03. Rotational Motion

3.0 Introduction

Rigid body:

It is a system of particles in which distance between any two particles does not change under the influence of external forces. The size and shape of the body will remain unaffected under the effect of external forces.

Ex.: Practical rigid bodies are stone, wood, steel, etc. However rubber, sponge are examples of non rigid body.

1. No body in the universe is perfectly rigid. However, the bodies in which strain effects are quite negligible under the influence of external forces are called as rigid bodies.
   Ex.: Earth, billiard ball etc.
2. Internal structure of a rigid body and its shape and size do not change in its state of motion.
3. A perfect rigid body is one for which the value of elastic constants (like Y, K, η) is infinity.
4. All the particles in a rigid body perform circular motion when it is in rotational motion.
5. Angular speed of all particles in a rigid body is same when it is rotating about a given axis.
6. The motion of a rigid body is studied by using the concept of centre of mass.

Rotatory motion :

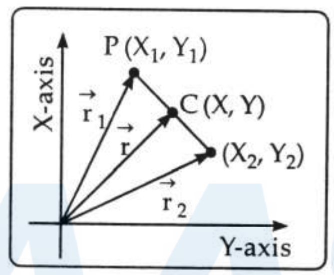
A body is said to be in rotational motion, when it moves in a circular path about a fixed point within the body or about an axis passing through the body.

1. Every particle of the body describes circular path and they move along concentric circles about the axis of rotation.
2. In this type of motion, angular velocity of all the particles is same but their linear velocities are different (since $v \propto r$).
3. Angular displacement of all the particles is same.
4. Angular acceleration of all the particles is same but their linear accelerations are different.
5. Translatory motion is progressive motion but rotatory motion is not.
6. When a particle describes circular path, the line joining the centre of the circle and the position of that particle at any instant is called radius vector or position vector.

Centre of mass of a rigid body :

It is a point at which the whole mass of the body is supposed to be concentrated in order to study the motion of the body.

1. Posi ti on vector of centre of mass of a system consisting of n particles is given by



$$\vec{r} = \frac{\sum_{i=1}^{n} m_i r_i}{\sum_{i=1}^{n} m_i}$$

2. The co-ordinates of the centre of mass may, therefore, be written as

$$x_{cm} = \frac{m_1x_1 + m_2x_2 + ...m_nx_n}{m_1 + m_2 + ...m_n}$$

$$y_{cm} = \frac{m_1y_1 + m_2y_2 + ...m_ny_n}{m_1 + m_2 + ...m_n}$$

$$z_{cm} = \frac{m_1z_1 + m_2z_2 + ...m_nz_n}{m_1 + m_2 + ...m_n}$$

3. As a centre of mass of a body is a point at which the whole mass of the body is suppose to be concentrated, therefore, sum of moments of masses of all the particles of the body, about the centre of mass is zero.

i.e. $\sum_{i=1}^{i=n} m_i \vec{r}_i = 0$, for two particle system, we have

$$m_1\vec{r}_1 + m_2\vec{r}_2 = 0$$

$$\therefore \quad \vec{r}_2 = \frac{-m_1\vec{r}_1}{m_2}$$

The magnitude of $r_2 = \left(\frac{m_1}{m_1+m_2}\right)r$

and $\vec{r}_1 = \frac{-m_2\vec{r}_2}{m_1}$

The magnitude of $r_1 = \left(\frac{m_2}{m_1+m_2}\right)r$

4. When no external force acts on a body, its centre of mass will remain either at rest or move with a constant velocity.

When $\vec{F}_{ext} = 0$

$$ma = 0 \qquad \therefore \quad m\frac{dv}{dt} = 0 \text{ as } m \neq 0$$

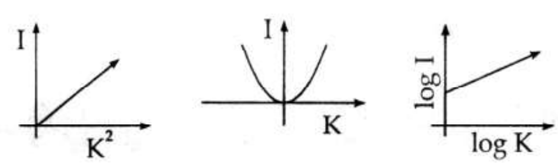
$$\therefore \quad \frac{dv}{dt} = 0 \text{ as} \qquad \therefore \quad v = \text{constant}$$

5. Any symmetrical bodies with uniform distribution of mass, centre of mass coincides with the geometrical centre of the body. For a plane triangular lamina, centre of mass is the centroid of the lamina i.e. point of intersection of the medians of the triangle.
6. Position of centre of mass is independent of the frame of reference. It depends only on masses of the particles and their relative positions.
7. Centre of mass is an imaginary point.
8. The position of centre of mass remains stable for the rotatory motion.
9. Centre of mass displaces with the linear motion.
10. Centre of mass depends upon distribution of mass in the body.

3.1 Moment of inertia

The moment of inertia of a rotating rigid body about given axis of rotation is sum of the products of mass of each particle and square of its distance from the axis of rotation.

1. The property of a body by virtue of which it opposes any change in its state of rest or of uniform rotation. It is also known as rotational inertia.
2. Moment of jnertia is a tensor quantity.
3. If the distribution of mass in the body is discrete, then $I = \sum_{i=1}^{n} m_i r_i^2$.
4. If the distribution of mass in the body is continuous, then, $I = \int r^2 dm$
5. The value of 'I' depends upon
   i) mass of particles,
   ii) their distance from the axis of rotation and
   iii) position of the axis of rotation.
6. The distribution of mass means the size, shape and density of the body.
7. The moment of inertia of the particles, through which the axis of rotation passes is zero.
8. Moment of inertia plays the same role in rotatory motion as mass plays in linear motion.
9. Greater the moment of inertia of the body, higher will be the torque required to change its state of rotation.
10. For the same mass and radius of a spherical body the moment of inertia of hollow spherical body is more than solid spherical body.
11. The M.L is affected with the variation in temperature.
12. $I = MR^2 = MK^2$
13. Graph of I and K^2 is straight line passing through origin.
14. Graph of I and K will be parabola.
15. The graph of log I and log K is a straight line shown in figure.



16. For a rigid body moment of inertia about the axis passing through its centre of gravity will be least.
17. We can distinguish a raw egg and hard boiled egg by spinning each one on a surface. The hard boil egg comes to rest earlier.
18. If the two particles of masses mt and m2 are

separated by a distance 'r', moment of inertia of the system about an axis passing though the centre of mass of that system and perpendicular to the line joining them is,

$$I = \left(\frac{m_1 m_2}{m_1 + m_2}\right) r^2.$$

19. Oil engines are provided with a fly wheel which has larger moment of inertia.
20. Moment of inertia of a body is not unique. Same body can have different moments of inertia about different axes.
21. Moment of inertia of a body is independent of angular velocity.
22. A and B are spheres of two different material having the same mass. Moment of inertia about the diameter will be more for sphere made of less denser material.
23. A wooden sphere and iron sphere have the same moments of inertia about their diameters. Then size of the wooden sphere is more.
24. A cycle wheel is fitted with spokes to increase moment of inertia.
25. The small change in radius of a rotating rigid body causes, the change in moment of inertia is,

$$\frac{dI}{I} = 2\frac{dR}{R}$$

3.2 Radius of gyration

1. The radius of gyration of a body about a given axis is the distance (K) between axis of rotation and a point, where whole mass of the body is to be concentrated, so that the point possesses the same moment of inertia, as that of the body. (It is not equal to the distance of the centre of mass.)
2. Radius of gyration (K) has no meaning without the axis of rotation.
3. It is a scalar quantity measured in metre.
4. The value of K depends on position and orientation of the axis of rotation and also on distribution of mass of the body and not on its mass. Radius of gyration is $I = MK^2$ $\quad \therefore \quad K = \sqrt{I/M}$
5. The radius of gyration of a body is not a constant quantity. Its value changes with change of position of its axis of rotation.
6. Radius of gyration is the root mean square distance of the particles from the axis of rotation.

$$K = \sqrt{\frac{r_1^2 + r_2^2 + r_3^2 + \ldots\ldots + r_n^2}{n}}$$

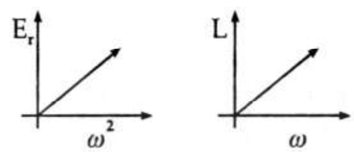
3.3 Kinetic energy of rotation

1. The kinetic energy is the energy possessed by the body by virtue of its rotational motion. It is given by

$$E_r = \frac{1}{2} I\omega^2$$

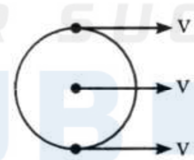
$$= \frac{L^2}{2I} = \frac{L\omega}{2} = \frac{MK^2\omega^2}{2} = \frac{mv^2}{2} \times \frac{K^2}{R^2}$$

2. For constant I, $E_r \propto \omega^2$.
The graph between E_r and ω^2 shown in figure.



From $L = I\omega$, when I is constant $L \propto \omega$. Therefore graph between L and ω will be straight line passing through origin.

3. Kinetic energy is a scalar quantity and measured in joule.
4. When a body is executing only linear motion, as shown in figure. Its K.E. is given by



$$E_t = \frac{1}{2} m v^2$$

5. When a body is rolling without slipping. Its centre of mass has linear motion too.
6. Total kinetic energy is sum of translational K.E. and rotational K.E.

$$E = E_t + E_r = \frac{1}{2} m v^2 + \frac{1}{2} I\omega^2$$

$$= \frac{1}{2} m v^2 + \frac{1}{2} m(K^2)\frac{v^2}{R^2}$$

$$E = \frac{1}{2} m v^2 \left(1 + \frac{K^2}{R^2}\right)$$

From $I = mK^2$, where m is constant, therefore $I \propto K^2$.

7. When the angular speed of all the particles of the rolling body is same, it is called rolling without slipping.
8. Linear speed of centre of mass is $v = R\omega$ where R is the radius of the body.
9. Kinetic energy is same for all bodies having same m, R and ω.
10. Rotational kinetic energy is maximum for ring and minimum for solid sphere of same mass.
11. Total energy is maximum for ring and minimum for solid sphere of same mass.
12. For a ring, kinetic energy of rotation is equal to kinetic energy of translation. Since K = R.
13. For a disc the kinetic energy of rotational motion is 50% of the kinetic energy of translational motion.

$$\text{Since, } \frac{mR^2}{2} = mK^2$$

$$\therefore \quad K = \frac{R}{\sqrt{2}} = 0.707\,R.$$

14. For a shell kinetic energy of rotational motion is 66.66% of the kinetic energy of translational motion.

Since, shell is a hollow sphere.

$$\therefore \quad \frac{2}{3} m\,R^2 = mK^2$$

$$\therefore \quad K^2 = 66.66\%\ R^2$$

15. For the solid sphere kinetic energy of rotational motion is 40% of kinetic energy of translational motion.

$$\text{Since, } \frac{2}{5} mR^2 = mK^2$$

$$\therefore \quad K^2 = 0.4\ R^2$$

16. Moment of inertia of a rigid body numerically equal to twice the kinetic energy of rotation if the body is rotating with a unit angular velocity i.e. $\omega = 1$ rad/s.

Combined translation and rotation :

1. If a rigid body performing translatory motion with certain velocity and rotates about any axis passing through its centre of mass with certain angular velocity, then the body possesses both translational and rotational kinetic energies e.g. rolling motion.
2. Motion of a Rolling body on a horizontal surface.

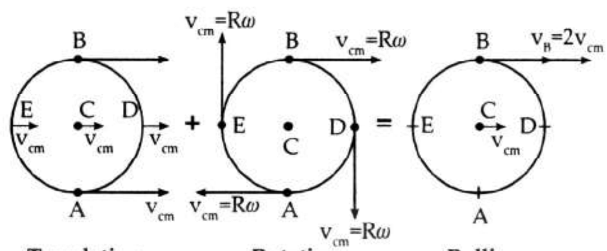
i) Condition for pure rolling

$X_{cm} = R\theta$

$v_{cm} = R\omega$

where X_{cm} is displacement of center of mass V_{cm} is velocity of center of mass.

ii) Rolling is the combination of translation and rotation. At any instant, linear speeds of different particles are different as given,



Translation Rotation Rolling

If A is the point of contact with the horizontal surface, B is the top most point of the rigid body, C is its centre of mass,

linear velocity of B is $v_T = v_{cm} + R\omega = 2v_{cm}$

linear velocity of A is $v_i = v_{cm} - R\omega = 0$

linear velocity of C is $V_C = v_{cm} + 0 = v_{cm}$

Similarly for the points D or E

$$v_D \text{ or } v_E = \sqrt{2}\, v_{cm}$$

Rolling motion can be treated as pure rotation about an axis passing through point of contact perpendicular to the plane of rotation and with the same angular velocity ω.

3. Kinetic energy of rotating body or rotational K.E is

$$\frac{1}{2} I\omega^2 = 2\pi \quad In^2 = \frac{2\pi I}{T^2}$$

4. Work done $W = \vec{\tau} \cdot \vec{\theta}$

Power $P = \vec{\tau} \cdot \vec{\omega}$

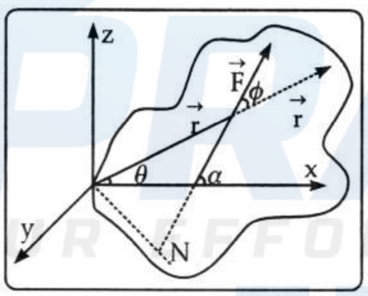
5. If I is moment of inertia of a rigid body, L is angular momentum and E is rotational kinetic energy, then $E = L^2/2I$

Comparison among various rolling bodies:

Body	Total K.E.	$\frac{KE_{trans}}{KE_{rot}}$	Frac. of KE_{trans}	% of KE_{trans}	Frac. of KE_{rot}	% of KE_{rot}	$\frac{K^2}{R^2}$
Ring and Hollow cylinder	mv^2	1 : 1	1/2	50%	1/2	50%	1
Disc and solid cylinder	$\frac{3}{4}mv^2$	2 : 1	2/3	66.67%	1/3	33.33%	$\frac{1}{2}$
Hollow sphere	$\frac{5}{6}mv^2$	3 : 2	3/5	60%	2/5	40%	$\frac{2}{3}$
Solid sphere	$\frac{7}{10}mv^2$	5 : 2	5/7	71.43%	2/7	28.57%	$\frac{2}{5}$

3.4 Torque of moment of force

The turning effect of the force acting on the body is known as torque. The general expression for torque is, $\vec{\tau} = \vec{r} \times \vec{F}$

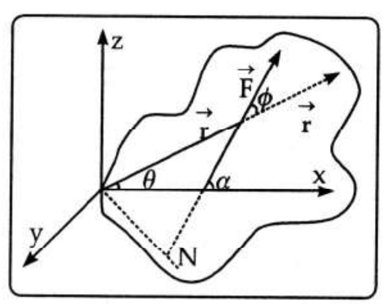


The direction of torque is given by right handed screw rule. It is perpendicular to the plane containing $\vec{r}$ and $\vec{F}$.

1. If ϕ is the angle between $\vec{r}$ and $\vec{F}$ then the magnitude of torque is, $\tau = r F \sin \phi = F \times d$, where $d = r \sin \phi$ is perpendicular distance of line of action of $\vec{F}$ from fixed point about which turning effects is produced.
2. When $\phi = 0°$ or $180°$, $r = r F \sin 0$ or $r F \sin 180 = 0$. There is no turning effect of force when force acts along $\vec{r}$ or opposite to $\vec{r}$. Therefore, the moment of force about the point on the line of action of force is equal to zero.
3. When $\phi = 90°$, $r = r F \sin 90 = r F$ = maximum.
4. To produce a turning effect, force required (F) is smaller when r is larger.
   i) Note that radial component of force makes no contribution to the torque.
   ii) Only the transverse component of force contributes to the torque.
5. Work done by a torque. in turning the body through a small angle d θ is, $dW = \tau d\theta$.
6. Power of the torque $P = \tau\left(\frac{d\theta}{dt}\right) = \tau . \omega$
7. Torque is a pseudo vector directed along the axis of rotation.
8. SI and CGS units of torque are Nm and dyne cm.
9. Torque's unit vector is called joule, J = 1 Nm. Its dimensional formula is $[L^2 M^1 T^{-2}]$.
10. If the particle of mass m is moving along a circular path of radius r with angular acceleration α (for non uniform circular motion) then torque on the particle is $\tau = I\alpha = m r^2 \alpha$.
11. The torque produced in the anticlockwise sense is taken as positive and torque in the clockwise sense is taken as negative.
12. Torque is measured as the product of moment of inertia and angular acceleration i.e . $\tau = I\alpha$.
13. Torque produces only rotational motion of the body.
14. In rotational motion, torque plays the same role as force plays in translational motion.

3.5 Angular momentum (Moment of momentum) and its conservation

1. The angular momentum of a particle about a given axis is the moment of linear momentum of the particle about that axis.
2. It is equal to the product of linear momentum of the particle and the perpendicular distance of the line of action of linear momentum from the axis of rotation.



3. For a particle rotating in x-y plane about z-axis, expression for angular momentum is, in terms of polar co-ordinates,

$\vec{L} = \vec{r} \times \vec{P} = r\,P \sin\phi = m\,r\,v \sin\phi = P \times d$,

where $d = r \sin\phi$ = perpendicular distance of line of action of $\vec{p}$ from the axis.

4. Angular momentum is a vector quantity, whose direction is given by right handed screw rule. $\vec{L}$ is perpendicular to $\vec{r}$ and $\vec{L}$ is perpendicular to $\vec{P}$.

5. Rate of change of angular momentum is torque i.e. $\tau = dL/dt$.

6. Torque, angular momentum of a body depends only on the transverse component of linear momentum and not on the radial component.

7. As $\vec{\tau} = \frac{d\vec{L}}{dt} = 0 \quad \therefore \quad L = \text{Constant}$

8. The angular momentum of rigid body rotating about a given axis may be written as $L = I\omega = mr^2\omega$. Torque acting on a rigid body rotating about a given axis with uniform angular acceleration a may be written as $\tau = I\alpha$.

As $\alpha = \frac{d\omega}{dt}$

$\therefore \quad \tau = I\frac{d\omega}{dt} = \frac{d}{dt}(I\omega) = \frac{dL}{dt}$

9. According to the law of conservation of angular momentum, when sum of external torques acting on a system is zero, then the total angular momentum of the system remains constant, when $\tau = 0$, $L = I\omega$ = constant

10. If I increases, ω decreases and vice-versa. For example, angular speed of a planet around the sun-increases, when it is closer to the sun.

11. The speed of rotation of a person standing on a rotating platform with his arms outstretched increases suddenly, when he folds his hands.

12. The change in angular momentum is known as angular impulse.

Conservation of angular momentum :

1. When no external torque acts, then angular momentum of the rotation system remains conserved.

2. When there is no external torque acting on a rigid body,

$L = I\omega$ = constant

$I_1\omega_1 = I_2\omega_2$

or $I_1n_1 = I_2n_2$ or $\frac{I_1}{T_1} = \frac{I_2}{T_2}$

3. If two rigid bodies with angular velocities ω_1 and ω_2 are coupled and ω is the final angular velocity of the arrangement,

$(I_1\omega_1 + I_2\omega_2) = (I_1 + I_2)\,\omega$ or $(I_1 n_1 + I_2n_1) = (I_1 + I_2)\,n$

4. If the -earth suddenly contracts, its moment of inertia decreases and angular velocity increases. As a result duration of the day would decrease.

5. If radius of the earth shrinks to (l/n)th of the present radius without change in its mass, duration of the new day is $(24/n^2)$ hours.

6. If the radius of the earth shrinks to (l/n)th of the present radius without any change in the mean density, duration of the new day is $(24/n^5)$ hours.

7. If radius of the earth 'R' shrinks at the rate of $\left(\frac{dR}{dt}\right)$ with time, variation of the new period of rotation is $\frac{dT}{dt} = 2\frac{T}{R}\left(\frac{dR}{dt}\right)$ (if mass of the earth is constant), $\frac{dT}{dt} = 5\frac{T}{R}\left(\frac{dR}{dt}\right)$ (if mean density of the earth is constant).

3.6 Principle of perpendicular and parallel axis

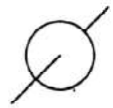
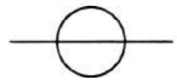
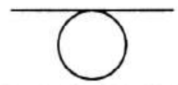
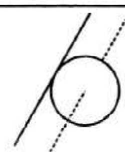
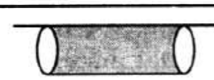
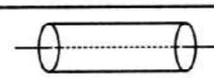
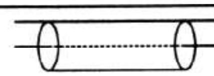
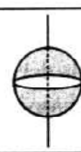
1. **Perpendicular axis:** The moment of inertia of a rotating rigid body about the given axis of rotation is equal to sum of its moment of inertia about two mutually perpendicular axes, intersecting at a point where perpendicular axis cuts the lamina.

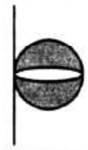
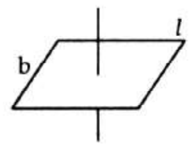
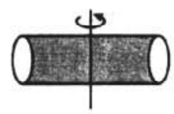
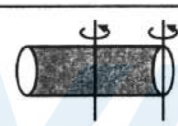
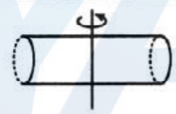
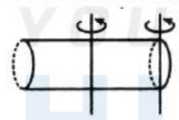
Thus, $I_z = I_x + I_y$

2. **Principle of parallel axis:** The moment of inertia of rotating rigid body about any axis is equal to sum of its moment of inertia about an axis passing through its centre and product of mass and square of the distance from the axis of rotation.

Thus, $I_o = I_c + M\,h^2$.

3.7 Applications of principles of moment of inertia of a thin uniform rod, ring, disc, solid cylinder and solid sphere

Sr. No.	Body	Axis	Figure	Moment of inertia	K^2/R^2
1.	Circular ring	Passing through the cetnre and perpendicular to the plane		MR^2	1
2.	Circular ring	Diameter		$\frac{MR^2}{2}$	$\frac{1}{2}$
3.	Circular ring	Tangent in a plane or axis parallel to the diameter		$\frac{3}{2}MR^2$	$\frac{3}{2}$
4.	Circular ring	Tangent to the plane or axis perpendicular to the plane		$2\,MR^2$	2
5.	Circular disc	Passing through the centre and perpendicular to the plane		$\frac{MR^2}{2}$	$\frac{1}{2}$
6.	Circular disc	Diameter		$\frac{MR^2}{4}$	$\frac{1}{4}$
7.	Circular disc	Tangent and parallel to the diameter		$\frac{5}{4}MR^2$	$\frac{5}{4}$
8.	Circular disc	Tangent and perpendicular to the plane		$\frac{3}{2}MR^2$	$\frac{3}{2}$
9.	Solid cylinder	Axis of cylinder		$\frac{MR^2}{2}$	$\frac{1}{2}$
10.	Solid cylinder	Tangent		$\frac{3}{2}MR^2$	$\frac{3}{2}$
11.	Hollow cylinder	Axis of cylinder		MR^2	1
12.	Hollow cylinder	Tangent		$2\,MR^2$	2
13.	Solid sphere	Diameter / Centre		$\frac{2}{5}MR^2$	$\frac{2}{5}$

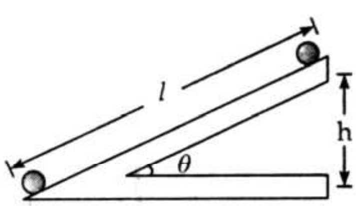
Sr. No.	Body	Axis	Figure	Moment of inertia	K^2/R^2
14.	Solid sphere	Tangent to the sphere / in a sphere		$\frac{7}{5}MR^2$	$\frac{7}{5}$
15.	Long thin rod of length l	Passing through the centre and perpendicular to the length.		$M\frac{l^2}{12}$	---
16.	Long thin rod of length l	Through the edge and perpendicular to the length		$\frac{Ml^2}{3}$	---
17.	Rectangular lamina of length l and breadth b	Passing through the CM and perpendicular to the plane		$\frac{M}{12}(l^2+b^2)$	---
18.	Solid cylinder	Passing through its centre ⊥ to l		$M\left[\frac{l^2}{12}+\frac{R^2}{4}\right]$	---
19.	Solid cylinder	Passing through one end solid cylinder		$M\left[\frac{l^2}{3}+\frac{R^2}{4}\right]$	---
20.	Hollow cylinder	Passing through its centre ⊥ to l		$M\left[\frac{l^2}{12}+\frac{R^2}{2}\right]$	---
21.	Hollow cylinder	Passing through one end solid cylinder		$M\left[\frac{l^2}{3}+\frac{R^2}{2}\right]$	---

Body rolling down on an inclined plane:

When the body of mass 'm' is on the top of inclined plane, its potential energy is mgh. When it starts rolling without slipping its potential energy is converted into rolling kinetic energy.

P.E. = $K.E._{rolling}$

$$mgh = \frac{1}{2}mv^2\left(1+\frac{K^2}{R^2}\right)$$



From the above formula, we get velocity, acceleration and displacement as given in the following table.

Body sliding down on an inclined plane:

When the body of mass 'm' is on the top of inclined plane, its potential energy is mgh. When it starts sliding without slipping its potential energy is converted into sliding kinetic energy.

P.E. = K.E.

$$mgh = \frac{1}{2}mv^2$$

From the above formula, we get velocity, acceleration and displacement as given in the following table.

- **Body rolling down an inclined plane:**

  Sliding and Rolling down an inclined plane of length l, height h, inclination θ so that $h = l \sin\theta$ is

Sliding

1. $m g h = \frac{1}{2}mv^2$
2. Velocity at the bottom $v = \sqrt{2gh}$
3. Acc. of body down the plane is
   $a = g \sin\theta$
4. Time taken in reaching the bottom is
   $t = \sqrt{\frac{2l}{g\sin\theta}}$

Rolling

1. $m g h = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$
2. Velocity at the bottom is $v = \sqrt{\frac{2gh}{1+K^2/R^2}}$
3. Acc. of body down the plane is
   $a = \frac{g\sin\theta}{(1+K^2/R^2)}$
4. Time taken in reaching the bottom is
   $t = \sqrt{\frac{2l(1+K^2/R^2)}{g\sin\theta}}$

- **Analogy between translatory motion and rotatory motion:**

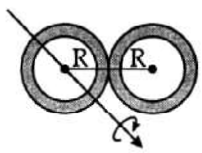
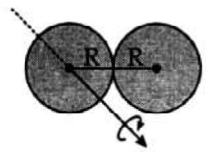
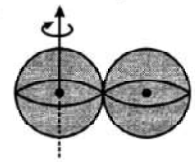
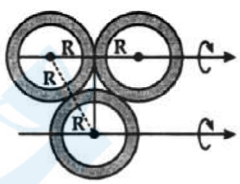
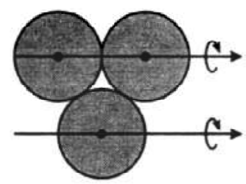
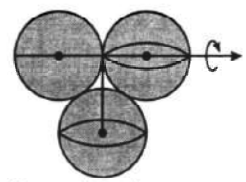
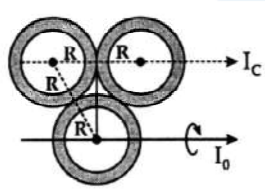
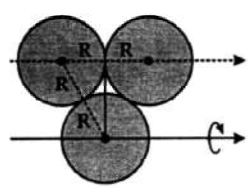
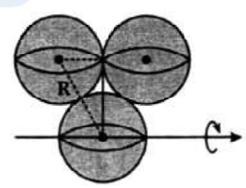
Translatory motion

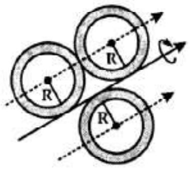
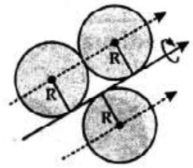
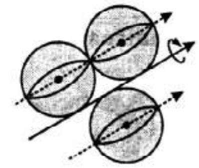
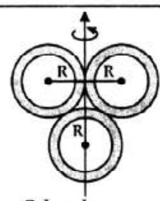
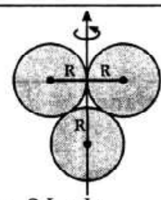
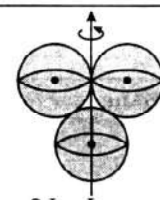
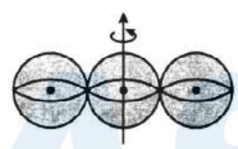
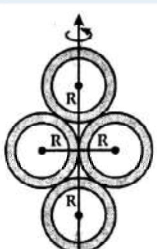
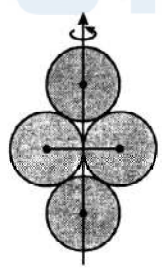
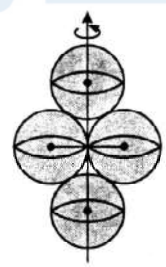
1. Displacement $\vec{r}$
2. Time (t)
3. Mass (m)
4. Linear velocity $\vec{v} = \frac{d\vec{r}}{dt}$
5. Linear acceleration $\vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2}$
6. Linear momentum $\vec{p} = m\vec{v}$
7. Linear impulse $= \vec{F}(\Delta t) = \Delta\vec{P}$
8. Force $\vec{F} = m\vec{a}$
9. Work $W = \vec{F}.\vec{r}$
10. K.E. of translation $E_t = \frac{1}{2}mv^2$
11. Power $P = \vec{F}.\vec{v}$
12. Equations of linear motion:
    i) $v = u + at$
    ii) $S = ut + \frac{1}{2}at^2$
    iii) $v^2 - u^2 = 2as$
    iv) $S_n th = u + \frac{a}{2}(2n-1)$

Rotatory motion

1. Angular displacement $\vec{\theta}$
2. Time (t)
3. Moment of inertia (I)
4. Angular velocity $\vec{\omega} = \frac{d\vec{\theta}}{dt}$
5. Angular acceleration $\vec{a} = \frac{d\vec{\omega}}{dt} = \frac{d^2\vec{\theta}}{dt^2}$
6. Angular momentum $\vec{L} = I\vec{\omega}$
7. Angular impulse $= \vec{\tau}(\Delta t) = \Delta\vec{L}$
8. Torque $\vec{\tau} = I\vec{\alpha}$
9. Work $W = \vec{\tau}.\vec{\theta}$
10. K.E. of rotation $E_r = \frac{1}{2}I\omega^2$
11. Power $= \vec{\tau}.\vec{\omega}$
12. Equations of rotational motion :
    i) $\omega_2 = \omega_1 + \alpha t$
    ii) $\theta = \omega_1 t + \frac{1}{2}\alpha t^2$
    iii) $\omega_2^2 - \omega_1^2 = 2\alpha\theta$
    iv) $\theta_n th = \omega_1 + \frac{\alpha}{2}(2n-1)$

MOMENT OF INERTIA ABOUT DIFFERENT AXIS OF ROTATION

	RINGS	DISCS	SOLID SPHERES
1.	Perpendicualr to plane  $I = I_G + I_1$ $= 2MR^2 + M(2R)^2$ $I = 6\,MR^2$	Perpendicualr to plane  $I = I_G + I_1$ $= 2\dfrac{MR^2}{2} + M(2R)^2$ $I = 5\,MR^2$	Perpendicualr to plane  $I = I_G + I_1$ $= \left(\dfrac{2}{5}MR^2 + \dfrac{2}{5}MR^2\right) + M(2R)^2$ $I = \dfrac{24}{5}MR^2$
2.	Same plane  $I = I_G + I_1$ $I = 3\dfrac{MR^2}{2} + M(\sqrt{3}R)^2$ $\because\ r = \sqrt{(2R)^2 - R^2} = \sqrt{3}R$ $\therefore\ I = \dfrac{9MR^2}{2}$	Same plane  $I = I_G + I_1$ $I_1 = \dfrac{MR^2}{4}$ $I = \dfrac{MR^2}{4} + M(\sqrt{3}R)^2$ $I = \dfrac{15}{4}MR^2$	Same plane  $I = I_G + I_1$ $I_1 = 2\dfrac{2}{5}MR^2$ $I = 2\dfrac{2}{5}MR^2 + M(\sqrt{3}R)^2$ $I = \dfrac{21}{5}MR^2$
3.	Same plane  $I = I_G + Mh^2$ $I = 3 \times I_d + Mh^2$ $= 3 \times \dfrac{MR^2}{2} + 3R^2 \times 2M$ $I = \dfrac{15}{2}MR^2$	Same plane  $I = I_G + Mh^2$ $I = 3\dfrac{MR^2}{4} + 2M(\sqrt{3}R)^2$ $I = \dfrac{27}{4}MR^2$	Same plane  $I = I_G + Mh^2$ $I = 3\dfrac{2}{5}MR^2 + 2M(\sqrt{3}R)^2$ $I = \dfrac{36}{5}MR^2$

	RINGS	DISCS	SOLID SPHERES
4.	 $I = \frac{3}{2} MR^2 \times 3$ $= \frac{9}{2} MR^2$	 $I = \frac{5}{4} MR^2 \times 3$ $\therefore I = \frac{15}{4} MR^2$	 $I = \frac{7}{5} MR^2 \times 3$ $\therefore I = \frac{21}{5} MR^2$
5.	 $I = 2 I_t + I_d$ $I = \frac{3}{2} MR^2 \times 2 + \frac{MR^2}{2}$ $\therefore I = \frac{7}{2} MR^2$	 $I = 2 I_t + I_d$ $I = 2 \times \frac{5}{4} MR^2 + \frac{MR^2}{4}$ $\therefore I = \frac{11}{4} MR^2$	 $I = 2 I_t + I_d$ $I = \frac{7}{5} MR^2 \times 2 + \frac{2}{5} MR^2$ $\therefore I = \frac{16}{5} MR^2$
6.	 $I = I_G + Mh^2$ $I = \frac{3}{2} MR^2 + 2M \times (2R)^2$ $\therefore I = \frac{19}{2} MR^2$	 $I = I_G + Mh^2$ $I = \frac{MR^2}{4} 3 + 2 \times M (2R)^2$ $\therefore I = \frac{35}{4} MR^2$	 $I = I_G + Mh^2$ $I = \frac{2}{5} MR^2 \times 3 + 2M \times (2R)^2$ $\therefore I = \frac{46}{5} MR^2$
7.	**Same plane**  $I = 2 I_d + 2 I_t$ $I = \frac{MR^2}{2} 2 + \frac{3}{2} MR^2 \times 2$ $\therefore I = 4 MR^2$	**Same plane**  $I = 2 I_d + 2 I_t$ $I = \frac{MR^2}{4} \times 2 + \frac{5}{4} MR^2 \times 2$ $\therefore I = 3 MR^2$	**Same plane**  $I = 2 I_d + 2 I_t$ $I = \frac{2}{5} MR^2 \times 2 + \frac{7}{5} MR^2 \times 2$ $\therefore I = \frac{18}{5} MR^2$

MULTIPLE CHOICE QUESTIONS

3.0 Centre of mass of a rigid body and rotational motion

1. The centre of mass of system of particles does not depend upon
   a) masses of the particles
   b) position of the particles
   c) forces on the particles
   d) relative distance between the particles
2. Rotational motion can be
   a) one or two dimensional
   b) one or three dimensional
   c) two or three dimensional
   d) one dimensional
3. A body is set into rotational motion due to
   a) a force acting at a point on the body
   b) equal and opposite forces acting at two different points on the same body
   c) equal forces acting at two different points on the body
   d) a force acting at the centre of the body
4. The centre of mass of a symmetrical and uniform distribution of mass of a rigid body is
   a) at the centre of the surface
   b) outside the body
   c) inside the body
   d) at the geometric centre of the body
5. The motion of centre of mass depends upon the total
   a) external forces b) internal forces
   c) sum of 'a' and 'b' d) none of these
6. The point at which total mass of a body is suppose to be concentrated is known as
   a) deep centre b) centre of gravity
   c) centre of mass d) geometric centre
7. In case of bodies of regular shapes, the centre of gravity coincides with the centre of
   a) mass b) equilibrium
   c) geometric centre d) both 'a' and 'c'
8. Three identical metal balls, each of radius 'r' are placed touching to each other on a horizontal surface such that an equilateral triangle is formed when centres of three balls are joined. The centre of mass of the system is located at
   a) The horizontal surface
   b) The line joining centres of any two balls
   c) The centre of one of the balls
   d) The point of intersection of the medians
9. If the resultant of all external forces is zero, then velocity of centre of mass will be
   a) zero b) infinite
   c) constant d) either 'a' or 'c'
10. A couple produces purely
    a) linear motion
    b) rotational motion
    c) translational motion
    d) oscillatory motion
11. A body is said to be rigid, if the distance between any two position of the particle
    a) changes with force
    b) remains constant with the force
    c) changes with the force initially and maximum force changes laterally
    d) erratical changes with force
12. The sum of moments of masses of all the particles in a system about the centre of mass is always
    a) zero b) maximum
    c) infinite d) minimum
13. A point at which the whole mass of the body is supposed to be concentrated in order to study the motion of an external force in accordance with Newton's laws of motion is
    a) centre of gravity
    b) weight of the body
    c) centre of mass of a body
    d) acceleration due to gravity acts on a body
14. A body performs rotational motion about the given axis, particles perform V.C.M. with same angular velocity. The particles at different positions have
    a) same velocity
    b) constant velocity
    c) different velocity
    d) nothing can be said about velocity
15. The centre of mass of a body lies
    a) on its surface b) inside the body
    c) outside the body d) 'b' and' c'
16. Two particles of masses 5 gm and 10 gm are 12 cm apart. What will be the location of the centre of mass of the system of these two particles from the lighter particle is ?
    a) 8 cm b) 6 cm

c) 4 cm d) 9 cm

17. Particles of masses 3 kg, 4 kg, 5 kg and 2 kg are placed at points A (3, 2), B(–2, 2), C (–2, –3) and D (1, –2) respectively of a co–ordinate system. The centre of mass of the system is at

a) $\left(-\frac{1}{2},-\frac{1}{2}\right)$ b) $\left(-\frac{1}{2},-\frac{5}{14}\right)$

c) $\left(0,-\frac{1}{2}\right)$ d) (0,0)

18. A system consists of 3 particles each of mass 'm' are located at (1, 1) (2, 2) and (3, 3). The co–ordinates of the centre of mass are

a) (6, 6) b) (2, 2)
c) (3, 3) d) (1, 1)

19. Two hydrogen atoms are located at the distances r_1 and r_2 from origin. Their centre of mass is at

a) $(r_1 - r_2) / 2$ b) $r_1 - r_2$
c) $(r_1 + r_2) / 2$ d) $r_1 + r_2$

20. A body rolling on a horizontal plane is an example of

a) rotational motion
b) oscillatory motion
c) translation motion
d) rotational and translational motion

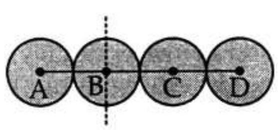
21. The rotational motion of a body can be produced due to applying

a) torque b) momentum
c) inertia d) force

22. Analogue of a force in a rotational motion, is

a) weight b) torque
c) angular momentum d) moment of inertia

23. Four identical bodies each of mass 1 kg are placed touching to each other with their centres on a straight line. If their centres are marked A, B, C and D respectively, then the distance of centre of mass of the system from B will be



a) $\frac{AB + BC + BC + CD}{4}$ b) $\frac{AB + BC + BD}{4}$

c) $AB + \frac{AC}{4} + AD$ d) $\frac{AB + BC + CD}{4}$

3.1 Moment of inertia and its physical significance

24. Dimensions of moment of inertia are

a) $[L^2M^2T^{-1}]$ b) $[L^2M\,T^0]$
c) $[L\,M\,T^{-1}]$ d) $[L^2\,M\,T^{-2}]$

25. If the moment of inertia of a rigid body is numerically equal to its mass, radius of gyration is

a) equal to its radius b) equal to diameter
c) equal to one unit d) infinite

26. Moment of inertia in rotatory motion is comparable to the quantity in translatory motion

a) momentum b) mass
c) weight d) velocity

27. A r ing and a disc have same mass and same radius. Then ratio of moment of inertia of ring to the moment of inertia of disc is

a) 4 b) 2
c) 0.5 d) 1

28. Moment of inertia comes into play

a) in trasalatory motion
b) in rotatory motion
c) when the body is rest
d) in all these case

29. If the angular velocity of a rotating rigid body is increased then its moment of inertia about that axis

a) increases b) decreases
c) becomes zero d) remains unchanged

30. A ring of mass M and radius r is melted and then moulded into a sphere. The moment of inertia of the sphere will be

a) more than that of the ring
b) less than that of the ring
c) equal to that of the ring
d) the information given is incomplete

31. A cycle wheel is fitted with spokes because

a) it increases the strength of the wheel
b) it gives a better shape to wheel
c) it increases the moment of inertia of wheel so that balance of cyclist is maintained
d) it decreases the moment of inertia of wheel so that less force is required on paddles to start the cycle

32. A steel sphere and a wooden sphere have the same mass. Then which will have greater moment of inertia about the diameter?

a) wooden sphere b) steel sphere
c) same of both d) can not be predicted

33. An iron ball and a wooden ball have the same radius. Then which will have smaller moment of inertia about the diameter?
a) wooden ball b) iron ball
c) same for both d) can not be predicted

34. Moment of inertia of a rigid body depends upon
a) mass of the body
b) distribution of mass of rotation of the body about the axis
c) both' a' and 'b'
d) neither' a' nor 'b'

35. Which of the following has the smallest moment of inertia about the central axis if all have equal mass and radii?
a) Ring b) Disc
c) Spherical shell d) Solid sphere

36. The moment of inertia is the property of a rotating rigid body possess in
a) linear motion b) rotational motion
c) circular motion d) all of these

37. The following bodies have same mass which of them have largest M.I. ?
a) Ring – about an axis perpendicular to its plane
b) Disc – about an axis perpendicular to its plane
c) Solid sphere – about an axis passing through its centre
d) Bar magnet – about an axis through its centre and perpendicular to its plane

38. The moment of inertia of a body does not depend upon the
a) mass of the body
b) distribution of the mass in the body
c) axis of rotation of the body
d) angular velocity of the body

39. If the position of axis of rotation of a body is changed, which of the following quantities will change?
a) Radius of gyration b) Moment of inertia
c) Both 'a' and 'b' d) Neither 'a' nor 'b'

40. The angular momentum and the moment of inertia are respectively
a) vector and tensor quantities
b) scalar and vector quantities
c) vector and vector quantities
d) scalar and scalar quantities

41. The mass of a flywheel is concentrated at its rim
a) to obtain a strong wheel
b) to decrease the moment of inertia
c) to increase the moment of inertia
d) to obtain the stable equilibrium

42. A circular disc is to be made by using iron and aluminium, so that it acquires maximum moment of inertia about its geometrical axis. It is possible with
a) iron and aluminium layers in alternate order
b) aluminium at interior and iron surrounding it
c) iron at interior and aluminium surrounding it
d) either 'a' or 'c'

43. About which of the following axis, the moment of inertia of a thin circular disc is minimum?
a) Through centre perpendicular to the surface
b) Tangential and perpendicular to the surface
c) Through centre parallel to the surface
d) Tangential and parallel to the surface

44. The angular displacement of a flywheel varies with time as $0 = at + bt^2 - ct^3$. Then the angular acceleration is given by
a) $a + 2bt - 3ct^2$ b) $2b - 6ct$
c) $a + 2b - 6t$ d) $2b - 6t$

45. A rigid body is rotating about an axis of rotation with uniform angular speed ω. The linear speed v of a particle at a perpendicular distance r from the axis of rotation and the angular speed ω are related as $\omega = \frac{v}{r}$. This implies that
a) $\omega \propto \frac{1}{r}$ b) ω is independent of r
c) $\omega = 0$ d) $\omega \propto r$

46. Moment of inertia of a rigid body about an axis passing through its centre of mass is 10 and moment of inertia of the same body about another axis parallel to the first axis is l. Then
a) I is always equal to I_0
b) I is always smaller than I_0
c) I is always greater than I_0
d) any of the above three

47. In rotatory motion, moment of inertia
a) imparts angular acceleration
b) maintains state of rotational motion
c) opposes the change in rotational motion
d) 'b' and 'c'

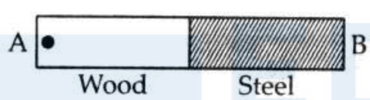
48. Two circular iron discs are of the same thickness. The diameter of A is twice that of B. The moment of inertia of A as compared to that of B is
a) twice as large
b) four times as large
c) sixteen times as large
d) eight limes of large

49. A solid sphere, hollow sphere and ring have the same mass and diameter. If they rotate about axes passing through centre of gravity and in the case of ring it is normal to its plane, which will have more moment of inertia?
a) Solid sphere b) Hollow sphere
c) Ring d) Same for all

50. A steel ring and a wooden ring have the same mass. Then which will have smaller moment of inertia about the diameter?
a) Wooden ring b) Steel ring
c) Same of both d) can not be predicted

51. An iron disc and a wooden disc have the same radius. Then which will have larger moment of inertia about the diameter?
a) Wooden disc b) Iron disc
c) Same for both d) can not be predicted

52. AB is a stick half of which is wood and the other half steel. I_A is moment of inertia about an axis passing through A and perpendicular to the length. I_B is moment of inertia about an axis passing through B and perpendicular to the length. Then



a) $I_A = I_B$ b) $I_A > I_B$
c) $I_B > I_A$ d) we can not say

53. A solid sphere and hollow sphere of the same material have same mass. Then moment of inertia about the diameter is more for
a) solid sphere b) hollow sphere
c) same for both d) none

54. Which of the following has the largest moment of inertia about the central axis if all have equal mass and radii ?
a) Solid sphere b) Disc
c) Spherical shell d) Ring

55. With the increase in temperate, moment of inertia of a solid sphere about the diameter.
a) decreases b) increases
c) does not change d) none of these

56. 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.

57. If the moment of inertia of a rigid body is numerically equal to twice its mass, its radius of gyration is
a) equal to its diameter b) equal to its radius
c) $\sqrt{2}$ units d) 1 unit

58. If temperature increases, the moment of inertia of a solid sphere about its diameter
a) increases b) decreases
c) remains unchanged d) becomes negative

59. Three particles of masses 1 kg, 2 kg and 3 kg are at distances 1 m, 2 m and 3 m from the axis of rotation. The moment of inertia of the system is
a) 24 kg m^2 b) 12 kg m^2
c) 36 kg–m^2 d) 48 kg m^2

60. Two bodies of masses 1 kg and 2 kg, separated by 6 m are rotating about the centre of mass of the system. The moment of inertia of the system is
a) 12 kg m^2 b) 24 kg m^2
c) 36 kg m^2 d) 6 kg m^2

61. Two particles of masses m_1 and m_2 are separated by a distance 'd'. Then moment of inertia of the system about an axis passing through centre of mass and perpendicular the line joining them is

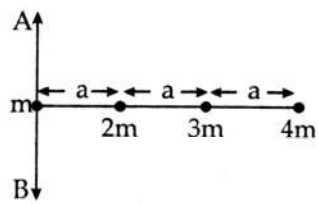
a) $\left(\frac{m_1m_2}{m_1+m_2}\right)\frac{d^2}{2}$ b) $\left(\frac{m_1m_2}{m_1+m_2}\right)d$

c) $\left(\frac{m_1m_2}{m_1+m_2}\right)d^2$ d) $\left(\frac{2m_1m_2}{m_1+m_2}\right)d^2$

62. Two particles of masses 2 kg and 3 kg are separated by 5 m. Then moment of inertia of the system about an axis passing through the centre of mass of the system and perpendicular to the line joining them is
a) 10 kg m^2 b) 20 kg m^2
c) 30 kg m^2 d) 40 kg m^2

63. Four masses m; 2 m; 3 m and 4 m are connected

by a rod of negligible mass. The moment of inertia of the system about the axis AB is



a) 52 ma^2 b) 9 ma^2
c) 50 ma^2 d) 20 ma^2

64. Three particles each of 'm' are kept at the three vertices of an equilateral triangle of side 'a'. Moment of inertia of the system about an axis passing through the centroid and perpendicular to its plane is
a) 3 ma^2 b) ma^2
c) $ma^2/3$ d) 2/3 ma^2

65. The square lamina of side 'b' has same mass as a disc of radius R. The M.I. of the two about an axis perpendicular to the plane and passing through the centre are equal. The ratio b/R is
a) 1 b) $\sqrt{6}$
c) $\sqrt{3}$ d) 1/3

66. Two circular disc of same mass and thickness are made from metals having densities P_1 and P_2 respectively. The ratio of their moment of inertia about an axis passing through its centre is,
a) $P_1 : P_2$ b) $P_1 P_2 : 1$
c) $P_2 : P_1$ d) $1 : P_1 P_2$

67. Moment of inertia of the earth about an axis passing through its centre of mass is (where R and P are radius and density of the earth respectively).
a) $(2/5)\pi R^5 \rho$ b) $(2/3)\pi R^5 \rho$
c) $(8/15)\pi R^5 \rho$ d) $(4/15)\pi R^5 \rho$

68. A small hole is made in a disc of mass M and radius R at a distance R/4 from centre. The disc is supported at the peg through this hole. The moment of inertia of disc about horizontal peg is
a) $MR^2/2$ b) $5MR^2/16$
c) $9MR^2/16$ d) 5MR2 / 4

69. Two circular discs A and B have equal masses and uniform thickness but have densities P_1 and P_2 such that $P_1 > P_2$, then their moments of inertia is
a) $I_1 > I_2$ b) $I_1 >> I_2$
c) $I_1 < I_2$ d) $I_1 = I_2$

70. If the masses of two uniform discs are in the ratio 1 : 2 and their diameters are in the ratio 2 : 1, then the ratio of their moment of inertia about the axes passing through their respective centres and perpendicular to their planes will be
a) 1 : 1 b) 1 : 2
c) 2 : 1 d) 1 : 4

71. If a body is lying in the Y–Z plane, then according to theorem of perpendicular axes the correct expression will be
a) $I_z = I_x + I_y$ b) $I_y = I_x + I_z$
c) $I_x = I_y + I_z$ d) $I_y = I_z + Md^2$

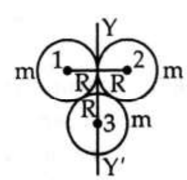
72. If the diameter of fly wheel is increases by 1%, then increase in its M.I. about an axis passing through centre and perpendicular to the plane will be
a) 1 % b) 0.5 %
c) 2 % d) 4 %

73. 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

74. A ring and a thin hollow cylinder have the same mass and radius. If I_r and I_s represent their moment of inertia about their axes, then
a) $I_r = 2I_s$ b) $I_s = 2I_r$
c) $I_s = I_r$ d) none of these

75. If a thin wire of length l and mass m is bent in the form of a semicircle, then its M.I. about an axis joining its free ends will be
a) $m l^2$ b) zero
c) $m l^2/\pi^2$ d) $m I^2/2\pi^2$

76. Three rings each of mass m and radius R are arranged as shown m 12 m in figure. The M.l. of the R arrangement about YY' will be



a) (7/2) mR^2 b) (2/5) mR^2
c) (5/2) mR^2 d) (2/7) mR^2

77. If two masses of 200 g and 300 g are attached to the 2.0 cm and 70 cm marks on a light metre rod

respectively, then the M.I. of the system about an axis passing through 50 cm mark will be

a) 0.15 kg m^2 b) 0.03 kg m^2
c) 0.3 kg m^2 d) zero

3.2 Radius of gyration

78. The radius of gyration is related to
a) moment of force
b) moment of momentum
c) simple harmonic motion
d) moment of inertia

79. The radius of gyration of a body depends upon
a) mass of the body
b) distribution of mass of the body
c) axis of rotation and distribution of mass of the body
d) all of the above

80. The dimensions of the radius of gyration are
a) $[L^1M^1T^0]$ b) $[L^1M^0T^0]$
c) $[L^1M^0T^1]$ d) $[L^1M^2T^0]$

81. A rod length 15 m stands vertically on the ground. With one end hinged to the ground. When it falls on the ground such that it rotates wi thou t slipping, the velocity of the upper tip on striking the ground is (g = 10 m/s)
a) 15 m/s b) 15 $\sqrt{2}$ m/s
c) 15/$\sqrt{2}$ m/s d) 15$\sqrt{3}$ m/s

82. 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) $\sqrt{31}$ cm b) 1 cm
c) 3 cm d) none

83. Radius of gyration of a body about an axis is 12 cm. Radius of gyration of the same body about a parallel axis passing through its centre of gravity is 13 cm. Then perpendicular distance between the two axes is
a) 5 cm b) 1 cm
c) 15 cm d) 10 cm

84. The moment of inertia of a circular disc about its diameter is 500 kg m^2. If its radius is 2 m, than its radius of gyration is
a) 1 m b) 2 m
c) 2$\sqrt{2}$ m d) 4 m

85. The radius of a solid sphere is 40 cm. The radius of gyration when the axis of rotation is along a tangent in a plane in cm is
a) 5$\sqrt{35}$ b) 10 $\sqrt{35}$
c) 8 $\sqrt{35}$ d) 4 $\sqrt{35}$

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

87. Angular acceleration of a body of mass 50 kg under the action of a torque of magnitude 500 Nm is 25 rad/s^2. Then radius of gyration of the body about its axis of rotation is nearly equal to
a) 0.2 m b) 0.6 m
c) 0.4 m d) 1 m

88. The angular velocity of the body changes from ω_1 to ω_2 without applying torque but by changing its M.1. The ratio of initial radius of gyration to final radius of gyration is
a) $\omega_2 : \omega_1$ b) $\omega_2^{1/2} : \omega_1^{1/2}$
c) $\omega_2^2 : \omega_1^2$ d) $\frac{1}{\omega_2} : \frac{1}{\omega_1}$

89. The radius of gyration of a disc about an axis coinciding with a tangent in its plane is
a) $\frac{R}{2}$ b) $\frac{R}{\sqrt{2}}$
c) $\sqrt{2}$ R d) $\frac{\sqrt{5}}{2}$R

90. The radius of disc is 2 m 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

91. A fly wheel of mass 4 kg has moment of inertia 16 kg m^2, then radius of gyration about the central axis perpendicular to its plane is
a) 1 m b) 2m
c) 4m d) 16m

92. The radius of gyration of a body about an axis at a distance of 6 cm from the centre of gravity is 10 cm. Its radius of gyration about a parallel axis through centre of gravity is
a) 4 cm b) 14 cm
c) 8 cm d) 16 cm

93. The moment of inertia of a ring about its geometrical axis is I, then its moment of inertia about its diameter will be

a) 2I b) I/2
c) I d) I/4

94. Radius of gyration of a bodyabout an axis is 1 cm. Radius of gyration of the same body about a parallel axis passing through its centre of gravity is 2 cm. Then perpendicular distance between the two axes is

a) $\sqrt{3}$ cm b) 1 cm
c) 4 cm d) 1.5 cm

95. The M.I. of a wheel of mass 8 kg and radius of gyration 25 cm is

a) 5 kg m^2 b) 1.5 kg m^2
c) 2.5 kg m^2 d) 0.5 kg m^2

3.3 Kinetic energy of a rotating rigid body

96. The angular momentum of two circular discs is same. The mass of the first disc is more than second disc, then the rotational K.E. is more for

a) lighter disc
b) heavier disc
c) both will have same rotational K.E.
d) depends upon shape

97. A cylinder full of water is rotating about its own axis with uniform angular velocity ω. Then the shape of free surface of water will be

a) parabola b) elliptical
c) circular d) spherical

98. A solid sphere and a disc of equal radii are rolling on an inclined plane without slipping. One reaches earlier than the other due to different

a) sizes b) frictional force
c) moment of inertia d) radius of gyration

99. A body rolls down an inclined plane. If its kinetic energy of rotational motion is 40% of its kinetic energy of translational then the body is

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

100. When a body starts to roll on an inclined plane, its potential energy is converted into

a) rotational kinetic energy only
b) translational kinetic energy only
c) both' a' and 'b'
d) neither 'a' nor 'b'

101. Kinetic energy of a wheel rotating about its central axis is E. Then kinetic energy of another wheel having twice the moment of inertia and half the angular momentum as that of the first wheel is

a) 8 E b) 4 E
c) E/8 d) E/4

102. The kinetic energy of rolling body is

a) $1/2\ I\ \omega^2$ b) $1/2\ I\ \omega^2 + 1/2\ mv^2$
c) $1/2\ mv^2$ d) $1/2\ mR^2$

103. A loop of mass M and radius R is rolling on a smooth horizontal surface with speed 'v'. It's total kinetic energy is

a) $1/2\ Mv^2$ b) $3/2\ Mv^2$
c) Mv^2 d) $1/2\ MR^2\ \omega^2$

104. A sphere of moment of inertia 'I' and mass 'rn' rolls down on an inclined plane without slipping its K.E. of rolling is

a) $I\ \omega + mv$ b) $0.5\ mv^2$
c) $0.5\ I\ \omega^2$ d) $0.5\ I\ \omega^2 + 0.5\ mv^2$

105. A fly wheel of mass 60 kg and radius 40 cm is revolving at 300 rpm. then its rotational K.E. is

a) $\frac{48}{\pi^2}$ J b) $480\ \pi$ J
c) $\frac{48}{\pi}$ J d) $240\ \pi^2$ J

106. A wheel of mass 8 kg and radius 40 cm is rolling on a horizontal road with angular velocity 15 rad/s. If the moment of inertia of the wheel about its axis is 0.64 kg m^2, then the rolling kinetic energy of wheel will be

a) 288 J b) 216 J
c) 72 J d) 144 J

107. If a solid sphere of mass 500 gram rolls without slipping with a velocity of 20 cm/s, then the rolling kinetic energy of the sphere will be

a) 140 J b) 280 J
c) 0.014 J d) 0.028 J

108. The M.I. of a solid cylinder about its axis is I. It is allowed to roll down an incline plane without slipping. If its angular velocity at the bottom be to, then kinetic energy of rolling cylinder will be

a) $I\ \omega^2$ b) $\frac{3}{2}\ I\ \omega^2$
c) $2\ I\ \omega^2$ d) $\frac{1}{2} I\ \omega^2$

109. A ring and a disc of different masses are rotating with the same kinetic energy. If we apply a retarding torque T on the ring and a ring stops after making n revolutions, then in how many revolutions will the disc stop under the same retarding torque?

a) n b) 2n
c) 4n d) n/2

110. Acoin is placed on a gramophone record rotating at a speed of 45 rpm, it flies away when the rotational speed is 50 rpm. If two such coins are placed one over the other on the same record both of them will flyaway when rotational speed is

a) 100 rpm b) 25 rpm
c) 12.5 rpm d) 50 rpm

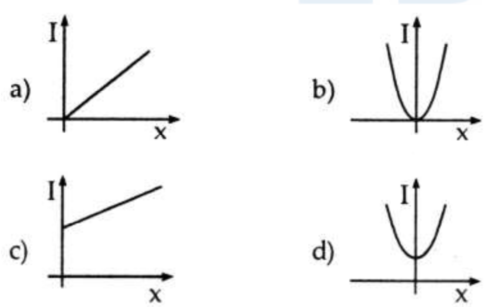
111. If a disc of mass 400 gm is rolling on a horizontal surface with uniform speed of 2 m/s, then its rolling kinetic energy will be

a) 0.12 J b) 1.2 J
c) 120 J d) 12 J

112. A body of mass 'm' and radius of gyration 'K' is rotating with angular acceleration α. Then the torque acting on the body is

a) $\frac{1}{2}$ mK^2 α b) $\frac{1}{4}$ mK^2 α
c) 2 mK^2 α d) mK^2 α

113. If I is the M.I. of a solid sphere about an axis parallel to a diameter of the sphere and at a distance x from it, which of following graphs represents the variation of I with x



114. If a circular loop of wire of mass 'm' and radius 'R' is making 'n' revolutions per second about a point on its rim perpendicular to the plane of the loop, Then its rotational kinetic energy will be

a) $\pi^2 mR^2 n^2$ b) $2\pi^2 mR^2 n^2$
c) $4\pi^2 mR^2 n^2$ d) $8\pi^2 mR^2 n^2$

115. If the angular momentum of a body increases by 50 %, its kinetic energy of rotation increases by

a) 50 % b) 25 %
c) 125 % d) 100 %

116. If a solid sphere of mass 1 kg and radius 3 cm is rotating about an axis passing through its centre with an angular velocity of 50 rad/s, then the kinetic energy of rotation will be

a) 9/20 J b) 90 J
c) 910 J d) 4500 J

117. A wheel 2 kg having practically all the mass concentrated along the circumference of a circle of radius 20 cm is rotating on its axis with angular velocity of 100 rad/s, then the rotational kinetic energy of wheel is

a) 4 J b) 70 J
c) 400 J d) 800 J

118. Two rigid bodies A and B rotates with angular momenta of magnitude L_A and L_B respectively. The moments of inertia of A and B about the axes of rotation are I_A and I_B respectively. If $I_A = I_B/4$ and $L_A = 5\ L_B$, then the ratio of rotational kinetic energy (KE_A) of A to the rotational kinetic energy (KE_B) of B is

a) 25/4 b) 5/4
c) 1/4 d) 100

119. A body of moment of inertia of 3 kg m^2 rotating with an angular velocity of 2 rad/s has the same kinetic energy as that of mass 12 kg moving with a velocity of

a) 1 m/s b) 2 m/s
c) 4 m/s d) 8 m/s

120. A ring rotates without slipping on a horizontal smooth surface, the ratio of translational energy to the total energy of the ring is

a) 2 b) 1/2
c) 4 d) 1/4

121. A body of moment of inertia about its axis of rotation is 3 kg m^2 and angular velocity 3 rad/s. The kinetic energy of rotating body is same as that of a body of mass 27 kg moving with a speed of

a) 1.0 m/s b) 0.5 m/s
c) 1.5 m/s d) 2.0 m/s

122. A circular disc rolls down on an inclined plane. The fraction of its total rolling energy associated with its rotational energy is,

a) 1 b) 1/3
c) 1/2 d) 1/4

123. A body of moment of inertia 3 kg m^2 is at rest, if it is rotated for 20 s with moment of force 6 Nm, then the work done will be
a) 60 J b) 2400 J
c) 120 J d) 4800 J

124. What fraction of translational kinetic energy of rolling circular disc to total kinetic energy?
a) 1/3 b) 1
c) 2/3 d) 1/2

125. If a body starts rotating from rest because of a torque of 2 Nm, then its kinetic energy after 20 revolutions will be
a) 60π J b) 80π J
c) 70π J d) 40π J

126. If a body starts rotating from rest due to a torque of 1.5 Nm, then its kinetic energy after it complete 20 revolution will be
a) 60π J b) 80π J
c) 70π J d) 40π J

127. If a solid sphere of mass 1 kg rolls with linear speed of 1mis, then the rolling kinetic energy will be
a) 0.7 J b) 1.4 J
c) 2.1 J d) 2.8 J

128. The part of total kinetic energy is the rotational kinetic energy of a solid ball rolling over a horizontal plane is
a) 2/5 b) 2/7
c) 1/2 d) 3/4

129. If a flywheel of mass m kg and radius r m is revolving at n rps, then the kinetic energy of rotation will be
a) $\pi^2 n^2 m^2 r^2$ b) $\pi^2 n^2 m^2 r$
c) $\pi^2 n^2 m r^2$ d) $\pi^2 n m^2 r^2$

130. A thin ring and a solid disc of same mass and radius are rolling with the same linear velocity. Then ratio of their kinetic energies is
a) 4 : 3 b) 3 : 4
c) 2 : 3 d) 3 : 2

131. When a solid sphere rolls without slipping on a surface, its rotational kinetic energy is 40 J. Then its total kinetic energy is
a) 100 J b) 70 J
c) 140 J d) 280 J

132. A ring and a disc having the same mass roll without slipping with the same linear velocity. If the kinetic energy of the ring is 8 J, then kinetic energy of the disc must be
a) 2 J b) 4 J
c) 6 J d) 12 J

133. A flywheel is in the form of solid circular wheel of mass 72 kg and radius of 0.5 m and it takes 70 rpm, then the energy of revolution is
a) 24 J b) 2.4 J
c) 240 J d) 2400 J

134. The radius of gyration of a flywheel is $(3/\pi)$ m and its mass is 1 kg. If the speed of the flywheel is changed from 20 rpm to 60 rpm, then the work done would be
a) 16 J b) 12 J
c) 24 J d) 32 J

135. The radius of a wheel is R and its radius of gyration about an axis passing through its centre arid perpendicular to its plane is k. If the wheel is rolling without slipping, the ratio of its rotational kinetic energy to its translational kinetic energy is
a) $\frac{k^2}{R^2}$ b) $\frac{R^2}{k^2}$
c) $\frac{k^2}{R^2+k^2}$ d) $\frac{R^2}{R^2+k^2}$

136. Two bodies with moment of inertia I_1 and I_2 $(I_1 > I_2)$ have equal angular momentum. Then kinetic energy of first body E_1 and kinetic energy of second body E_2 are related as
a) $E_1 = E_2$ b) $E_1 < E_2$
c) $E_1 > E_2$ d) $E_1 \geq E_2$

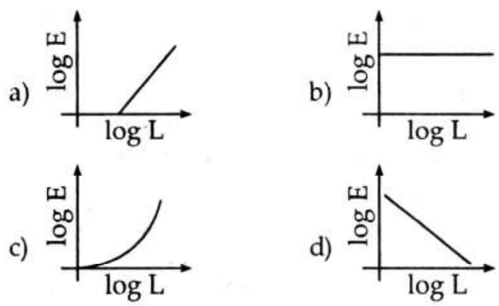
137. The rotational kinetic energy of a body is E. In the absence of external torque, the mass of the body is halved and its radius of gyration is doubled. Its rotational kinetic energy is
a) 2 E b) E/2
c) E d) E/4

138. Angular momentum of body changes by 80 kg m^2/s, when its angular velocity changes from 20 rad/s to 40 rad/s. Then the change in its kinetic energy is
a) 1200 J b) 1800 J
c) 1600 J d) 2400 J

139. A fly wheel rotating about a fixed axis has a kinetic energy of 360 J when its angular speed is 30 rad/s, then the moment of inertia of fly wheel about the axis of rotation will be
a) 0.6 kg m^2 b) 0.8 kg m^2
c) 0.15 kg m^2 d) 0.75 kg m^2

140. A disc of moment of inertia $9.8/\pi^2$ kg m^2 is rotating at 600 rpm. If the frequency of rotation changes from 600 rpm to 300 rpm, then what is the work done?
a) 1567 J b) 1452 J
c) 1467 J d) 1632 J

141. If the variation of rotational kinetic energy Ewith the angular momentum L of a body. The graph of log L and log E will be in the form of



142. A circular disc of mass 0.41 kg and radius 10 m rolls without slipping with a velocity of 2 m/s. The total kinetic energy of disc is
a) 0.41 J b) 1.23 J
c) 0.82 J d) 2.4 J

143. If the angular momentum of a rotating body about an axis is increased by 10 %. Its kinetic energy increases by
a) 20 % b) 21 %
c) 10 % d) – 21%

144. If the kinetic energy of a rotating body about an axis is decreased by 36 %, its angular momentum about that axis is
a) increases by 72 % b) decreases by 72 %
c) increases by 20 % d) decreases by 20 %

145. A boy stands on a freely rotating platform with his arms extended. His rotation speed is 0.3 revls, when he draws in, his speed increases to 0.5 tevls, then the ratio of his moment of inertia in these two cases will be
a) 3 : 5 b) 5 : 3
c) 9 : 25 d) 25 : 9

146. A rod of mass Mand length Z is suspended freely from its end and it can oscillate in the vertical plane about the point of suspension. It is pulled to one side and then released. It passes through the equilibrium position with angular speed 00. What is the kinetic energy while passing through the mean position?
a) $\frac{Ml^2\omega^2}{2}$ b) $\frac{Ml^2\omega^2}{6}$
c) $\frac{Ml^2\omega^2}{4}$ d) $\frac{Ml^2\omega^2}{8}$

147. A hollow sphere rolls on a horizontal surface without slipping. Then percentages of rotational kinetic energy in total energy is
a) 60 % b) 40 %
c) 72 % d) 28 %

148. A thin hollow cylinder open at both ends slides without rotating and then rolls without slipping with the same speed. The ratio of the kinetic energies in the two cases is
a) 1 : 1 b) 1 : 2
c) 2 : 1 d) 1 : 4

149. The kinetic energy of a body rotating at 300 revolutions per minute is 62.8 J. Its angular momentum (in kg m^{2}s^{-1}) is approximately
a) 1 b) 2
c) 4 d) 8

150. The rotational kinetic energies of two flywheels are equal. If the ratio of theiir moments of inertia is 1 : 9 then the ratio of their angular momenta is
a) 5 : 1 b) 1 : 4
c) 1 : 3 d) 4 : 1

151. A uniform rod of length 1 m and mass 1 kg is held vertical on a horizontal floor. Fixing its lower end, it is allowed to fall onto the ground. Its kinetic energy just before coming in contact with the ground is
a) 4.9 J b) 9.8 J
c) 19.6 J d) 2.45 J

3.4 Torque

152. The torque is a physical quantity which causes to produce
a) property of a body
b) linear motion of the body
c) rotational motion of the body
d) rolling motion of the body

153. The dimensional formula of torque is same as that of
a) power b) angular momentum
c) impulse d) kinetic energy

154. Force in linear motion is comparable to the quantity in rotatory motion is
a) moment of inertia b) angular velocity

c) torque d) impulse

155. When same torque acts on two rotating rigid bodies to stop them, which have same angular momentum,

a) body with greater moment of inertia stops first

b) body with smaller moment of inertia stops first

c) both the bodies will be stopped after the same time

d) we can not predict which stops first

156. When a steady torque or couple acts on a body, the body

a) continues in a state of rest or of steady motion by Newton's first law

b) gets linear acceleration by Newton's second law

c) continues to rotate at a steady rate

d) gets an angular acceleration

157. The dimensions of torque are

a) $[L^3M^0T^{-2}]$ b) $[L^2M^2T^{-3}]$

c) $[L^2M^1T^{-2}]$ d) $[L^2M^{-1}T^{-3}]$

158. If I, α and τ are the moment of inertia, angular acceleration and torque respectively of a body rotating about an axis with angular velocity ω then,

a) $\tau = I\alpha$ b) $\tau = I.\omega$

c) $\tau = I/\omega$ d) $\alpha = \tau.\omega$

159. The relation between the torque r and angular momentum L of a body of moment of inertia I rotating with angular velocity ω is

a) $\tau = dL/dt$ b) $\tau = L.\omega$

c) $\tau = dL/d\omega$ d) $\tau = L \times \omega$

160. A fly wheel of M.1. 0.32 kg m^2 is rotated steadily at 120 rad/s by 50 w electric motor. Then the value of the frictional couple opposing rotation is,

a) 4.2 Nm b) 0.42 Nm

c) 0.042 Nm d) 42 Nm

161. A flywheel revolves at 100 rev/min, a torque is applied to the flywheel for 10 s If the torque increases the speed to 200 rev/min, then the angular acceleration of the flywheel will be

a) $\frac{\pi}{6}$ rad/s^2 b) $\frac{\pi}{5}$ rad/s^2

c) $\frac{\pi}{4}$ rad/s^2 d) $\frac{\pi}{3}$ rad/s^2

162. The moment of inertia of flywheel is 4 kg m^2. If a torque of 10 Nm is applied on it, then the angular acceleration produced will be

a) 4 rad/s^2 b) 0.25 rad/s^2

c) 25 rad/s^2 d) 2.5 rad/s^2

163. If a wheel has mass 70 kg and radius of gyration 1 m, then the torque required an angular acceleration of 2 rev/s^2 will be

a) 140 π Nm b) 380 π Nm

c) 180 π Nm d) 280 π Nm

164. 8 kg wheel has radius of gyration (1/4) m. The torque required to give it an angular acceleration of 4 rad/s^2, is

a) $\frac{2}{3}$ Nm b) 2 Nm

c) $\frac{3}{2}$ Nm d) 3 Nm

165. A disc of moment of inertia 3 kg m^2 is acted upon by a constant torque of 60 Nm, if the disc is at rest, then the time after which the angular velocity of the disc is 90 rad/s, will be

a) 1.5 s b) 3 s

c) 4.5 s d) 6 s

166. A solid cylinder of radius 0.5 m and mass 50 kg is. rotating at 300 rpm. Then the torque which will bring it to rest in 5 seconds is

a) 25 π Nm b) 2 Nm

c) 50 π Nm d) 100 π Nm

167. Two rigid bodies have the same angular momentum about their axes of symmetry. If the same torque is applied about their axes, then the ratio of the times after which they will be stopped

a) 1 : 1 b) 1 : 2

c) 2 : 1 d) data is insufficient

168. A disc of mass 16 kg and radius 25 cm is rotated about its axis. What torque will increase its angular velocity from 0 to 8 π rad/s in 8 s ?

a) π Nm b) $\pi/2$ Nm

c) $\pi/4$ Nm d) 2 π Nm

169. If a torque of magnitude 100 Nm acting on a rigid body produces an angular acceleration of 2 rad/s^2, then the moment of inertia of that body will be

a) 50 kg m^2 b) 100 kg m^2

c) 200 kg m^2 d) 25 kg m^2

170. A disc of moment of inertia 2 kg m^2 is acted upon by a constant torque of 40 Nm. If it is initially at rest, then the time taken by it to acquire an angular velocity 100 rad/s will be

a) 20 s b) 10 s

c) 5 s d) 4 s

171. A shaft rotating at 6000 rpm is transmitting a power of 2π kilowatt. Then the magnitude of the driving torque is

a) 10 Nm b) 5 Nm
c) 1 Nm d) 0.1 Nm

172. A wheel with moment of inertia 10 kg m^2 is rotating at $(2/\pi)$ rps on its axis. The frictional. torque acting on it, if it makes 20 rotations before stopping is

a) π Nm b) $1/\pi$ Nm
c) 2π Nm d) $2/\pi$ Nm

173. A fly wheel is rotating with a kinetic energy of 200 J. A constant torque of·4 Nm acts on it to oppose its motion. Before coming to rest, the number of revolutions completed by it is

a) $100/\pi$ b) $50/\pi$
c) $25/\pi$ d) $25/2\pi$

174. An automobile engine develops 60 π kilowatt of power when it is rotating at the speed of 1800 rev/min, then the torque it can transfer to the wheels is

a) 100 Nm b) 10 Nm
c) 1000 Nm d) 1800 Nm

175. A thin rod of mass m and length 2 / is made to rotate about an axis passing through its centre and perpendicular to it. If its angular velocity changes from 0 to ω in time t, the torque acting on it is

a) $\frac{ml^2\omega}{l^2 t}$ b) $\frac{ml^2\omega}{3t}$

c) $\frac{ml^2\omega}{t}$ d) $\frac{4ml^2\omega}{3t}$

176. A disc of radius 10 cm can rotate about an axis passing through its centre and perpendicular to its plane. A force of 10 N is applied along the tangent in the plane of the disc. If the moment of inertia of the disc about its centre is 5 kg m^2, then the increase in the angular velocity of the disc in 10 s will be

a) 2 rad/s b) 4 rad/s
c) 1 rad/s d) 50 rad/s

177. A wheel of mass 40 kg and radius of gyration 0.5 m comes to rest from a speed of 180 revolutions per minute in 3 s. Assuming that the retardation is uniform, then the value of retarding torque t in Nm is

a) 10 π b) 20 π
c) 30 π d) 40 π

178. A torque of 100 Nm acting on a wheel at rest, rotates it through 200 radians in 10 s. The angular acceleration of the wheel, in rad/s^2 is

a) 2 b) 4
c) 1 d) 8

179. A disc of mass 2 kg and diameter 40 cm is free to rotate about an axis passing through its center and perpendicular to its plane. If a force of 50 N is applied to the disc tangentially Its angular acceleration will be

a) 100 rad/s^2 b) 25 rad/s^2
c) 250 rad/s^2 d) 500 rad/s^2

180. A wheel of mass 40 kg and radius of gyration 0.5 m comes to rest from a speed of 180 rpm in 30 s assuming that the retardation is uniform, then the value of the retarding torque, in Nm will be

a) I π b) 3 π
c) 2 π d) 4 π

181. A motor running at a rate of 1000 rpm can supply torque of 60 Nm, then the power developed is

a) 1 π kwatt b) 2 π kwatt
c) 5 π kwatt d) 15 π kwatt

182. If a motor running at a rate of 1200 revolutions per minute can supply torque of 80 Nm, then the power required will be

a) 10 π kwatt b) 192 π kwatt
c) 3.2 π kwatt d) 40 π kwatt

183. A rope is wound round a hollow cylinder of mass M and radius R. If the rope is pulled with a force F newton, then the angular acceleration of the cylinder will be

a) F/MR b) M/F R
c) R/MF d) MR/F

184. A wheel of moment of inertia 2×10^3 kg m^2 is rotating at uniform angular speed of 4 rad/s, then the torque required to stop it in one second is,

a) 8×10^2 Nm b) 8×10^4 Nm
c) 8×10^3 Nm d) 8×10^5 Nm

185. Starting from rest a fan takes 5 s to attain the maximum speed of 400 rpm. Assuming constant acceleration, the time taken by the fan in attaining half the maximum speed is

a) 20 s b) 2.5 s
c) 10 s d) 2.0 s

3.5 Principle of parallel and perpendicular axes

186. If I_x and I_y are moment of inertia of the lamina in the plane and I_z is moment of inertia of the lamina perpendicular to the plane, then the mathematical statement of the principle of perpendicular

a) $I_x = I_y + I_z$ b) $I_z = I_x + I_y$
c) $I_y = I_x + I_z$ d) $I_z = 2I_x + I_y$

3.6 Angular momentum and its conservation

187. Two flywheels of the same mass have radius R and r where R > r, and they have same rotational kinetic energy then the angular momentum (L) is more for

a) greater radius wheel
b) lesser radius wheel
c) both with have same L
d) depends upon shape

188. If all a sudden the radius of the earth increases, then

a) the angular momentum of the earth will be greater than that of the sun
b) the orbital speed of the earth will increase
c) the periodic time of the earth will increase
d) the energy and angular momentum will remain constant

189. A person can balance easily on a moving bicycle but cannot balance on stationary bicycle. This is possible because of law of conservation of

a) mechanical energy
b) mass
c) angular momentum
d) linear momentum

190. When the 'torque acting on a system is zero, then the conserved quantity is

a) linear momentum b) angular momentum
c) moment of inertia d) angular velocity

191. If a gymnast sitting on a rotating disc with his arms out stretched suddenly lowers his arms, then

a) angular velocity decreases
b) moment of inertia decreases
c) angular velocity remains constant
d) angular momentum decreases

192. A body moves with constant velocity parallel to X–axis. Its angular momentum with respect to origin

a) is zero b) remains constant
c) goes on increasing d) goes on decreasing

193. When a particle is rotating in a plane about a fixed point, its angular momentum is directed along the

a) radius
b) tangent to the orbit
c) axis of rotation
d) circumference of the circle

194. A person is standing on a rotating wheel. If he sits on the wheel, then the angular momentum 'of the system will

a) increase b) decrease
c) remain same d) double

195. A man stands at the centre of a turn table and the turn table is rotating with certain angular velocity. If he walks towards rim of the turn table, then

a) moment of inertia of the system decreases
b) angular momentum of system increases
c) angular velocity of the system increases
d) kinetic energy of the system decreases

196. A man turns on a rotating table with an angular velocity ω. He is holding two equal masses at arm's. Without moving his arms, he just drops the masses. Then his angular velocity

a) less than ω b) more than ω
c) equal to ω d) any of these three

197. When a polar ice caps melt, then the duration of day

a) increases
b) decreases
c) some times decreases, some times increases
d) remains constant

198. Two rigid bodies have same moment of inertia about there axes of symmetry. Then which will have more kinetic energy?

a) Body having greater angular momentum
b) Body having smaller angular momentum
c) Both will have same kinetic energy
d) Can not decided

199. There are two identical spherical balls of same material one being solid and the other being hollow. Then they can be distinguished by

a) spinning them by applying equal torques
b) rolling them down on the same inclined plane
c) determining their moments of inertia
d) aryyone of the three methods mentioned above

200. Angular momentum of the 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

201. The term moment of momentum is called
a) angular momentum b) torque
c) force d) couple

202. The dimensional formula of angular momentum is
a) $[L^2M^1T^{-1}]$ b) $[L^1M^1T^{-1}]$
c) $[L^1M^1T^{-2}]$ d) $[L^1M^2T^{-1}]$

203. If a body of mass 'm' and radius of gyration K rotates with angular velocity ω, then the angular momentum of the body will be
a) $m'^2 k \omega$ b) $m k^2 \omega$
c) $m k \omega^2$ d) $m k \omega$

204. The angular momentum of a particle is
a) parallel to its linear momentum
b) perpendicular to its linear momentum
c) inclined to its linear momentum
d) a scalar quantity

205. A heavy disc is rotating with uniform angular velocity ω about its own–axis. A piece of wax sticks to it. The angular velocity of the disc will
a) increase b) decrease
c) becomes zero d) remain unchanged

206. A boy comes and sits suddenly on a circular rotating table the quantity which conserved is
a) angular velocity b) angular momentum
c) linear momentum d) angular acceleration

207. A person standing on a rotating platform with his hands lowered and out stretches his arms. The angular momentum of the person
a) increases b) decreases
c) become zero d) remains constant

208. Which of the following physical quantity has unit kg m^2/s?
a) Torque b) Moment of inertia
c) Angular momentum
d) Force

209. Relation between torque and angular momentum is similar to the relation between
a) energy and displacement
b) acceleration and velocity
c) mass and moment of inertia
d) force and linear momentum

210. According to the principle of conservation of angular momentum, if moment of inertia of a rotating body decreases, then its angular velocity
a) decreases b) increases
c) remains constant d) becomes zero

211. Before jumping into water from a height, a swimmer bend his body to
a) increase moment of inertia
b) decrease the angular momentum
c) decrease moment of inertia
d) reduces the angular velocity

212. Angular momentum is vector product of
a) radius vector and linear momentum
b) linear momentum and angular velocity
c) moment of inertia and angular acceleration
d) linear velocity and radius vector

213. The angular momentum L, the linear momentum P and p–osition vector 'r' are related as
a) $\vec{L} = \vec{r} \times \vec{p}$ b) $L = P / r$
c) $\vec{L} = \vec{p} \times \vec{r}$ d) $L = p.r$

214. A fly wheel used in steam or diesel engine must have
a) large mass and moment of inertia
b) small mass and moment of inertia
c) large mass and small moment of inertia
d) large moment of inertia and small mass

215. If the resultant external torque acting on a body is zero, then angular momentum of the body
a) changes b) remains constant
c) is infinity d) zero

216. A dancer on ice spins faster when she folds her arms'. This is due to
a) increase in energy and increase in angular momentum
b) decrease in friction at the skates
c) constant angular momentum and increase in kinetic energy
d) increase in energy and decrease in angular momentum

217. Angular impulse is
a) torque / time b) torque × time
c) ½ torque × time d) torque × time

218. A ballet dancer is rotating about her own vertical axis on a smooth horizontal floor stretching her arms with I, ω, L and K as moment of inertia, angular velocity, angular momentum and rotational kinetic energy respectively. When she folds her

arms close to the axis of rotation, then

a) L' remains constant, I and K increase, ω decrease

b) L remains constant, I and K increase, ω increases

c) L remains constant, ω and K decrease, I increases

d) L remains constant ω and K increase, I decreases

219. A small body is attached to one end of a string is revolved around a rod so that the string winds upon the rod and get shortened. The quantity which is conserved is

a) angular momentum b) linear momentum
c) kinetic energy d) potential energy

220. When a raw egg and a boiled egg are made to spin on a smooth horizontal table by applying same torque, the egg which spins slower is

a) raw egg
b) boiled egg
c) both will have the same rate of spin
d) difficult to predict

221. A boiled egg anda raw egg of same size and mass are made to spin about their own axis. If I_1 and I_2 are moments of inertia of raw egg and boiled egg respectively, then

a) $I_1 > I_2$ b) $I_2 > I_1$
c) $I_1 = I_2$ d) $I_2 < I_1$

222. If polar ice caps melt, then the angular velocity of rotation of earth

a) increases
c) becomes zero

223. Angular momentum is

a) a polar vector b) an axial vector
c) a scalar d) none of these

224. The kinetic energy of a rotating body with an angular velocity ω depends on

a) angular speed
b) distribution of mass
c) both angular speed and distribution of mass
d) neither angular speed nor distribution of mass

225. A boiled egg and a raw egg of same mass and size are made to rotate about their own axes. If I_1 and I_2 are moments of inertia of boiled egg and raw egg respectively, ω_1 and ω_2 are their angular velocities respectively, then

a) $\omega_1 = \omega_2$ b) $\omega_1 > \omega_2$
c) $\omega_1 < \omega_2$ d) $\omega_2 = \sqrt{3}\ \omega_1$

226. When a circular disc of radius 0.5 m is rotating about its own axis, then the direction of its angular momentum is

a) along the tangent drawn at every point
b) radial
c) perpendicular to the direction of angular velocity
d) along the axis of rotation of the body

227. A circular disc of radius 20 cm is rotating about its own axis at an angular velocity ω. The angular velocity of a particle 'A' which is at a distance 10 cm from the axis of rotation is

a) 2ω b) $\omega/2$
c) ω d) $\omega/4$

228. A constant torque acting on a uniform circular disc changes its angular momentum from L to 4L/3 in 2 seconds. Then the magnitude of the torque applied is

a) L/3 b) 2L/3
c) 3L/2 d) L/6

229. If a particle of mass 1 gm is moving along a circular path of radius 1 m with a velocity of 1 m/s, then the its angular momentum is

a) 1 kg m^2/s b) 10^{-3} kg m^2/s
c) 10^{-2} kg m^2/s d) 10^{-1} kg m^2/s

230. A hollow sphere and solid sphere of the same radius rotate about their diameters with the same angular velocity and angular momentum. Then the ratio of their masses is

a) 3 : 8 b) 5 : 8
c) 3 : 5 d) 5 : 3

231. A constant torque acting on a uniform circular wheel changes its angular momentum from A to 4 A in 4 seconds, then the magnitude of the torque is

a) 0.75 A b) 4 A
c) A d) 12 A

232. A particle performs uniform circular motion with an angular momentum L. If the frequency of the particle is doubled and its kinetic energy is halved, then the angular momentum will be

a) 4 L b) 0.5 L
c) 2 L d) 0.25 L

233. 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 in 27 trevolutions is

a) 2.5×10^4 dyne cm b) 2.5×10^{-4} dyne cm

c) 2.5×10^6 dyne cm d) 2.5×10^5 dyne cm

234. The rotational kinetic energy of two bodies of moment of inertia 9 kg m^2 and 1 kg m^2 are same. The ratio of their angular momenta is

a) 1 : 3 b) 1 : 9

c) 9 : 1 d) 3 : 1

235. A wheel of moment of inertia 5×10^{-3} kg m^2 is making 20 revolutions per second. If it is stopped in 20 s, then its angular retardation would be

a) π rad / s^2 b) 4π rad / s^2

c) 2π rad / s^2 d) 8π rad / s^2

236. A wheel is rotating with frequency of 500 rpm on a shaft, second identical wheel initially at rest is suddenly coupled on same shaft. The frequency of the resultant combination is

(Neglect M.I.of shaft)

a) 250 rps b) 500 rps

c) 250 rpm d) 500 rpm

237. If the radius of the earth contracts to half of its present radius, then the length of the day will be (if the mass of the earth remaining same)

a) 48 h b) 24 h

c) 12 h d) 6 h

238. A thin circular ring of mass M is rotating about its axis with a constant angular velocity ω.

Two objects each of mass m are attached gently to the opposite ends of a diameter of the ring. Then the ring now rotates with an angular velocity

a) $\dfrac{\omega M}{M+m}$ b) $\dfrac{\omega(M-2m)}{(M+2m)}$

c) $\dfrac{\omega M}{M+m}$ d) $\dfrac{\omega(M+2m)}{M}$

239. Two discs of moment of inertia I_1 and I_2 about their respective axes normal to the disc and passing through the centre and rotating with angular speed ω_1 and ω_2 are brought into contact face to face with their axes of rotation coinciding. Then the angular speed of the two disc system is

a) $\dfrac{I_1+I_2}{I_1\omega_1+I_2\omega_2}$ b) $\dfrac{I_1+I_2}{I_1\omega_1-I_2\omega_2}$

c) $\dfrac{I_1\omega_1+I_2\omega_2}{I_1+I_2}$ d) $\dfrac{I_1-I_2}{I_1\omega_1-I_2\omega_2}$

240. A ring of mass m and radius R is rolling on a horizontal plane. If the ring suddenly starts rotating about its diameter, then its angular velocity in this state will be

a) $\dfrac{V}{R}$ b) $\dfrac{2V}{R}$

c) $\dfrac{V}{2R}$ d) $\sqrt{2}\dfrac{V}{R}$

241. A large disc has mass 2 kg and radius 0.2 m and initial angular velocity 50 rad/s and a small disc has mass 4 kg and radius 0.1 m and initial angular velocity 200 radls both rotating about their common axis. Then the common final angular velocity after discs are in contact is,

a) 100 rad/s b) 125 rad/s

c) 200 rad/s d) 150 rad/s

242. A man stands on a frictionless rotating platform rotates at 1 rps, his arms are out stretched and he holds a weight in his hands. In this position, the total moment of inertia of the system is 6 kg m^2, he leaves the weights, the moment of inertia decreases to 2 kg m^2. The resulting angular speed of the platform is

a) 2 rps b) 4 rps

c) 3 rps d) 6 rps

243. A ballet dancer spins about a vertical axis at 120 rpm with arms out stretched. With her arms fold the moment of inertia about the axis of rotation decreases by 40 %. What is new rate of revolution?

a) 100 rpm b) 150 rpm

c) 200 rpm d) 250 rpm

244. A disc rotates horizontal at the rate of 100 rpm and M.I. of the disc about the axis of rotation is 1 kg m^2. If a blob of molten wax weighing 50 gm drops gently at a distance 20 cm from the axis of rotation of the disc and remains stuck to it, then the increase in moment of inertia of the system will be

a) 2 % b) 0.2 %

c) 0.02 % d) 20 %

245. The value of angular momentum of the earth rotating about its own axis is

a) 7×10^{33} kg m^2/s b) 7×10^{33} kg m^2/s

c) 0.7×10^{33} kg m^2/s d) zero

246. The rotational kinetic energy of a body is E and its moment of inertia is 1, then the angular momentum of the body is

a) EI b) $2\sqrt{E}\,I$

c) $\sqrt{2EI}$ d) E/I

247. A torque of 50 Nm acts on a rotating body for 5 s. Its angular momentum is
a) increases by 250 kg m^2/s
b) increases by 10 kg m^2/s
c) increases by 55 kg m^2/s
d) decreases by 250 kg m^2/s

248. 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 co. Another disc of same dimensions but of mass M/4 is placed gently on the first disc co–axially, then the angular velocity of the system is
a) $\sqrt{2}\ \omega$ b) $4\ \omega/5$
c) $3\ \omega/4$ d) $4\ \omega$

249. A body of mass 2 kg and radius of gyration 0.5 m is rotating about an axis. If its angular speed is 2 rad/s, then the angular momentum of the body will be
a) 1 kg m^2/s b) 3 kg m^2/s
c) 2 kg m^2/s d) 4 kg m^2/s

250. Two rigid bodies with their moments of inertia in the ratio 2 : 3 have same rotational kinetic energy. Then ratio of their angular momenta is
a) 2 : 3 b) 3 : 2
c) $\sqrt{2} : \sqrt{3}$ d) $\sqrt{3} : \sqrt{2}$

251. Two wheels A and B are mounted on the same axle. Moment of inertia of A is 6 kg m^2 and is rotated at 600 rpm, when B is at rest. What will be moment of inertia of B, if their combined speed is 400 rpm ?
a) 8 kg m^2 b) 12 kg m^2
c) 3 kg m^2 d) 5 kg m^2

252. A particle of mass M is rotating in a plane in circular path of radius R. If its angular momentum is L, then the centripetal force acting on the particle will be
a) $\frac{L^2}{MR^3}$ b) $\frac{ML^2}{R^3}$
c) $\frac{MR^3}{L^2}$ d) $\frac{L^2}{2MR^3}$

253. If moment of inertia of a circular disc that makes 20 revolutions per second is 20 kg m^2. Its angular momentum in kg m^2/s
a) 2513 b) 400
c) 200 d) 1216

254. If a uniform solid sphere of diameter 0.2 m and mass 10 kg is rotated about its diameter with an angular velocity of 2 rad/s, then the its angular momentum in kg m^2/s will be
a) 0.01 b) 0.02
c) 0.08 d) 0.04

255. Mass remaining constant, if the earth suddenly contracts to one third of its present radius, the length of the day would be shorted by
a) 8/3 h b) 12 h
c) 8 h d) 64/3 h

256. If the radius of the earth decreases by 20 % such that mass does not change, then the length of the new day would be
a) $\frac{24\times16}{25}$h b) $\frac{24\times25}{16}$h
c) $\frac{25\times16}{24}$h d) $\frac{24}{16}$h

257. A uniform disc of mass M and radius R is rotating in a horizontal plane about an axis perpendicular to its plane with an angular velocity ω. Another disc of mass M/3 and radius R/2 is placed gently on the first disc coaxial. Then final angular velocity of the system is
a) $12\,\omega/13$ b) $13\,\omega/12$
c) $3\,\omega/4$ d) $11\,\omega/12$

258. A dancer spins about himself with an angular speed ω, with his arms extended. When he draws his hands in, his moment of inertia reduces by 40 %. Then his new angular velocity would be
a) $3\,\omega/5$ b) $4\,\omega/5$
c) $5\,\omega/4$ d) $5\,\omega/3$

259. A disc of mass 2 kg and radius 0.2 m is rotating about an axis passing through its centre and perpendicular to its plane with an angular velocity 50 rad/s. Another disc of mass 4 kg and radius 0.1 m rotates about an axis passing through its centre and perpendicular to its plane. If the two disc are coaxially coupled, then the angular velocity of the coupled system would be
a) 150 rad/s b) 120 rad/s
c) 100/3 rad/s d) 200/3 rad/s

260. The diameter of a fly wheel is 1 m. It has a mass of 20 kg. It is rotating aboutits axis with a speed of 120 rotations in one minute. Its angular

momentum in kg m^2s^{-1} is

a) 13.4 b) 31.4
c) 41.4 d) 43.4

261. Moment of inertia of a uniform horizontal solid cylinder of mass 'M' about an axis passing through its edge and perpendicular to the axis of the cylinder when its length is 6 times its radius 'R' is

a) $\frac{39MR^2}{4}$ b) $\frac{39MR}{4}$
c) $\frac{49MR}{4}$ d) $\frac{49MR^2}{4}$

262. The moment of inertia of a circular ring about an axis passing through its diameter is I. This ring is cut then unfolded into a uniform straight rod. The moment of inertia of the rod about an axis perpendicular to its length passing through one of its ends is

a) $\frac{4\pi^2 I}{3}$ b) $\frac{8\pi^2 I}{3}$
c) $\frac{16\pi^2 I}{3}$ d) $\frac{2\pi^2 I}{3}$

263. A circular disc P of radius R is made from an iron plate of thickness t and another disc Q of radius 2R is made from an iron plate of thickness $\frac{t}{2}$. The relation between their moments of inertia I_P and I_Q about their natural axes is

a) $I_Q = 4I_P$
b) $I_P = 8I_Q$
c) $I_P = 4I_Q$
d) $I_Q = 8I_P$

264. Two solid spheres (A and B) are made of metals of different densities r_A and r_B respectively. If their masses are equal, the ratio of their moments of inertia $\left(\frac{I_g}{I_A}\right)$ about their respective diameters is

a) $\left(\frac{\rho_B}{\rho_A}\right)^{2/3}$ b) $\left(\frac{\rho_A}{\rho_B}\right)^{2/3}$
c) $\frac{\rho_A}{\rho_B}$ d) $\frac{\rho_B}{\rho_A}$

3.7 Applications of principles of moment of inertia of a thin uniform rod, ring, disc, solid cylinder and solid sphere

265. The M.I. of a ring of mass M and radius R about an axis passing through its centre and perpendicular to its plane is

a) $MR^2/2$ b) $3/2\ MR^2$
c) MR^2 d) $2MR^2$

266. The M.I. of a circular ring of radius R and mass M about a tangent in its plane is

a) $MR^2/2$ b) $3/2\ MR^2$
c) MR^2 d) $2\ MR^2$

267. The M.I. of a circular ring of radius R and mass M about a tangent perpendicular to its plane is

a) $MR^2/2$ b) $3/2\ MR^2$
c) MR^2 d) $2\ MR^2$

268. The M.I. of a disc of mass M and radius R about an axis passing through its centre and perpendicular to its plane is

a) $MR^2/2$ b) $MR^2/4$
c) MR^2 d) $5/4\ MR^2$

269. The M.I. of a disc of mass M and radius R about a tangent to the plane is

a) $MR^2/2$ b) $5/4\ MR^2$
c) MR^2 d) $3/2\ MR^2$

270. The M.I. of a disc of mass M and radius R about a tangent in its plane is

a) $MR^2/2$ b) $MR^2/4$
c) MR^2 d) $5/4\ MR^2$

271. The M.I. of disc of mass M and radius 'R' about an axis passing through midway between centre and circumference and perpendicular to its plane is

a) $MR^2/2$ b) $5/4\ MR^2$
c) MR^2 d) $3/4\ MR^2$

272. The M.I.of thin uniform rod of mass 'M' and length 'l' about an axis passing through its one end and perpendicular to length is

a) Ml^2 b) $Ml^2 / 3$
c) $Ml^2 / 2$ d) $Ml^2/ 12$

273. The M.I.of thin uniform rod of mass 'M' and length 'l' about an axis passing through its centre and perpendicular to its length is

a) Ml^2 b) $Ml^2 / 3$
c) $Ml^2 / 2$ d) $Ml^2/12$

274. The M.I. of a rectangular plane lamina of mass M, length 'l' and breadth 'b' about an axis passing

through its centre and perpendicular to plane of lamina is

a) $\frac{Ml^2}{12}$ b) $\frac{Mb^2}{12}$

c) $\frac{M(l^2+b^2)}{12}$ d) $\frac{M}{12}\left(\frac{l^2}{b^2}+\frac{b^2}{4}\right)$

275. If I_1, I_2 and I_3 are the moments of inertia about the natural axies of solid sphere, hollow sphere and a spherical shell of same mass and radii, the correct result of the following is

a) $I_1 > I_2 > I_3$ b) $I_3 > I_2 > I_1$

c) $I_2 > I_1 > I_3$ d) $I_2 = I_3 > I_1$

276. The M.I. of solid sphere of mass M and radius R about its diameter is

a) $\frac{2}{5}MR^2$ b) $\frac{7}{5}MR^2$

c) $\frac{2}{3}MR^2$ d) $\frac{5}{3}MR^2$

277. The M.I. of a solid sphere of mass 'M' and radius 'R' about a tangent in its plane is

a) $\frac{2}{5}MR^2$ b) $\frac{7}{5}MR^2$

c) $\frac{2}{3}MR^2$ d) $\frac{5}{3}MR^2$

278. The radius of gyration of a solid sphere about a tangent in its plane is given by

a) $\sqrt{2/3}\ R$ b) $\sqrt{5/3}\ R$

c) $\sqrt{2/5}\ R$ d) $\sqrt{7/5}\ R$

279. A body of mass m slides down on an inclined plane and reaches the bottom with a velocity 'v', If the same mass were in the form of a ring which rolls down on the inclined plane, then the velocity of the ring at the bottom will be

a) v b) $\frac{v}{\sqrt{2}}$

c) $\sqrt{2}\ v$ d) $\frac{\sqrt{2}}{5}v$

280. 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) $M\left(\frac{L^2}{12}+\frac{D^2}{16}\right)$

281. If a thin rod of length L and mass M is bent at the middle point 0 at an angle of 60°, then the moment of inertia of the rod about an axis passing through 0 and perpendicular to plane of the rod will be

a) $\frac{ML^2}{6}$ b) $\frac{ML^2}{12}$

c) $\frac{ML^2}{24}$ d) $\frac{ML^2}{3}$

282. If the moment of inertia of a thin uniform circular disc about diameter is I, then its M.I. about an axis perpendicular to its plane and passing through a point on its rim will be

a) 5 I b) 3 I

c) 6 I d) 4 I

283. The moment of inertia of a solid sphere of mass M and radius R, about its diameter is (2/5) MR^2. Its M.I. about parallel axis passing through a point at a distance (R/2) from its centre is

a) $\frac{15}{20}MR^2$ b) $\frac{7}{5}MR^2$

c) $\frac{13}{20}MR^2$ d) $\frac{8}{15}MR^2$

284. The M.I. of a thin uniform rod of length L and mass M about an axis passing through a point at a distance of (L/4) from the centre and perpendicular to length of the rod is,

a) $\frac{19ML^2}{48}$ b) $\frac{38ML^2}{48}$

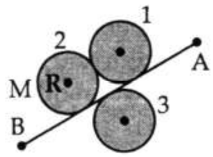
c) $\frac{7ML^2}{48}$ d) $\frac{ML^2}{12}$

285. Three identical rods, each of mass m and length l are placed ,along x, y and z axis respectively. One end of each rod is at the origin. The moment of inertia of the rods about x–axis will be

a) ml^2 b) $\frac{5ml^2}{3}$

c) $\frac{2ml^2}{3}$ d) $\frac{ml^2}{3}$

286. Three identical solid discs, each of mass M and radius R, are arranged as shown in figure. The moment of inertia of the system about an axis AB will be



a) $\frac{11}{4}MR^2$ b) $\frac{15}{4}MR^2$

c) $\frac{13}{4}MR^2$ d) $\frac{21}{5}MR^2$

287. If the moment of inertia of a ring about transverse axis passing through its centre is 6 kg m^2, then the M.I. about a tangent in its plane will be

a) 3 kg m^2 b) 9 kg m^2

c) 6 kg m^2 d) 12 kg m^2

288. Three spheres, each mass M and radius R, are arranged as shown in the figure. The moment of inertia of the system will be

a) 21/5 MR^2 b) 16/5 MR^2

c) 7/2 MR^2 d) 4/5 MR^2

289. What is the moment of inertia of a solid sphere of radius 3 cm and density 3 g/cm^3 about its diameter in C.G.S. system?

a) 148 π b) 388 π

c) 138 π d) 216 π

290. What is the moment of inertia of a hallow sphere of radius 3 cm and density 3 g/cm^3 about its diameter in C.G.S. system?

a) 148 π b) 648 π

c) 138 π d) 216 π

291. Three point masses, each of mass 2 kg are placed at the corners of an equilateral triangle of side 2 m. What is moment of inertia of this system about an axis along one side of a triangle?

a) 2 kg m^2 b) 4 kg m^2

c) 6 kg m^2 d) 8 kg m^2

292. If the position of axis of rotation of a body is changed, then 'a physical quantity changes which is

a) radius of gyration b) moment of inertia

c) total mass d) both' a' and 'b'

293. The moment of inertia of a ring about one of its diameter is 2 kg m^2. What will be its moment of inertia about a tangent parallel to the diameter?

a) 2 kg m^2 b) 6 kg m^2

c) 4 kg m^2 d) 5 kg m^2

294. If ρ is density of the material of a sphere of radius R. Then its moment of inertia about its diameter is

a) $\frac{8\pi}{15}\rho R^5$ b) $\frac{4\pi}{3}\rho R^5$

c) $\frac{2\pi}{5}\rho R^5$ d) $\frac{4\pi}{3}\rho R^4$

295. Moment of inertia of a uniform ring about its diameter is I. Then its moment of inertia about axis passing through its centre and perpendicular to its plane is

a) I/4 b) I/2

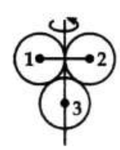
c) I d) 21

296. Moment of inertia of a rigid body about an axis through its centre of gravity is 10 kg m^2. If mass of the body is 2 kg, moment of inertia of the body about an axis parallel to the first axis and separated by a distance of 1 m is

a) 12 kg m^2 b) 8 kg m^2

c) 4 kg m^2 d) 2 kg m^2

297. Three rings, each of mass P and radius Q are arranged as shown in the figure. The moment of inertia of the arrangement about YY' axis will be



a) (7/2) PQ^2 b) (2/7) PQ^2

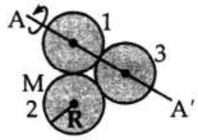
c) 2/5 PQ^2 d) (5/2) PQ^2

298. If moment of inertia of a solid sphere of mass 5 kg about its diameter is 50 kg m^2. Its moment of inertia about its tangent in kg m^2 is

a) 260 b) 250

c) 240 d) 175

299. Three identical solid discs, each A of mass M and radius R, are arranged as shown in the figure. The moment of inertia of the system about the axis AA' will be



a) (7/4) MR^2　　b) (11/4) MR^2
c) (15/4) MR^2　　d) (19/4) MR^2

300. The moment of inertia of a disc about an axis passing through its centre and perpendicular to its plane is 1 kg m^2. Its moment of inertia about an axis coincident with the tangent to it is

a) I　　b) $\frac{5}{4}I$
c) $\frac{5}{2}I$　　d) 3 I

301. Two rings of the same mass and radius are placed such that their centers are at a common point and their planes are perpendicular to each other. The moment of inertia of the system about an axis passing the diameter of one of the rings is I. Then moment of inertia of one ring of the system about the central axis and perpendicular to its plane would be

a) 3 I　　b) 3I/2
c) 2 I　　d) 2 I/3

302. Moment of inertia of a thin uniform rod about an axis passing through one end and perpendicular to its length is I. Then moment of inertia of the same rod about the central axis perpendicular to its plane is

a) I/4　　b) 2I
c) 4 I　　d) 3 I

303. A thin wire of mass m and length I is bent in the form of a ring. Moment of inertia of that ring about an axis passing through its centre and perpendicular to its plane is

a) $ml^2/4\pi$　　b) $ml^2/2\pi$
c) $ml^2/4\pi^2$　　d) $ml^2/2\pi^2$

304. Two solid spheres of different materials have the same moments of inertia about their diameters. If r_1 and r_2 are their radii, ratio of their densities is

a) $r_1^2 : r_2^3$　　b) $r_2^3 : r_2^3$
c) $r_1^5 : r_2^5$　　d) $r_2^5 : r_1^5$

305. 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 is

a) I/8　　b) I/16
c) I/24　　d) I/32

306. Particles each of mass 1 kg are placed at 1 m, 2 m and 4 m on X–axis with respect to origin. Then moment of inertia of the system about Y–axis is

a) 7 kg m^2　　b) 14 kg m^2
c) 21 kg m^2　　d) 28 kg m^2

307. The M.I. of the solid sphere of density 'p' and radius 'R' about an axis passing through its centre is given by

a) $\frac{105}{176}R^2\rho$　　b) $\frac{176}{105}R^2\rho$
c) $\frac{176}{105}R^5\rho$　　d) $\frac{105}{132}R^2\rho$

308. The M.I. of a thin uniform stick of mass 9 gm about an axis passing through one end perpendicular to the length of a meter stick is

a) 90 gm cm^2　　b) 9 kg m^2
c) 3 gm m^2　　d) 9.8 kg m^2

309. The moment of inertia of a circular disc about an axis passing through its centre and perpendicular to the plane is 4 kg m^2. Its moment of inertia about the diameter is

a) 2 kg m^2　　b) 6 kg m^2
c) 4 kg m^2　　d) 8 kg m^2

310. If a uniform solid sphere of radius R and mass m rotates about a tangent and has moment of inertia 42 kg m^2, then the moment of inertia of a solid sphere about an axis passing through its centre and perpendicular to its plane will be

a) 12 kg m^2　　b) 18 kg m^2
c) 300 kg m^2　　d) 24 kg m^2

311. A solid sphere and solid disc having the same mass and radius roll down on the same incline what is the ratio of their acceleration?

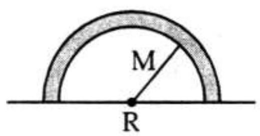
a) $\frac{15}{14}$　　b) $\frac{11}{14}$
c) $\frac{13}{14}$　　d) $\frac{17}{14}$

312. Two spheres each mass M and radius R are connected with massless rod of length 2R. Then moment of inertia of the system about an axis passing through the centre of one of sphere and perpendicular to the rod will be

a) $\frac{21}{5}MR^2$ b) $\frac{23}{5}MR^2$

c) $\frac{22}{5}MR^2$ d) $\frac{24}{5}MR^2$

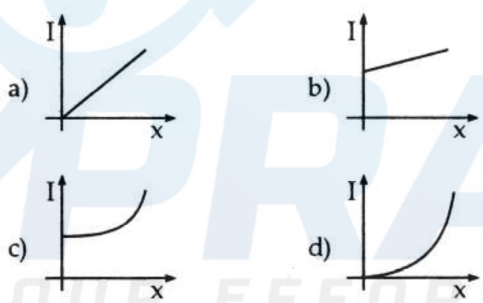
313. A semicircular ring of mass M and radius R is rotating about its diameter. The moment of inertia of the semicircular ring will be



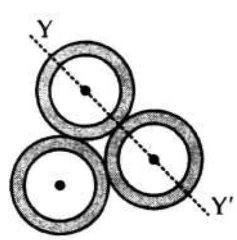
a) MR^2 b) $MR^2/2$

c) $MR^2/3$ d) $MR^2/4$

314. The moment of inertia of a solid sphere about an axis parallel to the diameter of the solid sphere and at a distance x from it is represented by I. Then, the correct variation of Iwith x is given by the curve



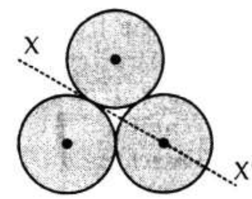
315. Three rings each of mass M and radius R are placed in contact with each other as shown. Then MI of the system about YY' axis is



a) MR^2 b) $\frac{1}{2}MR^2$

c) $\frac{3}{2}MR^2$ d) $\frac{9}{2}MR^2$

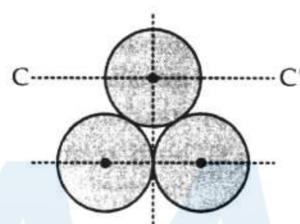
316. Three discs each of mass M and radius R are placed in X contact with each other as shown in figure here. Then the MI of the system about an axis XX' is



a) $\frac{11}{2}MR^2$ b) $\frac{11}{4}MR^2$

c) $\frac{7}{2}MR^2$ d) $\frac{7}{4}MR^2$

317. Thee spheres each of mass M and radius R are placed in contact with each other as shown in the figure here. Then the moment of inertia of the system about the axis CC' is



a) $\frac{15}{2}MR^2$ b) $\frac{27}{4}MR^2$

c) $\frac{36}{5}MR^2$ d) none of the above

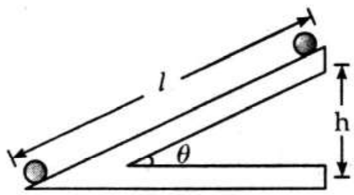
3.8 Rolling Motion

318. A disc and a hoop of the same mass and size roll down on inclined plane starting simultaneously. Then the one which reaches bottom first
a) hoop
b) disc
c) depends upon angle of incline
d) both

319. A sphere is rolled on a rough horizontal surface. It gradually slows down and stops. The force of friction tries to
a) decrease the linear velocity
b) increase the angular velocity
c) increase the linear momentum
d) decrease the angular velocity

320. A and B are two identical rings released from

the top of an inclined plane. A slides down and Broils down. Then which reaches the bottom first?



a) A b) B
c) both in same time d) none of these

321. In the above problem No. 320, which will reach the bottom with greater velocity?
a) A
b) B
c) both will same velocity
d) none of these

322. In rotatory motion, linear velocities of all the particles of a body
a) are same
b) are different
c) can not be predicted
d) are zero

323. The correct statement about angular momentum is
a) directly proportional to moment of inertia
b) a scalar quantity
c) inversely proportional to moment of
d) its direction always is tangential at a point

324. When a body starts to roo on an inclined plane, its potential energy is converted into
a) translational kinetic energy only
b) rotational kinetic energy only
c) both translational and rotational kinetic energies
d) neither translational nor rotational kinetic energies

325. If the angular momentum of any rotating body increases by 200 %, then the increase in its kinetic energy is
a) 400 % b) 800 %
c) 200 % d) 100 %

326. A ring, a disc, a hollow sphere, a solid sphere of the same mass and radius are released from the top of an inclined plane. Then the bodies which reach the bottom first and last are
a) solid sphere, hollow sphere
b) solid sphere, disc
c) ring, solid sphere
d) solid sphere, ring

327. In the above question No. 326, the reason for the bodies to have different times of descent is
a) they have same mass
b) they have same radius
c) they have different radii of gyration
d) all

328. If a body is rolling on a surface without slipping such that its kinetic energy of translation is equal to kinetic energy of rotation then it is a
a) ring b) disc
c) spherical shell d) sphere

329. If a ring, disc, hollow sphere and solid sphere rolling horizontally without slipping with the same velocity on a surface, then translational kinetic energy is more for
a) ring b) disc
c) sphere d) we can not say

330. A ring, disc, hollow sphere and solid sphere roll on a horizontal surface with the same linear speed. If they have same mass and radius and move without slipping, rotational kinetic energy is more for
a) ring b) disc
c) hollow sphere d) solid sphere

331. A ring, disc, spherical shell and solid sphere of same mass and radius are rolling on a horizontal surface without slipping with same velocity. If they move up an inclined plane, which can reach to a maximum height on the inclined plane?
a) ring b) disc
c) spherical shell d) solid sphere

332. A solid cylinder and a solid sphere rolls down on the same inclined plane. Then ratio of their accelerations is
a) 15 : 14 b) 14 : 15
c) 5 : 7 d) 7 : 5

333. Total kinetic energy of a rolling solid sphere of mass m with velocity is
a) $\frac{1}{2}$ mv^2 b) $\frac{1}{5}$ mv^2
c) $\frac{7}{10}$ mv^2 d) $\frac{7}{5}$ mv^2

334. A circular hoop rolls down an inclined plane. The ratio of its total energy to rotational kinetic energy is

a) 2 : 1 b) 1 : 3
c) 3 : 1 d) 4 : 1

335. A solid sphere rolls without slipping down a 30° inclined plane. If g = 10 ms^{-2} then the acceleration of the rolling sphere is

a) 5 ms^{-2} b) $\frac{7}{25}$ ms^{-2}
c) $\frac{25}{7}$ ms^{-2} d) $\frac{15}{7}$ ms^{-2}

336. A cylindrical ring is rolling without slipping. The ratio of rotational and translational kinetic energies is

a) 0.25 b) 0.5
c) 1 d) 1.5

337. A solid cylinder of mass 0.1 kg having radius 0.2 m rolls down an inclined plane of height 0.6 m without slipping. The linear velocity of the cylinder at the bottom of the inclined plane is

a) 28 ms^{-1} b) 2.8 ms^{-1}
c) 280 ms^{-1} d) 0.28 ms^{-1}

338. A circular disc first rolls without slipping and then slides without rolling down the same inclined plane. The ratio of velocities of the disc at the bottom of the plane in both the cases respectively is

a) $2 : \sqrt{3}$ b) $\sqrt{3} : 2$
c) $\sqrt{2} : \sqrt{3}$ d) 3 : 2

339. A circular ring starts rolling down an inclined plane from its top. On reaching the bottom of the inclined plane, the veocity of its centre of mass is v. If a block starts sliding down the same inclined plane from the top, its velocity on reaching the bottom of the inclined plane is

a) $\sqrt{3}$ v b) $\frac{v}{\sqrt{3}}$
c) $\frac{v}{\sqrt{2}}$ d) $\sqrt{2}$ v

340. A hollow cylinder and a solid cylinder having the same mass and diameter are released from rest simultaneously from the top of an inclined plane. They roll without slipping which will reach the bottom firstly

a) the solid cylinder
b) the hollow cylinder
c) both will reach the bottom together
d) can not be predicted

341. A string is wrapped several times round a solid cylinder. Then free end of the string is held stationary. If the cylinder is released to move down, then the acceleration of that cylinder is

a) g/3 b) g/2
c) 3g/2 d) 2g/3

342. When a solid sphere rolls down on an inclined plane of inclination 30° to the horizontal without slipping, acceleration of its centre of mass is

a) 2g/7 b) 5g/7
c) g/7 d) 5g/14

343. A uniform ring rolls on a horizontal surface with out slipping. Its centre of mass moves with a constant speed v. Then speed of the upper most point on its rim above the ground is

a) v b) 2v
c) v/2 d) $\sqrt{2}$ v

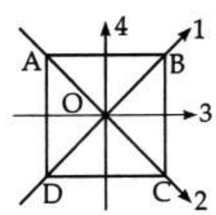
344. Two loops P and Q are made from a uniform wire. The radii of P and Q are r_1 and r_2 respectively and their moments of inertia are I_1 and I_2 respectively. If $I_1/I_2 = 4$, then r_2/r_1 equals

a) $4^{2/3} : 1$ b) $1 : 4^{1/3}$
c) 1 : 2 d) $4^{-1/2} : 1$

345. A ring of mass 10 kg and diameter 0.4 m is rotated about an axis passing through its centre and perpendicular to its plane moment of inertia of the ring is

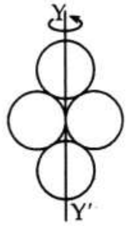
a) 1.4 kg m^2 b) 2.4 kg m^2
c) 0.4 kg m^2 d) 2 kg m^2

346. The moment of inertia of a thin square plate ABCD of uniform thickness about an axis passing through its center and perpendicular to its plane will be



a) $I_1 + I_2$ b) $I_1 - I_3$
c) $I_1 + I_2 + I_4$ d) $I_1 + I_2 + I_3$

347. Four rings each of mass M and radius R are arranged as shown in the figure. The moment of inertia of the system about YY' will be



a) $3\ MR^2$ b) $\frac{3}{2}MR^2$

c) $4\ MR^2$ d) $\frac{7}{2}MR^2$

348. Moment of inertia of a ring of mass m = 3 gm and radius r = 1 cm, about an axis passing through its edge and parallel to its natural axis is

a) 10 gm cm^2 b) 100 gm cm^2
c) 6 gm cm^2 d) 1 gm cm^2

349. A cylinder of 500 g and radius 10 cm has moment of inertia about an axis passing through its centre and parallel to its length is

a) 2.5×10^{-3} kg m^2 b) 2×10^{-3} kg m^2
c) 5×10^{-3} kg m^2 d) 3.5×10^{-3} kg m^2

350. Three point masses m_1, m_2, m_3 are located at the vertices of an equilateral triangle of length 'a'. The moment of inertia of this system about an axis along the altitude of the triangle passing through m_1, is

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

c) $(m_1 + m_2)\frac{a^2}{4}$ d) $(m_2 + m_3)\ a^2$

351. Three point masses each of mass m are placed at the corners of an equilateral triangle of side' a'. Then the moment of inertia of this system about an axis passing along one side of the triangle is

a) ma^2 b) $3\ ma^2$

c) $\frac{3}{4}\ ma^2$ d) $\frac{2}{3}\ ma^2$

352. Three rods of length L and mass M are placed along X, Y and Z axes in such a way that one end of each of the rod is at the origin. The moment of inertia of this system about Z axis is

a) $\frac{2ML^2}{3}$ b) $\frac{4ML^2}{3}$

c) $\frac{5ML^2}{3}$ d) $\frac{ML^2}{3}$

353. Two rings of the same radius and mass are placed such that their centres are at a common point and their planes are perpendicular to each other. The moment of inertia of the system about an axis passing through the centre and perpendicular to, the plane of one of the rings is
(Mass of the Ring = M and Radius = R)

a) $\frac{1}{2}\ MR^2$ b) MR^2

c) $\frac{3}{2}\ MR^2$ d) $2\ MR^2$

354. Two circular iron discs are of the same thickness. The diameter of A is twice that of B. The moment of inertia of A as compared to that of B is

a) twice as large b) four times as large
c) 8 times as large d) 16 times as large

355. The flywheel is so constructed that the entire mass of it is concentrated at its rim, because,

a) it increases the power
b) it increases the speed
c) it increases the moment of inertia
d) it save the flywheel fan breakage

356. Four spheres of diameter 2a and mass Mare 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) $\frac{4}{5}\ Ma^2 + 2\ Mb^2$ b) $\frac{8}{5}\ Ma^2 + 2\ Mb^2$

c) $\frac{8}{5}\ Ma^2$ d) $\frac{4}{5}\ Ma^2 + 4\ Mb^2$

357. Two discs have same mass and thickness. Their materials are of densities ρ_1 and ρ_2. The ratio of their moment of inertia about central axis will be

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

358. A wheel of moment of inertia 5×10^{-3} kg–m^2 is making 20 revolutions/sec. The torque required to stop it in 10 see is

a) $2\ \pi \times 10^{-2}$ Nm b) $2\ \pi \times 10^{2}$ N m
c) $4\ \pi \times 10^{-2}$ Nm d) $4\ \pi \times 10|$ Nm

359. If all of a sudden the radius of the earth decreases, then

a) the angular momentum of the earth will become greater than that of the sun

b) the angular speed of the earth will increase

c) the periodic time of the earth will increase

d) the energy and angular momentum will remain constant

Questions given in MHT–CET

360. The moment of inertia of a thin circular disc of mass M and radius R about any diameter is

a) $\frac{MR^2}{4}$ b) $\frac{MR^2}{2}$

c) MR^2 d) $2\ MR^2$

361. A body of moment of inertia of 3 k gm^2 rotating with an angular velocity or 2 rad/s has the same kinetic energy as a mass of 12 kg moving with a velocity of

a) 1 m/s b) 2 m/s

c) 4 m/s d) 8 m/s

362. The radius of gyration of a disc of mass 100 gm and radius 5 cm about an axis passing through its centre of gravity and perpendicular to the plane is

a) 0.5 cm b) 2.5 cm

c) 3.54 cm d) 6.54 cm

363. Two circular discs A and B have equal masses and uniform thickness but have densities ρ_1 and ρ_2 such that $\rho_1 > \rho_2$. Their moments of inertia is

a) $I_1 > I_2$ b) $I_1 >> I_2$

c) $I_1 < I_2$ d) $I_1 = I_2$

364. For increasing the angular velocity of a object by 10%, the kinetic energy has to be increased by

a) 40 % b) 20%

c) 10% d) 21%

365. M.I. of a thin uniform rod about the axis passing through its centre and perpendicular to its length is $ML^2/12$. The rod is cut transversely into two halves, which are then riveted end to end. 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) $\frac{ML^2}{12}$

c) $\frac{ML^2}{48}$ d) $\frac{ML^2}{6}$

366. The moment of inertia of an electron in nth orbit will be

a) $MR^2 \times n$ b) $\frac{MR^2 \times n}{2}$

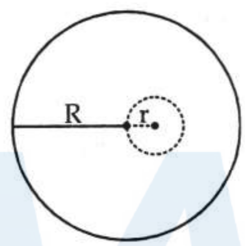
c) $\frac{2}{5}\ MR^2 \times n$ d) $\frac{2}{3}\ MR^2 \times n$

367. The moment of inertia of uniform circular disc about an axis passing through its centre is 6 kgm^2, Its M. I. about an axis perpendicular to its plane and just touching the rim will be

a) 18 kg m^2 b) 30 kg m^2

c) 15 kg m^2 d) 3 kg m^2

368. What will be distance of centre of mass of the disc (See fig.) from its geometrical centre?



a) $\frac{r}{\left(\frac{R^2}{r^2}-1\right)}$ to left b) R + r, to left

c) $\frac{r}{R+r}$, to left d) $\frac{r}{(r^2+R^2)}$, to left

369. Moment of inertia depends on

a) distribution of particles

b) mass

c) position of axis of rotation

d) all of these

370. The moment of inertia of a disc about a tangent axis in its plane is

a) $\frac{mR^2}{4}$ b) $\frac{3MR^2}{2}$

c) $\frac{5}{4}MR^2$ d) $\frac{7MR^2}{4}$

371. A sphere of mass 0.5 kg and diameter 1 m rolls without sliding with a constant velocity of 5 m/s.

What is the ratio of the rotational K.E. to the total kinetic energy of the sphere?

a) $\frac{7}{10}$ b) $\frac{5}{7}$

c) $\frac{2}{7}$ d) $\frac{1}{2}$

372. Radius of gyration of disc rotating about an axis perpendicular to its plane passing through its centre is (If R is the radius of disc)

a) $\frac{R}{2}$ b) $\frac{R}{\sqrt{2}}$

c) $\frac{R}{\sqrt{3}}$ d) $\frac{R}{3}$

373. $\frac{L^2}{2I}$ represents

a) rotational kinetic energy of a particle
b) potential energy of a particle
c) torque on a particle
d) power

374. A disc of moment of inertia $9.8/\pi^2$ kg m^2 is rotating at 600 rpm. If the frequency of rotation changes from 600 rpm to 300 rpm, then what is the work done?

a) 1470 J b) 1452 J
c) 1567 J d) 1632 J

375. The centre of mass of a system of two particles divides. The distance between them

a) inverse ratio of square of masses of particle
b) direct ratio of square of masses of particle
c) inverse ratio of rnasses of particle
d) direct ratio of masses of particle

376. A particle moves for 20 s with velocity 3 m/s and then moves with velocity 4 m/s for another 20 s and finally moves with velocity 5 m/s for next 20 s. What is the average velocity of the particle?

a) 3 m/s b) 4 m/s
c) 5 m/s d) zero

377. Dimensions of angular momentum is

a) $[L^1M^1T^{-2}]$ b) $[L^{-2}M^1T^{-1}]$
c) $[L^2M^1T^{-1}]$ d) $[L^0M^1T^{-1}]$

378. The torque acting is 2000 Nm with an angular acceleration of 2 rad/s^2. The moment of inertia of body is

a) 1200 kgm^2 b) 900 kgm^2
c) 1000 kgm^2 d) can't say

379. If radius of solid sphere is doubled by keeping its mass constant, then

a) $\frac{I_1}{I_2}=\frac{1}{4}$ b) $\frac{I_1}{I_2}=\frac{4}{1}$

c) $\frac{I_1}{I_2}=\frac{3}{2}$ d) $\frac{I_1}{I_2}=\frac{2}{3}$

380. Moment of inertia of a disc about an axis which is tangent and parallel to its plane is I. Then the moment of inertia of disc about a tangent, but perpendicular to its plane will be

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

c) $\frac{5I}{6}$ d) $\frac{6I}{5}$

381. By keeping moment of inertia of a body constant, if we double the time period, then angular momentum of body

a) remains constant b) becomes half
c) doubles d) quadruples

382. 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 m^2.

a) 12 kg m^2 b) 3 kg m^2
c) 6 kg m^2 d) 9 kg m^2

383. A uniform disc of mass 2 kg is rotated about an axis perpendicular to the plane of the disc. If radius of gyration is 50 cm, then the M.I. of disc about same axis is

a) 0.25 kg m^2 b) 0.5 kg m^2
c) 2 kg m^2 d) 1 kg m^2

384. The total energy of rolling ring of mass 'm' and radius 'R' is

a) 3/2 mv^2 b) 1/2 mv^2
c) mv^2 d) 5/2 mv^2

385. The diamentions of angular momentum are

a) $[L^{-2}\ M^1\ T^{-1}]$ b) $[L^2M^1\ T^{-1}]$
c) $[L^2M^1\ T^1]$ d) $[L^2M^2\ T^{-2}]$

386. Two discs has same mass rotates about the same axis with their densities ρ_1 and ρ_2 respectively such that ($\rho_1 > \rho_2$), then the relation between I_1 and I_2 will be

a) $I_1 < I_2$ b) $I_1 = I_2$

c) $I_1 > I_2$ d) $I_1 = 2I_2$

387. Kinetic energy of a body is 4 J and its moment of inertia is 2 kg m², then angular momentum is

a) 2 kg m²/s b) 6 kg m²/s
c) 8 kg m²/s d) 4 kg m²/s

388. A rod of length l, density of material D and area of cross section is A. If it rotates about its axis perpendicular to the length and passing through its centre, then its kinetic energy of rotation will be

a) $\frac{Al^3D.\omega^2}{12}$ b) $\frac{Al^3D.\omega^2}{24}$
c) $\frac{Al^3D.\omega^2}{6}$ d) $\frac{Al^3D.\omega^2}{48}$

389. A body is acted upon by a constant torque. In 4 seconds its angular momentum changes from L to 4 L. The magnitude of the torque is

a) $\frac{L}{4}$ b) $\frac{3L}{4}$
c) 3 L d) 12 L

390. Radius of gyration of a ring about a transverse axis passing through its centre is

a) 0.5 × diameter of ring
b) diameter of ring
c) 2 × diameter of ring
d) (diameter of ring)²

391. If the radius of the earth contracts to half of its present radius, then the length of the day will be (if density of the earth remaining same)

a) $\frac{3}{4}$ hour b) 6 hour
c) 12 hour d) 24 hour

392. 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.

393. 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 is

a) I/8 b) I/16
c) I/24 d) I/32

394. Two uniform circular disc A and B of radii Rand 4R with thickness x and x/4 respectively, rotates about their axes 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) $I_B > I_A$ d) data is insufficient

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

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

396. 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 (g = acceleration due to gravity)

a) $\frac{2}{5}MR^2$ b) $\frac{MR^2}{2}$
c) MR^2 d) $\frac{3}{2}MR^2$

397. 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) $\frac{8\pi^2}{5}$

398. 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) $\frac{AB + AC}{3}$

399. 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) $\frac{MR^2}{4} + \frac{Ml^2}{12}$

400. 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) $[mgh]^{1/2}$ b) $\left[\frac{2mgh}{I + 2mr^2}\right]^{1/2}$

c) $\left[\frac{2mgh}{I + mr^2}\right]^{1/2}$ d) $\left[\frac{mgh}{I + mr^2}\right]^{1/2}$

401. A hollow sphere of mass 'M' and radius 'R' is rotating with angular frequency 'ω'. It suddenly stops rotating and 75% of kinetic energy is converted to heat. If '5' is the specific heat of the materialin J/kg K then rise in temperature of the sphere is (M.I. of hollow sphere = $\frac{2}{3}$ MR^2)

a) $\frac{R\omega}{4S}$ b) $\frac{R^2\omega^2}{4S}$

c) $\frac{R\omega}{2S}$ d) $\frac{R^2\omega^2}{2S}$

❍❍❍

Answers

1. (c)	2. (c)	3. (b)	4. (d)	5. (a)	6. (c)	7. (d)	8. (d)	9. (c)	10. (b)
11. (b)	12. (a)	13. (c)	14. (c)	15. (d)	16. (a)	17. (b)	18. (b)	19. (c)	20. (d)
21. (a)	22. (b)	23. (b)	24. (b)	25. (c)	26. (b)	27. (b)	28. (b)	29. (d)	30. (b)
31. (c)	32. (a)	33. (a)	34. (c)	35. (d)	36. (b)	37. (a)	38. (d)	39. (c)	40. (a)
41. (c)	42. (b)	43. (c)	44. (b)	45. (b)	46. (c)	47. (d)	48. (c)	49. (c)	50. (b)
51. (b)	52. (b)	53. (b)	54. (d)	55. (b)	56. (b)	57. (c)	58. (a)	59. (c)	60. (b)
61. (c)	62. (c)	63. (c)	64. (b)	65. (c)	66. (c)	67. (c)	68. (c)	69. (c)	70. (c)
71. (c)	72. (c)	73. (c)	74. (c)	75. (d)	76. (a)	77. (b)	78. (d)	79. (c)	80. (b)
81. (b)	82. (c)	83. (a)	84. (a)	85. (c)	86. (c)	87. (b)	88. (b)	89. (d)	90. (c)
91. (b)	92. (c)	93. (b)	94. (a)	95. (d)	96. (a)	97. (a)	98. (d)	99. (d)	100. (c)
101. (c)	102. (b)	103. (c)	104. (d)	105. (d)	106. (b)	107. (c)	108. (b)	109. (a)	110. (d)
111. (b)	112. (d)	113. (d)	114. (c)	115. (c)	116. (a)	117. (c)	118. (d)	119. (a)	120. (b)
121. (a)	122. (b)	123. (b)	124. (c)	125. (b)	126. (a)	127. (a)	128. (b)	129. (c)	130. (a)
131. (c)	132. (c)	133. (c)	134. (a)	135. (a)	136. (b)	137. (b)	138. (d)	139. (b)	140. (c)
141. (a)	142. (b)	143. (b)	144. (d)	145. (b)	146. (b)	147. (b)	148. (b)	149. (c)	150. (c)
151. (a)	152. (c)	153. (d)	154. (c)	155. (c)	156. (c)	157. (c)	158. (a)	159. (a)	160. (b)
161. (d)	162. (d)	163. (d)	164. (b)	165. (c)	166. (b)	167. (a)	168. (b)	169. (a)	170. (c)
171. (a)	172. (d)	173. (c)	174. (c)	175. (b)	176. (a)	177. (b)	178. (b)	179. (c)	180. (c)
181. (b)	182. (c)	183. (a)	184. (c)	185. (b)	186. (b)	187. (a)	188. (c)	189. (d)	190. (b)
191. (b)	192. (b)	193. (c)	194. (c)	195. (d)	196. (b)	197. (a)	198. (a)	199. (d)	200. (b)
201. (a)	202. (a)	203. (b)	204. (b)	205. (b)	206. (b)	207. (d)	208. (c)	209. (d)	210. (b)
211. (c)	212. (a)	213. (a)	214. (d)	215. (b)	216. (c)	217. (b)	218. (d)	219. (a)	220. (a)
221. (a)	222. (b)	223. (b)	224. (c)	225. (b)	226. (d)	227. (c)	228. (d)	229. (b)	230. (c)
231. (a)	232. (d)	233. (d)	234. (d)	235. (c)	236. (c)	237. (d)	238. (c)	239. (c)	240. (b)
241. (a)	242. (c)	243. (c)	244. (b)	245. (a)	246. (c)	247. (a)	248. (b)	249. (a)	250. (c)
251. (c)	252. (a)	253. (a)	254. (c)	255. (d)	256. (a)	257. (a)	258. (d)	259. (c)	260. (b)
261. (d)	262. (b)	263. (d)	264. (b)	265. (c)	266. (b)	267. (d)	268. (a)	269. (d)	270. (d)
271. (d)	272. (b)	273. (d)	274. (c)	275. (d)	276. (a)	277. (b)	278. (d)	279. (b)	280. (d)
281. (b)	282. (c)	283. (c)	284. (c)	285. (c)	286. (b)	287. (b)	288. (b)	289. (b)	290. (b)
291. (c)	292. (d)	293. (b)	294. (a)	295. (d)	296. (a)	297. (a)	298. (d)	299. (c)	300. (d)
301. (d)	302. (a)	303. (c)	304. (d)	305. (d)	306. (c)	307. (c)	308. (c)	309. (a)	310. (a)
311. (a)	312. (d)	313. (b)	314. (c)	315. (d)	316. (b)	317. (c)	318. (b)	319. (a)	320. (a)
321. (a)	322. (b)	323. (a)	324. (c)	325. (b)	326. (d)	327. (c)	328. (a)	329. (d)	330. (a)
331. (a)	332. (b)	333. (c)	334. (a)	335. (c)	336. (c)	337. (b)	338. (c)	339. (d)	340. (a)
341. (d)	342. (d)	343. (b)	344. (b)	345. (c)	346. (a)	347. (c)	348. (c)	349. (a)	350. (a)
351. (c)	352. (a)	353. (c)	354. (d)	355. (c)	356. (b)	357. (d)	358. (a)	359. (b)	360. (a)
361. (a)	362. (c)	363. (c)	364. (d)	365. (b)	366. (a)	367. (a)	368. (a)	369. (d)	370. (c)
371. (c)	372. (b)	373. (a)	374. (a)	375. (c)	376. (b)	377. (c)	378. (c)	379. (a)	380. (d)
381. (b)	382. (c)	383. (b)	384. (c)	385. (b)	386. (a)	387. (d)	388. (b)	389. (b)	390. (a)
391. (a)	392. (b)	393. (d)	394. (c)	395. (c)	396. (b)	397. (b)	398. (d)	399. (d)	400. (c)
401. (b)									

16. $r_1 = \left(\frac{m_2}{m_1+m_2}\right) r = \frac{10}{15} \times 12 = 8 \text{ cm}$

17. (i) $x = \frac{m_1n_1 + m_2x_2 + m_2x_3 + m_4x_4}{m_1+m_2+m_3+m_4} = \frac{-7}{14} = \frac{-1}{2}$

(ii) $y = \frac{m_1y_1 + m_2y_2 + m_3y_3 + m_4y_4}{m_1+m_2+m_3+m_4} = \frac{-5}{14}$

(x, y) of centre of mass $= \left(\frac{-1}{2}, \frac{-5}{14}\right)$.

23. $R_g = \frac{m_1x_1 + m_2x_2 + m_3x_3 + m_4x_4}{m_1+m_2+m_3+m_4}$

$m_1 = m_2 = m_3 = m_4 = m$

$R = \frac{(x_1+x_2+x_3+x_4)}{4}$

$= \frac{AB+BC+BD}{4}$

57. $MK^2 = 2\text{ m} \Rightarrow K = \sqrt{2}$ units.

59. $l = \sum mr^2 = 1\,(1)^2 + 2\,(2)^2 + 3\,(3)^2$

$= 1 + 8 + 27$

$= 36 \text{ kg m}^2$.

60. $I = \left(\frac{m_1m_2}{m_1+m_2}\right) d^2$.

62. $r_2 = \left(\frac{m_1}{m_1+m_2}\right) r = \frac{6}{5} \times 25 = 30 \text{ kg.m}^2$.

63. $l = m_1r_1^2 + m_2r_2^2 + m_3r_3^2$

$= 2m\,(a^2) + 3m\,(4a^2) + 4m\,(9a^2)$

$= 2ma^2 + 12ma^2 + 36ma^2$

$= 50\text{ ma}^2$.

65. $I = \frac{M}{12}(b^2 + b^2)$

$= \frac{M}{12} 2b^2$

$\therefore \frac{MR^2}{2} = \frac{M2b^2}{12}$

$\therefore \frac{b}{R} = \sqrt{3}$

66. $\frac{I_1}{I_2} = \frac{R_1^2}{R_2^2}$

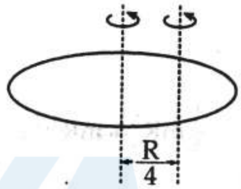
and $\rho_1 = \frac{m_1}{A_1}$ $\rho_2 = \frac{m_2}{A_2}$

$\therefore \frac{\rho_1}{\rho_2} = \frac{A_2}{A_1} = \frac{R_2^2}{R_1^2}$

67. $I = \frac{2}{5} MR^2 = \frac{2}{5} \rho V R^2$

$= \frac{2}{5} \rho \frac{4\pi}{3} R^3 \times R^2 = \frac{8}{15} \rho\pi R^5$

68.



$I_o = I_c + MR^2$

$= \frac{MR^2}{2} + \frac{MR^2}{16}$

$= \frac{9}{16} MR^2$

69. $I_1 = \frac{MR_1^2}{2}$ and $I_2 = \frac{MR_2^2}{2}$

$\frac{I_1}{I_2} = \frac{R_1^2}{R_2^2}$ and $\rho_1 = \frac{m}{A_1}$ and $\rho_2 = \frac{m}{A_2}$

$\frac{\rho_1}{\rho_2} = \frac{A_2}{A_1}$

$= \frac{R_1^2}{R_1^2}$

72. $I = MR^2$

Differentiating we get,

$\frac{dI}{I} = 0 + 2\frac{dR}{R}$

$\therefore \frac{dI}{I} \times 100 = 2\left(\frac{dR}{R}\right) \times 100$

$= 2 \times 1\% \times 100 = 2\ \%$

73. $I_s = \frac{2}{5} MR_s^2$ and $I_h = \frac{2}{3} MR_h^2$

As $I_s = I_h$ $\therefore \frac{2}{5} MR_s^2 = \frac{2}{3} MR_h^2$

$\therefore \frac{R_s}{R_h} = \frac{\sqrt{5}}{\sqrt{3}}$

74. As mass and radius of ring = mass and radius of hollow cylinder.

75. $\pi R = l$ $\therefore R = \frac{l}{\pi}$

M.I. of ring about its diameter $= \frac{1}{2} MR^2$

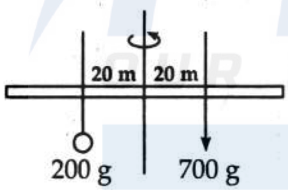
$\therefore$ MI of semicircle $= \frac{1}{2} m \left(\frac{l}{\pi}\right)^2 = \frac{ml^2}{2\pi^2}$

76. $I_d = \frac{1}{2} mR^2.$

We have

$$I = I_1 + I_2 + I_3$$
$$= \left(\frac{1}{2}mR^2 + mR^2\right) + \left(\frac{1}{2}mR^2 + mR^2\right) + \frac{1}{2}mR^2$$
$$= \frac{7}{2} mR^2$$

77.



$$I = m_1 r_1^2 + m_2 r_2^2$$
$$= 0.2 \times 0.3^2 + 0.3 \times 0.2^2$$
$$= 0.03 \text{ kgm}^2$$

85. $I_t = \frac{7}{5} mR^2 = mK^2$

$\therefore K = \sqrt{\frac{7}{5}} R$

86. $K = \frac{R}{\sqrt{2}} = R \times 0.707 = 3.535$ cm.

88. $I_1 \omega_1 = I_2 \omega_2.$

90. $I = mk^2 = \frac{mR^2}{4}$

$\therefore K = \frac{R}{2}$

97. Bacause difference in centrifugal force. ($F = mr\omega^2$ which is proportional to r)

99. $\frac{K^2}{R^2} = 0.4$, for solid sphere

104. $K.E_{Roll} = K.E._{rotation} + K.E._{translation}$

$= \frac{1}{2} I\omega^2 + \frac{1}{2} mv^2 = 0.5 I\omega^2 + 0.5 mv^2$

105. K.E. of rotation $= \frac{1}{2} I\omega^2$

$= \frac{1}{2}\left(\frac{1}{2} mR^2\right)\omega^2$

$= \frac{1}{4} mR^2 (2\pi n)^2 = \pi^2 n^2 m R^2$

$= \pi^2 \left(\frac{300}{60}\right)^2 \times 60 \times (0.4)^2 = 240\pi^2$ J

106. $K.E. = \frac{1}{2} mv^2 \left(1 + \frac{K^2}{R^2}\right)$

107. $K.E. = \frac{1}{2} mv^2 \left(1 + \frac{K^2}{R^2}\right)$

108. $KE_{Roll} = \frac{1}{2} I\omega^2 + \frac{1}{2} mv^2 = \frac{1}{2} I\omega^2 + \frac{1}{2} mr^2\omega^2$

$= \frac{1}{2} I\omega^2 + I\omega^2 = \frac{3}{2} I\omega^2$

109. Workdone = Change in KE

= $\tau\theta$

= Constant

As τ is same in the two cases, θ must be same i.e. number of revolutions must be same.

110. The 'ω' does not depend on the mass i.e. The coin flies off when centrifugal force

$mr\omega^2 \geq \mu mg$ $\therefore \omega \geq \sqrt{\frac{\mu g}{r}}$

111. $KE_{rolling} = \frac{1}{2} mv^2 \left(1 + \frac{K^2}{R^2}\right)$

113. $I = mK^2$

115. $KE_1 = \frac{1}{2}\frac{I^2\omega^2}{I} = \frac{1}{2}\frac{L_1^2}{I}$ and $KE_2 = \frac{1}{2}\frac{L_2^2}{I}$

$\frac{KE_2}{KE_1} = \left(\frac{L_2}{L_1}\right)^2 = \left(\frac{1.5L_1}{L_1}\right)^2 = 2.25$

$\frac{KE_2}{KE_1} - 1 = 1.25$ $\therefore \frac{KE_2 - KE_1}{KE_1} = 1.25$

$\therefore \frac{KE_2 - KE_1}{KE_1}\% = 125\%$

116. $I = \frac{2}{5} MR^2$ and $KE = \frac{1}{2} I\omega^2$

117. $KE = \frac{1}{2} I\omega^2$

119. $\frac{1}{2} I\omega^2 = \frac{1}{2} m v^2$

$\therefore \frac{1}{2} \times 3 \times 4 = \frac{1}{2} \times 12 v^2$

$\therefore v^2 = 1 \quad \therefore v = 1$ m/s

121. $\frac{1}{2} mv^2 = \frac{1}{2} I\omega^2$

122. $\frac{E_{rot}}{T.E.} = \frac{1}{4} \frac{mv^2}{(3/4) mv^2} = \frac{1}{3}$

123. $\tau = I\alpha$ and $\theta = \omega_1 t + \frac{1}{2} \alpha t^2$

Work done $= \tau\theta$

124. $\frac{KE_{trans}}{KE_{roll}} = \frac{(1/2) mv^2}{(3/4) mv^2} = \frac{2}{3}$

125. Change in K.E. $= \frac{1}{2} I(\omega_2^2 - \omega_1^2)$

$= \frac{1}{2} I(\omega_2 + \omega_1) \frac{(\omega_2 - \omega_1)}{t} t$

$= \frac{1}{2} I\alpha(\omega_2 + \omega_1) t = \tau\theta$

In one rev .... 2π rad

$\therefore$ 20 rev .... ?

$\theta = 20 \times 2\pi = 40\pi$

128. $\frac{KE_{rot}}{KE_{roll}} = \frac{(1/2) I\omega^2}{(1/2) mv^2 (1 + K^2/R^2)}$

129. $K.E. = \frac{1}{2} I\omega^2 = \frac{1}{2} \frac{mR^2}{2} \times 4\pi^2 n^2$

130. $\frac{KE_1}{KE_2} = \frac{\frac{1}{2} mv^2(1+1)}{\frac{1}{2} mv^2\left(\frac{3}{2}\right)}$

131. $T E_2 = \frac{1}{2} I\omega 2 + \frac{1}{2} mv^2 = 40 + \frac{1}{2} m R^2\omega^2$

$= 40 + \frac{1}{2}\left(\frac{2}{5} mR^2\omega^2\right) \times \frac{5}{2} = 40 + 40 \times \frac{5}{2}$

$= 140$ J

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

$= \frac{1}{2} \frac{MR^2}{2} \times 4\pi^2 n^2$

134. Work done = Change in K.E.

$K.E. = \frac{1}{2} I({\omega_2}^2 - {\omega_1}^2)$

$= \frac{1}{2} m k^2 4\pi^2 ({n_2}^2 - {n_1}^2)$

135. $\frac{K.E. rot}{K.E. roll} = \frac{1}{2} MK^2 \frac{v^2}{R^2} = \frac{1}{2} Mv^2 \left(1 + \frac{K^2}{R^2}\right)$

136. $K.E._1 = \frac{1}{2} \frac{L^2}{I_1}$

$\therefore K.E._1 \propto \frac{1}{I_1}$

$K.E._2 = \frac{1}{2} \frac{L^2}{I_2} \quad \therefore K.E._2 \propto \frac{1}{I_2}$

$\frac{K.E._2}{K.E._1} = \frac{I_1}{I_2}$

$\therefore K.E._1 < K.E._2$

137. $I_1 \omega_1 = I_2 \omega_2$ if no external torqe acts ont he system total angular momentum remains constant.

$I_1 = m_1 K_1^2 \qquad I_2 = m_2 K_2^2$

$\frac{I_1}{I_2} = \frac{m_1}{m_2} \frac{K_1^2}{K_2^2} = 2 \times \frac{1}{4} = \frac{1}{2}$

$\therefore I_2 = 2 I_1$

$\therefore \omega_2 = \frac{I_1\omega_1}{I_2} = \frac{I_1\omega_1}{2 I_2} = \frac{\omega_1}{2}$

$\frac{KE_1}{KE_2} = \frac{I_1}{I_2} \times \left(\frac{\omega_2}{\omega_1}\right)^2$

$= \frac{1}{2} \times 4 = 2$

138. $L_2 - L_1 = I(\omega_2 - \omega_1)$

$KE_2 - KE_1 = \frac{1}{2} I\left(\omega_2^2 - \omega_1^2\right)$

139. $K.E._1 = \frac{1}{2} I\omega^2$

143. $\frac{L_2 - L_1}{dt} = \frac{1}{2} \frac{(KE_2 - KE_1)}{KE_1}$

144. $\frac{L_2 - L_1}{L_1} = \frac{1}{2} \frac{\Delta KE}{KE_1}$

145. $I_1\omega_1 = I_2\omega_2$

$KE_2 = \frac{1}{2} I\omega^2$

146. $KE = \frac{1}{2} I\omega^2 = \frac{1}{2}\frac{M l^2\omega^2}{3} = \frac{M l^2\omega^2}{6}$

148. $KE_1 = \frac{1}{2} mv^2$

$KE_2 = \frac{1}{2} mv^2 + \frac{1}{2} l\omega^2$

$= \frac{1}{2} mv^2 + \frac{1}{2}(mr^2)\left(\frac{v^2}{r^2}\right) = mv^2$

$\Rightarrow \frac{KE_1}{KE_2} = +\frac{\frac{1}{2}mv^2}{mv^2} = \frac{1}{2} = 1:2.$

149. 300 rpm = 5 rps

$\omega = 2\pi(5) = 10\pi \text{ rad s}^{-1}$

Kinetic energy $= \frac{1}{2} I\omega^2 = \frac{1}{2} L\omega$

$\therefore L = \frac{2(KE)}{\omega} = \frac{2(62.8)}{10\pi}$

$= 4 \text{ kgm}^2/\text{s}^1.$

150. $\frac{1}{2} I_1\omega_1^2 = \frac{1}{2} I_2\omega_2^2 \Rightarrow \frac{\omega_1^2}{\omega_2^2} = \frac{I_2}{I_1}$

$\Rightarrow \frac{\omega_1}{\omega_2} = \sqrt{\frac{I_2}{I_1}} = \sqrt{\frac{9}{1}} = 3:1$

$\therefore \frac{L_1}{L_2} = \frac{\omega_2}{\omega_1} = \frac{1}{3} \Rightarrow L_1 : L_2$

$= 1:3.$

151. Rotational kinetic energy,

$= \frac{1}{2} I\omega^2 = \frac{1}{2}\left(\frac{Ml^2}{3}\right)\left(\frac{3g}{l}\right) = \frac{Mgl}{2}$

$= \left(\frac{(1)(9.8)(1)}{2}\right) = 4.9 \text{ J}.$

160. $P = \tau\omega$

161. $\alpha = \frac{\omega_2 - \omega_1}{t} = \frac{2\pi(n_2 - n_1)}{t} = \frac{2\pi}{6} = \frac{\pi}{3}$

162. $\tau = I\alpha$

163. $\tau = I\alpha = mk^2\alpha$ here $\alpha = 2 \times 2\pi \text{ rad/s}^2$

164. $\tau = I\alpha = MK^2\alpha$

165. $\tau = I\alpha = \frac{I(\omega_2 - \omega_1)}{t}$

166. $\tau = I\alpha = \frac{I(\omega_2 - \omega_1)}{t}$

167. $L = I\omega = mrv$

168. $\tau = \frac{MR^2}{2} \times \frac{(\omega_2 - \omega_1)}{t}$

169. $\tau = I\alpha$

170. $t = \frac{I(\Delta\omega)}{\lambda} = \frac{2\times 100}{40} = 5 \text{ sec.}$

171. $P = \tau\omega \quad \therefore \tau = \frac{P}{2\pi n} = \frac{2\pi\times 10^3}{2\pi\times 10^2} = 10 \text{ Nm}.$

172. $\omega_2^2 - \omega_1^2 = 2 \propto \theta$

$\therefore 4\pi^2(0 - \frac{4}{\pi^2}) = 2\times\alpha\times 2\pi N$

$16 = 4\times\pi\times 20\times\alpha$

$\therefore \alpha = \frac{16}{80\times\pi}$

$\therefore \tau = I\alpha = 10\times\frac{1}{5\pi} = \frac{2}{\pi} \text{ Nm}.$

174. $P = \tau\omega \quad \therefore \tau = \frac{60\pi\times 10^3}{2\pi\times 30} = 1000 \text{ Nm}.$

175. $t = Ia = \frac{m4l^2}{12}\frac{\omega}{t} = \frac{ml^2\omega}{3t}.$

176. $\tau = I\alpha$

$\therefore \alpha = \frac{\tau}{I} = \frac{rF}{I} = \frac{0.1\times 10}{5} = 0.2$

$\therefore \omega_2 = \omega_1 + \alpha t = 0 + 0.2\times 10 = 2$

177. $I = mK^2 = 40\times 0.25 = 10 \text{ kg m}^2$

$\alpha = \frac{\omega_2 - \omega_1}{t} = \frac{0 - 2\pi\times 3}{3} = -2\pi$

$\tau = I\alpha = -2\pi\times 10 = -20\pi$

178. $\theta = \omega_1 t + \frac{1}{2}\alpha t^2$

179. $\tau = I\alpha$

$\therefore \alpha = \frac{\tau}{I} = \frac{rF}{I} = \frac{0.2\times 50}{mR^2/2} = \frac{10\times 2}{2\times 0.2\times 0.2}$

$= 250 \text{ rad/s}^2$

180. $\tau = I\alpha = Mk^2\alpha.$

181. $P = \tau\omega = 60\times 2\pi\times n = 2\pi$ kwatt

182. $P = \tau\omega = 80\times 2\pi\times n$

$= \frac{80\times 2\pi\times 1200}{60} = 3.2\pi$ K w

183. $\tau = I\alpha$ and $\tau = rF$

184. $\tau = I\alpha = I\dfrac{\omega}{t}$

185.
$$\tau = \frac{\pi(n_2 - n_1)}{t}$$
$$\omega_2 = \omega_1 + \alpha t$$
$$\therefore \quad t = \frac{\omega_2}{\alpha}$$

192.
$$\vec{L} = \vec{r} \times \vec{p} = \vec{r} \times m\vec{v}$$
$$|\vec{L}| = |\vec{r} \times m\vec{v}|$$
$$= rmv = \text{constant}$$

206. As no torque is exerted by the boy.

207. As no external torque is acting.

209. $\tau = \dfrac{dL}{dt}$ i.e. $F = \dfrac{dP}{dt}$

221. As boiled egg spins faster, I should be less.

224. Kinetic energy $= \dfrac{1}{2} I\omega^2 \Rightarrow$ depends on I and ω.

225. When angular momentum is same, $I \propto \dfrac{1}{\omega}$.

227. ω remains same for every particle of the disc.

228. $\tau = \dfrac{dL}{dt} = \dfrac{L_2 - L_1}{dt}$

230.
$$\frac{I_1}{I_2} = \frac{\frac{2}{3} m_1 R_1^2}{\frac{2}{5} m_2 R_2^2} = \frac{5m_1}{3m_2} \quad \therefore \quad \frac{m_1}{m_2} = \frac{3}{5}$$

231. $\tau = \dfrac{dL}{dt} = \dfrac{4A - A}{4} = 0.75\ A$

232.
$$E_1 = \frac{1}{2} I_1 \omega_1^2 = \frac{1}{2} L_1 \omega_1$$
$$E_2 = \frac{1}{2} I_2 \omega_2^2 = \frac{1}{2} L_2 \omega_2$$
$$\therefore \quad \frac{L_2}{L_1} = \frac{E_2}{E_1} \times \frac{\omega_1}{\omega_2}$$
$$\therefore \quad L_2 = \frac{L_1}{4} = 0.25\ L$$

233. In one revolution angle discribed is 2π

$\therefore$ 2π revolution corresponds to $4\pi^2$.

$$\tau = I\alpha = \left(\frac{2}{5} MR^2\right)\left(\frac{\omega_2^2 - \omega_1^2}{2\theta}\right)$$
$$= \frac{2}{5} \times 2 \times 25 \times 10^{-4} \times \frac{4\pi^2(0 - 25)}{2 \times 4\pi^2}$$
$$= 2.5 \times 10^{-2}\ \text{Nm.}$$
$$= 2.5 \times 10^{-2} \times 10^7\ \text{dyne cm.}$$

234.
$$K.E._1 = K.E._2$$
$$\frac{1}{2} L_1 = \frac{1}{2} L_2$$
$$\therefore \quad \left(\frac{L_1}{L_2}\right)^2 = \frac{I_1}{I_2}$$
$$\frac{L_1}{L_2} = \sqrt{\frac{I_1}{I_2}} = \sqrt{\frac{9}{1}} = \frac{3}{1}$$

235. $\alpha = \dfrac{\omega_2 - \omega_1}{t} = \dfrac{2\pi(n_2 - n_1)}{t} = \dfrac{2\pi(0 - 20)}{t} = 2\pi$

236.
$$I_1\omega_1 = I_2\omega_2$$
$$I_1\omega_1 = 2I_1\omega_2$$
$$\therefore \quad \omega_2 = \frac{500}{2} = 250\ \text{rpm}$$

237. $T_2 = 24\ n^2$

238.
$$I_1\omega_1 = I_2\omega_2$$
$$\therefore \quad \omega_2 = \frac{MR^2\omega}{(M + 2m)R^2} = \frac{M\omega}{M + 2m}$$

239. $I_1\omega_1 + I_2\omega_2 = (I_1 + I_2)\omega$

240. $KE_{roll} = KE_{rot}$
$$\frac{1}{2} mv^2\left(1 + \frac{k^2}{R^2}\right) = \frac{1}{2} m\omega^2$$
$$mv^2\left(1 + \frac{k^2}{R_2}\right) = \frac{mR^2}{4}\omega^2$$
$$\omega = \frac{2v}{R}$$

241. $I_1\omega_1 + I_2\omega_2 = (I_1 + I_2)\omega$

242. $I_1\omega_1 = I_2\omega_2$

247. $\dfrac{dl}{dt} = \tau \qquad \therefore\ dl = \tau dt$

248. $I_1 w_1 + I_2 w_2 = (I_1 + I_2)\, w \setminus \quad w = \dfrac{\frac{MR^2\omega}{2} + I_1 \times 0}{I_1 + I_2}$

$$\therefore \quad \omega = \frac{MR^2\omega}{2} \times \frac{8}{MR^2\, 5} = \frac{4\omega}{5}.$$

249. $L = I\omega = mK^2\omega$

250. $K.E. = \dfrac{L^2}{2I} \quad \therefore\ L\ \alpha\ \sqrt{I} \quad \therefore\ \dfrac{L_1}{L_2} = \dfrac{\sqrt{2}}{\sqrt{3}}.$

251. Applying the principle of conservation of angular momentum.

$$(I_1 + I_2)\,\omega = I_1\,\omega_1 + I_2\,\omega_2$$

$$(6 + I_2) \times \frac{400}{60} \times 2\pi = 6 \times \frac{600}{60} \times 2\pi + I_2 \times 0$$

$$6 + I_2 = \frac{36}{4} = 9 \qquad \therefore\ I_2 = 3\ \text{kg m}^2$$

252. $CF = MR\omega^2 = \dfrac{MR^2\omega^2}{R}$

253. $L = I\,2\,\pi n = 20 \times 2 \times 314 \times 20$

$= 8 \times 314 = 2512\ \text{kgm}^2/\text{s}.$

254. $L = I\omega = \dfrac{2}{5}\,MR^2\omega = \dfrac{2}{5} \times 10 \times 10^{-2} \times 2$

$= 0.08\ \text{kgm}^2/\text{s}.$

255. $\dfrac{R_1}{R_2} = \sqrt{\dfrac{T_1}{T_2}} \qquad \therefore\ T_2 = \dfrac{24}{9} = \dfrac{8}{3}\ h$

$\therefore\quad \Delta T = T_1 - T_2 = 24 - \dfrac{8}{3} = \dfrac{64}{3}.$

256. $\dfrac{T_2}{T_1} = \left(\dfrac{R_2}{R_1}\right)^2$

257. $I_1\,\omega_1 = I_2\,\omega_2$

258. $w_2 = \dfrac{I\omega \times 100}{60\,I} = \dfrac{5\,\omega}{3}.$

260. $120\ \text{rpm} = 2\text{rps}$

$\Rightarrow \omega = 2\pi(2) = 4\pi\ \text{rad s}^{-1}$

$\therefore$ Angular momentum,

$L = I\omega$

$= \left(\dfrac{Mr^2}{2}\right)\omega = \left(\dfrac{(20)(0.5)^2}{2}\right)(4\pi)$

$= 31.4\ \text{kgm}^2\text{s}^{-1}.$

261. Moment of inertial, $I = \dfrac{ML^2}{3} + \dfrac{MR^2}{4}$

but, $L = 6\,R$

$\therefore\quad I = \dfrac{49}{4}\,MR^2.$

262. For the ring $I = \dfrac{mr^2}{2}$

for the rod, $l = 2\pi r$ and

$I' = \dfrac{ml^2}{3} = \dfrac{m(4\pi^2 r^2)}{3}$

$= \dfrac{8\pi^2 I}{3}$

263. $I_P = \dfrac{MR^2}{2}$

$= \dfrac{((\pi R^2)t)\,\rho\,(R^2)}{2} = \dfrac{\pi t\rho R^4}{2}$

$I_Q = \dfrac{MR^2}{2}$

$= \dfrac{(\pi(2R)^2(t/2))\,\rho\,(2R)^2}{2}$

$= \dfrac{\pi\,t\,\rho\,(8R^4)}{2} = 8I_P.$

264. $m_A = m_B$

$\Rightarrow \left(\dfrac{4}{3}\pi R_A^3\right)\rho_A = \left(\dfrac{4}{3}\pi R_B^3\right)\rho_B$

$\Rightarrow \dfrac{R_A^2}{R_B^2} = \left(\dfrac{\rho_B}{\rho_A}\right)^{2/3}$

Moment of inertia,

$I = \dfrac{2}{5}\,MR^2 \Rightarrow I \propto R^2$

$\Rightarrow\ \therefore\quad \dfrac{I_B}{I_A} = \dfrac{R_B^2}{R_A^2} = \left(\dfrac{\rho_A}{\rho_B}\right)^{2/3}$

275. $I_1 = \dfrac{2}{5}\,MR^2; = 0.4$

$I_2 = \dfrac{2}{3}\,MR^2; = 0.6$

$I_3 = \dfrac{2}{3}\,MR^2; = 0.6$

279. $E_1 = E_2$

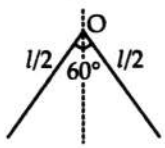
$\dfrac{1}{2}\,mv^2 = \dfrac{1}{2}\,m\,v_1^2\left(1 + \dfrac{k^2}{R^2}\right)$

$\therefore\quad v_1^2 = \dfrac{v}{2}$

$v_1 = \dfrac{v}{v_2}$

280. $I = \dfrac{ML}{12} + \dfrac{MR^2}{4}$

281.



$I = I_1 + I_2$

$= \dfrac{M}{2} \times \dfrac{l^2}{4} \times \dfrac{1}{3} + \dfrac{1}{3}\,\dfrac{m}{2}\,\dfrac{l^2}{4}$

282. $I_d = \frac{MR^2}{4} \quad \therefore MR^2 = 4I_d$

$I_T = \frac{3}{2}MR^2 I_T = \frac{3}{2}4I = 6I$

283. $I_0 = I_c + Mh^2$

$= Id + M\left(\frac{R}{2}\right)^2 = \frac{2}{5}MR^2 + \frac{MR^2}{4}$

$= \frac{13}{20}MR^2$

284. $I_0 = I_c + Mh^2 = \frac{ML^2}{12} + \frac{ML^2}{16}$

$= \frac{4ML^2 + 3ML^2}{48} = \frac{7ML^2}{48}$

285. $I = I_e + I_e = \frac{ml^2}{3} + \frac{ml^2}{3} = \frac{2ml^2}{3}$

286. $I = I_1 + I_2 + I_3$

$= \frac{5}{4}MR^2 + \frac{5}{4}MR^2 + \frac{5}{4}MR^2 = \frac{15MR^2}{4}.$

287. $MR^2 = 6 \text{ kg m}^2$

$I_t = \frac{3}{2}MR^2$

289. $I = \frac{2}{5}MR^2$

$= \frac{2}{5} \times 3 \times \frac{4}{3}\pi \times 27 \times 3 \times 3 = 388\pi \text{ gm cm}^2.$

290. $I = \frac{2}{3} \times 3 \times \frac{4}{3}\pi \times 27 \times 3 \times 3 = 648\pi \text{ gm cm}^2.$

291. $BD^2 = AB^2 - AC^2$

$= 4 - 1$

$= 3$

$I_0 = M(BD)^2 = 2 \times 3 = 6 \text{ kg m}^2$

293. $I_d = \frac{MR^2}{2} = 2 \quad \therefore I_t = \frac{3}{2}MR^2$

297. $I = \left(\frac{m_1 m_2}{m_1 + m_2}\right) r^2 = \frac{600}{50} \times 25 = 300 \text{ kg m}^2.$

298. $I_0 = I_C + Mh^2$

$= 50 + 5 \times 25 = 50 \times 125 = 175 \text{ kg m}^2.$

301. $I = I_1 + I_2 = MR^2 + \frac{MR^2}{2} = \frac{3}{2}MR^2$

$\therefore MR^2 = \frac{2I}{3} \quad \therefore I_1 = MR^2 = \frac{2I}{3}.$

309. $I_d = \frac{I_c}{2} = \frac{4}{2} = 2 \text{ kg m}^2$

312. $I = \frac{2}{5}MR^2 + \frac{2}{5}MR^2 + M(2R)^2$

$= \frac{4}{5}MR^2 + 4MR^2 = \frac{24}{5}MR^2$

335. $a = \frac{g\sin\theta}{1 + \frac{K^2}{R^2}} = \frac{10\sin 30^\circ}{1 + \frac{2}{5}} = \frac{25}{7} \text{ ms}^{-2}.$

336. $KE_{translational} = \frac{1}{2}mv^2$

$KE_{rotational} = \frac{1}{2}I\omega^2$

$= \frac{1}{2}(mr^2)\omega^2 = \frac{1}{2}mv^2$

$\frac{KE_{tans}}{KE_{rot}} = 1.$

337. According to the law of conservation of energy.

$\frac{3}{4}mv^2 = mgh \Rightarrow v = \sqrt{\frac{4gh}{3}} = \sqrt{\frac{4(9.8)(0.6)}{3}}$

$= \frac{28}{10} = 2.8 \text{ ms}^{-1}.$

338. $V_{rolling} = \sqrt{\frac{4gh}{3}}$

$V_{sliding} = \sqrt{2gh}$

$\therefore V_r : V_s = \sqrt{2} : \sqrt{3}.$

339. Given, $v = \sqrt{\frac{2gh}{1 + \frac{K^2}{R^2}}}$

$= \sqrt{\frac{2gh}{2}} = \sqrt{gh}$

for the block, $v' = \sqrt{2gh} = \sqrt{2}(\sqrt{gh})$

$= \sqrt{2}\, v.$

344. $I_1 = m_1 r_1^2$ and $I_2 = m_2 r_2^2$

$\rho = \frac{m_1}{l_1} \quad \therefore m_1 = \rho l_1$ and $m_2 = \rho l_2$

$\frac{m_1}{m_2} = \frac{l_1}{l_2} = \frac{2\pi r_1}{2\pi r_2}$

$\therefore \frac{I_1}{I_2} = \frac{r_1^2}{r_2^2} \times \frac{r_1}{r_2} \quad \therefore \frac{r_1}{r_2} = \sqrt[3]{4}$

345. $I = mR^2$

347. Moment of inertia of system about YY′

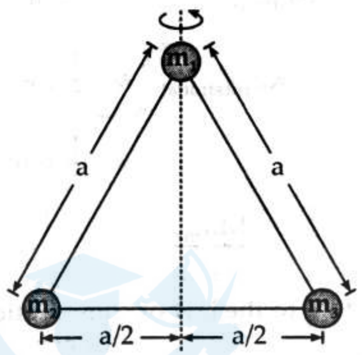
$$I = 2I_1 + I_2 + I_3$$

$$= 2\frac{MR^2}{2} + \frac{3}{2}MR^2 + \frac{3}{2}MR^2 = 4\,MR^2.$$

348. $I = 2\,MR^2 = 2 \times 3 \times (1)^2 = 6\ \text{gm cm}^2.$

349. $I = \frac{1}{2}MR^2 = \frac{1}{2} \times 0.5 \times (0.1)^2 = 2.5 \times 10^{-3}\ \text{kg m}^2.$

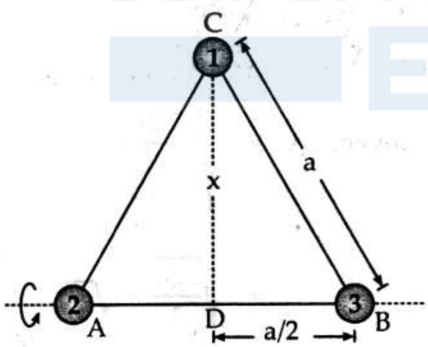
350. M.I. of system about the axis which passing through m_1



$$I_{system} = m_1(0)^2 + m_2\left(\frac{a}{2}\right)^2 + m_3\left(\frac{a}{2}\right)^2$$

$$I_{system} = (m_2 + m_3)\frac{a^2}{4}.$$

351.



From the triangle BCD

$$CD^2 = BC^2 - BD^2 = a^2 - \left(\frac{a}{2}\right)^2$$

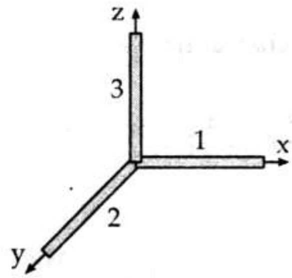
$$x^2 = \frac{3a^2}{4} \Rightarrow x = \frac{\sqrt{3}\,a}{2}$$

Moment of inertia of system along the side AB

$$I_{system} = I_1 + I_2 + I_3 = m \times (0)^2 + m \times (x)^2 + m \times (0)^2$$

$$= mx^2 = m\left(\frac{\sqrt{3}\,a}{2}\right)^2 = \frac{3\,ma^2}{4}.$$

352.



M.I. of rod (1) about Z - axis, $I_1 = \frac{Ml^2}{3}$

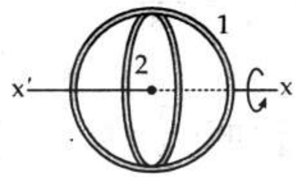
M.I. of rod (2) about Z - axis, $I_2 = \frac{Ml^2}{3}$

M.I. of rod (3) about Z - axis, $I_3 = 0$

Because this rod lies on Z-axis

$$\therefore I_{system} = I_1 + I_2 + I_3 = \frac{2\,Ml^2}{3}.$$

353.



I_1 = M.I. of ring about its diameter $= \frac{1}{2}\,mR^2$

I_2 = M.I. of ring about the axis normal to plane and passing through centre $= mR^2$

Two rings are placed according to figure, Then

$$I_{xx'} = I_1 + I_2 = \frac{1}{2}mR^2 + mR^2 = \frac{3}{2}mR^2.$$

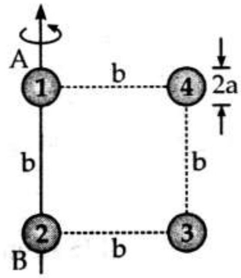
354. M.I. of disc $= \frac{1}{2}mR^2 = \frac{1}{2}(\pi R^2 t)\rho R^2 = \frac{1}{2}\pi R^4 t\rho$

[ρ = density, t = thickness]

If discs are made of same material and same thickness then $I \propto R^4 \propto (\text{Diameter})^4$

$$\therefore \frac{I_1}{I_2} = \left(\frac{D_A}{D_B}\right)^4 = \left(\frac{2}{1}\right)^4 - \frac{16}{1}.$$

356.



$I_1 = \frac{2}{5}\,Ma^2$ = M.I. of sphere 1 about AB axis

$I_2 = \frac{2}{5}\,Ma^2$ = M.I. of sphere 2 about AB axis

$I_3 = \frac{2}{5} Ma^2 + Mb^2$ = M.I. of sphere 3 about AB axis

$I_4 = \frac{2}{5} Ma^2 Mb^2$ = M.I. of sphere 4 about AB axis

M.I. of system about axis AB

$$I_{system} = I_1 + I_2 + I_3 + I_4$$
$$= 2\left(\frac{2}{5}Ma^2\right) + 2\left(\frac{2}{5}Ma^2 + Mb^2\right)$$
$$= \frac{8}{5} Ma^2 + 2\,Mb^2.$$

357. M.I. of disc $I = \frac{1}{2} MR^2 = \frac{1}{2} M\left(\frac{M}{\pi \rho t}\right) = \frac{1}{2} \frac{M^2}{\pi \rho t}$

$\left(\text{As } \rho = \frac{\text{Mass}}{\text{Volume}} = \frac{M}{\pi R^2 t} \text{ therefore } R^2 = \frac{M}{\pi \rho t}\right)$

$\therefore \quad I \propto \frac{1}{\rho}$ [If M and t are constant]

$\therefore \quad \frac{I_1}{I_2} = \frac{\rho_2}{\rho_1}.$

358. $\alpha = \frac{2\pi(n_2 - n_1)}{t} = \frac{2\pi(0-20)}{10} = -4\pi \text{ rad/s}^2$

Negative sign means retardation

Now $\tau = I\alpha = 5 \times 10^{-3} \times 4\pi = 2\pi \times 10^{-2}$ Nm.

359. If radius of earth decreases then its M.I. decreases.

As $L = I\omega \therefore \omega \propto \frac{1}{I}$ [L = constant]

i.e. angular velocity of the earth will increase.

364. $\frac{K.E._2}{K.E._1} = \frac{L_2^2}{L_1^2} = \frac{R_2^2\omega_2^2}{R_1^2\omega_1^2} = (1.1)^2 = 1.21$

$\therefore \quad \frac{K.E._2}{K.E._1} - 1 = 1.21 - 1 \quad \therefore K.E._1 = 21\%$

$\therefore$ K.E.$_2$ increased by 21%.

365. $I = 2I_1 = 2 \times \frac{\frac{M}{2}\left(\frac{l}{2}\right)^2}{3} = \frac{Ml^2}{12}$

366. $I = MR^2 n$

367. $I_c = \frac{MR^2}{2} = 6 \text{ kgm}^2$

$I_t = \frac{3MR^2}{2} = 3 \times 6 = 18$

370. $I_0 = I_c + m h^2 = \frac{MR^2}{2} + MR^2 = \frac{3}{2} MR^2$

371. $\frac{KE_{rot}}{KE_{rolling}} = \frac{k^2/R^2}{1 + k^2/R^2} = \frac{2/5}{1 + 2/5} = \frac{2/5}{3/5} = \frac{2}{7}$

372. $\frac{MR^2}{2} = MK^2 \therefore K^2 = \frac{R^2}{2} \quad \therefore K = \frac{R}{\sqrt{2}}.$

374. Work done $= \Delta K.E. = \frac{1}{2} I(\omega_2^2 - \omega_1^2)$

$$= \frac{9.8}{2 \times \pi^2} \times 4\pi^2$$

$(n_1^2 - n_2^2) = 19.6 \times 75$

$= 1470$ J.

376. $V_{av} = \frac{v_1 + v_2 + v_3}{3} = \frac{3+4+5}{3} = \frac{12}{3}$

$= 4$ m/s

380. $I_t = I, I_T = ?$

$$\frac{I_T}{I_t} = \frac{\frac{3}{2}MR^2}{\frac{5}{4}MR^2}$$

$$I_T = \frac{6}{5} I_t = \frac{6}{5} I$$

382. $\frac{I_T}{I_c} = \frac{\frac{3}{2}MR^2}{MR^2} = \frac{3}{2}$

$I_T = \frac{3}{2} I_c = \frac{3}{2} \times 4 = 6$

383. $I = M K_c^2 = 2 \times (0.5)^2 = 2 \times 0.25 = 0.5.$

384. $E = \frac{1}{2} mv^2 [1 + K^2/R^2]$

$= \frac{1}{2} mv^2 [1 + 1] = mv^2.$

386. $\frac{I_1}{I_2} = \frac{R_1^2}{R_2^2}$ .....(i)

$M_1 = M_2$

$\rho_1 \pi R_1^2 t = \rho_2 \pi R_2^2 t$

$\frac{\rho_1}{\rho_2} = \frac{R_2^2}{R_1^2}$

$\therefore$ The equation (i) becomes,

$\frac{I_1}{I_2} = \frac{\rho_2}{\rho_1}$ as $\rho_1 > \rho_2$

$\frac{I_1}{I_2} < 1$

$\therefore \quad I_1 < I_2.$

387. $KE = \dfrac{L^2}{2I}$

$L^2 = 2IE = 2 \times 2 \times 4$

$L = 2 \times 2 = 4 \text{ kg m}^2/\text{s}$

388. $KE = \dfrac{1}{2} I \omega^2$

$= \dfrac{1}{2} \dfrac{ML^2}{12} \times \omega^2$

$= \dfrac{1}{2} \times \dfrac{DAL^3}{12} \omega^2$

$= \dfrac{Al^3 D\omega^2}{24}$

395. By the law of conservation,

$PE = KE_{rolling}$

$mgh = \dfrac{1}{2} mv^2 (1 + \dfrac{K^2}{R^2})$

$g \times \dfrac{3v^2}{4g} = \dfrac{1}{2} v^2 (1 + \dfrac{K^2}{R^2})$

$\dfrac{3}{2} = 1 + \dfrac{K^2}{R^2}$

$\therefore \quad \dfrac{K^2}{R^2} = \dfrac{3}{2} - 1 = \dfrac{1}{2}$

The value of $\dfrac{K^2}{R^2}$ is $\dfrac{1}{2}$ for disc.

396. $PE = KE_{roll}$

$mgh = \dfrac{1}{2} mv^2 [1 + K^2/R^2]$

$g \times \dfrac{3v^2}{4g} = \dfrac{1}{2} v^2 [1 + K^2/R^2]$

$\dfrac{3}{2} = 1 + \dfrac{K^2}{R^2}$

$\dfrac{1}{2} = \dfrac{K^2}{R^2}$

$K^2 = \dfrac{R^2}{2}$

$I = MK^2 = \dfrac{MR^2}{2}$

397. $I = \dfrac{mL^2}{3}, I_1 = \dfrac{mR^2}{2}$

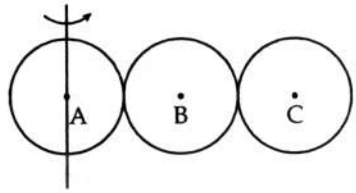
$\dfrac{I}{I_1} = \dfrac{mL^2}{3} \times \dfrac{2}{MR^2}$

$= \dfrac{2}{3} \times \dfrac{L^2}{R^2}$

$= \dfrac{2}{3} \times \dfrac{(2\pi R^2)}{R^2} \quad \because L = 2\pi R$

$= \dfrac{2}{3} \times \dfrac{4\pi^2 R^2}{R^2}$

$\dfrac{I}{I_1} = \dfrac{8\pi^2}{3}.$

398. 

$x_{cm} = \dfrac{(x_1 + x_2 + x_3)m}{m + m + m}$

$= \dfrac{x_1 + x_2 + x_3}{3}$

$= \dfrac{0 + AB + AC}{2}.$

399. $I_C = \dfrac{MR^2}{4} + \dfrac{Ml^2}{12}$

$I_C = \dfrac{Ml^2}{12} + \dfrac{MR^2}{4}$

400. $PE = $ Rolling KE

$mgh = \dfrac{1}{2} mv^2 [1 + k^2/r^2]$

$v^2 = \dfrac{2mgh}{m[1 + k^2 r^2]} \quad \therefore v = \sqrt{\dfrac{2mgh}{m[1 + k^2/r^2]}}$

$\omega = \sqrt{\dfrac{2mgh}{mr^2 + mk^2}} = \sqrt{\dfrac{2mgh}{I + mr^2}}$

401. KE of rotating = Heat energy

$\dfrac{1}{2} I\omega^2 = MSd\theta$

$\dfrac{75}{100} \times \dfrac{1}{2} \times \dfrac{2}{3} MR^2\omega^2 = MSd\theta$

$\therefore \quad d\theta = \dfrac{2}{3} \times \dfrac{1}{2} \dfrac{R^2\omega^2}{S} \times \dfrac{75}{100}$

$= \dfrac{R^2\omega^2}{4S}$