600 gram are attached to the 10 cm and 80 cm marks respectively of a light metre scale. The moment of inertia of this system about an axis passing through the centre of the scale will be
   (a) 0.134 kg m² (b) 2 kg m² (c) 0.56 kg m² (d) 4.5 kg m²

4. About which axis, the moment of inertia in the given triangular lamina is maximum?
   (a) AB (b) BC (c) CD (d) BD

5. Three point masses $m_1$, $m_2$ and $m_3$ are located at the vertices of an equilateral triangle, having each side of length $L$. The moment of inertia of the system about an axis along an altitude of the triangle passing through $m_1$ is given by
   (a) $I = (m_1 + m_2 + m_3)L^2$ (b) $I = (m_1 + m_2)L^2/2$ (c) $I = (m_2 + m_3)L^2$ (d) $I = (m_2 + m_3)L^2/4$

6. In a rectangle $ABCD$ ($BC = 2AB$). Along which axis, the moment of inertia will be the minimum?

7. $ABC$ is a triangular plate of uniform thickness. Its sides are in the ratio shown in the figure. $I_{AB}$, $I_{BC}$ and $I_{CA}$ are the moments of inertia of the plate about $AB$, $BC$ and $CA$ as axes respectively. Which one of the following relations is correct?
   (a) $I_{AB} + I_{BC} = I_{CA}$ (b) $I_{CA}$ is maximum (c) $I_{AB} > I_{BC}$ (d) $I_{BC} > I_{AC}$

8. Three point masses, each of mass $m$ are placed at the corners of an equilateral triangle of side $l$. Moment of inertia of this system about an axis along one side of triangle is
   (a) $3ml^2$ (b) $3ml^2/2$ (c) $ml^2$ (d) $3ml^2/4$

9. The masses of 200 g and 300 g are attached to the 20 cm and 70 cm marks of a light metre rod respectively. The moment of inertia of the system about an axis passing through 50 cm mark is
   (a) 0.15 kg m² (b) 0.036 kg m² (c) 0.3 kg m² (d) zero

10. The moment of inertia of a dumb-bell, consisting of point masses $m_1 = 2$ kg and $m_2 = 1$ kg, fixed to the ends of a rigid massless rod of length $L = 0.6$ m, about an axis passing through the centre of mass and perpendicular to its length, is
    (a) 0.72 kg m² (b) 0.36 kg m² (c) 0.27 kg m² (d) 0.24 kg m²

11. Select the WRONG statement.
The location of centre of mass of a system of particles
    (a) depends on the masses of particles
    (b) depends on the relative positions of the particles
    (c) depends on the reference frame used to locate it
    (d) does not depend on the reference frame used.
12. Choose the CORRECT statement out of the following.
(a) The moment of inertia of a body is a vector.
(b) The dimension of moment of inertia is [M^1L^2T^{-1}].
(c) Moment of inertia plays the same role in rotational motion as mass does in translational motion.
(d) Moment of inertia of a body does not depend on its dimension.

13. Select the WRONG statement.
(a) The moment of inertia is the torque acting per unit angular acceleration.
(b) The S.I. unit of moment of inertia is kg m^2.
(c) The dimensions of moment of inertia are [M^1L^2T^0].
(d) The moment of inertia for a given body is a constant.

14. If the position of axis of rotation of a body is changed, then which of the following quantities will change?
(a) Torque (b) Moment of inertia (c) Momentum (d) Force

15. If a mass shifts towards the axis of rotation, its M.I. will
(a) decrease (b) increase (c) remain unchanged (d) first increases then decreases.

16. Which of the following quantities is/are directionless?
(a) Moment of momentum (b) Moment of force (c) Both (a) and (b) (d) Moment of inertia

17. The dimensional formula for the moment of inertia of a body is
(a) [M^1L^0T^{-2}] (b) [M^1L^2T^0] (c) [M^1L^1T^0] (d) [M^2L^3T^0]

18. The M.I. of a cube will be minimum about an axis which
(a) joins mid points (b) is an edge of the cube (c) is a face diagonal (d) is a body diagonal.

19. On account of melting of ice at the north pole, the moment of inertia of spinning earth
(a) increases (b) decreases (c) remains unchanged (d) depends on the time.

20. Five particles of mass 2 kg each are attached to the rim of a circular disc of radius 0.1 m and negligible mass. Moment of inertia of the system about an axis passing through the centre of the disc and perpendicular to its plane is
(a) 1 kg m^2 (b) 0.1 kg m^2 (c) 2 kg m^2 (d) 0.2 kg m^2

3.2 Kinetic Energy of a Rotating Body

21. The angular velocity of seconds hand of a watch will be
(a) \( \frac{\pi}{60} \) rad s^{-1} (b) \( \frac{\pi}{30} \) rad s^{-1} (c) 60 \( \pi \) rad s^{-1} (d) 30 \( \pi \) rad s^{-1}

22. In the rotational motion of a rigid body, all particles move with
(a) the same linear velocity and angular velocity (b) the same linear velocity and different angular velocities (c) different linear velocities and same angular velocity (d) different linear velocities and different angular velocities.

23. When the speed of a flywheel is increased from 240 rpm to 360 rpm, the energy spent is 1936 J. What is the moment of inertia of the flywheel?
(a) 4.9 kg m^2 (b) 9.8 kg m^2 (c) 2 kg m^2 (d) 15 kg m^2

24. The moment of inertia of a body about a given axis is 1.2 kg m^2. Initially, the body is at rest. In order to produce a rotational kinetic energy of 1500 joule, an angular acceleration of 25 rad/sec^2 must be applied about that axis for a duration of
(a) 4 s (b) 2 s (c) 8 s (d) 10 s

25. A flywheel rotating about a fixed axis has a kinetic energy of 225 J when its angular speed is 30 rad/s. What is the moment of inertia of the flywheel about its axis of rotation?
(a) 0.5 kg m^2 (b) 0.6 kg m^2 (c) 0.8 kg m^2 (d) 0.3 kg m^2

26. A solid sphere of mass \( M \) and radius \( R \) spins about an axis passing through its centre making 600 rpm. Its kinetic energy of rotation is
(a) \( \frac{2}{5} \pi^2 MR \) (b) \( \frac{2}{5} \pi M^2 R^2 \) (c) 80\pi MR (d) 80\pi^2 M^2 R^2
27. The moment of inertia of a flywheel having kinetic energy 360 J and angular speed of 20 rad/s is
   (a) 18 kg m² (b) 1.8 kg m²
   (c) 2.5 kg m² (d) 9 kg m²

28. A flywheel is a uniform disc of mass 72 kg and radius 50 cm. When it is rotating at the rate of 70 rpm, its kinetic energy is
   (a) 142 J (b) 242 J
   (c) 342 J (d) 300 J

29. A flywheel of mass 4 kg has a radius of gyration of 0.1 m. If it makes 4 revolutions/sec, then its rotational K.E. is (use $\pi^2 = 10$)
   (a) 8 J (b) 6.4 J
   (c) 12.8 J (d) 16 J

30. A wheel of mass 10 kg and radius of gyration 50 cm is rotating at 300 rpm. The rotational kinetic energy of the wheel is (Use $\pi^2 = 10$)
   (a) 625 J (b) 1000 J
   (c) 1250 J (d) 1500 J

31. A body of M.I. of 3 kg m², rotating with an angular velocity of 2 rad/s, has the same K.E. as a mass of 12 kg moving with a velocity of ________
   (a) 8 m/s (b) 4 m/s
   (c) 2 m/s (d) 1 m/s

32. A flywheel rotating about a fixed axis has a kinetic energy of 360 joule, when its angular speed is 30 rad/sec. The moment of inertia of the flywheel about the axis of rotation is
   (a) 0.6 kg m² (b) 0.4 kg m²
   (c) 0.8 kg m² (d) 0.55 kg m²

33. A circular disc of mass 2 kg and radius 0.1 m is rotating at a angular speed of 2 rad/s, about an axis passing through its centre and perpendicular to its plane. What is its rotational kinetic energy?
   (a) 0.1 J (b) 0.2 J
   (c) 0.02 J (d) 0.05 J

34. A body having M.I. of 5 kg m² about its axis of rotation is rotating with angular velocity of 6 rad/s. The kinetic energy of the rotating body is the same as that of a body of mass 5 kg moving with a speed of
   (a) 2 m/s (b) 4 m/s
   (c) 6 m/s (d) 8 m/s

35. The moment of inertia about an axis of a body which is rotating with angular velocity 1 rad/s numerically equal to
   (a) twice the rotational kinetic energy (b) one-fourth of its rotational kinetic energy
   (c) half of the rotational kinetic energy (d) rotational kinetic energy.

36. A thin metal disc of mass 2 kg starts from rest and rolls down a smooth inclined plane. Its rotational K.E. is 4 J at the bottom of the inclined plane. What is the linear velocity at the same point?
   (a) $3\sqrt{2}$ m/s (b) $2\sqrt{3}$ m/s
   (c) $2\sqrt{2}$ m/s (d) 2 m/s

37. A body having moment of inertia about its axis of rotation equal to 3 kg m² is rotating with angular velocity equal to 3 rad s⁻¹. Kinetic energy of this rotating body is the same as that of a body of mass 27 kg moving with a speed of
   (a) 1.0 m s⁻¹ (b) 0.5 m s⁻¹
   (c) 1.5 m s⁻¹ (d) 2.0 m s⁻¹

38. A disc of mass 2 kg is rolling on a horizontal surface without slipping with a velocity of 0.1 m/s. What is its rotational kinetic energy?
   (a) $5 \times 10^{-3}$ J (b) $2.5 \times 10^{-3}$ J
   (c) $15 \times 10^{-3}$ J (d) $8 \times 10^{-3}$ J

39. The rotational kinetic energy of a body rotating about some axis is directly proportional to
   (a) periodic time (b) (periodic time)²
   (c) (periodic time)⁻¹ (d) (periodic time)⁻²

40. If the kinetic energy of rotation of a body about an axis is 9 J and the moment of inertia is 2 kg m², then the angular velocity of the body about the axis of rotation in rad/s is
   (a) 2 (b) 3
   (c) 1 (d) 9

41. The moment of inertia of a body about a given axis is 2.4 kg m². To produce a rotational kinetic energy of 750 J, an angular acceleration of 5 rad s⁻² must be applied about that axis for
   (a) 6 s (b) 5 s
   (c) 4 s (d) 3 s

3.3 Physical Significance of Moment of Inertia

42. A light rod AB of length 2L is acted upon by two forces at their ends as shown in the following figures. These two forces have the same magnitude. In which case the rod is in rotational equilibrium?
43. The diameter of a flywheel is increased by 1%. Increase in its moment of inertia about the central axis is
(a) 1%  (b) 0.5%  (c) 2%  (d) 4%

44. A wheel starts from rest and acquires a rotational speed of 240 rps in 2 min. Its acceleration is
(a) 5 rps$^2$  (b) 2 rps$^2$  (c) 8 rps$^2$  (d) 11 rps$^2$

45. Generally, most of the mass of the flywheel is placed on the rim
(a) to decrease moment of inertia  (b) to obtain equilibrium  (c) to increase moment of inertia  (d) to obtain strong wheel.

46. A flywheel of mass 50 kg and radius of gyration 0.5 m about its axis of rotation is acted upon by a constant torque of 12.5 N m. Its angular velocity at $t = 5$ s is
(a) 2.5 rad s$^{-1}$  (b) 5 rad s$^{-1}$  (c) 7.5 rad s$^{-1}$  (d) 10 rad s$^{-1}$

47. The physical quantity in translational motion, which is analogous to moment of inertia in rotational motion is
(a) velocity  (b) force  (c) energy  (d) mass

48. A rod 0.5 m long has two masses each of 20 gram stuck at its ends. If the masses are treated as point masses and if the mass of the rod is neglected, then the moment of inertia of the system about a transverse axis passing through the centre is
(a) $1.25 \times 10^{-3}$ kg m$^2$  (b) $2.5 \times 10^{-3}$ kg m$^2$  (c) $4 \times 10^{-3}$ kg m$^2$  (d) $5 \times 10^{-3}$ kg m$^2$

49. The angular displacement of a flywheel varies with time as $\theta = at + bt^2 - ct^3$. Then the angular acceleration is given by
(a) $a + 2bt - 3ct^2$  (b) $2b - 6t$  (c) $a + 2b - 6t$  (d) $2b - 6ct$

50. A disc of mass 1 kg and radius 10 cm is rotating about its axis with an angular velocity of 2 rad/s. The linear momentum of the disc
(a) 0.2 kg m/s  (b) zero  (c) 0.4 kg m/s  (d) 0.02 kg m/s

51. A circular disc is to be made by using equal masses of aluminium and iron. To get maximum moment of inertia, about its geometrical axis, it should be so prepared that
(a) aluminium is at the interior and the iron surrounding it  (b) iron is at the interior and the aluminium surrounding it  (c) aluminium and iron are used in alternate layers  (d) aluminium and iron discs should be kept one above the other.

52. A metre stick made of half wood and half steel is pivoted at the wooden end and a force is applied perpendicular to its length at the steel end. Then the stick is pivoted at the steel end and the same force is applied perpendicular to its length at the wooden end. The angular acceleration produced is
(a) smaller in the first case  (b) smaller in the second case  (c) equal in both the cases  (d) larger in the first case.

53. When a rigid body is in motion, few particles of the body remain at rest at all times. What kind of motion is the rigid body having?
(a) Translational motion  (b) Rotational motion  (c) Rolling motion  (d) Uniform circular motion

54. If a horizontal cylindrical tube, partly filled with water is rapidly rotated about a vertical axis passing through its centre, the moment of inertia of the water about its axis will
(a) decrease  (b) increase  (c) not change  (d) increase or decrease depending upon clockwise or anticlockwise sense of rotation.

55. A ring and a thin hollow cylinder have equal masses and radii. If $I_R$ and $I_C$ denote their M.I. about their axes, then
(a) $I_R = I_C$  (b) $I_R = \frac{1}{2} I_C$  (c) $I_R = 2 I_C$  (d) $I_R = \sqrt{2} I_C$
56. A solid disc is rotating at an angular speed of 20 rad/s. It is decelerated at a constant rate of 2 rad/s². Through what angle the disc will turn before coming to rest?
(a) 100 radian (b) 50 radian (c) 200 radian (d) 300 radian

57. A wheel is rotating at 900 rpm about its axis of rotation. When the power is cut off, it comes to rest in one minute. What is its angular retardation (assuming it to be uniform) expressed in rad/s²?
(a) \( \pi \) (b) \( \frac{\pi}{2} \) (c) \( \frac{\pi}{6} \) (d) \( \frac{\pi}{4} \)

58. When a disc rotates with a uniform angular velocity, which of the following is not true?
(a) The sense of rotation remains same.
(b) The orientation of the axis of rotation remains same.
(c) The speed of rotation is non-zero and remains same.
(d) The angular acceleration is non-zero and remains same.

59. A disc at rest, gets an angular velocity of 40 rad/s in 5 second, under constant angular acceleration. Through what angle the disc is turned during this time?
(a) 50 radian (b) 75 radian (c) 100 radian (d) 25 radian

60. If \( P \) is the power supplied to a rotating body, having moment of inertia \( I \) and angular acceleration \( \alpha \), then its instantaneous angular velocity is given by
(a) \( \omega = \frac{Pl}{\alpha} \) (b) \( \omega = \frac{P}{I\alpha} \) (c) \( \omega = P \) (d) \( \omega = \frac{I}{P\alpha} \)

61. When a ceiling fan is switched OFF, its angular velocity falls to half while it makes 36 rotations. How many more rotations will it make before coming to rest? (Assume uniform angular retardation)
(a) 36 (b) 24 (c) 18 (d) 12

62. A gramophone turn table rotating at 75 rpm slows down uniformly and stops in 5 s after the motor is turned-off. Its angular acceleration (in rad s⁻²) is
(a) \(-0.42\) (b) \(-0.89\) (c) \(-1.57\) (d) \(-1.96\)

63. The corresponding quantities in rotational motion related to \( m, \vec{F}, \vec{p} \) and \( \vec{v} \) in linear motion are respectively
(a) \( I, \vec{L}, \vec{r} \) and \( \vec{\omega} \) (b) \( I, \vec{r}, \vec{L} \) and \( \vec{\omega} \) (c) \( I, \vec{\omega}, \vec{L} \) and \( \vec{r} \) (d) \( I, \vec{\omega}, \vec{L} \) and \( \vec{\tau} \)

64. A pot-maker rotates pot-making wheel of radius 3 m by applying a force of 200 N tangentially. Due to this, if the wheel completes exactly \( \frac{3}{2} \) revolution, the work done by him is
(a) 5654.86 J (b) 4321.32 J (c) 4197.5 J (d) 5000 J

65. When sand is poured on a rotating disc, angular velocity of disc will
(a) decrease (b) increase (c) remain constant (d) none of these.

66. A circular turn table rotates about its normal axis with uniform angular speed \( \omega \). A thick circular layer of ice and of radius much smaller than the table top rotates along with the table. If \( \omega' \) is the new angular speed of the table when ice starts melting, then
(a) \( \omega' > \omega \) (b) \( \omega' < \omega \) (c) \( \omega' = \omega \) (d) a relation cannot be established between \( \omega \) and \( \omega' \) due to insufficient data.

67. The angular speed of a fly wheel making 120 revolution per minute is
(a) \( \pi \) rad s⁻¹ (b) \( 2\pi \) rad s⁻¹ (c) \( 4\pi \) rad s⁻¹ (d) \( 4\pi^2 \) rad s⁻¹

68. A point \( P \) on the rim of wheel is initially at rest and in contact with the ground. If the radius of the wheel is 5 m and the wheel rolls forward through half a revolution, the displacement of the point \( P \) is
(a) 5 m (b) 100 m (c) 2.5 m (d) \( 5\sqrt{\pi^2 + 4} \) m

69. A constant torque of 1000 N m turns a wheel of moment of inertia 200 kg m² about an axis through its centre. Its angular velocity after 3 s is
(a) 1 rad s⁻¹ (b) 5 rad s⁻¹ (c) 10 rad s⁻¹ (d) 15 rad s⁻¹

70. A flywheel gains a speed of 540 rpm in 6 s. Its angular acceleration will be
(a) \( 3\pi \) rad s⁻² (b) \( 9\pi \) rad s⁻² (c) \( 18\pi \) rad s⁻² (d) \( 54\pi \) rad s⁻²
71. A car is moving at a speed of 72 km hr$^{-1}$. The radius of its wheels is 0.25 m. If the wheels are stopped in 20 rotations by applying brakes, then angular retardation produced by the brakes is
(a) $-25.5$ rad s$^{-2}$  (b) $-29.5$ rad s$^{-2}$
(c) $-33.5$ rad s$^{-2}$  (d) $-45.5$ rad s$^{-2}$

72. Out of the following cases, the application of angular velocity is useful in the case
(a) when a body is rotating about an axis
(b) when a body is moving in a straight line with a uniform velocity
(c) when a body is moving in a straight line with a uniform acceleration
(d) when a body is at rest

73. A body is in pure rotation. The linear speed $v$ of a particle at a distance $r$ from the axis and the angular velocity $\omega$ of the body are related as $\omega = \frac{v}{r}$. Then
(a) $\omega \propto \frac{1}{r}$  (b) $\omega \propto r$
(c) $\omega$ is independent of $r$  (d) $\omega \propto v$

74. Figures show overhead views of three structures on each of which three forces act. The directions of forces are shown. If the magnitudes of the forces are adjusted properly, which structure can be in a stable equilibrium?

(A)  
(B)  
(C)  

(a) $A$  (b) $B$
(c) $C$  (d) None of these

3.4 Radius of Gyration

75. A body is rotating uniformly about vertical axis fixed in an inertial frame. The resultant force on the particle of the body not on the axis is
(a) vertical
(b) horizontal skew with the axis
(c) horizontal and intersecting the axis
(d) none of these.

76. A body is rolling down an inclined plane. If the rotational K.E. of the body is 40% of its translational K.E., then the body is
(a) ring  (b) cylinder
(c) solid sphere  (d) hollow sphere.

77. The radius of gyration of a disc of mass 100 gram and radius 5 cm about an axis passing through its centre of gravity and perpendicular to the plane is
(a) 0.5 m  (b) 2.5 m
(c) 3.54 m  (d) 6.54 m

78. The radius of gyration of a body about an axis at a distance of 4 cm from the centre of gravity is 5 cm. Its radius of gyration about a parallel axis through centre of gravity is
(a) $\sqrt{51}$ cm  (b) 1 cm
(c) 3 cm  (d) none

79. The radius of gyration of a uniform rod of length $L$ about an axis passing through its centre of mass and perpendicular to its length is
(a) $\frac{L}{\sqrt{12}}$  (b) $\frac{L^2}{12}$
(c) $\frac{L}{\sqrt{3}}$  (d) $\frac{L}{\sqrt{2}}$

80. Radius of gyration of disc of mass 50 g and radius 2.5 cm about an axis passing through its centre of gravity and perpendicular to the plane is
(a) 6.54 cm  (b) 3.64 cm
(c) 1.77 cm  (d) 0.88 cm

81. The radius of gyration of a rod of length $L$ and mass $M$ about an axis perpendicular to its length and passing through a point at a distance $\frac{L}{3}$ from one of its ends is
(a) $\sqrt{7}\frac{L}{6}$  (b) $\frac{L}{9}$
(c) $\frac{L}{3}$  (d) $\frac{\sqrt{5}L}{2}$

82. The ratio of the radii of gyration of a circular disc about a tangential axis in the plane of the disc and of a circular ring of the same radius about a tangential axis in the plane of the ring is
(a) $2:3$  (b) $2:1$
(c) $\sqrt{3}:\sqrt{6}$  (d) $1:\sqrt{2}$

83. The ratio of the radii of gyration of a circular disc to that of a circular ring, each of the same mass and radius, around their respective axes is
(a) $\sqrt{3}:\sqrt{2}$  (b) $1:\sqrt{2}$
(c) $\sqrt{2}:1$  (d) $\sqrt{2}:\sqrt{3}$

84. The radius of gyration of a homogeneous body is independent of
(a) mass of the body  (b) axis of rotation
(c) distance from the axis of rotation  (d) distribution of mass of the system.
85. The dimensions of radius of gyration are the same as that of
(a) moment of inertia (b) length
(c) angular acceleration (d) \( \sqrt{\text{length}^2 / \text{mass}} \)

86. The dimensional formula for the radius of gyration of a body is
(a) [M⁰L⁰T⁰] (b) [M⁰L¹T⁰]
(c) [M¹L¹T⁰] (d) [M²L⁰T⁰]

87. Radius of gyration of a disc rotating about an axis perpendicular to its plane and passing through its centre is
(a) \( R / \sqrt{2} \) (b) \( R / \sqrt{3} \)
(c) \( R / 3 \) (d) \( R / 2 \)

88. A wheel of mass 10 kg has a moment of inertia 160 kg m² about its own axis. The radius of gyration will be
(a) 10 m (b) 8 m
(c) 6 m (d) 4 m

89. Four particles each of the mass \( m \) are placed at the corners of a square of side length \( l \). The radius of gyration of the system about an axis perpendicular to the square and passing through its centre is
(a) \( l / \sqrt{2} \) (b) \( l / 2 \)
(c) \( l \) (d) \( \sqrt{2}l \)

90. If the radius of a solid sphere is 35 cm, the radius of gyration when the axis is along a tangent is
(a) 7\( \sqrt{10} \) cm (b) 7\( \sqrt{35} \) cm
(c) \( 7 \) cm (d) \( \frac{7}{5} \) cm

3.5 Torque Acting on a Rotating Body

91. A particle moves along a circle of radius \( 20 \pi \) m with constant tangential acceleration. If the velocity of the particle is 80 m s⁻¹ at the end of the second revolution after motion has begun, the tangential acceleration is
(a) 640 \( \pi \) m s⁻² (b) 140 \( \pi \) m s⁻²
(c) 40 \( \pi \) m s⁻² (d) 40 m s⁻²

92. A wheel whose moment of inertia is 2 kg m² has an initial angular velocity of 50 rad/s. A constant torque of 10 N m acts on the wheel. The time in which the wheel is accelerated to 80 rad/s is
(a) 12 s (b) 3 s
(c) 6 s (d) 9 s

93. If \( \vec{F} \) is the force acting on a particle having position vector \( \vec{r} \) and \( \vec{\tau} \) be the torque of this force about the origin, then
(a) \( \vec{r} \cdot \vec{\tau} > 0 \) and \( \vec{F} \cdot \vec{\tau} < 0 \)
(b) \( \vec{r} \cdot \vec{\tau} = 0 \) and \( \vec{F} \cdot \vec{\tau} = 0 \)
(c) \( \vec{r} \cdot \vec{\tau} = 0 \) and \( \vec{F} \cdot \vec{\tau} \neq 0 \)
(d) \( \vec{r} \cdot \vec{\tau} \neq 0 \) and \( \vec{F} \cdot \vec{\tau} = 0 \)

94. A wheel has moment of inertia \( 5 \times 10^{-3} \) kg m² and is making 20 rev s⁻¹. The torque in N m needed to stop it in 10 s is
(a) \( 2\pi \times 10^{-2} \) (b) \( 2.5\pi \times 10^{-3} \)
(c) \( 4\pi \times 10^{-2} \) (d) \( 4.5\pi \times 10^{-4} \)

95. A one kg stone attached to the end of a 60 cm chain is revolving at the rate of 3 revolution/second. If after 30 seconds, it is making only one revolution per second, find the mean torque.
(a) 0.45 N m (b) 0.35 N m
(c) 0.25 N m (d) 0.15 N m

96. The torque acting on a body is the rotational analogue of
(a) mass of the body
(b) linear kinetic energy of the body
(c) linear velocity of the body
(d) force in linear motion.

97. Four equal and parallel forces are acting on a rod of length 100 cm, as shown in figure, at distances of 20 cm, 40 cm, 60 cm and 80 cm respectively from one end of the rod. Under the influence of these forces, the rod (neglecting its weight)
(a) experiences no torque
(b) experiences torque
(c) experiences a linear motion
(d) experiences torque and also a linear motion.

98. A force of \( -\hat{k} \) acts on \( O \), the origin of the coordinate system. The torque about the point \((1, -1)\) is
(a) \( -F(\hat{i} + \hat{j}) \) (b) \( F(\hat{i} + \hat{j}) \)
(c) \( -F(\hat{i} - \hat{j}) \) (d) \( F(\hat{i} - \hat{j}) \)

99. A torque of magnitude 4000 N m, acting on a body produces an angular acceleration of 20 rad/s². The moment of inertia of the body is
(a) 50 kg m² (b) 100 kg m²
(c) 150 kg m² (d) 200 kg m²
100. An automobile engine develops a power of 100 kilowatt, when rotating at a speed of 30 rev/sec. What torque does it deliver?
(a) \( \frac{1000}{3\pi} \) N m (b) \( \frac{2000}{3\pi} \) N m (c) \( \frac{5000}{3\pi} \) N m (d) \( \frac{4000}{3\pi} \) N m

101. The flywheel of a motor has a moment of inertia of 90 kg m\(^2\). If the motor produces a constant torque of 270 N m, then the angular acceleration produced in the flywheel
(a) 3 rad/s\(^2\) (b) 6 rad/s\(^2\) (c) 9 rad/s\(^2\) (d) 12 rad/s\(^2\)

102. If there is a change in the angular momentum of a body from 5 kg m\(^2\)/s to 8 kg m\(^2\)/s in 4 seconds, then the torque acting on the body is
(a) 1 N m (b) \( \frac{3}{4} \) N m (c) \( \frac{1}{2} \) N m (d) 2 N m

103. A constant torque of 1500 N m turns a wheel of M.I. 300 kg m\(^2\), about an axis passing through its centre. The angular velocity of the wheel after 3 second will be
(a) 5 rad/s (b) 10 rad/s (c) 15 rad/s (d) 20 rad/s

104. A torque of magnitude 500 N m acts on a body of mass 16 kg and produces an angular acceleration of 20 rad/s\(^2\). The radius of gyration of the body is
(a) \( \frac{5}{4} \) m (b) \( \frac{4}{5} \) m (c) \( \frac{2}{3} \) m (d) \( \frac{3}{2} \) m

105. A constant torque of 31.4 N m is applied to a pivoted wheel. If the angular acceleration of the wheel is 2\( \pi \) rad/s\(^2\), then its moment of inertia is
(a) 5 kg m\(^2\) (b) 2.5 kg m\(^2\) (c) 10 kg m\(^2\) (d) 1.25 kg m\(^2\)

106. Under a constant torque, the angular momentum of a body changes from 2\( \pi \) to 5\( \pi \) in 8 sec. The torque acting on the body is
(a) \( \frac{\pi}{4} \) (b) \( \frac{3\pi}{4} \) (c) \( \frac{3\pi}{8} \) (d) \( \frac{3\pi}{16} \)

107. A constant torque of 125.6 N m is applied to a pivoted wheel. If the angular acceleration of the wheel is 4\( \pi \) rad/s\(^2\), then the moment of inertia of the wheel is
(a) 15 kg m\(^2\) (b) 10 kg m\(^2\) (c) 30 kg m\(^2\) (d) 25 kg m\(^2\)

108. Torque of equal magnitude are applied to a thin hollow cylinder and a solid sphere, both having the same mass and radius. Both of them are free to rotate about their axis of symmetry. If \( \alpha_c \) and \( \alpha_s \) are the angular accelerations of the cylinder and the sphere respectively, then the ratio \( \frac{\alpha_c}{\alpha_s} \) will be
(a) \( \frac{5}{2} \) (b) \( \frac{2}{5} \) (c) \( \frac{4}{3} \) (d) \( \frac{3}{4} \)

109. A torque of 100 N m acting on a wheel at rest, rotates it through 200 radian in 10 s. What is the moment of inertia of the wheel?
(a) 10 kg m\(^2\) (b) 15 kg m\(^2\) (c) 20 kg m\(^2\) (d) 25 kg m\(^2\)

110. A torque of magnitude 4000 N m, acts on a body of mass 2 kg. If the angular acceleration produced in the body is 20 rad/s\(^2\), then the radius of gyration of the body is
(a) 5 m (b) 10 m (c) 15 m (d) 20 m

111. What is the torque (in N m) of the force \( \mathbf{F} = (2\hat{i} - 3\hat{j} + 4\hat{k}) \) N acting at the point \( \mathbf{r} = (3\hat{i} + 2\hat{j} + 3\hat{k}) \) m about the origin?
(a) 17\( \hat{i} \) + 6\( \hat{j} \) - 13\( \hat{k} \) (b) -6\( \hat{i} \) + 6\( \hat{j} \) - 12\( \hat{k} \) (c) 17\( \hat{i} \) - 6\( \hat{j} \) - 13\( \hat{k} \) (d) 6\( \hat{i} \) + 6\( \hat{j} \) - 12\( \hat{k} \)

112. A uniform disc of mass \( M \) and radius \( R \) is mounted on an axle supported in frictionless bearings. A light cord is wrapped around the rim of the disc and a steady downward pull \( T \) is exerted on the cord. The angular acceleration of the disc is
(a) \( \frac{MR}{2T} \) (b) \( \frac{2T}{MR} \) (c) \( \frac{T}{MR} \) (d) \( \frac{MR}{T} \)

113. A thin rod of mass \( m \) and length 2\( l \) is make to rotate about an axis passing through its centre and perpendicular to it. If its angular velocity changes from 0 to \( \omega \) in time \( t \), the torque acting on it is
(a) \( \frac{ml^2\omega}{12t} \) (b) \( \frac{ml^2\omega}{3t} \) (c) \( \frac{ml^2\omega}{6t} \) (d) \( \frac{4ml^2\omega}{3t} \)
114. The instantaneous angular position of a point on a rotating wheel is given by the equation
\[ \theta(t) = 2t^3 - 6t^2 \]
The torque on the wheel becomes zero at
(a) \( t = 0.5 \) s  
(b) \( t = 0.25 \) s  
(c) \( t = 2 \) s  
(d) \( t = 1 \) s

115. A flywheel of moment of inertia 0.4 kg m\(^2\) and radius 0.2 m is free to rotate about a central axis. If a string is wrapped around it and it is pulled with a force of 10 N, then its angular velocity after 4 s will be
(a) 10 rad s\(^{-1}\)  
(b) 5 rad s\(^{-1}\)  
(c) 20 rad s\(^{-1}\)  
(d) None of these

116. The angular momentum of a rotating body changes from \( A_0 \) to \( 4A_0 \) in 4 min. The torque acting on the body is
(a) \( \frac{3}{4} A_0 \)  
(b) \( 4A_0 \)  
(c) \( 3A_0 \)  
(d) \( \frac{3}{2} A_0 \)

117. What torque will increase angular velocity of a solid disc of mass 16 kg and diameter 1 m from zero to 120 rpm in 8 s?
(a) \( \left( \frac{\pi}{4} \right) \) Nm  
(b) \( \left( \frac{\pi}{2} \right) \) Nm  
(c) \( \left( \frac{\pi}{3} \right) \) Nm  
(d) \( (\pi) \) Nm

118. A force of 100 N is applied perpendicular to the left edge of the rectangle as shown in the figure. The torque (magnitude and direction) produced by this force with respect to an axis perpendicular to the plane of the rectangle at corner \( A \) and with respect to a similar axis at corner \( B \) are respectively

(a) 75 N m counter-clockwise, 125 N m clockwise  
(b) 125 N m counter-clockwise, 75 N m clockwise  
(c) 125 N m clockwise, 75 N m counter-clockwise  
(d) 125 N m counter-clockwise, 75 N m clockwise

119. A wheel having moment of inertia 2 kg m\(^2\) about its vertical axis, rotates at the rate of 60 rpm about this axis. The torque which can stop the wheel's rotation in one minute would be
(a) \( \frac{2\pi}{15} \) Nm  
(b) \( \frac{\pi}{12} \) Nm  
(c) \( \frac{\pi}{15} \) Nm  
(d) \( \frac{\pi}{18} \) Nm

120. A stone of mass \( m \) tied to a string of length \( l \) is rotating along a circular path with constant speed \( v \). The torque on the stone is
(a) \( mvl \)  
(b) \( \frac{mv}{l} \)  
(c) \( mv^2l \)  
(d) zero

121. Four 2 kg masses are connected by \( \frac{1}{4} \) m spokes to an axle. A force of 24 N acts on a lever \( \frac{1}{2} \) m long to produce angular acceleration \( \alpha \). The magnitude of \( \alpha \) (in rad s\(^{-2}\)) is
(a) 24  
(b) 12  
(c) 6  
(d) 3

122. The product of moment of inertia \( (I) \) and angular acceleration \( (\alpha) \) is called
(a) force  
(b) torque  
(c) angular momentum  
(d) work.

123. Ratio of torque and moment of inertia gives
(a) angular velocity  
(b) angular acceleration  
(c) angular momentum  
(d) force.

124. Which of the following statements is correct?
(a) Torque is always directed along momentum.  
(b) Torque is always directed along angular momentum.  
(c) Torque is always directed along the change in angular momentum.  
(d) Torque is always directed towards centre.

125. The dimensions of torque are
(a) \([M^1L^2T^{-2}]\)  
(b) \([M^1L^2T^{-1}]\)  
(c) \([M^1L^2T^{-1}]\)  
(d) \([M^1L^2T^2]\)

126. A force \( \vec{F} \) is acting on a particle of position vector \( \vec{r} \), the torque will be
(a) \( \vec{r} \times \vec{F} \)  
(b) \( \vec{F} \times \vec{r} \)  
(c) \( r\vec{F} \)  
(d) \( \frac{\vec{F}}{\vec{r}} \)

127. The dimensions of torque are the same as that of
(a) power  
(b) angular momentum  
(c) impulse  
(d) rotational kinetic energy

128. A particle of mass \( M \) and radius of gyration \( K \) is rotating with angular acceleration \( \alpha \). The torque acting on the particle is
(a) \( \frac{1}{2}MK^2\alpha \)  
(b) \( MK^2\alpha \)  
(c) \( \frac{MK^2}{\alpha} \)  
(d) \( \frac{1}{4}MK^2\alpha^2 \)
129. If the moment of inertia of a body is 2.5 kg m², then the torque required to produce an angular acceleration of 18 rad/s² in the body is
(a) 47 N m  (b) 50 N m  (c) 55 N m  (d) 45 N m

130. If a constant couple of 500 N m turns a wheel of moment of inertia 100 kg m² about an axis through its centre, the angular velocity gained in 2 second is
(a) 10 rad/s  (b) 50 rad/s  (c) 200 rad/s  (d) 100 rad/s

131. A torque of magnitude 2000 N m acting on a body produces an angular acceleration of 20 rad/s². The moment of inertia of the body is
(a) 150 kg m²  (b) 50 kg m²  (c) 200 kg m²  (d) 100 kg m²

132. A flywheel of M.I. 0.32 kg m² is rotated steadily at 120 rad/s by a 50 W electric motor. The value of the frictional couple opposing rotation is
(a) 0.025 N m  (b) 0.42 N m  (c) 0.042 N m  (d) 0.25 N m

133. A motor rotates at a constant speed of 25 rev/s. The power delivered by the motor, if it supplies a torque of 60 N m, is
(a) 2500 W  (b) 1500 π W  (c) 1250 W  (d) 3000 π W

134. A wheel having a rotational inertia of 0.20 kg m² rotates at 360 rpm about a vertical axis. When a torque of –1 N m is applied about the same axis for 3.0 s, the final angular speed of the wheel is
(a) 12.68 rad s⁻¹  (b) 22.68 rad s⁻¹  (c) 32.68 rad s⁻¹  (d) 42.68 rad s⁻¹

135. If the external torque acting on a system \( \vec{\tau} = 0 \), then
(a) the system may be in rotational equilibrium
(b) the system is in rotational equilibrium
(c) the system may be in translational equilibrium
(d) the system is in translational equilibrium

136. An automobile engine develops 100 kW when rotating at a speed of 1800 rpm. The torque delivered by the engine is
(a) 350 N m  (b) 440 N m  (c) 531 N m  (d) 628 N m

137. A couple produces
(a) purely linear motion
(b) purely rotational motion
(c) linear and rotational motion
(d) vibration.

138. When a torque acting upon a system is zero, then out of the following, the constant is
(a) force  (b) linear momentum  (c) angular momentum  (d) linear impulse.

139. If \( I, \alpha \) and \( \tau \) are the moment of inertia, angular acceleration and torque respectively of a body rotating about any axis with angular velocity \( \omega \), then
(a) \( \tau = I\alpha \)  (b) \( \tau = I\omega \)  (c) \( \alpha = I\omega \)  (d) \( \alpha = \tau \omega \)

140. The moment of a force \( \vec{F} = -3\hat{i} + 3\hat{j} + 5\hat{k} \) acting at the point \( \vec{r} = 7\hat{i} + 3\hat{j} + \hat{k} \), is
(a) \( 14\hat{i} - 38\hat{j} + 16\hat{k} \)  (b) \( 4\hat{i} + 4\hat{j} + 6\hat{k} \)  (c) \( -14\hat{i} + 38\hat{j} - 16\hat{k} \)  (d) \( -21\hat{i} + 3\hat{j} + 5\hat{k} \)

141. A constant torque of 31.4 N m is exerted on a pivoted wheel. If the angular acceleration of wheel is 4 rad s⁻², then the moment of inertia of the wheel is
(a) 2.5 kg m²  (b) 3.5 kg m²  (c) 4.5 kg m²  (d) 5.5 kg m²

3.6 Rolling Motion

142. Two bodies of masses of 2 kg and 4 kg are moving with velocities of 2 m/s and 10 m/s towards each other under mutual gravitational attraction. What is the velocity of their centre of mass?
(a) 6 m/s  (b) zero  (c) 5 m/s  (d) 8 m/s

143. The centre of mass of a system of two particles divides the distance between them
(a) in the inverse ratio of the masses of the particles
(b) in direct ratio of the masses of the particles
(c) in inverse ratio of the squares of the masses of particles
(d) in direct ratio of the squares of the masses of particles.

144. Four particles, each of mass 1 kg are placed at the corners of a square OABC of side 1 m. O is at the origin of the coordinate system. OA and OC are aligned along positive X-axis and positive Y-axis respectively. What is the position vector of the their centre of mass?
(a) \( \vec{r} \)  (b) \( \hat{i} + \hat{j} \)  (c) \( \frac{1}{2}(\hat{i} - \hat{j}) \)  (d) \( \frac{1}{2}(\hat{i} + \hat{j}) \)
145. Two particles A and B are at rest. They move towards each other under their mutual force of attraction. At the instant when the speed of A is \( v \) and the speed of B is \( 2v \), the speed of the centre of mass of the system is
(a) Zero  
(b) \( v \)  
(c) \( 1.5v \)  
(d) \( 3v \)

146. A disc is rolling on a horizontal surface. C is its centre and P and Q are two points equidistant from its centre. Let \( V_C \), \( V_P \) and \( V_Q \) be the magnitudes of its velocities at C, P and Q respectively. Then

(a) \( V_Q < V_C < V_P \)  
(b) \( V_Q > V_C > V_P \)  
(c) \( V_P = V_Q \) and \( V_C = \frac{1}{2} V_P \)  
(d) \( V_Q < V_P < V_C \)

147. Two blocks of masses 10 kg and 4 kg are connected by a spring of negligible mass and placed on a horizontal frictionless surface. An impulse gives a velocity of 14 m/s to the heavier block in the direction of the lighter block. What is the velocity of the centre of mass?
(a) 5 m/s  
(b) 10 m/s  
(c) 20 m/s  
(d) 30 m/s

148. At any instant, a rolling body may be considered to be in pure rotation about an axis passing through the point of contact. This axis is translated forward with a speed
(a) zero  
(b) data is insufficient  
(c) twice that of the centre of mass  
(d) equal to that of the centre of mass.

149. The centre of mass of a rigid body cannot lie
(a) inside the body always  
(b) outside the body always  
(c) always on its surface  
(d) at two points.

150. A solid sphere is given a kinetic energy \( E \). What fraction of kinetic energy is associated with rotation?
(a) \( \frac{3}{7} \)  
(b) \( \frac{5}{7} \)  
(c) \( \frac{1}{2} \)  
(d) \( \frac{2}{7} \)

151. 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 20 cm s\(^{-1}\). How much work has to be done to stop it?
(a) 2 J  
(b) 4 J  
(c) 6 J  
(d) 8 J

152. A wheel of mass 8 kg and radius 40 cm is rolling on a horizontal road with angular velocity of 15 rad s\(^{-1}\). The moment of inertia of the wheel about its axis is 0.64 kg m\(^2\). Total kinetic energy of wheel is
(a) 288 J  
(b) 216 J  
(c) 72 J  
(d) 144 J

153. A cord is wound round the circumference of a wheel of radius \( r \). The axis of the wheel is horizontal and moment of inertia about it is \( I \). A weight \( mg \) is attached to the end of the cord and falls from rest. After falling through a distance \( h \), the angular velocity of the wheel will be
(a) \( \left( \frac{2gh}{I + mr} \right)^{1/2} \)  
(b) \( \left( \frac{2mgh}{I + mr^2} \right)^{1/2} \)  
(c) \( \left( \frac{2mgh}{I + 2m} \right)^{1/2} \)  
(d) \( (2gh)^{1/2} \)

154. A ball rolls without slipping. The radius of gyration of the ball about an axis passing through its centre of mass is \( k \). If radius of the ball be \( R \), then the fraction of total energy associated with its rotation will be
(a) \( \frac{k^2 + R^2}{R^2} \)  
(b) \( \frac{k^2}{R^2} \)  
(c) \( \frac{k^2}{k^2 + R^2} \)  
(d) \( \frac{R^2}{k^2 + R^2} \)

155. A sphere cannot roll on
(a) a smooth horizontal surface  
(b) a smooth inclined surface  
(c) a rough horizontal surface  
(d) a rough inclined surface.

156. Which of the following conditions is true for a rigid body rolling without slipping on an inclined plane?
(a) It has acceleration less than \( g \).  
(b) It has equal rotational and translational K.E.  
(c) It has linear velocity equal to radius times angular velocity.  
(d) The plane is frictionless.

157. A solid sphere of mass 10 kg and diameter 5 cm rolls without slipping on a smooth horizontal surface with velocity 5 cm/s. Its total kinetic energy is
(a) \( 175 \times 10^{-4} \) J  
(b) \( 175 \times 10^{-3} \) J  
(c) \( 175 \times 10^{-5} \) J  
(d) \( 175 \times 10^{-6} \) J

158. A solid sphere at the top of an inclined plane 0.6 m high is released and rolls down the incline without slipping and without loss of energy due to friction. Its linear speed at the bottom is about
(a) \( 2.90 \) m/s  
(b) \( 2.42 \) m/s  
(c) \( 3.87 \) m/s  
(d) \( 1.53 \) m/s
159. An inclined plane makes an angle of 30° with the horizontal. A ring rolling down the inclined plane from rest without slipping has a linear acceleration equal to
(a) $\frac{2g}{3}$  (b) $\frac{g}{2}$  
(c) $\frac{g}{3}$  (d) $\frac{g}{4}$

160. A solid sphere of mass 1 kg and radius 10 cm rolls without slipping on a horizontal surface with a velocity of 20 cm/s. The total kinetic energy of the sphere is
(a) 0.014 J  (b) 0.028 J  
(c) 14 J  (d) 28 J

161. Total KE of a sphere of mass $M$ rolling with velocity $v$ is
(a) $\frac{7}{10}Mv^2$  (b) $\frac{5}{6}Mv^2$  
(c) $\frac{7}{5}Mv^2$  (d) $\frac{10}{7}Mv^2$

162. When a solid sphere rolls without slipping down an inclined plane making an angle $\theta$ with the horizontal, the acceleration of its centre of mass is $a$. If the same sphere slides without friction, its acceleration $a'$ will be
(a) $\frac{7}{2}a$  (b) $\frac{5}{2}a$  
(c) $\frac{7}{5}a$  (d) $\frac{5}{2}a$

163. A solid sphere rolls down smooth inclined plane of height $h$. If it starts from rest then the speed of the sphere when it reaches the bottom is given by
(a) $\sqrt{gh}$  (b) $\frac{10}{\sqrt{7gh}}$  
(c) $\sqrt{\frac{4}{7}gh}$  (d) $\frac{5}{4gh}$

164. A sphere of moment of inertia $I$ rolls down a smooth inclined plane. The ratio of its translational K.E. to the total energy is
(a) $\frac{2}{7}$  (b) $\frac{3}{7}$  
(c) $\frac{5}{7}$  (d) $\frac{3}{5}$

165. A solid cylinder rolls down on a smooth inclined plane 4.8 m high without slipping. What is its linear speed at the foot of the plane, if it starts rolling from the top of the plane? (use $g = 10 \text{ m/s}^2$)
(a) 4 m/s  (b) 2 m/s  
(c) 10 m/s  (d) 8 m/s

166. A solid cylinder of mass 1 kg and radius 0.02 m, is rolling on a smooth horizontal surface with a uniform velocity of 0.1 m/s. Its total energy is
(a) $7.5 \times 10^{-3}$ J  (b) $7.5 \times 10^{-2}$ J  
(c) $7.5 \times 10^{-4}$ J  (d) $7.5 \times 10^{-6}$ J

167. A sphere is rolling on a horizontal surface without slipping. The ratio of the rotational K.E. to the total kinetic energy of the sphere is
(a) $\frac{2}{5}$  (b) $\frac{2}{7}$  
(c) $\frac{5}{7}$  (d) $\frac{3}{7}$

168. A disc of mass 2 kg is rolling on a horizontal surface without slipping with a velocity of 0.1 m/s. The total kinetic energy of the rolling disc is
(a) $10^{-2}$ J  (b) $2 \times 10^{-2}$ J  
(c) $1.5 \times 10^{-2}$ J  (d) $5 \times 10^{-2}$ J

169. A solid cylinder and a solid sphere, both having the same mass and radius, are released from a rough inclined plane of inclination $\theta$ one by one. They roll on the inclined plane without slipping. The force of friction that acts
(a) on the two bodies is the same  
(b) on the sphere is less than that for a cylinder  
(c) on the sphere is more than that for a cylinder  
(d) on the two bodies is independent of their sizes and shapes.

170. A disc of mass 4.8 kg and radius 1 m is rolling on a horizontal surface without sliding with angular velocity of 600 rotations/min. What is the total kinetic energy of the disc?
(a) $1440 \pi^2$ J  (b) 360 J  
(c) 600 $\pi^2$ J  (d) 4000 $\pi^2$ J

171. What is the total energy of a rolling ring of mass $m$ and radius $R$ ?
(a) $\frac{3}{2}mv^2$  (b) $\frac{1}{2}mv^2$  
(c) $mv^2$  (d) $\frac{5}{2}mv^2$

172. A body is rolling without slipping on a horizontal surface and its rotational kinetic energy is equal to its translational kinetic energy. The body is a
(a) disc  (b) sphere  
(c) cylinder  (d) ring.

173. What is the ratio of the rolling kinetic energy and rotational kinetic energy in the motion of a disc?
(a) 1 : 1  (b) 2 : 7  
(c) 1 : 2  (d) 3 : 1
174. A solid cylinder rolls down an inclined plane of height 3 m and reaches the bottom of plane with angular velocity of $2\sqrt{2}$ rad s$^{-1}$. The radius of cylinder must be \(g = 10 \text{ m s}^{-2}\)

(a) 5 m (b) 0.5 m (c) $\sqrt{10}$ m (d) $\sqrt{7.5}$ m

175. A sphere and a hollow cylinder roll down without slipping on two separate inclined planes and travel the same distances in the same time. If the angle of the plane down which the sphere rolls is 30°, the angle of the other plane is

(a) 60° (b) 53° (c) 37° (d) 45°

176. If a sphere is rolling on an inclined plane with velocity \(v\) without slipping, the vertical height of the incline in terms of velocity will be

(a) $\frac{7v}{10g}$ (b) $\frac{7v^2}{10g}$ (c) $\frac{2v^2}{5g}$ (d) $\frac{2v^2}{5g}$

177. A cylinder is rolling down on an inclined plane of inclination 60°. What is the acceleration?

(a) $\frac{g}{3}$ (b) $\frac{g}{\sqrt{3}}$ (c) $\frac{2g}{3}$ (d) None of these

178. A drum of radius \(R\) and mass \(M\), rolls down without slipping along an inclined plane of angle \(\theta\). The frictional force

(a) converts translational energy to rotational energy
(b) dissipates energy as heat
(c) decreases the rotational motion
(d) decreases the rotational and translational motion.

179. A rupee coin starting from rest rolls down a distance of 1 m on an inclined plane at an angle of 30° with the horizontal. Assuming that \(g = 9.81 \text{ m s}^{-2}\), time taken is

(a) 0.78 s (b) 0.6 s (c) 0.5 s (d) 0.7 s

180. When a uniform solid sphere and a disc of the same mass and of the same radius roll down an inclined smooth plane from rest to the same distance, then the ratio of the time taken by them is

(a) $15 : 14$ (b) $15^2 : 14^2$ (c) $\sqrt{14} : \sqrt{15}$ (d) $14 : 15$

181. At any instant, a rolling body may be considered to be in pure rotation about an axis through the point of contact. This axis is translating forward with speed

(a) equal to centre of mass
(b) zero
(c) twice of centre of mass
(d) no sufficient data.

182. A thin metal disc of radius 0.25 m and mass 2 kg starts from rest and rolls down an inclined plane. If its rotational kinetic energy is 4 J at the foot of the inclined plane, then its linear velocity at the same point is

(a) 1.2 m s$^{-1}$ (b) $2\sqrt{2}$ m s$^{-1}$ (c) 20 m s$^{-1}$ (d) 2 m s$^{-1}$

183. In the figures shown, spheres are identical and angle of inclination and height of all the three inclined planes are same. The rough part of the surface is shown in bold line. If three spheres are released from rest at the tops and \(K_A\), \(K_B\) and \(K_C\) are respectively the energies at the bottom of the inclined planes, then

(A) \(K_A < K_B \) (b) \(K_A = K_B < K_C\) (c) \(K_A < K_B = K_C\) (d) \(K_A = K_B > K_C\)

184. The figures show four rotating disks that are sliding on a frictionless floor. Three forces \(F, 2F, 3F\) act on disks, either at the rim or at the centre or half way between rim and centre. The disks in equilibrium are

(i) \(F\) \(2F\) \(3F\) (ii) \(F\) \(2F\) \(F\) (iii) \(2F\) \(F\) (iv) \(F\) \(F\) \(F\)

(a) (i), (iv) (b) (i), (ii) (c) (iii), (iv) (d) (i), (iii)
185. A rod of negligible mass is pivoted at one end so that it can swing freely as a pendulum. Two masses \(2m\) and \(m\) are attached to it at distances \(b\) and \(3b\) respectively, from the pivot. The rod is held horizontal and then released. Angular acceleration of the rod at the instant it is released is

\[
\frac{2mg}{11b} \quad \frac{4mg}{17b} \quad \frac{5mg}{12b}
\]

186. A sphere is rotating about its diameter then

(a) the particles on the surface of the sphere do not have any linear acceleration
(b) the particles on the diameter, do not have any linear acceleration
(c) different particles on the surface have different angular speeds
(d) all the particles on the surface have same linear speed.

3.7 Theorem of Parallel and Perpendicular Axes

187. A hoop of mass \(M\) and radius \(R\) is hung from a support fixed in a wall. Its moment of inertia about the support is

(a) \(2MR^2\)  (b) \(3MR^2\)
(c) \(4MR^2\)  (d) \(6MR^2\)

188. A coin of mass \(m\) and radius \(r\) having moment of inertia \(I\) about the axis passes through its centre and perpendicular to its plane. It is beaten uniformly to form a disc of radius \(2r\). What will be the moment of inertia about the same axis?

(a) \(I\)  (b) \(2I\)
(c) \(4I\)  (d) \(16I\)

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

(a) \(\frac{7}{36}ML^2\)  (b) \(\frac{7}{48}ML^2\)
(c) \(\frac{11}{48}ML^2\)  (d) \(\frac{ML^2}{12}\)

190. Four similar point masses are symmetrically placed on the circumference of a disc of mass \(M\) and radius \(R\). The moment of inertia of this system about an axis passing through \(O\) and perpendicular to the plane of the disc is

(a) \(MR^2 + 4mR^2\)
(b) \(\frac{MR^2}{2} + 4mR^2\)
(c) \(MR^2 + mR^2\)
(d) \(\frac{MR^2}{3} + 8mR^2\)

191. A uniform disc of mass 5 kg has a radius of 0.5 m. Its moment of inertia about an axis passing through a point on its circumference and perpendicular to its plane is

(a) 1.25 kg m² (b) 0.5 kg m²
(c) 4 kg m²  (d) 1.875 kg m²

192. The moment of inertia of a sphere about its axis passing through its centre is given by \(I = \frac{2}{5}MR^2\). What is the M.I. about a tangent to its surface?

(a) \(\frac{5}{7}MR^2\)  (b) \(\frac{7}{5}MR^2\)
(c) \(\frac{7}{10}MR^2\)  (d) \(\frac{3}{4}MR^2\)

193. The diameter of a thin circular disc of mass 2 kg is 0.2 m. Its moment of inertia about an axis passing through the edge and perpendicular to the plane of the disc is

(a) 0.01 kg m²  (b) 0.02 kg m²
(c) 0.03 kg m²  (d) 0.04 kg m²

194. The moment of inertia of a ring of mass 5 gram and radius 1 cm about an axis passing through its edge and parallel to its natural axis is

(a) 5 g cm²  (b) 2.5 g cm²
(c) 20 g cm²  (d) 10 g cm²

195. The M.I. of a ring about an axis passing through its centre and perpendicular to its plane is 2 kg m², then its M.I. about any diameter is

(a) 3 kg m²  (b) 1 kg m²
(c) 4 kg m²  (d) 2 kg m²

196. The M.I. of a solid cylinder of mass \(M\) and radius \(R\) about a line parallel to the axis of the cylinder and lying on the surface of the cylinder is

(a) \(\frac{2}{5}MR^2\)  (b) \(\frac{3}{5}MR^2\)
(c) \(\frac{3}{2}MR^2\)  (d) \(\frac{5}{2}MR^2\)
197. The ratio of the radii of gyration of a circular disc and a circular ring of the same radius and same mass about a tangential axis perpendicular to plane of disc or ring is
(a) $\sqrt{3}:2$  
(b) $2:3$  
(c) $1:2$  
(d) $\sqrt{5}:\sqrt{6}$

198. Two identical concentric rings each of mass $m$ and radius $R$ are placed perpendicular. What is the moment of inertia of the system about the axis of one of the rings?
(a) $3M R^2$  
(b) $\frac{3}{2} M R^2$  
(c) $\frac{5}{2} M R^2$  
(d) $2M R^2$

199. The moment of inertia of a circular disc of radius 2 m and mass 1 kg about an axis passing through the centre of mass but perpendicular to the plane of the disc is 2 kg m$^2$. Its moment of inertia about an axis parallel to this axis but passing through the edge of the disc is (see the given figure)
(a) 8 kg m$^2$  
(b) 4 kg m$^2$  
(c) 10 kg m$^2$  
(d) 6 kg m$^2$

200. Moment of inertia of a circular loop of radius $R$ about the axis of rotation parallel to horizontal diameter at a distance $\frac{R}{2}$ from it is
(a) $MR^2$  
(b) $\frac{1}{2} MR^2$  
(c) $2 MR^2$  
(d) $\frac{3}{4} MR^2$

201. If the moment of inertia of a disc about an axis tangential and parallel to its surface be $I$, then what will be the moment of inertia about the axis tangential but perpendicular to the surface?
(a) $\frac{6}{5} I$  
(b) $\frac{3}{4} I$  
(c) $\frac{3}{2} I$  
(d) $\frac{5}{4} I$

202. The moment of inertia of a circular disc of radius 2 m and mass 2 kg, about an axis passing through its centre of mass is 2 kg m$^2$. Its moment of inertia about an axis parallel to this axis and passing through its edge (in kg m$^2$) is
(a) 10  
(b) 8  
(c) 6  
(d) 4

203. Two thin uniform circular rings each of radius 10 cm and mass 0.1 kg are arranged such that they have a common centre and their planes are perpendicular to each other. The moment of inertia of this system about an axis passing through their common centre and perpendicular to the plane of one of the rings in kg m$^2$ is
(a) $1.5 \times 10^{-3}$  
(b) $5 \times 10^{-3}$  
(c) $1.5 \times 10^{-6}$  
(d) $18 \times 10^{-4}$

204. Moment of inertia of a thin rod of mass $M$ and length $L$ about an axis passing through its centre is $\frac{ML^2}{12}$. Its moment of inertia about a parallel axis at a distance of $\frac{L}{3}$ from this axis is given by
(a) $\frac{ML^2}{48}$  
(b) $\frac{ML^3}{48}$  
(c) $\frac{ML^2}{12}$  
(d) $\frac{7ML^2}{36}$

205. Which of the following statements is true in case of the principle of perpendicular axes?
(a) It is applicable to only three dimensional objects.
(b) It is applicable to planar as well as three dimensional objects.
(c) It is applicable to only planar objects.
(d) It is applicable to only denser objects.

206. From the theorem of perpendicular axes, if the lamina is in $X-Y$ plane, then
(a) $I_x - I_y = I_z$  
(b) $I_x + I_z = I_y$  
(c) $I_x + I_y = I_z$  
(d) $I_y + I_z = I_x$

207. Let $I$ be the moment of inertia of the body about an axis passing through any point and $I_G$ be the moment of inertia of the body about centre of mass. And $d$ be the distance between any point and centre of mass. Then from the theorem of parallel axes,
(a) $I = I_G - Md^2$  
(b) $I = I_G + Md^2$  
(c) $I + I_G = Md^2$  
(d) $I_G = I - Md^2$

3.8 Applications - Rod, Ring, Disc, Solid Cylinder, Solid Sphere

208. The moment of inertia of a ring of mass $M$ and radius $R$ about its diameter is
(a) $MR^2$  
(b) $2MR^2$  
(c) $\frac{MR^2}{2}$  
(d) $\frac{MR^2}{4}$.  

209. The moment of inertia of a circular disc of radius 3 m and mass 2 kg about an axis passing through its edge is 3 kg m$^2$. Its moment of inertia about an axis parallel to this axis and passing through its edge (in kg m$^2$) is
(a) 10  
(b) 8  
(c) 6  
(d) 4
209. Moment of inertia of a hollow cylinder of mass $M$ and radius $r$ about its own axis is

(a) $\frac{2}{3} Mr^2$  
(b) $\frac{2}{5} Mr^2$  
(c) $\frac{1}{3} Mr^2$  
(d) $Mr^2$

210. Which of the following has the highest moment of inertia when each of them has the same mass and the same radius?

(a) A ring about any of its diameter.  
(b) A disc about any of its diameter.  
(c) A hollow sphere about any of its diameter.  
(d) A solid sphere about any of its diameter.

211. A solid cylinder of mass 20 kg has length 1 m and radius 0.2 m. Then its moment of inertia (in kg m$^2$) about its geometrical axis is (in kg m$^2$)

(a) 0.8  
(b) 0.4  
(c) 0.2  
(d) 20.2

212. Two circular disc of same mass and thickness are made from metals having densities $\rho_1$ and $\rho_2$ respectively. The ratio of their moment of inertia about an axis passing through its centre is,

(a) $\rho_1 : \rho_2$  
(b) $\rho_1 \rho_2 : 1$  
(c) $\rho_2 : \rho_1$  
(d) $1 : \rho_1 \rho_2$

213. The M.I. of two spheres of equal masses about their diameters are equal. If one of them is solid and other is hollow, the ratio of their radius is

(a) $\sqrt{3} : \sqrt{5}$  
(b) $3 : 5$  
(c) $\sqrt{5} : \sqrt{3}$  
(d) $5 : 3$

214. The radius of disc is 2 m then the radius of gyration of disc about an axis passing through its diameter is

(a) 2 m  
(b) 2 cm  
(c) 1 m  
(d) 0.2 m

215. A thin rod of length $l$ and mass $m$ is turned at midpoint $O$ at angle of 60°. The moment of inertia of the rod about an axis passing through $O$ and perpendicular to the plane of the rod will be

\[ \frac{ml^2}{3} \]

(a) $\frac{ml^2}{3}$  
(b) $\frac{ml^2}{6}$  
(c) $\frac{ml^2}{8}$  
(d) $\frac{ml^2}{12}$

216. The moment of inertia of a circular ring about one of its diameters is $I$. What will be its moment of inertia about a tangent parallel to the diameter?

(a) $4I$  
(b) $2I$  
(c) $\frac{3}{2}I$  
(d) $3I$

217. A rope of negligible mass is wound around a hollow cylinder of mass 4 kg and radius 40 cm. What is the angular acceleration of the cylinder, if the rope is pulled with a force of 4 N? Assume that there is no slipping.

(a) 2 rad/s$^2$  
(b) 1.5 rad/s$^2$  
(c) 2.5 rad/s$^2$  
(d) 3 rad/s$^2$

218. A ring of mass 10 kg and radius 0.2 m is rotating about its geometrical axis at 20 rev/sec. Its moment of inertia is

(a) 0.2 kg m$^2$  
(b) 3.0 kg m$^2$  
(c) 0.4 kg m$^2$  
(d) 5.0 kg m$^2$

219. A rod of length 2 m, has a mass of 0.12 kg. Its moment of inertia is

(a) 0.16 kg m$^2$  
(b) 0.12 kg m$^2$  
(c) 0.32 kg m$^2$  
(d) 0.08 kg m$^2$

220. A rod of length of 2 m has a mass of 0.24 kg. Its moment of inertia of the rod is

(a) 0.04 kg m$^2$  
(b) 0.08 kg m$^2$  
(c) 0.12 kg m$^2$  
(d) 0.02 kg m$^2$

221. The moment of inertia of a circular disc about an axis passing through its centre and normal to its plane is 50 kg m$^2$. Then its moment of inertia about a diameter is

(a) 100 kg m$^2$  
(b) 25 kg m$^2$  
(c) 200 kg m$^2$  
(d) 10 kg m$^2$

222. Two rings have their M.I. in the ratio 2 : 1. If their diameter are in the ratio of 2 : 1, then the ratio of their masses will be

(a) 2 : 1  
(b) 1 : 1  
(c) 1 : 2  
(d) 1 : 4

223. Two circular copper discs $A$ and $B$ have the same thickness. If the diameter of $A$ is twice that of $B$, the ratio of the moments of inertia of $A$ and $B$ is

(a) 4  
(b) 16  
(c) 8  
(d) 2
224. The M.I. of a thin uniform rod about the axis passing through its centre and perpendicular to its length is \( \frac{Ml^2}{12} \). The rod is cut transversely into the halves, which are then riveted end to end. The M.I. of the composite rod about the axis passing through its centre and perpendicular to its length will be

(a) \( \frac{Ml^2}{3} \)  
(b) \( \frac{Ml^2}{6} \)  
(c) \( \frac{Ml^2}{48} \)  
(d) \( \frac{Ml^2}{24} \)

225. The moment of inertia of a metre scale of mass 0.6 kg about an axis perpendicular to the scale and passing through 30 cm position on the scale is given by (Breadth of the scale is negligible)

(a) 0.104 kg m²  
(b) 0.208 kg m²  
(c) 0.074 kg m²  
(d) 0.148 kg m²

226. Two discs one of density 7200 kg/m³ and another of density 9000 kg/m³ have the same masses and thicknesses. What is the ratio of their moments of inertia?

(a) \( \frac{4}{5} \)  
(b) \( \frac{5}{4} \)  
(c) \( \frac{5}{9} \)  
(d) \( \frac{1}{9 \times 7.2} \)

227. A solid cylinder of mass 20 kg has length 1 m and radius 0.5 m. Then its moment of inertia in kg m² about its geometrical axis is

(a) 2.5  
(b) 5  
(c) 1.5  
(d) 3

228. What is the moment of inertia of a solid sphere of radius \( R \) and density \( \rho \) about its diameter?

(a) \( \frac{8}{3} \pi R^3 \rho \)  
(b) \( \frac{8}{15} \pi R^4 \rho \)  
(c) \( \frac{8}{15} \pi R^5 \rho \)  
(d) \( \frac{15}{8} \pi R^3 \rho^2 \)

229. The M.I. of a disc of mass \( M \) and radius \( R \), about an axis passing through the centre \( O \) and perpendicular to the plane of the disc is \( \frac{MR^2}{2} \). If one quarter of the disc is removed, the new moment of inertia of the disc will be

\[ \frac{MR^2}{2} \]
237. One quarter sector is cut from a uniform disc of radius \( R \). This sector has mass \( M \). It is made to rotate about a line perpendicular to its plane and passing through the centre of the original disc. What is its moment of inertia about the axis of rotation?

(a) \( \frac{ML^2}{8} \)  
(b) \( \sqrt{2} MR^2 \)  
(c) \( \frac{MR^2}{4} \)  
(d) \( \frac{MR^2}{2} \)

238. One solid sphere \( A \) and another hollow sphere \( B \) are of the same mass and outer radii. Their moments of inertia about their diameters are respectively \( I_A \) and \( I_B \) and \( d_A \) and \( d_B \) are their densities such that

(a) \( I_A < I_B \)  
(b) \( \frac{I_A}{I_B} = \frac{d_A}{d_B} \)  
(c) \( I_A = I_B \)  
(d) \( I_A > I_B \)

239. What is the moment of inertia of a circular wire of mass \( M \) and radius \( R \) about its diameter?

(a) \( MR^2 \)  
(b) \( \frac{MR^2}{2} \)  
(c) \( \frac{MR^2}{4} \)  
(d) \( 2MR^2 \)

240. A sphere of mass 10 kg and radius 0.5 m rotates about a tangent. The moment of inertia of the sphere is

(a) \( 5 \text{ kg m}^2 \)  
(b) \( 2.7 \text{ kg m}^2 \)  
(c) \( 3.5 \text{ kg m}^2 \)  
(d) \( 4.5 \text{ kg m}^2 \)

241. The moment of inertia of a circular disc about one of its diameters is \( I \). What will be its moment of inertia about a tangent parallel to the diameter?

(a) \( 4I \)  
(b) \( 2I \)  
(c) \( 5I \)  
(d) \( 3I \)

242. The moment of inertia of two equal masses each of mass \( m \) at separation \( L \) connected by a rod of mass \( M \), about an axis passing through centre and perpendicular to length of rod is

(a) \( \frac{(M + 3m)L^2}{12} \)  
(b) \( \frac{(M + 6m)L^2}{12} \)  
(c) \( \frac{ML^2}{4} \)  
(d) \( \frac{ML^2}{12} \)

243. Moment of inertia of ring about its diameter is \( I \). Then, moment of inertia about an axis passing through centre and perpendicular to its plane is

(a) \( 2I \)  
(b) \( \frac{I}{2} \)  
(c) \( \frac{3}{2}I \)  
(d) \( I \)

244. The moment of inertia of a circular ring of mass 1 kg about an axis passing through its centre and perpendicular to its plane is 4 kg m\(^2\). The diameter of the ring is

(a) \( 2 \text{ m} \)  
(b) \( 4 \text{ m} \)  
(c) \( 5 \text{ m} \)  
(d) \( 6 \text{ m} \)

245. Four similar point masses \( m \) each are symmetrical placed on the circumference of a disc of mass \( M \) and radius \( R \). Moment of inertia of the system about an axis passing through centre \( O \) and perpendicular to the plane of the disc will be

(a) \( MR^2 + 4mR^2 \)  
(b) \( MR^2 + \frac{8}{5}mR^2 \)  
(c) \( mR^2 + 4mR^2 \)  
(d) \( \frac{MR^2}{2} + 4mR^2 \)

246. The moment of inertia of a sphere of mass \( M \) and radius \( R \) about an axis passing through its centre is \( \frac{2}{5}MR^2 \). The radius of gyration of the sphere about a parallel axis to the above and tangent to the sphere is

(a) \( \frac{7}{5}R \)  
(b) \( \frac{3}{5}R \)  
(c) \( \sqrt{\frac{7}{5}}R \)  
(d) \( \sqrt{\frac{3}{5}}R \)

247. One half of the disc of mass \( m \) is removed. If \( r \) be the radius of the disc, the new moment of inertia is

(a) \( \frac{3}{2}mr^2 \)  
(b) \( \frac{mr^2}{2} \)  
(c) \( \frac{3}{8}mr^2 \)  
(d) \( \frac{mr^2}{4} \)

248. Of the two eggs which have identical sizes, shapes and weights, one is raw and other is half boiled. The ratio between the moment of inertia of the raw to the half boiled egg about central axis is

(a) one (b) greater than one  
(c) less than one  
(d) not comparable

249. Moment of inertia of a solid cylinder of length \( L \) and diameter \( D \) about an axis passing through its centre of gravity and perpendicular to its geometric axis is

(a) \( M \left( \frac{D^2}{4} + \frac{L^2}{12} \right) \)  
(b) \( M \left( \frac{L^2}{16} + \frac{D^2}{8} \right) \)  
(c) \( M \left( \frac{D^2}{4} + \frac{L^2}{6} \right) \)  
(d) \( M \left( \frac{L^2}{12} + \frac{D^2}{16} \right) \)

250. Four spheres each of diameter \( 2a \) and mass \( M \) are placed with their centres on the four corners of a square of side \( b \). Then, the moment of inertia of the system about an axis along one of the sides of the square is

(a) \( \frac{4}{5}Ma^2 + 2Mb^2 \)  
(b) \( \frac{8}{5}Ma^2 + 2Mb^2 \)  
(c) \( \frac{8}{5}Ma^2 \)  
(d) \( \frac{4}{5}Ma^2 + 4Mb^2 \)
251. A spherical solid ball of 1 kg mass and radius 3 cm is rotating about an axis passing through its centre with an angular velocity of 50 rad s\(^{-1}\). K.E. of rotation is
(a) 450 J  
(b) 45 J  
(c) 90 J  
(d) 0.45 J

252. A thin uniform rod \(AB\) of mass \(m\) and length \(L\) is hinged at one end \(A\) to the level floor. Initially, it stands vertically and is allowed to fall freely to the floor in the vertical plane. The angular velocity of the rod, when its end \(B\) strikes the floor is (where, \(g\) is acceleration due to gravity)
(a) \(mgL\)  
(b) \(\frac{mg}{3L}\)  
(c) \(\frac{gL}{2}\)  
(d) \(\frac{3gL}{4}\)

253. M.I. of a thin uniform circular disc about one of the diameters is \(I\). Its M.I. about an axis perpendicular to the plane of disc and passing through its centre is
(a) \(\sqrt{2} I\)  
(b) \(2 I\)  
(c) \(I\)  
(d) \(\frac{1}{4} I\)

254. Moment of inertia of a circular loop of radius \(R\) about the axis of rotation parallel to horizontal diameter at a distance \(\frac{R}{2}\) from it is
(a) \(MR^2\)  
(b) \(\frac{1}{2} MR^2\)  
(c) \(2 MR^2\)  
(d) \(\frac{3}{4} MR^2\)

255. A solid cylinder of mass \(M\) and radius \(R\) rolls without slipping on a flat horizontal surface. Its moment of inertia about the line of contact is
(a) \(\frac{MR^2}{2}\)  
(b) \(MR^2\)  
(c) \(\frac{3}{2} MR^2\)  
(d) \(2MR^2\)

256. The moment of inertia of a cylinder of radius \(R\), length \(L\) and mass \(M\) about an axis passing through its centre of mass and normal to its length is
(a) \(\frac{ML^2}{12}\)  
(b) \(\frac{ML^2}{4}\)  
(c) \(M \left[ \frac{L^2}{12} + \frac{R^2}{4} \right]\)  
(d) \(M \left[ \frac{L^2}{12} + \frac{R^2}{2} \right]\)

257. Three uniform thin rods, each of mass 1 kg and length \(\sqrt{3}\) m are placed along three co-ordinate axes with one end at the origin. The moment of inertia of the system about \(X\)-axis is
(a) \(2\) kg m\(^2\)  
(b) \(3\) kg m\(^2\)  
(c) \(0.75\) kg m\(^2\)  
(d) \(1\) kg m\(^2\)

258. A uniform cylinder has radius \(R\) and length \(L\). If the moment of inertia of this cylinder about an axis passing through its centre and normal to its circular face is equal to the moment of inertia of the same cylinder about an axis passing through its centre and normal to its length, then
(a) \(L = R\)  
(b) \(L = \sqrt{3} R\)  
(c) \(L = \frac{R}{\sqrt{3}}\)  
(d) \(L = 0\)

259. The moment of inertia of a solid sphere about an axis passing through centre of gravity is \(\frac{2}{5} MR^2\). Its radius of gyration about a parallel axis at a distance \(2R\) from the first axis is
(a) \(5R\)  
(b) \(\frac{22}{5} R\)  
(c) \(\frac{5}{2} R\)  
(d) \(\frac{12}{5} R\)

260. A book of mass 0.5 kg has its length 75 cm and breadth 25 cm. Then the moment of inertia about an axis perpendicular to the book and passing through the centre of gravity of the book is
(a) \(\frac{10}{289}\) kg m\(^2\)  
(b) \(\frac{282}{10}\) kg m\(^2\)  
(c) \(\frac{10}{384}\) kg m\(^2\)  
(d) \(\frac{10}{483}\) kg m\(^2\)

261. Two circular discs are of same thickness and are made of same material. The diameter of \(A\) is twice that of \(B\). The moment of inertia of \(A\) as compared to that of \(B\) is
(a) twice as large  
(b) four times as large  
(c) 8 times as large  
(d) 16 times as large

262. A wire of mass \(m\) and length \(l\) is bent in the form of a circular ring. The moment of inertia of the ring about one of its diameter is
(a) \(ml^2\)  
(b) \(\frac{ml^2}{4}\)  
(c) \(\frac{ml^2}{2\pi^2}\)  
(d) \(\frac{ml^2}{8\pi^2}\)

263. Two discs of the same material and thickness have radii 0.2 m and 0.6 m. Their moments of inertia about their axes will be in the ratio
(a) \(1 : 81\)  
(b) \(1 : 27\)  
(c) \(1 : 9\)  
(d) \(1 : 3\)
Rotational Motion

264. Moment of inertia of a disc about its own axis is \( I \). Its moment of inertia about a tangential axis in the plane of the disc is
   (a) \( \frac{5}{2} I \)  (b) \( 3 I \)
   (c) \( \frac{3}{2} I \)  (d) \( 2 I \)

265. A cylinder of 500 g and radius 10 cm has moment of inertia (about its natural axis)
   (a) \( 2.5 \times 10^{-3} \text{ kg m}^2 \)  (b) \( 2 \times 10^{-3} \text{ kg m}^2 \)
   (c) \( 5 \times 10^{-3} \text{ kg m}^2 \)  (d) \( 3.5 \times 10^{-3} \text{ kg m}^2 \)

3.9 Angular Momentum

266. The K.E. of a body is 3 joule and its moment of inertia is 6 kg m\(^2\). Then its angular momentum will be
   (a) \( 3 \text{ kg m}^2/\text{s} \)  (b) \( 4 \text{ kg m}^2/\text{s} \)
   (c) \( 5 \text{ kg m}^2/\text{s} \)  (d) \( 6 \text{ kg m}^2/\text{s} \)

267. Two wheels A and B are mounted on the same axle. Moment of inertia of A is 6 kg m\(^2\) and it is rotating at 600 rpm when B is at rest. What is moment of inertia of B, if their combined speed is 400 rpm?
   (a) \( 8 \text{ kg m}^2 \)  (b) \( 4 \text{ kg m}^2 \)
   (c) \( 3 \text{ kg m}^2 \)  (d) \( 5 \text{ kg m}^2 \)

268. A particle performs uniform circular motion with an angular momentum \( L \). If the frequency of particle's motion is doubled and its kinetic energy is halved, the angular momentum becomes
   (a) \( 2L \)  (b) \( 4L \)
   (c) \( \frac{L}{2} \)  (d) \( \frac{L}{4} \)

269. A child is standing with folded hands at the centre of a platform rotating about its central axis. The kinetic energy of the system is \( K \). The child now stretches his arms so that the moment of inertia of the system doubles. The kinetic energy of the system, now, is
   (a) \( K \)  (b) \( \frac{K}{3} \)
   (c) \( \frac{K}{2} \)  (d) \( \frac{K}{4} \)

270. In the absence of external torque for a body revolving about any axis, the quantity that remains constant is
   (a) kinetic energy  (b) potential energy
   (c) linear momentum  (d) angular momentum

271. A particle of mass \( m \) describes uniform circular motion in a horizontal plane. The quantity that is conserved is
   (a) linear velocity  (b) linear momentum
   (c) angular momentum  (d) linear acceleration.

272. The angular momentum of a particle
   (a) is perpendicular to the plane of the surface in which it moves
   (b) along the plane of motion
   (c) inclined at any angle with the plane
   (d) has no particular direction.

273. Angular momentum is conserved
   (a) always  (b) never
   (c) when external force is absent
   (d) when external torque is absent.

274. The \( z \) component of the angular momentum of a particle whose position vector is \( \vec{r} \) with components \( x, y \) and \( z \) and linear momentum is \( \vec{p} \) with components \( p_x, p_y \) and \( p_z \) is
   (a) \( xp_y - yp_x \)  (b) \( yp_z - zp_y \)
   (c) \( zp_x - xp_z \)  (d) \( xp_y + yp_z \)

275. A particle with position vector \( \vec{r} \) has a linear momentum \( \vec{p} \). Which of the following statements is true with respect of its angular momentum \( \vec{L} \) about the origin?
   (a) \( \vec{L} \) acts along \( \vec{p} \).  (b) \( \vec{L} \) acts along \( \vec{r} \).
   (c) \( \vec{L} \) is maximum when \( \vec{p} \) and \( \vec{r} \) are parallel.
   (d) \( \vec{L} \) is maximum when \( \vec{p} \) is perpendicular to \( \vec{r} \).

276. Angular momentum of a body is defined as the product of
   (a) mass and angular velocity
   (b) centripetal force and radius
   (c) linear velocity and angular velocity
   (d) moment of inertia and angular velocity.

277. A ballet dancer, dancing on a smooth floor is spinning about a vertical axis with her arms folded with an angular velocity of 20 rad/s. When she stretches her arms fully, the spinning speed decreases to 10 rad/s. If \( I \) is the initial moment of inertia of the dancer, the new moment of inertia is
   (a) \( 2I \)  (b) \( 3I \)
   (c) \( I/2 \)  (d) \( I/3 \)

278. A small steel sphere is tied to a string and is whirled in a horizontal circle with a uniform angular velocity \( \omega_1 \). The string is suddenly pulled so that the radius of the circle is halved. If \( \omega_2 \) is the new angular velocity, then
   (a) \( \omega_1 > \omega_2 \)  (b) \( \omega_1 = 2\omega_2 \)
   (c) \( \omega_1 = \omega_2 \)  (d) \( \omega_2 > \omega_1 \)
279. A person with outstretched arms is spinning on a rotating stool. He suddenly brings his arms down to his sides. Which of the following is true about his kinetic energy $K$ and angular momentum $L$?
(a) Both $K$ and $L$ increase.
(b) Both $K$ and $L$ remain unchanged.
(c) $K$ remains constant, $L$ increases.
(d) $K$ increases but $L$ remains constant.

280. The radius vector and linear momentum are respectively given by vectors
\[ 2\hat{i} + \hat{j} + \hat{k} \text{ and } 2\hat{i} - 3\hat{j} + \hat{k}. \]
Then the angular momentum is
(a) $2\hat{i} - 4\hat{k}$
(b) $4\hat{i} - 8\hat{k}$
(c) $2\hat{i} - 4\hat{j} + 2\hat{k}$
(d) $4\hat{i} - 8\hat{j}$

281. A mass is whirled in a circular path with constant angular velocity and its angular momentum is $L$. If the string is now halved keeping angular velocity same, the angular momentum is
(a) $L/4$
(b) $L/2$
(c) $L$
(d) $2L$

282. A thin uniform circular disc of mass $M$ and radius $R$ is rotating in a horizontal plane about an axis passing through its centre and perpendicular to its plane with an angular velocity $\omega$. Another disc of same dimensions but of mass $M/4$ is placed gently on the first disc coaxially. The angular velocity of the system now is
(a) $2\omega/\sqrt{2}$
(b) $4\omega/5$
(c) $5\omega/4$
(d) $3\omega/4$

283. The angular speed of a body changes from $\omega_1$ to $\omega_2$ without applying a torque, but due to changes in moment of inertia. The ratio of radii of gyration in the two cases is
(a) $\omega_2 : \omega_1$
(b) $\sqrt[4]{\omega_1} : \sqrt[4]{\omega_2}$
(c) $\sqrt[4]{\omega_2} : \sqrt[4]{\omega_1}$
(d) $\omega_1 : \omega_2$

284. When a torque acting on a system is increased, then which one of the following quantities will increase?
(a) Linear momentum (b) Angular momentum (c) Force (d) Displacement

285. If $I$ is the moment of inertia and $E$ is the kinetic energy of rotation of a body, then its angular momentum is given by
(a) $\sqrt{EI}$
(b) $\sqrt{2EI}$
(c) $E/I$
(d) $2EI$

286. If $L$ is the angular momentum and $I$ is the moment of inertia of a rotating body, then $\frac{L^2}{2I}$ represents
(a) rotational potential energy
(b) total energy
(c) rotational kinetic energy
(d) translational kinetic energy.

287. A disc of mass 4 kg and radius 0.2 m makes 20 rev/s, about an axis passing through its centre and perpendicular to the plane of the disc. The angular momentum of the disc is approximately equal to
(a) 10 kg m²/sec
(b) 5 kg m²/sec
(c) 15 kg m²/sec
(d) 20 kg m²/sec

288. A gramophone record of mass $M$ and radius $R$ is rotating with angular speed $\omega$. If two pieces of wax, each of the mass $m$ are kept on it at a distance of $R/2$ from the centre on opposite sides, then the new angular velocity will be
(a) $\omega$
(b) $m\omega/M + m$
(c) $M\omega/M + m$
(d) $M\omega/M$

289. A particle of mass 0.75 kg is moving in the XY plane parallel to Y-axis with a uniform speed of 4 m/s. It crosses the X-axis at 3 m from the origin. What is the angular momentum of the particle about the origin?
(a) 3 kg m²/s
(b) 9 kg m²/s
(c) 6 kg m²/s
(d) 1.5 kg m²/s

290. A body of mass 2 kg is rotating on a circular path of radius 0.5 m with an angular velocity of 20 rad/s. If the radius of the path is doubled, then the new angular velocity will be
(a) 5 rad/sec
(b) 2.5 rad/sec
(c) 10 rad/sec
(d) 8 rad/sec

291. A circular disc rotates about an axis passing through its centre with a certain angular velocity. Suddenly a small piece of the disc is broken from the edge and falls down. Then
(a) its M.I will increase and angular velocity will decrease
(b) its M.I will decrease and the angular velocity will increase
(c) both the M.I and the angular velocity will increase
(d) both the M.I and the angular velocity will decrease.
292. A body of mass \( m \) and radius of gyration \( K \) has an angular momentum \( L \). Then its angular velocity is
   \[ (a) \quad \frac{mK^2}{L} \quad (b) \quad \frac{L}{mk^2} \quad (c) \quad mk^2L \quad (d) \quad \frac{K^2}{mL} \]

293. A man standing on a rotational horizontal circular table, suddenly sits down. What is conserved in this process?
   (a) Kinetic energy  (b) Angular speed  
   (c) Angular momentum  (d) Linear momentum

294. A particle performs a uniform circular motion with angular momentum \( L \). If its angular frequency is halved and the rotational kinetic energy is doubled, then the new angular momentum will be
   \[ (a) \quad 2L \quad (b) \quad 3L \quad (c) \quad 4L \quad (d) \quad \frac{L}{4} \]

295. A thin circular ring of mass \( M \) and radius \( R \) is rotating about an axis passing through its centre and perpendicular to its plane with a constant angular velocity \( \omega_1 \). Two small bodies each of mass \( m \) are attached gently to the opposite ends of a diameter of the ring. The new angular velocity \( \omega_2 \) of the ring will be
   \[ (a) \quad \frac{M + 2m}{M} \omega_1 \quad (b) \quad \frac{M}{M + 2m} \omega_1 \quad (c) \quad \frac{\omega_1 (M + 2m)}{M} \quad (d) \quad \frac{\omega_1 (m - 2M)}{2m} \]

296. The position vector of a particle of mass 10 g about the origin is \((4 \hat{i} + 3 \hat{j})\) m. If its moves with a linear velocity of \(4 \hat{i} \text{ m/s}\), then its angular momentum will be
   \[ (a) \quad 12 \hat{k} \text{ J s} \quad (b) \quad 0.2 \hat{k} \text{ J s} \quad (c) \quad -0.12 \hat{k} \text{ J s} \quad (d) \quad -1.2 \hat{k} \text{ J s} \]

297. A disc of moment of inertia \( I_1 \) is rotating with angular velocity \( \omega_1 \) about an axis perpendicular to its plane and passing through its centre. If another disc of moment of inertia \( I_2 \) about the same axis is gently placed over it, then the new angular velocity of the combined disc will be
   \[ (a) \quad \frac{(I_1 + I_2)\omega_1}{I_1} \quad (b) \quad \frac{I_1\omega_1}{I_1 + I_2} \quad (c) \quad \omega_1 \quad (d) \quad \frac{I_2\omega_1}{I_1 + I_2} \]

298. If the earth suddenly contracts to \(1/n\)th of the present size without any change in its mass, the duration of the new day will be
   \[ (a) \quad 24 n^2 \text{ hour} \quad (b) \quad \frac{24}{n^2} \text{ hour} \quad (c) \quad 24 n \text{ hour} \quad (d) \quad \frac{24}{n} \text{ hour} \]

299. A car of mass 1200 kg is travelling around a circular path of radius 250 m with a steady speed of 72 km/hour. What is its angular momentum?
   (a) \( 3 \times 10^6 \text{ kg m}^2/\text{s} \)  (b) \( 4 \times 10^6 \text{ kg m}^2/\text{s} \)  
   (c) \( 5 \times 10^6 \text{ kg m}^2/\text{s} \)  (d) \( 6 \times 10^6 \text{ kg m}^2/\text{s} \)

300. The moment of inertia of a disc rotating about an axis passing through its centre and perpendicular to its axis is 20 kg m\(^2\). If its rotational K.E. is 10 J, then its angular momentum will be
   \[ (a) \quad 10 \text{ kg m}^2/\text{s} \quad (b) \quad 15 \text{ kg m}^2/\text{s} \quad (c) \quad 20 \text{ kg m}^2/\text{s} \quad (d) \quad 25 \text{ kg m}^2/\text{s} \]

301. A solid cylinder of moment of inertia 0.625 kg m\(^2\), rotates about its axis with an angular speed of 200 rad/s. What is the magnitude of angular momentum of the cylinder about its axis?
   \[ (a) \quad 25 \text{ kg m}^2/\text{s} \quad (b) \quad 12.5 \text{ kg m}^2/\text{s} \quad (c) \quad 62.5 \text{ kg m}^2/\text{s} \quad (d) \quad 125 \text{ kg m}^2/\text{s} \]

302. A man standing at the centre of a rotating table, with his hands stretched outwards. The table is rotating at the rate of 30 rev/minute. If the man brings his hands towards his chest and thereby reduces his moment of inertia \( \frac{3}{5} \) times of its original moment of inertia, then the number of revolutions performed by the rotating table per minute will be
   \[ (a) \quad 25 \quad (b) \quad 30 \quad (c) \quad 40 \quad (d) \quad 50 \]

303. A uniform metre scale of mass 0.2 kg is rotated about an axis passing through its one end perpendicular to its length at the rate of 60 revolutions/minute. What is its angular momentum?
   \[ (a) \quad \frac{2\pi}{15} \text{ kg m}^2/\text{s} \quad (b) \quad \frac{4\pi}{15} \text{ kg m}^2/\text{s} \quad (c) \quad \frac{\pi}{15} \text{ kg m}^2/\text{s} \quad (d) \quad 1 \text{ kg m}^2/\text{s} \]

304. A swimmer while jumping into water from a height easily forms a loop in the air if
   (a) he keeps himself straight
   (b) he spreads his arms and legs
   (c) he pulls his arms and legs in
   (d) he jumps, making an angle of 45° with the horizontal.
305. A ballet dancer revolves at 24 rpm with her hands folded. If she stretches her hands so that her M.I. increases by 20%, then the new frequency of rotation will be
(a) 18 rpm (b) 20 rpm (c) 22 rpm (d) 24 rpm

306. An electron revolves around the nucleus of an atom in a circular orbit of radius 4 Å with a speed of $5 \times 10^6$ m/s. What is the angular momentum of the electron? $[m_e = 9 \times 10^{-31}$ kg$]$ (a) $2 \times 10^{-33}$ kg m$^2$/s (b) $1.8 \times 10^{-33}$ kg m$^2$/s (c) $3 \times 10^{-32}$ kg m$^2$/s (d) $0.8 \times 10^{-34}$ kg m$^2$/s

307. The moments of inertia of two rotating bodies $A$ and $B$ are $I_1$ and $I_2$ where $I_1 > I_2$. If $K_1$ and $K_2$ are their kinetic energies and if their angular momenta are equal, then
(a) $K_1 = K_2$ (b) $K_1 < K_2$ (c) $K_1 > K_2$ (d) $K_1 = \frac{1}{2} K_2$

308. Two bodies have their moments of inertia $I$ and $2I$ respectively, about their axis of rotation. If their kinetic energies of rotation are equal, then the ratio of their angular momenta will be
(a) $2 : 1$ (b) $1 : 2$ (c) $\sqrt{2} : 1$ (d) $1 : \sqrt{2}$

309. A particle is moving in a circular orbit of radius $r_1$ with an angular velocity $\omega_1$. It jumps to another circular orbit of radius $r_2$ and attains an angular velocity $\omega_2$. If $r_2 = 0.5 r_1$, and if no external torque is applied to the system, then the new angular velocity $\omega_2$ is given by
(a) $\omega_2 = \omega_1$ (b) $\omega_2 = 2\omega_1$ (c) $\omega_2 = 3\omega_1$ (d) $\omega_2 = 4\omega_1$

310. A solid sphere is rotating in a free space. If the radius of the sphere is increased, keeping the mass same, which one of the following will not be affected?
(a) Angular velocity (b) Moment of inertia (c) Angular momentum (d) Rotational kinetic energy

311. A solid sphere is rotating about a diameter at an angular velocity $\omega$. It is kept in an extremely cold surrounding so that its radius shrinks to $(1/n)^{th}$ of its original radius. What will be its new angular velocity?
(a) $n^2\omega$ (b) $n\omega$ (c) $\omega$ (d) $\omega/n$

312. $r$ denotes the distance between the sun and the earth. Assume that the earth moves around the sun in a circular orbit of radius $r$. The angular momentum of the earth around the sun is proportional to
(a) $r$ (b) $r^3$ (c) $\sqrt{r}$ (d) $r^2$

313. A body of moment of inertia 2 kg m$^2$ has rotational kinetic energy of 4 J. What is the angular momentum of the body?
(a) $\sqrt{2}$ kg m$^2$/s (b) 2 kg m$^2$/s (c) 4 kg m$^2$/s (d) 8 kg m$^2$/s

314. A thin horizontal circular disc is rotating about a vertical axis passing through its centre. An insect is at rest at a point near the rim of the disc. The insect now moves along a diameter of the disc to reach its other end. During the journey of the insect, the angular speed of the disc
(a) remains unchanged (b) continuously decreases (c) continuously increases (d) first increases and then decreases.

315. A particle undergoes uniform circular motion. About which point on the plane of the circle, will the angular momentum of the particle remain constant?
(a) Centre of the circle (b) On the circumference of the circle (c) Inside the circle (d) Outside the circle

316. A particle of mass $m$ moves along the line $PC$ with velocity $v$ as shown in the figure. What is the angular momentum of the particle about $P$?
(a) $mvl$ (b) $mvr$ (c) zero (d) $mvL$

317. A thin circular ring of mass $M$ and radius $r$ is rotating about its axis with a constant angular velocity $\omega$. Four objects each of mass $m$ are kept gently on the opposite ends of two perpendicular diameters of the ring. The angular velocity of the ring will be
(a) $\frac{Mo}{4m}$ (b) $\frac{Mo}{M + 4m}$ (c) $\frac{(M + 4m)\omega}{M}$ (d) $\frac{(M - 4m)\omega}{M + 4m}$
318. A uniform metallic rod rotates about its perpendicular bisector with constant angular speed. If it is heated uniformly to raise its temperature slightly,
(a) its speed of rotation increases
(b) its speed of rotation decreases
(c) its speed of rotation remains same
(d) its speed increases because its moment of inertia decreases.

319. A mass is whirled in a circular path with a constant angular velocity and its angular momentum is \( L \). If the string is now halved keeping the angular velocity same, the angular momentum is
(a) \( \frac{L}{4} \)
(b) \( \frac{L}{2} \)
(c) \( L \)
(d) \( 2L \).

320. The unit mass have \( \vec{r} = 8 \hat{i} - 4 \hat{j} \) and \( \vec{v} = 8 \hat{i} + 4 \hat{j} \). Its angular momentum is
(a) 64 unit in \(-\hat{k}\) direction
(b) 64 unit in \(+\hat{k}\) direction
(c) 64 unit in \(+\hat{j}\) direction
(d) 64 unit in \(+\hat{i}\) direction.

321. A ballet dancer spins with 2.8 rps with her arms outstretched. When the moment of inertia about the same axis becomes 0.7 \( I_1 \), the new rate of spin is
(a) 3.2 rps
(b) 4.0 rps
(c) 4.8 rps
(d) 5.6 rps.

322. If the earth suddenly changes its radius \( x \) times the present value, the new period of rotation would be
(a) \( 6x^2 \) h
(b) \( 12x^2 \) h
(c) \( 24x^2 \) h
(d) \( 48x^2 \) h.

323. A small object of mass \( m \) is attached to a light string which passes through a hollow tube. The tube is hold by one hand and the string by the other. The object is set into rotation in a circle of radius \( r \) and velocity \( v \). The string is then pulled down, shortening the radius of path of \( r \). What is conserved?
(a) Angular momentum
(b) Linear momentum
(c) Kinetic energy
(d) None of these.

324. A particle is projected with a speed \( v \) at 45° with the horizontal. The magnitude of angular momentum of the projectile about the point of projection when the particle is at its maximum height \( h \) is
(a) zero
(b) \( \frac{mv^2h^2}{\sqrt{2}} \)
(c) \( \frac{mv^2h}{2} \)
(d) \( \frac{mgh}{\sqrt{2}} \).

325. A particle of mass \( m \) is projected with a velocity \( v \) making an angle of 45° with the horizontal. The magnitude of angular momentum of the projectile about an axis of projection when the particle is at maximum height \( h \) is
(a) zero
(b) \( \frac{mv^3}{4\sqrt{2} \ g} \)
(c) \( \frac{mv^2}{\sqrt{2}g} \)
(d) \( m(2gh^3) \).

326. An ice skater spins at \( 3\pi \) rad s\(^{-1} \) with her arms extended. If her moment of inertia with arms folded is 75% of that with arms extended, her angular velocity when she folds her arms is
(a) \( \pi \) rad s\(^{-1} \)
(b) \( 2\pi \) rad s\(^{-1} \)
(c) \( 3\pi \) rad s\(^{-1} \)
(d) \( 4\pi \) rad s\(^{-1} \).

327. A ring of diameter 0.4 m and of mass 10 kg is rotating about its axis at the rate of 1200 rpm. The angular momentum of the ring is
(a) 60.28 kg m\(^2\)s\(^{-1} \)
(b) 55.26 kg m\(^2\)s\(^{-1} \)
(c) 40.28 kg m\(^2\)s\(^{-1} \)
(d) 50.28 kg m\(^2\)s\(^{-1} \).

328. A 3 kg particle moves with constant speed of 2 m s\(^{-1} \) in the xy-plane in the y-direction along the line \( x = 4 \) m. The angular momentum (in kg m\(^2\)s\(^{-1} \)) relative to the origin and the torque about the origin needed to maintain this motion are respectively
(a) 12, 0
(b) 24, 0
(c) 24
(d) 12.

329. A disc of mass 2 kg and radius 0.2 m is rotating with angular velocity 30 rad s\(^{-1} \). What is angular velocity, if a mass of 0.25 kg is put on periphery of the disc?
(a) 24 rad s\(^{-1} \)
(b) 36 rad s\(^{-1} \)
(c) 15 rad s\(^{-1} \)
(d) 26 rad s\(^{-1} \).

330. A solid cylinder of mass 2 kg and radius 0.2 m is rotating about its own axis without friction with angular velocity of 3 rad s\(^{-1} \). Angular momentum of the cylinder is
(a) 0.2 J s
(b) 1.12 J s
(c) 0.12 J s
(d) 12 J s.

331. In a circular motion, the angle between a particle’s linear momentum and its angular momentum is
(a) 0°
(b) 45°
(c) 90°
(d) 180°.

332. A mass of 10 kg is moving with a constant velocity of 0.5 m s\(^{-1} \) parallel to the X-axis. The shortest distance of the mass from the origin during its motion is 20 cm. What will be angular momentum of the mass about the origin in SI units?
(a) 0.1 kg m\(^2\)s\(^{-1} \)
(b) 0.5 kg m\(^2\)s\(^{-1} \)
(c) 0 kg m\(^2\)s\(^{-1} \)
(d) 1 kg m\(^2\)s\(^{-1} \).
333. Direction of angular momentum of rotating body in a vertical plane is
(a) vertical  (b) tangential
(c) horizontal  (d) radial.

334. The relation between the torque $\tau$ and the angular momentum $I$ of a body of moment of inertia $I$ rotating with angular velocity $\omega$ is
(a) $\tau = \frac{dI}{dt}$  (b) $\tau = I \cdot \omega$
(c) $\tau = \frac{dL}{d\omega}$  (d) $\tau = I \times \omega$

335. Unit of angular momentum is
(a) N s  (b) N s$^{-1}$
(c) J s$^{-1}$  (d) J s

336. A constant torque is applied on a circular wheel, which changes its angular momentum from 0 to 4 $L$ in 4 seconds. The torque is
(a) $\frac{3L}{4}$  (b) $L$
(c) $4L$  (d) $12L$

337. A uniform stick of length $l$ and mass $m$ lies on a smooth table. It rotates with angular velocity $\omega$ about an axis perpendicular to the table and through one end of the stick. The angular momentum of the stick about the end is
(a) $Ml^2\omega$  (b) $\frac{Ml^2\omega}{3}$
(c) $\frac{Ml^2\omega}{12}$  (d) $\frac{Ml^2\omega}{6}$

338. The diameter of a flywheel is 1 m. It has a mass of 20 kg. It is rotating about its axis with a speed of 120 rotations in one minute. Its angular momentum (in kg m$^2$ s$^{-1}$) is
(a) 13.4  (b) 31.4
(c) 41.4  (d) 43.4

339. If $L$ and $p$ represent the angular momentum and the linear momentum of a particle respectively, the plot between $\log_e L$ and $\log_e p$ is

340. The angular momentum of a particle rotating with a central force is constant due to
(a) zero torque  (b) constant torque
(c) constant force  (d) constant linear momentum.

341. If the earth suddenly shrinks such that its radius reduces to half of its present value, then the period of rotation of the earth reduces to
(a) 6 hr  (b) 14 hr
(c) 12 hr  (d) 18 hr

342. The motion of planets in the solar system is an example of the conservation of
(a) mass  (b) linear momentum
(c) angular momentum  (d) energy.

343. Angular momentum is
(a) vector (axial)  (b) vector (polar)
(c) scalar  (d) a mathematical ratio.

344. A disc is rotating with an angular speed $\omega$. If a child sits on it, out of the following the quantity conserved is
(a) kinetic energy  (b) potential energy
(c) linear momentum  (d) angular momentum.

345. Angular momentum of a system of particles changes when
(a) force acts on a body  (b) torque acts on a body
(c) direction of velocity changes  (d) None of these.

LEVEL - 2

1. Four point masses, each of value $m$, are placed at the corners of a square $ABCD$ of side $l$. The moment of inertia of this system about an axis through $A$ and parallel to $BD$ is
(a) $ml^2$  (b) $2ml^2$
(c) $\sqrt{3}ml^2$  (d) $3ml^2$

2. Two wheels are connected by a belt. The radius of the larger wheel is three times that of the smaller one. What is the ratio of the moment of inertia of larger wheel to the smaller wheel, when both wheels have same angular momentum?
(a) 3  (b) 6
(c) 9  (d) 12
3. A square plate of side $l$ has mass $M$. What is its moment of inertia about one of its diagonals?
   (a) $\frac{Ml^2}{6}$  (b) $\frac{Ml^2}{12}$
   (c) $\frac{Ml^2}{3}$  (d) $\frac{Ml^2}{4}$

4. A uniform ladder 3 m long weighing 20 kg leans against a frictionless wall. Its foot rest on a rough floor 1 m from the wall. The reaction forces of the wall and floor are
   (a) $25\sqrt{2}$ N, 203 N  (b) $50\sqrt{2}$ N, 230 N
   (c) $203$ N, $25\sqrt{2}$ N  (d) $230$ N, $50\sqrt{2}$ N

5. A particle is moving along a straight line parallel to $x$-axis with constant velocity. Its angular momentum about the origin
   (a) decreases with time  (b) increases with time
   (c) remains constant  (d) is zero.

6. Four particles each of mass $m$ are lying symmetrically on the rim of a disc of mass $M$ and radius $R$. Moment of inertia of this system about an axis passing through one of the particles and perpendicular to plane of disc is
   (a) $16mR^2$  (b) $(3M + 16m)\frac{R^2}{2}$
   (c) $(3m + 12M)\frac{R^2}{2}$  (d) zero

7. A circular disc $X$ of radius $R$ is made from an iron plate of thickness $t$, and another disc $Y$ of radius $4R$ is made from an iron plate of thickness $\frac{t}{4}$. Then the relation between the moment of inertia $I_X$ and $I_Y$ is
   (a) $I_Y = 32I_X$  (b) $I_Y = 16I_X$
   (c) $I_Y = I_X$  (d) $I_Y = 64I_X$

8. A cord is wound over the rim of a flywheel of mass 20 kg and radius 25 cm. A mass 2.5 kg attached to the cord is allowed to fall under gravity. Calculate the angular acceleration of the flywheel.
   (a) 25 rad/s$^2$  (b) 20 rad/s$^2$
   (c) 10 rad/s$^2$  (d) 5 rad/s$^2$

9. Three bodies, a ring, a solid cylinder and a solid sphere roll down the same inclined plane without slipping. They start from rest. The radii of the bodies are identical. Which of the body reaches the ground with maximum velocity?
   (a) Ring  (b) Solid cylinder
   (c) Solid sphere  (d) All reach the ground with same velocity

10. Two discs one of density 7.2 g/cm$^3$ and the other of density 8.9 g/cm$^3$, are of the same masses and thicknesses. Their moments of inertia are in the ratio
    (a) 8.9 : 7.2  (b) 7.2 : 8.9
    (c) $(8.9 \times 7.2) : 1$  (d) $1 : (8.9 \times 7.2)$

11. The moment of inertia of a uniform circular disc of mass $M$ and of radius $R$ about one of its diameters is
    (a) $\frac{1}{4}MR^2$  (b) $\frac{1}{2}MR^2$
    (c) $\frac{2}{3}MR^2$  (d) $\frac{2}{5}MR^2$

12. The moment of inertia of a circular disc of mass $M$ and radius $R$ about an axis passing through the center of mass is $I_0$. The moment of inertia of another circular disc of same mass and thickness but half the density about the same axis is
    (a) $\frac{I_0}{8}$  (b) $\frac{I_0}{4}$
    (c) $8I_0$  (d) $2I_0$

13. When a ceiling fan is switched off, its angular velocity reduces to half its initial value after it completes 36 rotations. The number of rotations it will make further before coming to rest (assume angular retardation to be uniform) is
    (a) 10  (b) 20
    (c) 18  (d) 12

14. A solid cylinder rolls down an inclined plane of height 3 m and reaches the bottom of plane with angular velocity $2\sqrt{2}$ rad s$^{-1}$. The radius of cylinder must be [Take $g = 10$ m s$^{-2}$]
    (a) 5 cm  (b) 0.5 m
    (c) $\sqrt{10}$ cm  (d) $\sqrt{5}$ m

15. When a ceiling fan is switched on, it makes 10 revolutions in the first 3 seconds. Assuming a uniform angular acceleration, how many rotations it will make in the next 3 seconds?
    (a) 10  (b) 20
    (c) 30  (d) 40

16. A 2 kg mass is rotating on a circular path of radius 0.8 m with angular velocity of 44 rad/sec. If radius of the path becomes 1 m, then what will be the value of angular velocity?
    (a) 28.16 rad/sec  (b) 19.28 rad/sec
    (c) 8.12 rad/sec  (d) 35.26 rad/sec

17. A rigid horizontal smooth rod $AB$ of mass 0.75 kg and length 40 cm can rotate freely about a fixed vertical axis through its midpoint $O$. Two rings each of mass 1 kg initially at rest are placed at a distance of 10 cm from $O$ on either side of the rod.
132

The rod is set in rotation with an angular velocity of 30 radian per sec and when the rings reach the ends of the rod, the angular velocity in rad/sec is
(a) 5  (b) 10  (c) 15  (d) 20

18. A uniform disc of mass $M$ and radius $R$ is resting on a table on its rim. The coefficient of friction between disc and table is $\mu$. Now the disc is pulled with a force $F$ as shown in the figure. What is the maximum value of $F$ for which the disc rolls without slipping?

![Figure](image)

(a) $\mu Mg$  (b) $2\mu Mg$  (c) $3\mu Mg$  (d) $4\mu Mg$

19. From a circular disc of radius $R$ and mass $9M$, a small disc of radius $R/3$ is removed. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through $O$ is
(a) $4MR^2$  (b) $\frac{40}{9}MR^2$  (c) $10MR^2$  (d) $\frac{37}{9}MR^2$

20. A rotating body has angular momentum $L$. If its frequency and kinetic energy are halved, its angular momentum becomes
(a) $L$  (b) $\frac{L}{2}$  (c) $4L$  (d) $\frac{L}{4}$

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

![Figure](image)

(a) $2Mr^2$  (b) $3Mr^2$  (c) $4Mr^2$  (d) $5Mr^2$

22. The moment of inertia of a thin uniform rod of mass $M$ and length $l$ about an axis perpendicular to the rod through its centre is $I$. The moment of inertia of the rod through its end point is
(a) $\frac{I}{4}$  (b) $\frac{I}{2}$  (c) $2I$  (d) $4I$

23. An electric motor drill rated 350 W has an efficiency of 35%. The torque produced, if it is working at 3000 rpm is
(a) 0.25 N m  (b) 0.35 N m  (c) 0.39 N m  (d) 0.30 N m

24. A wheel of mass 5 kg and radius 0.40 m is rolling on a road without sliding with angular velocity 10 rad s$^{-1}$. The moment of inertia of the wheel about the axis of rotation is 0.65 kg m$^2$. The percentage of kinetic energy of rotation in the total kinetic energy of the wheel is
(a) 22.4 %  (b) 11.2 %  (c) 88.8 %  (d) 44.8 %

25. A uniform thin bar of mass $6m$ and length 12$L$ is bent to make a regular hexagon. Its moment of inertia about an axis passing through the centre of mass and perpendicular to the plane of hexagon is
(a) $20mL^2$  (b) $30mL^2$  (c) $\left(\frac{12}{5}\right)ml^2$  (d) $6ml^2$

26. If the angular velocity of a body increases by 20%, then its kinetic energy of rotation will increase by
(a) 20%  (b) 30%  (c) 44%  (d) 66%

27. A thin uniform rod of length $L$, area of cross section $A$ is rotating with uniform angular velocity $\omega$ about an axis passing through its centre and perpendicular to its length. If $\rho$ is the density of its material, then its rotational K.E. is given by
(a) $\frac{AL^3\rho \omega^2}{24}$  (b) $\frac{AL^3\rho \omega^2}{6}$  (c) $\frac{AL^2\rho \omega^2}{24}$  (d) $\frac{AL^2\rho ^2 \omega}{24}$

28. Two discs A and B are mounted coaxially on a vertical axle. The discs have moments of inertia $I$ and $2I$ respectively about the common axis. Disc A is imparted a initial angular velocity $2\omega$ using the entire potential energy of a spring compressed by a distance $x_1$. Disc B is imparted an angular velocity $\omega$ by a spring having the same spring constant and compressed by a distance $x_2$. Both the discs rotate in the clockwise direction. The ratio $\frac{x_1}{x_2}$ is
Rotational Motion

29. A wheel at rest is subjected to a uniform angular acceleration about its axis. In the first second of its motion, it describes an angle \( \theta_1 \). In the 2nd second of its motion, it describes an angle \( \theta_2 \). Then the ratio \( \frac{\theta_1}{\theta_2} \) is
(a) 1 : 2 (b) 1 : 3 (c) 1 : 4 (d) 2 : 5

30. A uniform disc of mass 500 kg and radius 2 metres is rotating at the rate of 600 rpm. What is the torque required to rotate the disc in the opposite direction with the same speed in a time of 100 seconds?
(a) 600 \( \pi \) N m (b) 500 \( \pi \) N m (c) 400 \( \pi \) N m (d) 300 \( \pi \) N m

31. A circular disc of radius \( R \) and thickness \( \frac{R}{6} \) has moment of inertia \( I \) about an axis passing through its centre and perpendicular to its plane. It is melted and recast into a solid sphere. What is the moment of inertia of the solid sphere about its diameter as the axis of rotation?
(a) \( \frac{I}{10} \) (b) \( \frac{2I}{8} \) (c) \( I \) (d) \( \frac{I}{5} \)

32. A uniform horizontal circular platform of mass 200 kg is rotating at 10 rpm about a vertical axis passing through its centre. A boy of mass 50 kg is standing on its edge. If the boy moves to the centre of the platform, the frequency of rotation would be
(a) 12.5 rpm (b) 7.5 rpm (c) 20 rpm (d) 15 rpm

33. A smooth uniform rod of length \( L \) and mass \( M \) has two identical beads of negligible size, each of mass \( m \), which can slide freely along the rod. Initially the two beads are at the centre of the rod and the system is rotating with an angular velocity \( \omega_0 \) about an axis perpendicular to the rod and passing through the midpoint of the rod as shown in the figure.

There are no external forces. What is the angular velocity of the system, when the beads reach the ends of the rod?

34. A stone of mass \( m \), tied to the end of a string, is whirled around in a horizontal circle. (Neglect the force due to gravity). The length of the string is reduced gradually, keeping the angular momentum of the stone about the centre of the circle constant. If the tension in the string is given by \( T = Ar^n \), where \( A \) is a constant, \( r \) is the instantaneous radius of the circle, then the value of \( n \) is
(a) –2 (b) –1 (c) 1 (d) –3

35. If the earth suddenly contracts to one third of its present size without any change in its mass, the ratio of the kinetic energies of the earth after and before contraction will be
(a) 9 (b) 8 (c) 7 (d) 3

36. A wheel of a bicycle is rolling without slipping on a levelled road. The velocity of the centre of mass is \( v_{cm} \).

Which one is the true statement?

37. A solid sphere is rolling on a frictionless surface as shown in the figure, with a translational velocity of \( v \) m s\(^{-1}\). If it is to climb the inclined surface, then \( v \) should be

(a) \( 2gh \) (b) \( \frac{10}{7} gh \) (c) \( \sqrt{2gh} \) (d) \( \sqrt[7]{10} gh \)
38. A solid cylinder of mass $M$ and radius $R$ rolls down a smooth inclined plane of height $h$ without slipping. What is the speed of its centre of mass when it reaches the bottom?

(a) $\sqrt{2gh}$  
(b) $\sqrt{4gh/3}$

(c) $\sqrt{3gh/4}$  
(d) $\sqrt{4g/h}$

39. A thin uniform rod of mass $m$ and length $L$ is hinged at its lower end to a level floor and stands vertically. It is now allowed to fall. Then its upper end will strike the floor with a velocity $v$ given by

(a) $mgL$  
(b) $2g l$

(c) $3gL$  
(d) $5gL$

40. A solid sphere, resting at the top of a smooth inclined plane of inclination $30^\circ$ with the horizontal, rolls down the plane and reaches the bottom, which is $15.75$ m from the top. How much time it will take to reach the bottom?

(a) $2$ s  
(b) $2.5$ s

(c) $3$ s  
(d) $4$ s

41. Two spheres of unequal masses but of the same radii are released from the top of a smooth inclined plane. They roll down the plane without slipping. Which one will reach the bottom first?

(a) Both will reach the bottom at the same time. 
(b) Heavier sphere. 
(c) Lighter sphere. 
(d) None of the above.

42. A solid cylinder rolls down a smooth inclined plane of height $3$ m and reaches the bottom of the inclined plane with angular velocity of $2\sqrt{2}$ rad/s. What must be the radius of cylinder? (Take $g = 10$ m/s$^2$)

(a) $\sqrt{5}$ m  
(b) $\sqrt{10}$ cm

(c) $10$ cm  
(d) $0.5$ cm

43. A solid cylinder rolls up a smooth 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 $5$ m/s. How far will the cylinder go up the plane? (Take $g = 10$ m/s$^2$)

(a) $\frac{10}{3}$ m  
(b) $\frac{3}{10}$ m

(c) $\frac{4}{13}$ m  
(d) $\frac{15}{4}$ m

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

(a) $\frac{g \sin \theta}{1 + \frac{MR^2}{I}}$  
(b) $\frac{g \sin \theta}{1 - \frac{MR^2}{I}}$

(c) $\frac{g \sin \theta}{1 - \frac{MR^2}{I}}$  
(d) $\frac{g \sin \theta}{1 + \frac{MR^2}{I}}$

45. In a CO molecule, the distance between C (mass = 12 a.m.u.) and O (mass = 16 a.m.u.), where 1 a.m.u. = $\frac{5}{3} \times 10^{-27}$ kg is close to

(Given : $I_{CO} = 1.87 \times 10^{-46}$ kg m$^2$)

(a) $2.4 \times 10^{-10}$ m  
(b) $1.9 \times 10^{-10}$ m

(c) $1.3 \times 10^{-10}$ m  
(d) $4.4 \times 10^{-11}$ m

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

(a) $\vec{v}_C - \vec{v}_A = 2(\vec{v}_B - \vec{v}_C)$

(b) $\vec{v}_C - \vec{v}_B = \vec{v}_B - \vec{v}_A$

(c) $|\vec{v}_C - \vec{v}_A| = |\vec{v}_B - \vec{v}_C|$

(d) $|\vec{v}_C - \vec{v}_A| = 4 |\vec{v}_B|$

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

(a) Both cylinders $P$ and $Q$ reach the ground at the same time.

(b) Cylinder $P$ has larger linear acceleration than cylinder $Q$.

(c) Both cylinders reach the ground with same translational kinetic energy.

(d) Cylinder $Q$ reaches the ground with larger angular speed.

48. A circular plate of uniform thickness has a diameter of 56 cm. A circular plate of diameter 42 cm is removed from one end of the plate as shown in the figure. What is the distance of the centre of mass of the remaining portion from the centre of the original plate?
49. A solid sphere, a disc and a solid cylinder all of the same mass and made of the same material are allowed to roll down (from rest) from the top of an inclined plane, then
(a) disc will reach the bottom first
(b) solid sphere reaches the bottom first
(c) solid sphere reaches the bottom last
(d) all reach the bottom at the same time.

50. A rotating wheel changes angular speed from 1800 rpm to 3000 rpm in 20 s. What is the angular acceleration assuming to be uniform?
(a) 60 \, \text{rad} \, \text{s}^{-2}
(b) 90 \, \text{rad} \, \text{s}^{-2}
(c) 2 \, \text{rad} \, \text{s}^{-2}
(d) 40 \, \text{rad} \, \text{s}^{-2}

51. The ratio of the accelerations for a solid sphere (mass \(m\) and radius \(R\)) rolling down an incline of angle \(\theta\) without slipping and slipping down the incline without rolling is
(a) 5 : 7
(b) 2 : 3
(c) 2 : 5
(d) 7 : 5

52. A solid uniform sphere resting on a rough horizontal plane is given a horizontal impulse directed through its centre, so that it starts sliding with an initial velocity \(v_0\). When it finally starts rolling without slipping the speed of its centre is
(a) \(\frac{2}{7} v_0\)
(b) \(\frac{3}{7} v_0\)
(c) \(\frac{5}{7} v_0\)
(d) \(\frac{6}{7} v_0\)

53. A pulley fixed to the ceiling carries a string with blocks of masses \(m\) and \(3m\) attached to its ends. The masses of string and pulley are negligible. When the system is released, the acceleration of centre of mass will be
(a) zero
(b) \(-\frac{g}{4}\)
(c) \(\frac{g}{2}\)
(d) \(-\frac{g}{2}\)

54. A pulley of radius 2 m is rotating about its axis by a force \(F = (20t - 5t^2)\) N (where, \(t\) is measured in second) applied tangentially. If the moment of inertia of the pulley about its axis of rotation is 10 kg m², the number of rotations made by the pulley before its direction of motion is reversed, is
(a) more than 3 but less than 6
(b) more than 6 but less than 9
(c) more than 9
(d) less than 3.

55. As disc like reel with massless thread unrolls itself while falling vertically downwards. The acceleration of its fall is
(a) \(g\)
(b) \(\frac{g}{2}\)
(c) zero
(d) \(\frac{2}{3} g\)

56. From a solid sphere of mass \(M\) and radius \(R\), a cube of maximum possible volume is cut. Moment of inertia of cube about an axis passing through its centre and perpendicular to one of its faces is
(a) \(\frac{MR^2}{32\sqrt{2}\pi}\)
(b) \(\frac{MR^2}{16\sqrt{2}\pi}\)
(c) \(\frac{4MR^2}{9\sqrt{3}\pi}\)
(d) \(\frac{4MR^2}{3\sqrt{3}\pi}\)

57. Moment of inertia of a thin uniform rod rotating about the perpendicular axis passing through its centre is \(I\). If the same rod is bent into a ring and its moment of inertia about its diameter is \(I'\), then the ratio \(\frac{I}{I'}\) is
(a) \(\frac{2}{3} \pi^2\)
(b) \(\frac{3}{2} \pi^2\)
(c) \(\frac{5}{3} \pi^2\)
(d) \(\frac{8}{3} \pi^2\)

58. A circular portion of diameter \(R\) is cut out from a uniform circular disc of mass \(M\) and radius \(R\) as shown in the figure. The moment of inertia of the remaining (shaded) portion of the disc about an axis passing through the centre \(O\) of the disc and perpendicular to its plane is

![Cut out circular portion](image)

(a) \(\frac{15}{32} MR^2\)
(b) \(\frac{7}{16} MR^2\)
(c) \(\frac{13}{32} MR^2\)
(d) \(\frac{3}{8} MR^2\)

59. Suppose a body of mass \(M\) and radius \(R\) is allowed to roll on an inclined plane without slipping from its topmost point \(A\). The velocity acquired by the body as it reaches the bottom of the inclined plane is given by

\[
\text{Assume, } \left(1 + \frac{K^2}{R^2}\right) = \beta
\]
60. Two identical masses are connected to a horizontal thin (massless) rod as shown in the figure. When their distances from the pivot is \(D\), a torque \(\tau\) produces an angular acceleration of \(\alpha_1\). The masses are now repositioned so that they are \(2D\) from the pivot. The same torque produces an angular acceleration \(\alpha_2\) which is given by
\[
\frac{\alpha_2}{\alpha_1} = \frac{4}{1}
\]
(a) \(\alpha_2 = 4\alpha_1\)  
(b) \(\alpha_2 = \alpha_1\)  
(c) \(\alpha_2 = \frac{1}{2}\alpha_1\)  
(d) \(\alpha_2 = \frac{1}{4}\alpha_1\)

61. Two discs of moments of inertia \(I_1\) and \(I_2\) about their respective axes, rotating with angular frequencies \(\omega_1\) and \(\omega_2\) respectively, are brought into contact face to face with their axes of rotation coincident. The angular frequency of the composite disc will be
\[
\frac{I_1\omega_1 + I_2\omega_2}{I_1 + I_2} = \frac{I_1\omega_1 - I_2\omega_2}{I_1 - I_2}
\]
(a) \(\frac{I_1\omega_1 - I_2\omega_2}{I_1 + I_2}\)  
(b) \(\frac{I_1\omega_1 + I_2\omega_2}{I_1 + I_2}\)  
(c) \(\frac{I_2\omega_1 + I_1\omega_2}{I_1 + I_2}\)  
(d) \(\frac{I_2\omega_1 - I_1\omega_2}{I_1 - I_2}\)

62. A wheel is rotating freely at an angular speed of 800 rev/min on a shaft whose rotational inertia is negligible. A second wheel initially at rest with twice the rotational inertia of the first is suddenly coupled to the same shaft. The fraction of original kinetic energy lost is
\[
\frac{2}{3}
\]
(a) \(\frac{2}{3}\)  
(b) \(\frac{1}{3}\)  
(c) \(\frac{1}{4}\)  
(d) \(\frac{1}{2}\)

63. A disc rotates horizontally at the rate of 100 rpm. Moment of inertia of the disc about the axis of rotation is 1 kg m\(^2\). A lump of molten wax weighing 50 gm drops gently at the distance of 20 cm from the axis of rotation of the disc and remains stuck to it. Then increase in moment of inertia of the system is
\[
2\% \quad 0.2\% \quad 0.02\% \quad 20\%
\]
(a) 2%  
(b) 0.2%  
(c) 0.02%  
(d) 20%

64. A ring and a disc of different masses are rotating with the same kinetic energy. If we apply a retarding torque \(\tau\) on the ring and it stops after making \(n\) revolutions, then in how many revolutions will the disc stop under the same retarding torque?
\[
\frac{I_2}{I_1} = \frac{11}{5}
\]
(a) \(n\)  
(b) \(2n\)  
(c) \(4n\)  
(d) \(\frac{n}{2}\)

65. The moment of inertia of a hollow cylinder of mass \(M\), length \(2R\) and radius \(R\) about an axis passing through the centre of mass and perpendicular to the axis of the cylinder is \(I_1\) and about an axis passing through one end of the cylinder and perpendicular to the axis of cylinder is \(I_2\). Then,
\[
\frac{I_2}{I_1} = \frac{19}{12}
\]
(a) \(I_2 = I_1 + MR^2\)  
(b) \(\frac{I_1}{I_2} = \frac{11}{5}\)  
(c) \(\frac{I_2}{I_1} = \frac{19}{12}\)  
(d) \(I_1 - I_2 = MR^2\)

66. Moment of inertia of a rod is minimum, when the axis passes through
(a) its end  
(b) its centre  
(c) at a point midway between the end and centre  
(d) at a point \(\frac{1}{8}\) length from centre.

67. About which of the following axis is the M.I. of thin circular disc minimum?
(a) Through centre perpendicular to the surface.  
(b) Through centre parallel to the surface.  
(c) Tangential and perpendicular to surface.  
(d) Tangential and parallel to the surface.

68. Moment of inertia of disc about the tangent parallel to plane is \(I\). The moment of inertia of disc about tangent and perpendicular to its plane is
\[
\frac{3I}{4} \quad \frac{3I}{2} \quad \frac{5I}{6} \quad \frac{6I}{5}
\]
(a) \(\frac{3I}{4}\)  
(b) \(\frac{3I}{2}\)  
(c) \(\frac{5I}{6}\)  
(d) \(\frac{6I}{5}\)

69. The M.I. of a uniform disc about the diameter is \(I\). Its M.I. about an axis perpendicular to its plane and passing through a point on its rim is
\[
4I \quad 5I \quad 6I \quad I
\]
(a) \(4I\)  
(b) \(5I\)  
(c) \(6I\)  
(d) \(I\)
70. A rod PQ of mass M and length L is hinged at end P. The rod is kept horizontal by a massless string tied to point Q as shown in figure. When string is cut, the initial angular acceleration of the rod is
(a) \( \frac{3g}{2L} \) (b) \( \frac{g}{L} \)
(c) \( \frac{2g}{L} \) (d) \( \frac{2g}{3L} \)

71. A small mass attached to a string rotates on a frictionless table top as shown. If the tension on the string is increased by pulling the string causing the radius of the circular motion to decrease by a factor of 2, the kinetic energy of the mass will
(a) increase by a factor of 4 (b) decrease by a factor of 2
(c) remain constant (d) increase by a factor of 2.

72. A small object of uniform density rolls up a curved surface with an initial velocity v. It reaches up to a maximum height of \( \frac{3v^2}{4g} \) with respect to the initial position. The object is a
(a) ring (b) solid sphere
(c) hollow sphere (d) disc

73. A ring rolls along an inclined plane without slipping. What fraction of the total kinetic energy will be rotational?
(a) 1  (b) \( \frac{1}{2} \)
(c) \( \frac{1}{4} \)  (d) \( \frac{3}{4} \)

74. A disc of mass 2 kg and diameter 2 m is performing rotational motion. Find the work done, if the disc is rotating from 300 rpm to 600 rpm is
(a) 1479 J  (b) 14.79 J
(c) 147.9 J  (d) 1.479 J

75. A ring rolls along an inclined plane without slipping. What fraction of the total kinetic energy will be translational?
(a) 1  (b) \( \frac{1}{2} \)
(c) \( \frac{1}{4} \)  (d) \( \frac{3}{4} \)

76. The speed of a homogeneous hollow sphere after rolling down an inclined plane of vertical height h from rest without sliding is
(a) \( \sqrt{\frac{10}{7}gh} \) (b) \( \sqrt{\frac{16}{9}gh} \)
(c) \( \sqrt{\frac{6}{7}gh} \) (d) \( \sqrt{\frac{4}{9}gh} \)

77. The ratio of the accelerations for a hollow sphere (mass m and radius R) rolling down an incline of angle \( \theta \) without slipping and slipping down the incline without rolling is
(a) 5 : 7 (b) 2 : 3
(c) 3 : 5 (d) 7 : 5

78. Calculate the M.I. of a thin uniform ring about an axis tangent to the ring and in a plane of the ring, if its M.I. about an axis passing through the centre and perpendicular to plane is 4 kg m².
(a) 12 kg m²  (b) 3 kg m²
(c) 6 kg m²  (d) 9 kg m²

79. The moment of inertia of a uniform circular disc of mass M and radius R about any of its diameters is \( \frac{1}{4} MR^2 \). What is the moment of inertia of the disc about an axis passing through its centre and normal to the disc?
(a) \( MR^2 \)  (b) \( \frac{1}{2} MR^2 \)
(c) \( \frac{3}{2} MR^2 \)  (d) \( 2MR^2 \)

80. A rigid body is made of three identical thin rods, each of the length L fastened together in the form of the letter H. The moment of inertia of this body about an axis that runs along the length of one of the legs of H is
(a) \( \frac{ML^3}{3} \)  (b) \( \frac{4ML^2}{3} \)
(c) \( ML^2 \)  (d) \( 3ML^2 \)

81. The angular velocity of a body rotating about a given axis is doubled. Its kinetic energy
(a) is doubled  (b) is halved
(c) becomes four times  (d) becomes one-fourth
82. A solid sphere of mass 2 kg and radius 5 cm is rotating at the rate of 300 rpm. The torque required to stop it with 2π rad/s in 2 s is
(a) $-2.5 \times 10^4$ dyne cm  (b) $-2.5 \times 10^4$ dyne cm
(c) $-2.5 \times 10^5$ dyne cm  (d) $-2.5 \times 10^6$ dyne cm

83. The radius of gyration of a flywheel is $\left( \frac{3}{\pi} \right)$ m and its mass is 1 kg. The speed of the flywheel is changed from 20 r.p.m. to 60 r.p.m. The work required to be done is
(a) 16 J  (b) 20 J  (c) 24 J  (d) 32 J

84. Two identical cylinders are released from the top of two identical inclined planes. If one rolls without slipping and the other slips without rolling, then
(a) slipping cylinder reaches the bottom first with greater speed  (b) rolling cylinder reaches the bottom first with greater speed
(c) both reach the bottom simultaneously and with the same speed  (d) both reach the bottom simultaneously but with different speeds.

85. A ring of mass 0.3 kg and radius 0.1 m and a solid cylinder of mass 0.4 kg and of the same radius are given the same kinetic energy and released simultaneously on a flat horizontal surface. They begin to roll as soon as released towards a wall which is at the same distance from the ring and cylinder. Which will reach the wall first?
(a) Ring  (b) Cylinder  (c) Both ring and cylinder will reach simultaneously  (d) Data is insufficient

86. A dancer is standing on a stool rotating about the vertical axis passing through its centre. She pulls her arms towards the body reducing her moment of inertia by a factor of $n$. The new angular speed of turn table is proportional to
(a) $n^0$  (b) $n^1$  (c) $n^{-1}$  (d) $n^2$

87. A circular disc of moment of inertia $I_1$ is rotating in a horizontal plane about its symmetry axis with a constant angular speed of $\omega_1$. Another disc of moment of inertia $I_2$ is dropped coaxially onto the rotating disc. Initially, the second disc has zero angular speed. Eventually, both the discs rotate with a constant angular speed $\omega$. The energy lost by the initially rotating disc to friction is
(a) $\frac{1}{2} \frac{I_1 I_2}{I_1 + I_2} \omega_1^2$  (b) $\frac{1}{2} \frac{I_2^2}{I_1 + I_2} \omega_1^2$  (c) $\frac{1}{2} \frac{I_1^2}{I_1 + I_2} \omega_1^2$  (d) $\frac{I_b - I_i}{I_i} \omega_1^2$

88. Three thin rods, each of length 2 m and mass 3 kg are placed along $x$, $y$ and $z$ axes, such that one end of each rod is at the origin. The moment of inertia of this system about the $x$-axis is
(a) 2 kg m$^2$  (b) 4 kg m$^2$  (c) 6 kg m$^2$  (d) 8 kg m$^2$

89. A uniform square plate has a small piece $Q$ of an irregular shape removed and glued to the centre of the plate leaving a hole behind in figure. The moment of inertia of the square plate about the $z$-axis is then
(a) increased  (b) decreased  (c) the same  (d) changed in unpredicted manner

90. A metre scale of mass $M$ is standing vertically on a horizontal table on one of its ends. It now falls on the table without slipping. The velocity with which the free end of the metre scale strikes the table is
Given: $m/g = \begin{bmatrix} 2 & 2 \\ 3 & 10 \end{bmatrix}$
(a) $20 \text{ m/s}$  (b) $15 \text{ m/s}$  (c) $30 \text{ m/s}$  (d) $10 \text{ m/s}$

91. About which axis in the following figure the moment of inertia of the rectangular lamina is maximum?
(a) 1  (b) 2  (c) 3  (d) 4

92. O is the centre of an equilateral triangle $ABC$. $F_1$, $F_2$ and $F_3$ are three forces acting along the sides $AB$, $BC$ and $AC$ as shown in the figure. What should be the magnitude of $F_B$ so that the total torque about $O$ is zero?
Rotational Motion

(a) \((F_1 - F_2)\)  
(b) \((F_1 + F_2)\)  
(c) \(2 \left(F_1 + F_2\right)\)  
(d) \(\frac{F_1 + F_2}{2}\)

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

(a) \(\frac{ML\omega^2}{2}\)  
(b) \(\frac{ML^2\omega}{2}\)  
(c) \(ML\omega^2\)  
(d) \(\frac{ML^2\omega^2}{2}\)

94. A uniform rod \(AB\) of length \(l\) and mass \(m\) is free to rotate about point \(A\). The rod is released from rest in the horizontal position. Given that, the moment of inertia of the rod about \(A\) is \(\frac{ml^2}{3}\), the initial angular acceleration of the rod will be

(a) \(\frac{2g}{3l}\)  
(b) \(\frac{mg l}{2}\)  
(c) \(\frac{3}{2} gl\)  
(d) \(\frac{3g}{2l}\)

95. A thin wire of length \(l\) and mass \(m\) is bent in the form of a semicircle as shown in the figure. Its moment of inertia about an axis joining its free ends will be

(a) \(ml^2\)  
(b) \(zero\)  
(c) \(ml^2/\pi^2\)  
(d) \(ml^2/2\pi^2\)

96. The moment of inertia of a thin uniform rod of length \(L\) and mass \(M\) about an axis passing through a point at a distance of \(\frac{L}{3}\) from one of its ends and perpendicular to the rod is

(a) \(ML\omega^2\)  
(b) \(ML^2\omega\)  
(c) \(ML\omega^2\)  
(d) \(ML^2\omega^2\)

97. If the mass of the earth remains constant but the duration of the day reduces from 24 hours to 6 hours, then the relation between its new and original radii \((R_2 and R_1)\) is given by

(a) \(R_2 = 2R_1\)  
(b) \(R_2 = \frac{R_1}{2}\)  
(c) \(R_2 = \frac{R_1}{3}\)  
(d) \(R_2 = 3R_1\)

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

(a) \(L_A > L_B\)  
(b) \(L_A = L_B\)  
(c) the relationship between \(L_A\) and \(L_B\) depends upon the slope of the line \(AB\)  
(d) \(L_A < L_B\)

99. A particle of mass \(m = 5\) unit is moving with a uniform speed \(v = 3\sqrt{2}\) unit in the \(XOY\) plane along the line \(y = x + 4\). The magnitude of the angular momentum of the particle about the origin is

(a) 60 unit  
(b) 40\(\sqrt{2}\) unit  
(c) zero  
(d) 7.5 unit

100. A horizontal platform is rotating with a uniform angular velocity around a vertical axis passing through its centre. At a certain instant of time, a viscous fluid of mass \(m\) is dropped at the centre and is allowed to spread out and finally fall. The angular velocity during this period,

(a) decreases continuously  
(b) decreases initially and increases again  
(c) remains unaltered  
(d) increases continuously.
2015
1. A solid cylinder has mass ‘M’, radius ‘R’ and length ‘l’. Its moment of inertia about an axis passing through its centre and perpendicular to its own axis is
   (a) \( \frac{2MR^2}{3} + \frac{Ml^2}{12} \)  
   (b) \( \frac{MR^2}{3} + \frac{Ml^2}{12} \)  
   (c) \( \frac{3MR^2}{4} + \frac{Ml^2}{12} \)  
   (d) \( \frac{MR^2}{4} + \frac{Ml^2}{12} \)  

2. A cord is wound around the circumference of wheel of radius ‘r’. The axis of the wheel is horizontal and moment of inertia about it is ‘I’. The weight ‘mg’ is attached to the end of the cord and falls from rest. After falling through a distance ‘h’, the angular velocity of the wheel will be
   (a) \( \sqrt{\frac{2mgh}{I + 2mr^2}} \)  
   (b) \( \sqrt{\frac{mgh}{I + 2mr^2}} \)  
   (c) \( \sqrt{\frac{2mgh}{I + mr^2}} \)  
   (d) \( \sqrt{\frac{mgh}{I + mr^2}} \)  

3. A hollow sphere of mass ‘M’ and radius ‘R’ is rotating with angular frequency ‘\( \omega \)’. It suddenly stops rotating and 75% of kinetic energy is converted to heat. If ‘S’ is the specific heat of the material in J/kg K then rise in temperature of the sphere is (M.I. of hollow sphere = \( \frac{2}{3}MR^2 \))
   (a) \( \frac{R\omega^2}{4S} \)  
   (b) \( \frac{R^2\omega^2}{4S} \)  
   (c) \( \frac{R\omega^2}{2S} \)  
   (d) \( \frac{R^2\omega^2}{2S} \)  

4. An automobile moves on a road with a speed of 54 km h\(^{-1}\). The radius of its wheels is 0.45 m and the moment of inertia of the wheel about its axis of rotation is 3 kg m\(^2\). If the vehicle is brought to rest in 15 s, the magnitude of average torque transmitted by its brakes to the wheel is
   (a) 10.86 kg m\(^2\) s\(^{-2}\)  
   (b) 2.86 kg m\(^2\) s\(^{-2}\)  
   (c) 6.66 kg m\(^2\) s\(^{-2}\)  
   (d) 8.58 kg m\(^2\) s\(^{-2}\)  

5. A force \( \vec{F} = \alpha \hat{i} + 3\hat{j} + 6\hat{k} \) is acting at a point \( \vec{r} = 2\hat{i} - 6\hat{j} - 12\hat{k} \). The value of \( \alpha \) for which angular momentum about origin is conserved is
   (a) zero  
   (b) 1  
   (c) -1  
   (d) 2  

6. Distance of the centre of mass of a solid uniform cone from its vertex is \( z_0 \). If the radius of its base is \( R \) and its height is \( h \) then \( z_0 \) is equal to
   (a) \( \frac{5h}{8} \)  
   (b) \( \frac{3h^2}{8R} \)  
   (c) \( \frac{h^2}{4R} \)  
   (d) \( \frac{3h}{4} \)  

7. From a solid sphere of mass \( M \) and radius \( R \) a cube of maximum possible volume is cut. Moment of inertia of cube about an axis passing through its centre and perpendicular to one of its faces is
   (a) \( \frac{4MR^2}{9\sqrt{3}\pi} \)  
   (b) \( \frac{4MR^2}{3\sqrt{3}\pi} \)  
   (c) \( \frac{MR^2}{32\sqrt{2}\pi} \)  
   (d) \( \frac{MR^2}{16\sqrt{2}\pi} \)  

2014
8. An object of radius \( R \) and mass \( M \) is rolling horizontally without slipping with speed \( v \). It then rolls up the hill to a maximum height \( h = \frac{3v^2}{4g} \). The moment of inertia of the object is
Rotational Motion

(g = acceleration due to gravity)

9. The moment of inertia of a thin uniform rod rotating about the perpendicular axis passing through one end is \( I \). The same rod is bent into a ring and its moment of inertia about the diameter is \( I_1 \). The ratio \( \frac{I}{I_1} \) is

(a) \( \frac{4\pi}{3} \)  
(b) \( \frac{8\pi^2}{3} \)  
(c) \( \frac{5\pi}{3} \)  
(d) \( \frac{8\pi^2}{5} \)  

(MH-CET)

10. Three identical spheres each of mass 1 kg are placed touching one another with their centres in a straight line. Their centres are marked as \( A, B, C \) respectively. The distance of centre of mass of the system from \( A \) is

(a) \( \frac{AB + AC}{2} \)  
(b) \( \frac{AB + BC}{2} \)  
(c) \( \frac{AC - AB}{3} \)  
(d) \( \frac{AB + AC}{3} \)

(MH-CET)

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

(a) 25 N  
(b) 50 N  
(c) 78.5 N  
(d) 157 N

(AIPMT)

12. The ratio of the accelerations for a solid sphere (mass \( m \) and radius \( R \)) rolling down an incline of angle \( \theta \) without slipping and slipping down the incline without rolling is

(a) 5:7  
(b) 2:3  
(c) 2:5  
(d) 7:5

(AIPMT)

13. A bob of mass \( m \) attached to an inextensible string of length \( l \) is suspended from a vertical support. The bob rotates in a horizontal circle with an angular speed \( \omega \) rad s\(^{-1}\) about the vertical. About the point of suspension

(a) angular momentum changes both in direction and magnitude.  
(b) angular momentum is conserved.

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

(a) \( g \)  
(b) \( \frac{2g}{3} \)  
(c) \( \frac{g}{2} \)  
(d) \( \frac{5g}{6} \)

(JEE Main)

2013

15. A rod \( PQ \) of mass \( M \) and length \( L \) is hinged at end \( P \). The rod is kept horizontal by a massless string tied to point \( Q \) as shown in figure. When string is cut, the initial angular acceleration of the rod is

(a) \( \frac{2g}{L} \)  
(b) \( \frac{2g}{2L} \)  
(c) \( \frac{3g}{2L} \)  
(d) \( \frac{g}{L} \)

(NEET)

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

(a) hollow sphere  
(b) disc  
(c) ring  
(d) solid sphere

(NEET)

17. A hoop of radius \( r \) and mass \( m \) rotating with an angular velocity \( \omega_0 \) is placed on a rough horizontal surface. The initial velocity of the centre of the hoop is zero. What will be the velocity of the centre of the hoop when it ceases to slip?
18. Moment of inertia of a solid sphere about its diameter is \( I \). If that sphere is recast into 8 identical small spheres, then moment of inertia of such small sphere about its diameter will be
(a) \( \frac{I}{8} \) (b) \( \frac{I}{16} \) (c) \( \frac{I}{24} \) (d) \( \frac{I}{32} \)  
(MH-CET)

19. Two uniform circular discs \( A \) and \( B \) of radii \( R \) and \( 4R \) with thickness \( x \) and \( x/4 \) respectively, rotates about their axis passing through its centre and perpendicular to its plane. If M.I. of first disc is \( I_A \) and second disc is \( I_B \), then
(a) \( I_A = I_B \) (b) \( I_A > I_B \) (c) \( I_A < I_B \) (d) data is insufficient  
(MH-CET)

20. When a mass is rotating in a plane about a fixed point, its angular momentum is directed along
(a) a line perpendicular to the plane of rotation
(b) the line making an angle of 45° to the plane of rotation
(c) the radius
(d) the tangent to the orbit  
(AIPMT)

21. Two persons of masses 55 kg and 65 kg respectively, are at the opposite ends of a boat. The length of the boat is 3.0 m and weighs 100 kg. The 55 kg man walks up to the 65 kg man and sits with him. If the boat is in still water the center of mass of the system shifts by
(a) 3.0 m (b) 2.3 m (c) zero (d) 0.75 m  
(AIPMT)

22. \( \triangle ABC \) is an equilateral triangle with \( O \) as its centre. \( \overrightarrow{F_1}, \overrightarrow{F_2} \) and \( \overrightarrow{F_3} \) represent three forces acting along the sides \( AB, BC \) and \( AC \) respectively. If the total torque about \( O \) is zero then the magnitude of \( \overrightarrow{F_3} \) is
(a) \( F_1 + F_2 \) (b) \( F_1 - F_2 \) (c) \( \frac{F_1 + F_2}{2} \) (d) \( 2(F_1 + F_2) \)  
(AIPMT)

23. A circular platform is mounted on a frictionless vertical axle. Its radius \( R = 2 \text{ m} \) and its moment of inertia about the axle is \( 200 \text{ kg m}^2 \). It is initially at rest. A 50 kg man stands on the edge of the platform and begins to walk along the edge at the speed of 1 \( \text{ms}^{-1} \) relative to the ground. Time taken by the man to complete one revolution is
(a) \( \pi \text{ s} \) (b) \( \frac{3\pi}{2} \text{ s} \) (c) \( 2\pi \text{ s} \) (d) \( \frac{\pi}{2} \text{ s} \)  
(AIPMT Mains)

24. The moment of inertia of a uniform circular disc is maximum about an axis perpendicular to the disc and passing through
(a) \( B \) (b) \( C \) (c) \( D \) (d) \( A \)  
(AIPMT Mains)

25. Three masses are placed on the x-axis : 300 g at origin, 500 g at \( x = 40 \text{ cm} \) and 400 g at \( x = 70 \text{ cm} \). The distance of the centre of mass from the origin is
(a) 40 cm (b) 45 cm (c) 50 cm (d) 30 cm  
(AIPMT Mains)

26. About which of the following axes moment of inertia of a disc is minimum?
(a) Axis passing through its centre and perpendicular to its plane.
(b) Axis along the diameter.
(c) Axis along the tangent and in its own plane.
(d)Axis along the tangent and perpendicular to its plane.  
(MH-CET)

27. The instantaneous angular position of a point on a rotating wheel is given by the equation \( \theta(t) = 2t^3 - 6t^2 \)
The torque on the wheel becomes zero at
(a) \( t = 1 \text{ s} \) (b) \( t = 0.5 \text{ s} \) (c) \( t = 0.25 \text{ s} \) (d) \( t = 2 \text{ s} \)  
(AIPMT)

28. The moment of inertia of a thin uniform rod of mass \( M \) and length \( L \) about an axis passing through its midpoint and perpendicular to its length is \( I_0 \). Its moment of inertia about an axis passing through one of its ends and perpendicular to its length is
Rotational Motion

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

(a) decrease by a factor of 2
(b) remain constant
(c) increase by a factor of 2
(d) increase by a factor of 4

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

(a) remains unchanged
(b) continuously decreases

31. A mass $m$ hangs with the help of a string wrapped around a pulley on a frictionless bearing. The pulley has mass $m$ and radius $R$. Assuming pulley to be a perfect uniform circular disc, the acceleration of the mass $m$, if the string does not slip on the pulley, is

(a) \( \frac{3}{2}g \)
(b) \( g \)
(c) \( \frac{2}{3}g \)
(d) \( \frac{g}{3} \)

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

(a) less than 3
(b) more than 3 but less than 6
(c) more than 6 but less than 9
(d) more than 9
MTG Presents the BEST BOOK to Excel in
MHT-CET
STRICTLY BASED ON MAHARASHTRA 12TH HSC BOARD

22000+ CHAPTERWISE-TOPICWISE MCQs

The wait is over!!! The most reliable and updated source for MHT-CET entrance exam is now available. An excellent blend of accuracy with authenticity, these books focus on all the basic needs of a student to efficiently prepare for the exam. With comprehensive theory, exhaustive practice and actual MCQs, these books are the best self scorer guides for every MHT-CET aspirant. So no more waiting, go grab your copy today and ensure your seat in MHT-CET.

HIGHLIGHTS
- Strictly based on Maharashtra 12th HSC Board syllabus
- Synopsis of chapters complemented with illustrations & concept maps
- Simple and lucid language
- MCQs divided in three levels: Level-I (Topicwise easy and medium level questions) and Level-II (questions of higher standard) from entire chapters to make the students better equipped
- 22000+ Chapterwise-Topicwise MCQs framed from each line of the Maharashtra syllabus with detailed explanations
- Previous years' (2015-2011) MCQs of MH-CET, AIPMT and JEE Main* (Level-III)
- Three Model Test Papers for the final practice

*In Physics, Chemistry and Mathematics only

Visit www.mtg.in for latest offers and to buy online!

Available at all leading book shops throughout the country.
For more information or for help in placing your order:
Call 0124-6601200 or e-mail: info@mtg.in
**Hints & Explanations**

**LEVEL-1**

1. (b) : \( I = MK^2 = 4 \times \frac{4}{10} \times \frac{4}{10} = 0.64 \text{ kg m}^2 \)

2. (d) : Moment of inertia, \( I = \sum m_i r_i^2 \)

3. (a) : The M.I. of the system about an axis passing through the centre \( O \) of the metre scale is

\[
I = m_1 r_1^2 + m_2 r_2^2 \\
\therefore I = 0.5 \times 0.4 \times 0.4 + 0.6 \times 0.3 \times 0.3 \\
= \frac{80}{1000} + \frac{54}{1000} = 0.134 \text{ kg m}^2
\]

4. (b) : \( I = \sum m_i r_i^2 \)
M.I. is maximum for the axis \( BC \) because the masses are situated at very large distances.

5. (d) : Perpendicular distance of \( m_2 \) and \( m_3 \) from the altitude \( = \frac{L}{2} \)

\[
I = m_1 \times (0)^2 + m_2 \times \left( \frac{L}{2} \right)^2 + m_3 \left( \frac{L}{2} \right)^2 \\
= (m_2 + m_3) \left( \frac{L}{2} \right)^2
\]

6. (d) : Along \( EG \), the M.I. will be minimum. The maximum distance from the axis is the least.

7. (d) : In the given triangular plate, \( BC \) is the shortest side. The M.I. of the triangular plate is maximum about \( BC \) as the axis, because the particles of the plate are distributed at maximum distances from \( BC \). From the figure, we find that \( I_{BC} > I_{AB} > I_{AC} \) or \( I_{BC} > I_{AC} \)

8. (d) : Distance of corner mass from opposite side,

\[
r = \sqrt{\left( \frac{l}{2} \right)^2 - \left( \frac{r}{2} \right)^2} = \frac{\sqrt{3}}{2} l \\
\therefore I = m r^2 = \frac{3}{4} m l^2
\]

9. (b) : \( I = m_1 r_1^2 + m_2 r_2^2 = \frac{200}{1000} \left( \frac{30}{100} \right)^2 + \frac{300}{1000} \left( \frac{20}{100} \right)^2 \\
\therefore I = 0.036 \text{ kg m}^2
\]

10. (c) : Required moment of inertia, \( I = m_1 r_1^2 + m_2 r_2^2 = 2(0.3)^2 + 1(0.3)^2 = 0.27 \text{ kg m}^2 \)

11. (c) : Location of centre of mass does not depend upon choice of reference frame.

12. (c)

13. (d) : Moment of inertia of a given body is \( I = MR^2 \). Thus, M.I. of a body depends on position of the axis of rotation and hence is not constant.

14. (b) : As axis of rotation changes, distribution of mass about the axis of rotation is changed. \( I = MR^2 \Rightarrow I \) will change.

15. (a)

16. (d)

17. (b)

18. (d) 19. (a)

20. (b) : As the mass of disc is negligible, therefore only moment of inertia of five particles will be considered.
\( I = \sum m_i r_i^2 = 5 \times 2 \times (0.1)^2 = 0.1 \text{ kg m}^2 \)

21. (b) : \( \omega = \frac{2\pi}{T} = \frac{2\pi}{60} = \frac{\pi}{30} \text{ rad s}^{-1} \)

22. (c) : As the body is rigid therefore angular velocity of all particles will be same
\( i.e., \omega = \text{constant} \).
\( \text{From } v = r \omega, \) \( v \propto r (\text{if } \omega = \text{constant}) \).
It means linear velocity of that particle will be more, whose distance from the centre is more.
\( i.e., v_A < v_B < v_C \) but \( \omega_A = \omega_B = \omega_C \).

23. (a) : \( E = \frac{1}{2} I \left( \omega^2 - \omega_1^2 \right) = \frac{1}{2} I A \pi^2 \left( n_2^2 - n_1^2 \right) \)
\( \therefore 1936 = \frac{1}{2} \times I \times \frac{22}{7} \times \frac{22}{7} \times (36 - 16) \times 4 \)
\( \therefore 49 = 10I \) \( \therefore I = 4.9 \text{ kg m}^2 \)

24. (b) : \( K_r = \frac{1}{2} I \omega^2 = \frac{1}{2} I (\alpha t)^2 = \frac{1}{2} I \alpha^2 t^2 \)
1500 = \frac{1}{2} \times 1.2 \times (25)^2 \times 2

or \quad t^2 = 4 \quad \text{or} \quad t = 2 \text{ s}

25. (a) : \quad E = \frac{1}{2} I \omega^2

\therefore \quad I = \frac{2E}{\omega^2} = \frac{2 \times 225}{30 \times 30} = \frac{1}{2} = 0.5 \text{ kg m}^2

26. (d) : \quad \text{K.E. of rotation} = \frac{1}{2} I \omega^2

I = \frac{2}{5} MR^2; \quad \omega = \frac{600 \times 2\pi}{60} = 20\pi \text{ rad/s}

\text{K.E. of rotation} = \frac{1}{2} \times \frac{2}{5} MR^2 \times (20\pi)^2 = 80\pi^2 MR^2

27. (b) : \quad \text{Given: kinetic energy} K = 360 \text{ J}

\text{Angular speed} \quad \omega = 20 \text{ rad/s}

\therefore \quad K = \frac{1}{2} I \omega^2 \quad \text{where} \quad I = \text{moment of inertia}

or \quad I = \frac{2K}{\omega^2} = \frac{2 \times 360}{20 \times 20} = 1.8 \text{ kg m}^2

28. (b) : \quad \text{Kinetic energy of flywheel,} \quad K = \frac{1}{2} I \omega^2

= \frac{1}{2} \times \frac{1}{4} m r^2 \omega^2 = \frac{1}{4} m r^2 \omega^2

= \frac{1}{4} \times 72 \left( \frac{50}{100} \right)^2 \left( \frac{2\pi \times 70}{60} \right)^2 = 242 \text{ J}

29. (c) : \quad \text{K.E.} = \frac{1}{2} I \omega^2 = \frac{1}{2} MK^2 \times 4\pi^2 n^2

= 2 \times 4 \times 10^{-2} \times 10 \times 16 = 12.8 \text{ J}

30. (c) : \quad \text{Rotational K.E.} = \frac{1}{2} I \omega^2 = \frac{1}{2} MK^2 \times 4\pi^2 n^2

= 2\pi^2 n^2 \times MK^2 = 2 \times 10 \times 25 \times 10 \times \frac{1}{4} = 1250 \text{ J}

31. (d) : \quad \text{K.E.} = \frac{1}{2} \omega^2 = \frac{1}{2} \text{ (Translational)}

\frac{1}{2} I \omega^2 = \frac{1}{2} m v^2 \therefore 3 \times 4 = 12 v^2 \therefore \quad v = 1 \text{ m/s}

32. (c) : \quad E = \frac{1}{2} I \omega^2

\therefore \quad 360 = \frac{1}{2} \times (30)^2 \therefore \quad I = \frac{720}{900} = 0.8 \text{ kg m}^2

33. (c) : \quad \text{K.E.} = \frac{1}{2} I \omega^2 = \frac{1}{2} \left( \frac{1}{2} MR^2 \right) \omega^2

= \frac{1}{2} \times \frac{1}{2} \times 2 \times 0.1 \times 0.1 \times 2 \times 2 = 0.02 \text{ J}

34. (c) : \quad \text{K.E. of the rotating body} = \frac{1}{2} I \omega^2

\text{K.E. of the body having translational motion} = \frac{1}{2} m v^2

\therefore \quad \frac{1}{2} I \omega^2 = \frac{1}{2} m v^2 \therefore \quad \frac{1}{2} \times 5 \times 36 = \frac{1}{2} \times 5 \times v^2

\therefore \quad v^2 = 36 \therefore \quad v = 6 \text{ m/s}

35. (a) : \quad \text{The rotational K.E. of a body} (K) = \frac{1}{2} I \omega^2

\text{If} \quad \omega = 1 \text{ rad/s}, \quad \text{then} \quad K = \frac{1}{2} I \therefore \quad I = 2K

36. (c) : \quad \text{Rotational K.E.} = \frac{1}{2} I \omega^2

= \frac{1}{2} \left( \frac{1}{2} m r^2 \right) \omega^2 = \frac{1}{4} m v^2

\text{But it is given that rotational K.E.} = 4 \text{ J}

\therefore \quad 4 = \frac{1}{4} \times 2 \times \omega^2 \quad \Rightarrow \quad \omega^2 = 8, \quad \therefore \quad \omega = 2\sqrt{2} \text{ m/s}

37. (a) : \quad \frac{1}{2} I \omega^2 = \frac{1}{2} m v^2

\therefore \quad 3 \times 9 = 27 \times v^2 \quad \therefore \quad \omega = 1 \text{ m/s}

38. (a) : \quad \text{Rotational K.E.} = \frac{1}{2} I \omega^2 = \frac{1}{2} \times \frac{MR^2}{2} \times \frac{v^2}{R^2}

= \frac{1}{4} m v^2 = \frac{1}{4} \times 2 \times 10^{-2} = 5 \times 10^{-3} \text{ J}

39. (d) : \quad \text{K.E.} = \frac{1}{2} I \omega^2 = \frac{1}{2} \left( \frac{2\pi}{T} \right)^2 = \frac{2\pi^2}{T^2}

\Rightarrow \quad \text{K.E.} \propto T^{-2}

40. (b) : \quad E = \frac{1}{2} I \omega^2

\therefore \quad \omega = \sqrt{\frac{2E}{I}} = \sqrt{\frac{2 \times 9}{2}} = 3 \text{ rad/s}

41. (b) : \quad \frac{1}{2} I \omega^2 = 750 \text{ J} \Rightarrow \quad \omega^2 = \frac{750 \times 2}{2.4} = 625

\Rightarrow \quad \omega = 25 \text{ rad s}^{-1}

\alpha = \frac{\omega_2 - \omega_1}{t} \Rightarrow \quad 5 = \frac{25 - 0}{t} \Rightarrow t = 5 \text{ s}

42. (d) : \quad \text{In case (I), the moment of the force} F \text{ at} A \text{ and force} F \text{ at} B \text{ about} C \text{ are equal in magnitude} (LF), \text{ but they are oppositely directed.}

\therefore \quad \text{The net moment is zero and the rod is in rotational equilibrium.}

\text{But in case (II), the moment of} \quad F \text{ and} \quad F \text{ have the same magnitude} (LF), \text{ but both of them have the anticlockwise sense. They produce a couple or torque.}

\therefore \quad \text{The rod is not in rotational equilibrium.}
Complete chapter available in