SAMPLE CONTENT

FOUNDATION

MHT-CET PHYSICS

From vision to victory

Includes Authentic Questions from Latest MHT-CET Examination

- Based on Latest Paper Pattern
- Key Notes for Good Practice
- Quick Review
- Previous Years' Questions

Std. XII

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XII

Foundation

MHT-CET

PHYSICS MULTIPLE CHOICE QUESTIONS

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CONTENTS

Chapter

1

Rotational Dynamics

Key Notes For Good Practice

- *In U.C.M., angular velocity* $\vec{\omega}$ *is only constant vector but angular acceleration* $\vec{\alpha}$ *and angular displacement* $\vec{\theta}$ *are variable vectors.*
- *When measured in rad/s, the order of magnitude of angular velocities for hour hand, minute hand and second hand are* 10^{-4}, 10^{-3} *and* 10^{-1} *respectively.*
- *Circular motion is a two-dimensional motion in which the linear velocity and linear acceleration vectors lie in the plane of the circle but the angular velocity and angular acceleration vectors are perpendicular to the plane of the circle.*
- *An observer on the moving particle experiences only the centrifugal force, but an observer stationary with respect to the centre can experience or measure only the centripetal force.*
- *Whenever a particle is in a U.C.M. or non U.C.M., centripetal and centrifugal forces act simultaneously. They are both equal and opposite but do not cancel each other.*
- *Centripetal force and Centrifugal force are not action-reaction forces as action-reaction forces act on different bodies.*
- *Since the centripetal force acting on a particle in circular motion acts perpendicular to its displacement (and also its velocity), the work done by it is always zero. Hence, there is no change in linear speed and kinetic energy of particle due to centripetal force.*
- *The radius of the curved path is the distance from the centre of curved path to the centre of gravity of the body. It is to be considered when the centre of gravity of body is at a height from the surface of road or surface of spherical body.*
- *Whenever a car is taking a horizontal turn, the normal reaction is at the inner wheel.*
- *While taking a turn, when car overturns, its inner wheels leave the ground first.*
- *For a vehicle negotiating a turn along a circular path, if its speed is very high, then the vehicle starts skidding outwards. This causes the radius of the circle to increase resulting in the decrease in the centripetal force.* $[\because F_{cp} \propto \frac{1}{r}]$
- *If a body moves in a cylindrical well (well of death) the velocity required will be minimum safest velocity and in this case the weight of the body will be balanced by component of normal reaction and the minimum safest velocity is given by the formula* $\sqrt{\mu rg}$.
- *For non uniform circular motion* $\vec{a} = \vec{\alpha} \times \vec{r} + \vec{\omega} \times \vec{v}$
- *If a body is kept at rest at the highest point of convex road and pushed along the surface to perform circular motion, the body will fall after travelling a vertical distance of* $\frac{r}{3}$ *from the highest point where r is the radius of the circular path.*
- *Since the centripetal force is not zero for a particle in circular motion, the torque acting is zero i.e.,* $\vec{\tau} = 0$ *(as the force is central) Hence the angular momentum is constant i.e.* $\vec{L}$ = *constant.*
- *If a particle performing circular motion comes to rest momentarily, i.e.* $\vec{v} = 0$*, then it will move along the radius towards the centre and if its radial acceleration is zero, i.e.* $a_r = 0$*, then the body will move along the tangent drawn at that point.*
- *If bodies of same shape but different masses and radii are allowed to roll down an inclined plane, then they will reach the bottom with the same speed and at the same time.*
- *Moment of inertia of the body will be minimum along the axis passing through its centre of mass.*
- *M.I. of cube is minimum about its diagonal.*

- *For same mass and dimensions, moment of inertia of a hollow body is more than moment of inertia of solid body.*
- *Angular velocity of fan is constant due to applied torque. It is balanced by some frictional torque. Whenever applied torque is removed, fan comes to rest because of frictional torque.*
- *Angular momentum has same direction as that of angular velocity.*

Quick Review

Circular Motion

- It is an Accelerated Motion
- It is a Periodic Motion

Uniform circular Motion (UCM)

- Speed is constant
- Acceleration is radial and always directed towards the centre.

Centripetal force

Centripetal force is directed along the radius towards the centre of a circle.
In vector form, it is given by $\vec{F} = -\frac{mv^2}{r}\hat{r}_0$

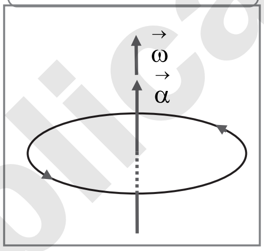
Centrifugal force

Centrifugal force is directed along the radius away from the centre of a circle.
In vector form, it is given by, $\vec{F} = +\frac{mv^2}{r}\hat{r}_0$

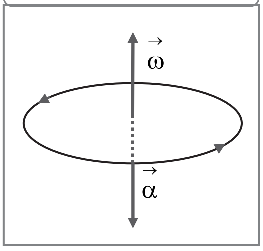
Non-uniform circular Motion (Non-UCM)

- Speed is not constant
- The acceleration of the particle is radial ($\vec{a}$) as well as tangential ($\vec{\alpha}$)

Increasing speed



Decreasing speed



➢ **Application of Uniform circular Motion (U.C.M):**

1 Banking of Roads

- **Unbanked Road**: Vehicles moving on a circular horizontal road have to follow a speed limit considering the friction between the tyre and the road. The maximum possible speed, $v_s = \sqrt{\mu rg}$
- **Banked Road**: To avoid the skidding of vehicles travelling on a circular path, the roads are banked at certain angle (θ).

i. **Most safe speed**: The most safe speed a vehicle can move on a road banked at angle θ is, $v = \sqrt{rg\tan\theta}$

ii. **Banking angle**: The angle by which a road should be banked is, $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$

iii. **Speed limits**: Minimum speed a vehicle should maintain is, $v_{min} = \sqrt{rg\left(\frac{\tan\theta - \mu_s}{1+\mu_s\tan\theta}\right)}$

Maximum speed a vehicle can attain is, $v_{max} = \sqrt{rg\left(\frac{\tan\theta + \mu_s}{1-\mu_s\tan\theta}\right)}$

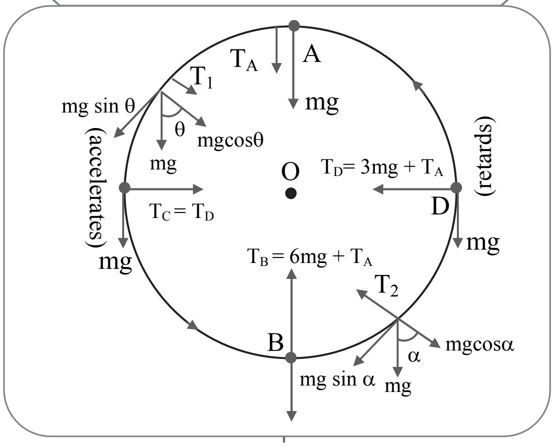
2 Well of death

- A person performing in a well of death has to maintain the minimum speed of his vehicle as $v_{min} = \sqrt{\frac{rg}{\mu_s}}$

3 Conical Pendulum

- When string of a pendulum is revolved the pendulum performs uniform circular motion.

Vertical Circular Motion (VCM)



Highest Point	Middle Point	Lowest Point
• Tension = (minimum) • Velocity = $\sqrt{rg}$ (minimum)	• Tension = (intermediate) • Velocity = $\sqrt{3rg}$	• Tension = (maximum) • Velocity = $\sqrt{5rg}$ (maximum)

➢ **Terms involved in Rotational Motion:**

Rotational Motion

Moment of Inertia (M.I.)

Moment of inertia of a rigid body about an axis of rotation is defined as the sum of product of the mass of each particle and the square of its perpendicular distance from the axis of rotation.

K.E. of rotation

Rotational K.E. of the object, is the sum of individual translational kinetic energies.

Angular Momentum (L)

- The quantity in rotational mechanics, analogous to linear momentum is angular momentum.
- **Law of conservation of angular momentum:** Angular momentum of an isolated system is conserved in the absence of an external unbalanced torque.

Torque (τ)

The turning effect of a force about the axis of rotation is called moment of force or torque due to that force. In case of rotational motion, torque is given as, $\tau = I\,\alpha$

Radius of Gyration (K)

The radius of gyration of a rigid body about a given axis of rotation is defined as the distance between the axis of rotation and a point at which the entire mass of the body can be supposed to be concentrated so as to possess the same moment of inertia as that of the body about that axis.

Moment of inertia

Perpendicular Axis Theorem

Statement: The moment of inertia (I_z) of a laminar object about an axis (z) perpendicular to its plane is the sum of its moment of inertias about two mutually perpendicular axes (x and y) in its plane, all the three axes being concurrent,

$$I_z = I_x + I_y$$

Parallel Axis Theorem

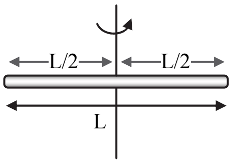
Statement: The moment of inertia (I_o) of an object about any axis is the sum of its moment of inertia (I_C) about an axis parallel to the given axis, and passing through the centre of mass and the product of the mass of the object and the square of the distance between the two axes,

$$I_o = I_c + Mh^2$$

➢ **Application of perpendicular and parallel axes theorem on different regular bodies:**

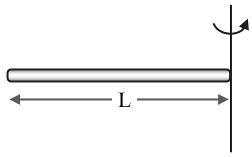
M. I of a thin rod of mass M and length L about

an axis passing through its centre and perpendicular to its length: $\mathbf{\frac{ML^2}{12}}$



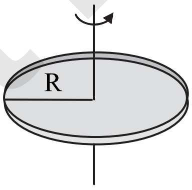
Using parallel axes theorem $\left[+M\left(\frac{L}{2}\right)^2\right]$ ⇒

an axis passing through its one end and perpendicular to its length: $\mathbf{\frac{ML^2}{3}}$



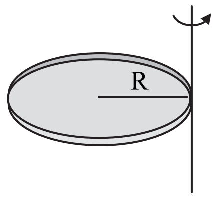
M. I of a circular ring of mass M and radius R about

an axis passing through its centre and perpendicular to the plane of the ring: $\mathbf{MR^2}$



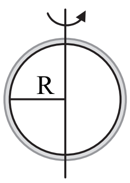
Using parallel axes theorem $(+ MR^2)$ ⇒

a tangent, and perpendicular to the plane of the ring: $\mathbf{2MR^2}$



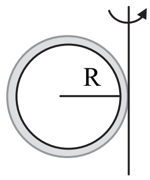
Using perpendicular axes theorem $\left(\times\frac{1}{2}\right)$ ⇓

an axis passing through its diameter: $\mathbf{\frac{1}{2}MR^2}$



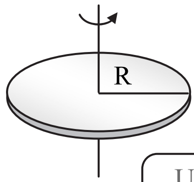
Using parallel axes theorem $(+ MR^2)$ ⇒

a tangent, and in the plane of the ring: $\mathbf{\frac{3}{2}MR^2}$



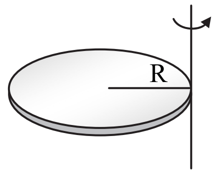
M. I of a circular disc of mass M and radius R about

an axis passing through its centre and perpendicular to the plane of the disc: $\frac{1}{2}MR^2$



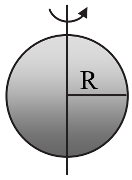
Using parallel axes theorem (+ MR^2) →

a tangent, and perpendicular to the plane of the disc: $\frac{3}{2}MR^2$



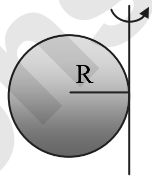
Using perpendicular axes theorem $\left(\times\frac{1}{2}\right)$ ↓

an axis passing through its diameter: $\frac{1}{4}MR^2$



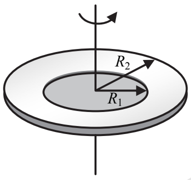
Using parallel axes theorem (+ MR^2) →

a tangent, and in the plane of the disc: $\frac{5}{4}MR^2$



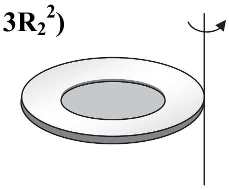
M. I of a flat annular disc of mass M and inner and outer radii R_1 and R_2 about

an axis passing through its centre and perpendicular to the plane of the disc: $\frac{M}{2}(R_1^2 + R_2^2)$



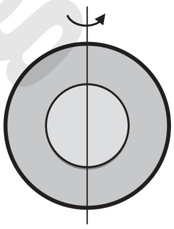
Using parallel axes theorem (+ MR_2^2) →

a tangent, and perpendicular to the plane of the disc: $\frac{M}{2}(R_1^2 + 3R_2^2)$



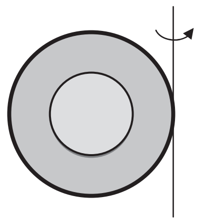
Using perpendicular axes theorem $\left(\times\frac{1}{2}\right)$ ↓

an axis passing through its diameter: $\frac{M}{4}(R_1^2 + R_2^2)$



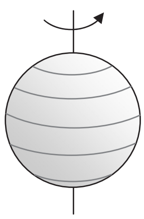
Using parallel axes theorem (+ MR_2^2) →

a tangent, and in the plane of the disc: $\frac{M}{4}(R_1^2 + 5R_2^2)$



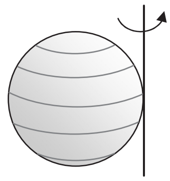
M. I of a solid sphere of mass M and radius R about an axis passing through

its diameter $\frac{2}{5}MR^2$



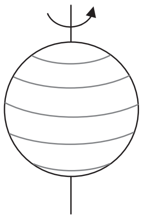
Using parallel axes theorem (+ MR^2) →

its tangent $\frac{7}{5}MR^2$



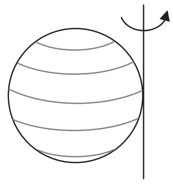
M. I of a hollow sphere of mass M and radius R about an axis passing through

its diameter $\frac{2}{3}MR^2$



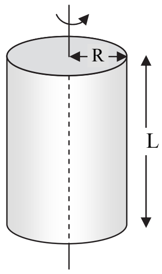
Using parallel axes theorem (+ MR^2)

its tangent $\frac{5}{3}MR^2$



M. I of a cylinder of mass M, radius R and length L about an axis passing through

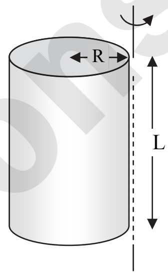
its own axis: $\frac{1}{2}MR^2$



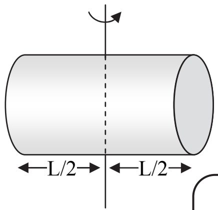
Using parallel axes theorem (+ MR^2)

a tangent parallel to its length:

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



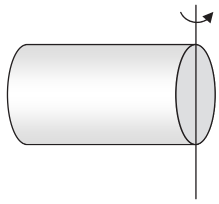
centre and perpendicular to length: $M\left(\frac{R^2}{4}+\frac{L^2}{12}\right)$



Using parallel axes theorem $\left[+M\left(\frac{L}{2}\right)^2\right]$

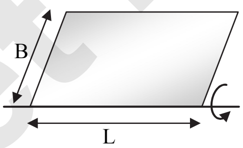
one of its end face and perpendicular to length:

$M\left(\frac{R^2}{4}+\frac{L^2}{3}\right)$

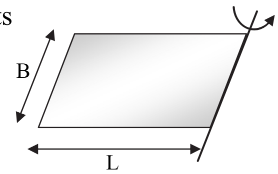


M. I of a rectangular lamina of mass M, length L and breadth B about an axis passing through

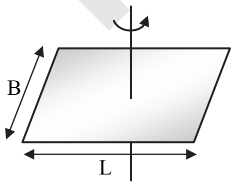
length of lamina and in its plane $\frac{MB^2}{3}$



breadth of lamina and in its plane $\frac{ML^2}{3}$

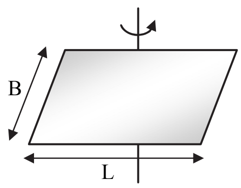


centre of mass of lamina and perpendicular to its plane $M\left(\frac{L^2+B^2}{12}\right)$



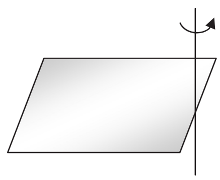
Using parallel axes theorem $\left[+M\left(\frac{B}{2}\right)^2\right]$

centre of length and perpendicular to its plane $M\left(\frac{L^2}{12}+\frac{B^2}{3}\right)$

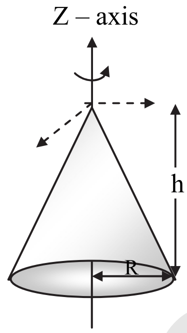


Using parallel axes theorem $\left[+M\left(\frac{L}{2}\right)^2\right]$

centre of breadth and perpendicular to its plane $M\left(\frac{L^2}{3}+\frac{B^2}{12}\right)$



M. I. of solid cone of mass M, Radius R and height h about an axis passing through
its central axis along Z – axis is $\frac{3}{10}MR^2$



Classical Thinking

1.2 Characteristics of Circular Motion

1. The quantity $\vec{\alpha} \times \vec{r}$ is directed along
   (A) tangent to the path.
   (B) perpendicular to the path.
   (C) parallel to the path.
   (D) along the path.

2. A body moves with constant angular velocity on a circle. Magnitude of angular acceleration is
   (A) $r\omega^2$ (B) constant
   (C) zero (D) $r\omega$

3. For a particle in a non-uniform accelerated circular motion,
   (A) velocity is radial and acceleration is transverse only.
   (B) velocity is transverse and acceleration is radial only.
   (C) velocity is radial and acceleration has both radial and transverse components.
   (D) velocity is transverse and acceleration has both radial and transverse components.

4. Calculate the angular acceleration of a centrifuge which is accelerated from rest to 350 r.p.s. in 220 s.
   (A) 10 rad s^{-2} (B) 20 rad s^{-2}
   (C) 25 rad s^{-2} (D) 30 rad s^{-2}

5. **Assertion:** In circular motion, the centripetal and centrifugal forces acting in opposite direction balance each other.
   Reason: Centripetal and centrifugal forces don't act at the same time.
   (A) Assertion is True, Reason is True; Reason is a correct explanation for Assertion
   (B) Assertion is True, Reason is True; Reason is not a correct explanation for Assertion
   (C) Assertion is True, Reason is False
   (D) Assertion is False but Reason is True.

6. When a body moves with a constant speed along a circle,
   (A) its linear velocity remains constant.
   (B) no force acts on it.
   (C) no work is done on it.
   (D) no acceleration is produced in it.

7. In uniform circular motion,
   (A) both the angular velocity and the angular momentum vary.
   (B) the angular velocity varies but the angular momentum remains constant.
   (C) both the angular velocity and the angular momentum remains constant.
   (D) the angular momentum varies but the angular velocity remains constant.

8. **Assertion:** If a body moving in a circular path has constant speed, then there is no force acting on it.
   Reason: The direction of the velocity vector of a body moving in a circular path is changing.
   (A) Assertion is True, Reason is True; Reason is a correct explanation for Assertion
   (B) Assertion is True, Reason is True; Reason is not a correct explanation for Assertion
   (C) Assertion is True, Reason is False
   (D) Assertion is False but Reason is True.

9. A particle moves along a circular orbit with constant angular velocity. This necessarily means,
   (A) its motion is confined to a single plane.
   (B) its motion is not confined to a single plane.
   (C) nothing can be said regarding the plane of motion.
   (D) its motion is one-dimensional.

10. A car travels due north with a uniform velocity. As the car moves over muddy area, mud sticks to the tyre. The particles of the mud as it leaves the ground are thrown
(A) vertically upwards.
(B) vertically inwards.
(C) towards north.
(D) towards south.

11. The force required to keep a body in uniform circular motion is
(A) centripetal force.
(B) centrifugal force.
(C) frictional force.
(D) breaking force.

12. The centripetal acceleration is given by
(A) v^2/r (B) vr
(C) vr^2 (D) v/r

13. An important consequence of centrifugal force is that the earth is,
(A) bulged at poles and flat at the equator.
(B) flat at poles and bulged at the equator.
(C) high tides and low tides.
(D) rising and setting of sun.

14. When a car is going round a circular track, the resultant of all the forces on the car in an inertial frame is
(A) acting away from the centre.
(B) acting towards the centre.
(C) zero.
(D) acting tangential to the track.

15. Place a coin on gramophone disc near its centre and set the disc into rotation. As the speed of rotation increases, the coin will slide away from the centre of the disc. The motion of coin is due to
(A) radial force towards centre.
(B) non-conservative force.
(C) centrifugal force.
(D) centripetal force.

16. A flywheel rotates at a constant speed of 3000 r.p.m. The angle described by the shaft in one second is
(A) 3π rad (B) 30π rad
(C) 100π rad (D) 3000π rad

1.3 Applications of Uniform Circular Motion

1. The safe speed of a vehicle on a horizontal curve road is independent of
(A) mass of vehicle.
(B) coefficient of friction between road surface and tyre of vehicle.
(C) radius of curve.
(D) acceleration due to gravity.

2. The rail tracks are banked on the curves so that
(A) resultant force will be decreased.
(B) weight of train may be reduced.
(C) centrifugal force may be balanced by the horizontal component of the normal reaction of the rail.
(D) frictional force may be produced between the wheels and tracks.

3. For a banked curved road, the necessary centripetal force on any vehicle is provided by
(A) vertical component of normal reaction of the vehicle.
(B) horizontal component of the normal reaction of the vehicle.
(C) both vertical and horizontal components of the normal reaction of the vehicle.
(D) weight of the vehicle.

4. If the radius of the circular track decreases, then the angle of banking
(A) increases.
(B) decreases.
(C) first increases then decreases.
(D) does not change.

5. A car is negotiating a curved road of radius R. The road is banked at an angle θ. The coefficient of friction between the tyres of the car and the road is μ_s. The maximum safe velocity on this road is
(A) $\sqrt{\frac{g}{R}\frac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}}$ (B) $\sqrt{\frac{g}{R^2}\frac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}}$
(C) $\sqrt{gR^2\frac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}}$ (D) $\sqrt{gR\frac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}}$

6. A 500 kg car takes a round turn of radius 50 m with a velocity of 36 km/hr. The centripetal force is
(A) 250 N (B) 750 N
(C) 1000 N (D) 1200 N

1.4 Vertical Circular Motion

1. For a particle moving in a vertical circle,
(A) kinetic energy is constant.
(B) potential energy is constant.
(C) neither K.E. nor P.E. is constant.
(D) both kinetic energy and potential energy are constant.

2. If a body is tied to a string and whirled in vertical circle, then the tension in the string at the highest position is
(A) maximum.
(B) minimum.
(C) between maximum and minimum values.
(D) zero.

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

(A) $\sqrt{3gR}$ (B) $\sqrt{5gR}$
(C) $\sqrt{gR}$ (D) $\sqrt{2gR}$

4. **Assertion:** For looping a vertical loop of radius r, the minimum velocity at the lowest point should be $\sqrt{5gr}$.

Reason: Velocity at the highest point would be zero.

(A) Assertion is True, Reason is True; Reason is a correct explanation for Assertion
(B) Assertion is True, Reason is True; Reason is not a correct explanation for Assertion
(C) Assertion is True, Reason is False
(D) Assertion is False but Reason is True.

5. If the overbridge is concave instead of being convex, the thrust on the road at the lowest position will be

(A) $mg + \frac{mv^2}{r}$ (B) $mg - \frac{mv^2}{r}$
(C) $\frac{m^2v^2g}{r}$ (D) $\frac{v^2g}{r}$

6. A mass m is attached to a thin wire and whirled in a vertical circle. The wire is most likely to break when:

(A) the mass is at the lowest point
(B) inclined at an angle of 60° from vertical
(C) the mass is at the highest point
(D) the wire is horizontal

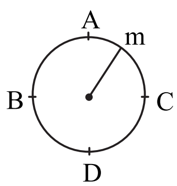
7. A particle of mass m is rotating by means of a string in a vertical circle. The difference in tensions at the top and the bottom would be

(A) 6 mg (B) 4 mg
(C) 2 mg (D) 3 mg

8. A motor cycle is going on an over bridge of radius R. The driver maintains a constant speed. As motor cycle is descending, normal force on it

(A) increases (B) decreases
(C) remain the same (D) fluctuates

9. A particle of mass m tied with string is revolving in vertical circular motion with same speed. Maximum possibility of breaking the string is at point



(A) A
(B) B
(C) C
(D) D

10. A body of mass m is tied to a string of length l and whirled in a vertical circle. The velocity of the body at the lowest position is u. Then the tension in the string at a position when the string makes an angle θ with the vertical is

(A) $\frac{mu^2}{l}$
(B) $\frac{mu^2}{l} + mg\cos\theta$
(C) $\frac{mu^2}{l} + mg(2\cos\theta - 3)$
(D) $\frac{mu^2}{l} + mg(3\cos\theta - 2)$

11. A particle is moving in a vertical circle. If v_1 is the velocity of particle at highest point and v_2 is the velocity of particle at lowest point, then the relation between v_1 and v_2 is

(A) $v_1 = v_2$ (B) $v_1 < v_2$
(C) $v_2 = \sqrt{5}\, v_1$ (D) $v_1 = \sqrt{5}\, v_2$

1.5 Moment of Inertia as an Analogous Quantity for Mass

1. In rotational motion of a rigid body, all particles move with

(A) same linear and angular velocity.
(B) same linear velocity and different angular velocities.
(C) different linear velocities and same angular velocity.
(D) different linear and angular velocities.

2. Choose the CORRECT statement out of the following.

(A) The moment of inertia of a body is a vector.
(B) The dimensions of moment of inertia are $[M^1L^2T^{-1}]$.
(C) Moment of inertia plays the same role in rotational motion as mass does in translational motion.
(D) Moment of inertia of a body does not depend on its dimensions.

3. If a mass shifts towards the axis of rotation, its M.I. will

(A) decrease.
(B) increase.
(C) remain unchanged.
(D) first increases then decreases.

4. Generally, most of the mass of the flywheel is placed on the rim

(A) to decrease moment of inertia.
(B) to obtain equilibrium.
(C) to increase moment of inertia.
(D) to obtain strong wheel.

5. Which of the following quantities is/are directionless?
   (A) Moment of momentum
   (B) Moment of force
   (C) Both (A) and (B)
   (D) Moment of inertia

6. M.I. of a body doesn't depend upon
   (A) angular velocity of the body.
   (B) mass of the body.
   (C) distribution of mass in the body.
   (D) axis of rotation of the body.

7. The M.I. of a cube will be minimum about an axis which
   (A) joins mid points.
   (B) is an edge of the cube.
   (C) is a face diagonal.
   (D) is a body diagonal.

8. On account of melting of ice at the north pole, the moment of inertia of spinning earth
   (A) increases.
   (B) decreases.
   (C) remains unchanged.
   (D) depends on the time.

9. The corresponding quantities in rotational motion related to m, $\vec{F}$, $\vec{p}$ and $\vec{v}$ in linear motion are respectively
   (A) I, $\vec{L}$, $\vec{\tau}$ and $\vec{\omega}$ (B) L, $\vec{\tau}$, $\vec{\omega}$ and I
   (C) I, $\vec{\tau}$, $\vec{L}$ and $\vec{\omega}$ (D) I, $\vec{\omega}$, $\vec{L}$ and $\vec{\tau}$

10. **Assertion:** A judo fighter in order to throw his opponent onto the mattress, initially bends his opponent and then rotates him around his hip.
    Reason: As the mass of the opponent is brought closer to the fighter's hip, the force required to throw the opponent is reduced.
    (A) Assertion is True, Reason is True; Reason is a correct explanation for assertion.
    (B) Assertion is True, Reason is True; Reason is not a correct explanation for assertion.
    (C) Assertion is True, Reason is False
    (D) Assertion is False but, Reason is True.

11. The rotational kinetic energy of a body rotating about some axis is directly proportional to
    (A) periodic time (B) $(\text{periodic time})^2$
    (C) $(\text{periodic time})^{-1}$ (D) $(\text{periodic time})^{-2}$

12. If the kinetic energy of rotation of a body about an axis is 9 J and the moment of inertia is 2 kg m^2, then the angular velocity of the body about the axis of rotation in rad/s is
    (A) 2 (B) 3
    (C) 1 (D) 9

13. A flywheel rotating about a fixed axis has a kinetic energy of 360 joule, when its angular speed is 30 radian/s. The moment of inertia of the wheel about the axis of rotation is
    (A) 0.6 kg m^2 (B) 0.15 kg m^2
    (C) 0.8 kg m^2 (D) 0.75 kg m^2

1.6 Radius of Gyration

1. The radius of gyration of a homogeneous body is independent of
   (A) mass of the body.
   (B) axis of rotation.
   (C) distance from the axis of rotation.
   (D) distribution of mass of the system.

2. The dimensions of radius of gyration are the same as that of
   (A) moment of inertia
   (B) length
   (C) angular acceleration
   (D) $\sqrt{(\text{length}^2/\text{mass})}$

3. The radius of gyration depends on
   (A) mass
   (B) the relative position of axis
   (C) volume
   (D) torque

4. Radius of gyration of a uniform circular disc about an axis passing through its centre of gravity and perpendicular to its plane is
   (A) R (B) $\frac{R}{2}$
   (C) $\sqrt{2}$ R (D) $\frac{R}{\sqrt{2}}$

5. Radius of gyration of a disc rotating about a tangent in its plane is
   (A) $\frac{5R}{\sqrt{2}}$ (B) $\sqrt{\frac{5R}{3}}$
   (C) $\frac{5R}{\sqrt{3}}$ (D) $\frac{\sqrt{5}R}{2}$

1.7 Theorem of Parallel Axes and Theorem of Perpendicular Axes

1. Which of the following statements is true in case of the principle of perpendicular axes?
   (A) It is applicable to only three dimensional objects.
   (B) It is applicable to planar as well as three dimensional objects.
   (C) It is applicable to only planar objects.
   (D) It is applicable to only denser objects.

2. From the theorem of perpendicular axes, if the lamina is in X- Y plane, then
   (A) $I_x - I_y = I_z$ (B) $I_x + I_z = I_y$
   (C) $I_x + I_y = I_z$ (D) $I_y + I_z = I_x$

3. From the theorem of parallel axes,
(A) $I_O = I_C - Md^2$ (B) $I_O = I_C + Md^2$
(C) $I_O + I_C = Md^2$ (D) $I_C = I_O + Md^2$

4. M.I. of a thin uniform circular disc about one of the diameters is I. Its M.I. about an axis perpendicular to the plane of disc and passing through its centre is
(A) $\sqrt{2}$ I (B) 2I
(C) I/2 (D) I/4

5. Moment of inertia of a circular loop of radius R about the axis of rotation parallel to horizontal diameter at a distance R/2 from it is
(A) MR^2 (B) $\frac{1}{2}MR^2$
(C) $2\ MR^2$ (D) $\frac{3}{4}MR^2$

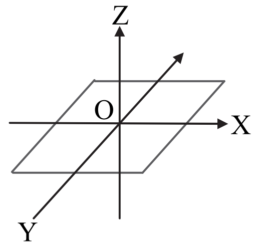
6. A solid cylinder of mass M and radius R rolls without slipping on a flat horizontal surface. Its moment of inertia about the line of contact is
(A) $\frac{MR^2}{2}$ (B) MR^2
(C) $\frac{3}{2}MR^2$ (D) $2MR^2$

7. The moment of inertia of a cylinder of radius R, length L and mass M about an axis passing through its centre of mass and normal to its length is
(A) $\frac{ML^2}{12}$ (B) $\frac{MR^2}{4}$
(C) $M\left[\frac{L^2}{12}+\frac{R^2}{4}\right]$ (D) $M\left[\frac{L^2}{12}+\frac{R^2}{2}\right]$

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

9. Moment of inertia of a body about two perpendicular axes X and Y in the plane of lamina are 20 kg m^2 and 25 kg m^2 respectively. Its moment of inertia about an axis perpendicular to the plane of the lamina and passing through the point of intersection of X and Y axes is
(A) 5 kg m^2 (B) 45 kg m^2
(C) 12.5 kg m^2 (D) 500 kg m^2

10. A thin uniform rectangular plate of mass 2 kg is placed in X-Y plane as shown in figure. The moment of inertia about X-axis is $I_x = 0.2$ kg m^2 and the moment of inertia about Y-axis is $I_y = 0.3$ kg m^2. The radius of gyration of the plate about the axis passing through O and perpendicular to the plane of the plate is



(A) 38.7 cm
(B) 31.6 cm
(C) 50 cm
(D) 5 cm

1.8 Angular Momentum or Moment of Linear Momentum

1. The angular momentum of a rigid body is
(A) the moment of the acting force.
(B) moment of the momentum.
(C) moment of the mass.
(D) moment of the acceleration.

2. Unit of angular momentum is
(A) N s (B) N s^{-1}
(C) J s^{-1} (D) J s

3. Dimensions of angular momentum are
(A) $[M^1L^2T^{-2}]$ (B) $[M^1L^{-2}T^{-1}]$
(C) $[M^1L^2T^{-1}]$ (D) $[M^1L^0T^{-1}]$

4. Angular momentum of a body is the product of
(A) linear velocity and angular velocity.
(B) centripetal force and velocity.
(C) force and angular velocity.
(D) moment of inertia and angular velocity.

5. When a mass is rotating in a plane about a fixed point, its angular momentum is directed along
(A) a line perpendicular to the plane of rotation.
(B) the line making an angle of 45° to the plane of rotation.
(C) the radius.
(D) the tangent to the orbit.

6. The rate of change of angular momentum is called
(A) angular velocity.
(B) force.
(C) torque.
(D) linear momentum.

7. A bob of mass m attached to an inextensible string of length *l* is suspended from a vertical support. The bob rotates in a horizontal circle with an angular speed ω rad/s about the vertical. About the point of suspension,
(A) angular momentum is conserved.
(B) angular momentum changes in magnitude but not in direction.
(C) angular momentum changes in direction but not in magnitude.
(D) angular momentum changes both in direction and magnitude.

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

1.9 Expression for Torque in Terms of Moment of Inertia

1. The product of moment of inertia (I) and angular acceleration (α) is called
(A) force
(B) torque
(C) angular momentum
(D) work

2. Which of the following statements is correct?
(A) Torque is always directed along momentum.
(B) Torque is always directed along angular momentum.
(C) Torque is always directed along the change in angular momentum.
(D) Torque is always directed towards centre.

3. The dimensions of torque are
(A) $[M^1L^2T^{-2}]$ (B) $[M^1L^2T^{-1}]$
(C) $[M^1L^1T^{-1}]$ (D) $[M^1L^2T^2]$

4. A force $\vec{F}$ is acting on a particle of position vector $\vec{r}$, the torque will be
(A) $\vec{r} \times \vec{F}$ (B) $\vec{F} \times \vec{r}$
(C) rF (D) $\frac{\vec{F}}{\vec{r}}$

5. A particle of mass M and radius of gyration K is rotating with angular acceleration α. The torque acting on the particle is
(A) $\frac{1}{2}MK^2\alpha$ (B) $MK^2\alpha$
(C) $\frac{MK^2}{\alpha}$ (D) $\frac{1}{4}MK^2\alpha^2$

6. If the moment of inertia of a body is 2.5 kg m^2, then the torque required to produce an angular acceleration of 18 rad/s^2 in the body is
(A) 47 Nm (B) 50 Nm
(C) 55 Nm (D) 45 Nm

7. If a constant couple of 500 N-m turns a wheel of moment of inertia 100 kg m^2 about an axis through its centre, the angular velocity gained in 2 seconds is
(A) 10 rad/s (B) 50 rad/s
(C) 200 rad/s (D) 100 rad/s

8. A torque of magnitude 2000 Nm acting on a body produces an angular acceleration of 20 rad/s^2. The moment of inertia of the body is
(A) 150 kg m^2 (B) 50 kg m^2
(C) 200 kg m^2 (D) 100 kg m^2

1.10 Conservation of Angular Momentum

1. The relation between the torque $\vec{\tau}$ and the angular momentum $\vec{L}$ of a body of moment of inertia I rotating with angular velocity ω is
(A) $\vec{\tau} = \frac{d\vec{L}}{dt}$ (B) $\vec{\tau} = \vec{L} \cdot \vec{\omega}$
(C) $\vec{\tau} = \frac{d\vec{L}}{d\omega}$ (D) $\vec{\tau} = \vec{L} \times \vec{\omega}$

2. When torque acting on a rotating body is zero, then which of the following remains constant?
(A) Force
(B) Linear momentum
(C) Angular momentum
(D) All of the above

3. A solid sphere is rotating freely about its symmetry axis in free space. The radius of the sphere is increased keeping its mass same. Which of the following physical quantities would remain constant for the sphere?
(A) Angular velocity
(B) Moment of inertia
(C) Rotational kinetic energy
(D) Angular momentum

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

5. A constant torque is applied on a circular wheel, which changes its angular momentum from 0 to 4L in 4 seconds. The torque is
(A) 3L/4 (B) L
(C) 4L (D) 12L

6. A swimmer while jumping into water from a height easily forms a loop in air, if
(A) he pulls his arms and legs in.
(B) he keeps himself straight.
(C) he spreads his legs and arms.
(D) his body has no particular form.

1.11 Rolling Motion

1. A sphere cannot roll on
   (A) a smooth horizontal surface.
   (B) a smooth inclined surface.
   (C) a rough horizontal surface.
   (D) a rough inclined surface.

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

3. A disc and a sphere of same radius but different masses roll off on two inclined planes of the same altitude and length. Which one of the two objects gets to the bottom of the plane first?
   (A) Both reach at the same time
   (B) Depends on their masses
   (C) Disc
   (D) Sphere

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

5. A solid sphere at the top of an inclined plane 0.6 m high is released and rolls down the incline without slipping and without loss of energy due to friction. Its linear speed at the bottom is about
   (A) 2.9 m/s (B) 2.42 m/s
   (C) 3.87 m/s (D) 1.53 m/s

6. Three bodies, a ring, a solid disc and a solid sphere roll down the same inclined plane without slipping. The radii of the bodies are identical and they start from rest. If v_S, v_R, and v_D are the speeds of the sphere, ring and disc respectively when they reach the bottom, then the correct option is
   (A) $v_S > v_R > v_D$ (B) $v_D > v_S > v_R$
   (C) $v_R > v_D > v_S$ (D) $v_S > v_D > v_R$

7. A uniform round body of radius R, mass M and moment of inertia I rolls down (without slipping) an inclined plane making an angle θ with the horizontal then the acceleration is
   (A) $\frac{g\sin\theta}{1+I/MR^2}$ (B) $\frac{g\sin\theta}{1+MR^2/I}$
   (C) $\frac{g\sin\theta}{1-I/MR^2}$ (D) $\frac{g\sin\theta}{1-MR^2/I}$

8. An inclined plane makes an angle of 30° with the horizontal. A solid sphere rolling down this inclined plane from rest without slipping has a linear acceleration equal to
   (A) $\frac{g}{3}$ (B) $\frac{2g}{3}$
   (C) $\frac{5g}{7}$ (D) $\frac{5g}{14}$

9. An inclined plane makes an angle of 30° with the horizontal. A ring rolling down the inclined plane from rest without slipping has a linear acceleration equal to
   (A) 2g/3 (B) g/2
   (C) g/3 (D) g/4

MHT-CET Previous Years' Questions

1. The angle of banking is independent of **[2005]**
   (A) speed of vehicle
   (B) radius of curvature of road
   (C) height of inclination
   (D) None of these

2. The moment of inertia of a uniform thin rod of length L and mass M about an axis passing through a point at a distance of $\frac{L}{3}$ from one of its ends and perpendicular to the rod is **[2010]**
   (A) $\frac{7ML^2}{48}$ (B) $\frac{ML^2}{9}$
   (C) $\frac{ML^2}{12}$ (D) $\frac{ML^2}{3}$

3. The M.I. of a uniform disc about the diameter is I. Its M.I. about an axis perpendicular to its plane and passing through a point on its rim is **[2010]**
   (A) 4 I (B) 5 I
   (C) 6 I (D) I

4. Which of the following is not correct? **[2010]**
   (A) Torque = M.I × Angular acceleration
   (B) Angular momentum = M.I × Angular velocity
   (C) Force = mass × acceleration
   (D) Moment of Inertia = Torque × Angular acceleration

5. 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) **[2014]**
(A) $\frac{2}{5}MR^2$ (B) $\frac{MR^2}{2}$
(C) MR^2 (D) $\frac{3}{2}MR^2$

6. 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 **[2015]**
(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) $\frac{MR^2}{4}+\frac{Ml^2}{12}$

7. A particle of mass 'm' is moving in circular path of constant radius 'r' such that centripetal acceleration is varying with time 't' as $K^2 r t^2$ where K is a constant. The power delivered to the particle by the force acting on it is **[2015]**
(A) $m^2 K^2 r^2 t^2$ (B) $mK^2 r^2 t$
(C) $m K^2 r t^2$ (D) $m K r^2 t$

8. 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 **[2015]**
(A) $[mgh]^{\frac{1}{2}}$ (B) $\left[\frac{2mgh}{I+2mr^2}\right]^{\frac{1}{2}}$
(C) $\left[\frac{2mgh}{I+mr^2}\right]^{\frac{1}{2}}$ (D) $\left[\frac{mgh}{I+mr^2}\right]^{\frac{1}{2}}$

9. 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 'S' is the specific heat of the material in J/kg K then rise in temperature of the sphere is (M.I. of hollow sphere $= \frac{2}{3}MR^2$) **[2015]**
(A) $\frac{R\omega}{4S}$ (B) $\frac{R^2\omega^2}{4S}$ (C) $\frac{R\omega}{2S}$ (D) $\frac{R^2\omega^2}{2S}$

10. In vertical circular motion, the ratio of kinetic energy of a particle at highest point to that at lowest point is **[2016]**
(A) 5 (B) 2 (C) 0.5 (D) 0.2

11. A disc of moment of inertia 'I_1' is rotating in horizontal plane about an axis passing through a centre and perpendicular to its plane with constant angular speed 'ω_1'. Another disc of moment of inertia 'I_2' having zero angular speed is placed coaxially on a rotating disc. Now both the discs are rotating with constant angular speed 'ω_2'. The energy lost by the initial rotating disc is **[2017, 2010]**
(A) $\frac{1}{2}\left[\frac{I_1+I_2}{I_1I_2}\right]\omega_1^2$ (B) $\frac{1}{2}\left[\frac{I_1I_2}{I_1-I_2}\right]\omega_1^2$
(C) $\frac{1}{2}\left[\frac{I_1-I_2}{I_1I_2}\right]\omega_1^2$ (D) $\frac{1}{2}\left[\frac{I_1I_2}{I_1+I_2}\right]\omega_1^2$

12. A flywheel at rest is to reach an angular velocity of 24 rad/s in 8 second with constant angular acceleration. The total angle turned through during this interval is **[2017]**
(A) 24 rad (B) 48 rad
(C) 72 rad (D) 96 rad

13. A wheel of moment of inertia 2 kg m^2 is rotating about an axis passing through centre and perpendicular to its plane at a speed 60 rad/s. Due to friction, it comes to rest in 5 minutes. The angular momentum of the wheel three minutes before it stops rotating is **[2017]**
(A) 24 kg m^2/s (B) 48 kg m^2/s
(C) 72 kg m^2/s (D) 96 kg m^2/s

14. A ceiling fan rotates about its own axis with some angular velocity. When the fan is switched off, the angular velocity becomes $\left(\frac{1}{4}\right)^{th}$ of the original in time 't' and 'n' revolutions are made in that time. The number of revolutions made by the fan during the time interval between switch off and rest are (Angular retardation is uniform) **[2017]**
(A) $\frac{4n}{15}$ (B) $\frac{8n}{15}$ (C) $\frac{16n}{15}$ (D) $\frac{32n}{15}$

15. In non uniform circular motion, the ratio of tangential to radial acceleration is (r = radius of circle, v = speed of the particle, α = angular acceleration) **[2018]**
(A) $\frac{\alpha^2 r^2}{v}$ (B) $\frac{\alpha^2 r}{v^2}$
(C) $\frac{\alpha r^2}{v^2}$ (D) $\frac{v^2}{r^2\alpha}$

16. A mass attached to one end of a string crosses top-most point on a vertical circle with critical speed. Its centripetal acceleration when string becomes horizontal will be (g = gravitational acceleration) **[2018]**
(A) g (B) 3 g (C) 4 g (D) 6 g

17. The moment of inertia of a ring about an axis passing through the centre and perpendicular to its plane is 'I'. It is rotating with angular velocity 'ω'. Another identical ring is gently placed on it so that their centres coincide. If both the rings are rotating about the same axis then loss in kinetic energy is **[2018]**

(A) $\frac{I\omega^2}{2}$ (B) $\frac{I\omega^2}{4}$ (C) $\frac{I\omega^2}{6}$ (D) $\frac{I\omega^2}{8}$

18. A disc has mass 'M' and radius 'R'. How much tangential force should be applied to the rim of the disc so as to rotate with angular velocity 'ω' in time 't'? **[2018]**

(A) $\frac{MR\omega}{4t}$ (B) $\frac{MR\omega}{2t}$

(C) $\frac{MR\omega}{t}$ (D) $MR\omega t$

19. Which of the following statements is false? Centripetal force and centrifugal force **[2019]**

(A) are equal in magnitude.
(B) constitute an action - reaction pair.
(C) act on the same body.
(D) act along the radius.

20. A uniform cylinder has length 'L' and radius 'R'. The moment of inertia of the cylinder about an axis passing through its centre and perpendicular to its length is equal to moment of inertia of the same cylinder about an axis passing through its centre and perpendicular to its circular face. The relation between 'L' and 'R' is **[2019]**

(A) $L = 3R$ (B) $L = 2R$

(C) $L = R\sqrt{2}$ (D) $L = R\sqrt{3}$

21. A ballet dancer spins about vertical axis at 1.5 π rad/s with arms outstretched. With the arms folded, the moment on inertia about the same axis of rotation changes by 25%. The new frequency of rotation is **[2019]**

(A) 100 rpm (B) 60 rpm
(C) 150 rpm (D) 120 rpm

22. When 'W' joule of work is done on a flywheel, its frequency of rotation increases from 'n_1' Hz to 'n_2' Hz. The M.I. of the flywheel about its axis of rotation is given by **[2019]**

(A) $\frac{W}{2\pi^2\left(n_2^2-n_1^2\right)}$ (B) $\frac{W}{4\pi^2\left(n_2^2+n_1^2\right)}$

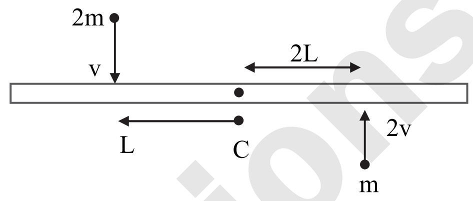
(C) $\frac{W}{4\pi^2\left(n_2^2-n_1^2\right)}$ (D) $\frac{W}{2\pi^2\left(n_2^2+n_1^2\right)}$

23. A stone of mass 1 kg is tied to a string 2 m long and is rotated at constant speed of 40 ms^{-1} in a vertical circle. The ratio of the tension at the top and the bottom is [Take g = 10 ms^{-2}] **[2019]**

(A) $\frac{12}{19}$ (B) $\frac{79}{81}$

(C) $\frac{19}{12}$ (D) $\frac{81}{79}$

24. A uniform rod of length '6L' and mass '8m' is pivoted at its centre 'C'. Two masses 'm' and '2m' with speed 2v and v (as shown) strike the rod and stick to the rod. Initially the rod is at rest. Due to impact, if it rotates with angular velocity 'ω' then 'ω' will be **[2019]**



(A) $\frac{8v}{6L}$ (B) $\frac{11v}{3L}$

(C) $\frac{v}{5L}$ (D) zero

25. 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 **[2020, 2014]**

(A) $\frac{4\pi}{3}$ (B) $\frac{8\pi^2}{3}$

(C) $\frac{5\pi}{3}$ (D) $\frac{8\pi^2}{5}$

26. Let 'M' be the mass and 'L' be the length of a thin uniform rod. In first case, axis of rotation is passing through centre and perpendicular to the length of the rod. In second case, axis of rotation is passing through one end and perpendicular to the length of the rod. The ratio of radius of gyration in first case to second case is **[2020, 2016]**

(A) 1 (B) $\frac{1}{2}$ (C) $\frac{1}{4}$ (D) $\frac{1}{8}$

27. A motorcyclist rides in a horizontal circle along the inner wall of cylindrical chamber of radius r. If the coefficient of friction between the tyres and the inner surface of chamber is μ, the minimum speed of motorcyclist to prevent him from skidding is **[2020]**

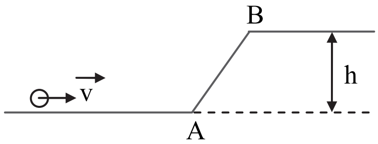
(A) $\sqrt{\frac{rg}{\mu}}$ (B) $\sqrt{\frac{\mu g}{r}}$

(C) $\sqrt{\frac{g}{r\mu}}$ (D) $\sqrt{\frac{r\mu}{g}}$

28. Two rings of radius 'R' and 'nR' made of same material have the ratio of moment of inertia about an axis passing through its centre and perpendicular to the plane as 1 : 8. The value of 'n' is (mass per unit length is constant) **[2020]**
(A) 1 (B) 3
(C) 4 (D) 2

29. A satellite of 'm', revolving round the earth of radius 'r' has kinetic energy (E). Its angular momentum is **[2020]**
(A) (mEr^2) (B) $(2mEr^2)$
(C) $(2mEr^2)^{\frac{1}{2}}$ (D) $(mEr^2)^{\frac{1}{2}}$

30. A solid sphere is rolling on a frictionless surface with translational velocity 'v'. It climbs the inclined plane from 'A' to 'B' and then moves away from B on smooth horizontal surface. The value of 'v' should be **[2020]**



(A) $\geq\left[\frac{10gh}{7}\right]^{\frac{1}{2}}$ (B) $\sqrt{2gh}$
(C) $\frac{10gh}{7}$ (D) $\sqrt{gh}$

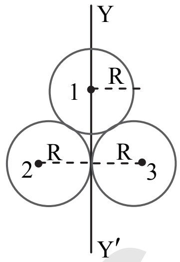
31. If 'I' is the moment of inertia and 'L' is angular momentum of a rotating body, then $\frac{L^2}{2I}$ is its **[2020]**
(A) translational kinetic energy
(B) rotational kinetic energy
(C) linear momentum
(D) torque

32. The maximum velocity with which vehicle can safely travel along banked road does NOT depend upon **[2020]**
(A) mass of the vehicle.
(B) acceleration due to gravity at a place.
(C) radius of the curved road.
(D) angle of banking.

33. In the case of conical pendulum, if 'T' is the tension in the string and 'θ' is the semi-vertical angle of cone, then the component which provides necessary centripetal force is **[2020]**
(A) T sin θ (B) T tan θ
(C) T cos θ (D) (T sin θ)/2

34. A motor cycle racer takes a round with speed 20 m/s on a curved road of radius 40 m. The leaning angle of motor cycle with vertical for safe turn is ($g = 10\ m/s^2$, $\tan 45^o = 1$) **[2020]**
(A) 30^o (B) 75^o (C) 60^o (D) 45^o

35. Three 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 **[2021]**
(A) $3\ MR^2$
(B) $\frac{3}{2}MR^2$
(C) $5\ MR^2$
(D) $\frac{7}{2}MR^2$



36. A flywheel of mass 50 kg and radius of gyration about its axis of rotation is 0.6 m. It is acted upon by a constant torque of 18 Nm. Its angular velocity at t = 8 second is (Initially flywheel is at rest) **[2021]**
(A) $36\ rad\ s^{-1}$ (B) $4\ rad\ s^{-1}$
(C) $8\ rad\ s^{-1}$ (D) $18\ rad\ s^{-1}$

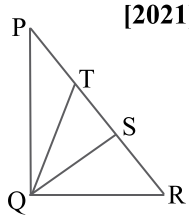
37. A particle with position vector $\vec{r}$ has a linear momentum $\vec{P}$. Which one of the following statements is true in respect of its angular momentum 'L' about the origin? **[2021]**
(A) $\vec{L}$ acts along $\vec{P}$
(B) L is maximum when $\vec{P}$ is perpendicular to $\vec{r}$.
(C) $\vec{L}$ acts along $\vec{r}$.
(D) L is maximum when $\vec{P}$ and $\vec{r}$ are parallel.

38. The angle of banking 'θ' for a meter gauge railway line is given by $\theta = \tan^{-1}\left(\frac{1}{20}\right)$.
What is the elevation of the outer rail above the inner rail? **[2021]**
(A) 20 cm (B) 10 cm
(C) 0.2 cm (D) 5 cm

39. A bob of a simple pendulum of mass 'm' is displaced through 90^o from mean position and released. When the bob is at lowest position, the tension in the string is **[2021]**
(A) 4mg (B) 2mg
(C) mg (D) 3mg

40. A child is standing with folded hands at the centre of the platform rotating about its central axis. The kinetic energy of the system is 'K'. The child now stretches his arms so that the moment of inertia of the system becomes double. The kinetic energy of the system now is **[2021]**
(A) $\frac{K}{2}$ (B) 2K
(C) 4K (D) $\frac{K}{4}$

41. Figure shows triangular lamina which can rotate about different axes moment of inertia is maximum, about the axis **[2021]**



(A) PR
(B) QS
(C) QR
(D) PQ

42. A mass tied to a string is whirled in a horizontal circular path with a constant angular velocity A mass tied to a string is whirled in a horizontal circular path with a constant angular velocity and its angular momentum is L. If the string is now halved, keeping angular velocity same, then the angular momentum will be **[2022]**

(A) L (B) $\frac{L}{4}$ (C) 2L (D) $\frac{L}{2}$

43. A van is moving with a speed of 108 km/hr on a level road where the coefficient of friction between the tyres and the road is 0.5. For the safe driving of the van, the minimum radius of curvature of the road shall be (Acceleration due to gravity, $g = 10\ m/s^2$) **[2022]**

(A) 180 m (B) 120 m
(C) 80 m (D) 40 m

44. Match the following columns (R = radius, K = Radium of gyration) **[2022]**

	Column I		Column II
(i)	'K' for a solid sphere rotating about its tangent.	(a)	$\sqrt{2}R$
(ii)	'K' for a ring rotating about its tangent perpendicular to its plane.	(b)	$\frac{R}{2}$
(iii)	'K' for a uniform solid right circular cone rotating about its central axis	(c)	$\frac{\sqrt{7}}{\sqrt{5}}R$
(iv)	'K' for a uniform disc rotating about its diameter	(d)	$\frac{\sqrt{3}}{\sqrt{10}}R$

(A) (i) → (b); (ii) → (c); (iii) → (a); (iv) → (d)
(B) (i) → (c); (ii) → (b); (iii) → (d); (iv) → (a)
(C) (i) → (a); (ii) → (c); (iii) → (b); (iv) → (d)
(D) (i) → (c); (ii) → (a); (iii) → (d); (iv) → (b)

45. A stone of a mass 200 g attached at the end of inextensible string 1 m long is whirled in a vertical circle. If the speed of the stone is 50 cm/s and the tension in the string is 1.05 N, the angle (θ) made by the string with the vertical, measured from the lowest position is [Take $g = 10\ m/s^2$] **[2022]**

(A) $\cos^{-1}(1)$ (B) $\sin^{-1}\left(\frac{1}{2}\right)$
(C) $\cos^{-1}\left(\frac{1}{2}\right)$ (D) $\sin^{-1}\left(\frac{1}{\sqrt{2}}\right)$

46. A uniform solid sphere having radius 'R' and density 'ρ' is rotating about a tangent to the surface of the sphere. The moment of inertia of the solid sphere is **[2022]**

(A) $\frac{28}{15}\pi R^5\rho$ (B) $\frac{21}{20}\pi R^3\rho$
(C) $\frac{28}{15}\pi R^3\rho$ (D) $\frac{21}{20}\pi R^5\rho$

47. A ring of moment of inertia $\frac{4.9}{\pi^2}$ kg m^2 is rotating with 300 r.p.m. If frequency of rotating is reduced by 120 r.p.m., then the work done is **[2022]**

(A) 148 J (B) 157 J
(C) 96 J (D) 115 J

48. Two solid spheres A and B having same mass and different radii rotate with kinetic energies E_A and E_B respectively. The M.I. about their axis of rotation are I_A and I_B respectively. If $I_A = \frac{I_B}{4}$ and $E_A = 100\ E_B$, then the ratio of their angular momenta L_A to L_B is **[2022]**

(A) $\frac{5}{4}$ (B) $\frac{1}{4}$
(C) 25 (D) 5

49. A particle is moving on a circular path of 10 m radius. At any instant of time its speed is 5 ms^{-1} and the speed is increasing at a rate of 2 ms^{-2}. The magnitude of net acceleration at that instant is nearly **[2022]**

(A) 3.2 ms^{-2} (B) 2 ms^{-2}
(C) 5 ms^{-2} (D) 4.3 ms^{-2}

50. A can filled with water is revolved in a vertical circle of radius 'r' and water just does not fall down. The time period of revolution is (g = acceleration due to gravity) **[2022]**

(A) $2\pi\sqrt{rg}$ (B) $2\pi\sqrt{\frac{r}{g}}$
(C) $2\pi\sqrt{5rg}$ (D) $2\pi\sqrt{\frac{g}{r}}$

51. A square frame ABCD is formed by four identical rods each of mass 'm' and length 'l'. This frame is in X-Y plane such that side AB coincides with X-axis and side AD along Y-axis. The moment of inertia of the frame about X-axis is **[2023, 2018]**

(A) $\frac{5ml^2}{3}$ (B) $\frac{2ml^2}{3}$
(C) $\frac{4ml^2}{3}$ (D) $\frac{ml^2}{12}$

52. A railway track is banked for a speed 'v' by elevating outer rail by a height 'h' above the inner rail. The distance between two rails is 'd' then the radius of curvature of track is (g = gravitational acceleration) **[2023]**

(A) $\frac{v^2d}{gh}$ (B) $\frac{2v^2}{gdh}$
(C) $\frac{gd}{2v^2h}$ (D) $\frac{v^2}{2ghd}$

53. Two particles having mass 'M' and 'm' are moving in a circular path with radius 'R' and 'r' respectively. The time period for both the particles is same. The ratio of angular velocity of the first particle to the second particle will be **[2023]**

(A) 1 :1 (B) 1 : 2
(C) 2 : 3 (D) 3 : 4

54. If 'I' is moment of inertia of a thin circular disc about an axis passing through the tangent of the disc and in the plane of disc. The moment of inertia of same circular disc about an axis perpendicular to plane and passing through its centre is **[2023]**

(A) $\frac{4I}{5}$ (B) $\frac{2I}{5}$
(C) $\frac{4I}{3}$ (D) $\frac{2I}{3}$

55. A particle at rest starts moving with constant angular acceleration 'α' in circular path. At what time the magnitude of centripetal acceleration is half the tangential acceleration? **[2023]**

(A) $\frac{1}{\sqrt{2\alpha}}$ (B) $\frac{1}{\sqrt{\alpha}}$
(C) $\frac{2}{\sqrt{\alpha}}$ (D) $\frac{\sqrt{\alpha}}{2}$

56. Three point masses, each of mass 'm' are kept at the corners of an equilateral triangle of side 'L'. The system rotates about the centre of the triangle without any change in the separation of masses during rotation. The period of rotation is directly proportional to ($\cos 30^\circ = \frac{\sqrt{3}}{2}$) **[2023]**

(A) $L^{3/2}$ (B) L^{-2}
(C) L (D) $\sqrt{L}$

57. The ratio of radius of gyration of a ring to circular disc of same radii and mass about a tangential axis perpendicular to the plane is **[2023]**

(A) $\frac{3}{2}$ (B) $\frac{2}{3}$ (C) $\frac{1}{\sqrt{3}}$ (D) $\frac{2}{\sqrt{3}}$

58. A square lamina of side 'b' has same mass as a disc of radius 'R' the moment of inertia of the two objects about an axis perpendicular to the plane and passing through the centre is equal. The ratio $\frac{b}{R}$ is **[2023]**

(A) 1 : 1 (B) $\sqrt{3}$: 1
(C) $\sqrt{6}$: 1 (D) 1 : $\sqrt{3}$

59. A solid sphere rolls without slipping on an inclined plane at an angle θ. The ratio of total kinetic energy to its rotational kinetic energy is **[2023]**

(A) $\frac{7}{2}$ (B) $\frac{5}{2}$ (C) $\frac{7}{3}$ (D) $\frac{5}{4}$

60. Two discs of same mass and same thickness (t) are made from two different materials of densities 'd_1' and 'd_2' respectively. The ratio of the moment of inertia I_1 to I_2 of two discs about an axis passing through the centre and perpendicular to the plane of disc is **[2023]**

(A) $d_1 : d_2$ (B) $d_2 : d_1$
(C) $1 : d_1d_2$ (D) $1 : d_1^2 d_2$

61. The radius of gyration K of a hollow sphere of mass M and radius R about an axis XY is equal to R. The distance of that axis from the centre of the sphere is h. The value of h is **[2023]**

(A) $\frac{2R}{\sqrt{3}}$ (B) $\frac{R}{2}$ (C) $\frac{R}{\sqrt{2}}$ (D) $\frac{R}{\sqrt{3}}$

62. A particle rotates in a horizontal circle of radius 'R' in a conical funnel with constant speed 'V'. The inner surface of the funnel is smooth. The height of the plane of the circle from the vertex of the funnel is (g-acceleration due to gravity) **[2024, 2014]**

(A) $\frac{V}{g}$ (B) $\frac{V}{2g}$ (C) $\frac{V^2}{2g}$ (D) $\frac{V^2}{g}$

63. For a particle moving in vertical circle, the total energy at different positions along the path [The motion is under gravity] **[2024, 2017]**

(A) may increase or decrease.
(B) decreases.
(C) is conserved.
(D) increases.

64. A thin rod of length 'L' and mass 'M' is bent at the middle point 'O' at an angle of 60°. The moment of inertia of rod about an axis passing through 'O' and perpendicular to plane of system of rod will be **[2024, 2020]**

(A) $\frac{ML^2}{6}$ (B) $\frac{ML^2}{12}$ (C) $\frac{ML^2}{24}$ (D) $\frac{ML^2}{3}$

65. Two bodies A and B have their moments of inertia I_1 and I_2 respectively about their axis of rotation. If their kinetic energies of rotation are equal and their angular momenta L_1 and L_2 respectively are in the ratio $1:\sqrt{3}$, then I_2 will be **[2024, 2021]**

(A) $\frac{1}{3}I_1$ (B) $\sqrt{3}I_1$ (C) $2\ I_1$ (D) $3\ I_1$

66. A particle at rest starts moving with a constant angular acceleration of 4 rad/s^2 along a circular path. The time at which magnitude of its centripetal acceleration and tangential acceleration will be equal to **[2024, 2021]**

(A) 0.33 s (B) 0.50 s
(C) 0.66 s (D) 0.25 s

67. A particle moves along a circle of radius 'r' with constant tangential acceleration. If the velocity of the particle is 'V' at the end of third revolution from its start, then its tangential acceleration is **[2024, 2022, 2016]**

(A) $\frac{V^2}{2\pi r}$ (B) $\frac{V^2}{4\pi r}$ (C) $\frac{V^2}{6\pi r}$ (D) $\frac{V^2}{12\pi r}$

68. A circular disc of radius 'R' and thickness $\frac{R}{8}$ has moment of inertia 'I' about an axis passing through its centre and perpendicular to its plane. It is melted and recasted into a solid sphere then moment of inertia of sphere about an axis passing through diameter is **[2024, 2023, 2016]**

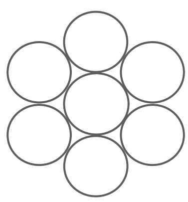
(A) I (B) $\frac{2I}{3}$ (C) $\frac{I}{5}$ (D) $\frac{I}{10}$

69. A thin uniform circular disc of mass 'M' and radius 'R' is rotating with angular velocity 'ω' in a horizontal plane about an axis passing through its centre and perpendicular to its plane. Another disc of same radius but of mass $\left(\frac{M}{3}\right)$ is placed gently on the first disc co-axially. The new angular velocity will be **[2024, 2023]**

(A) $\frac{2}{3}\omega$ (B) $\frac{3}{4}\omega$ (C) $\frac{4}{3}\omega$ (D) $\frac{5}{4}\omega$

70. Seven identical discs are arranged in a planar pattern, so as to touch other as shown in the figure. Each disc has mass 'm' and radius R. What is the moment of inertia of system of discs about an axis passing through the centre of central disc and normal to plane of all discs? **[2024, 2023]**

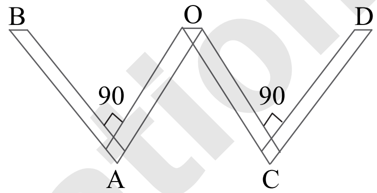
(A) $\frac{55mR^2}{2}$
(B) $\frac{85mR^2}{2}$
(C) $27mR^2$
(D) $10027mR^2$



71. A particle of mass 'm' is rotating in a circular path of radius 'r'. Its angular momentum is 'L'. The centripetal force acting on it is 'F'. The relation between 'F', 'L', 'r' and 'm' is **[2024, 2023]**

(A) $F=\frac{L}{mr^2}$ (B) $L = m^2\ Fr^2$
(C) $\frac{L^2}{m}=Fr^3$ (D) $\frac{F}{L^3}=mr^2$

72. A thin rod of length '4L' and mass '4m' is bent at the points as shown in the figure. The moment of inertia of the rod about an axis passing through point 'O' and perpendicular to plane of the paper is **[2024]**

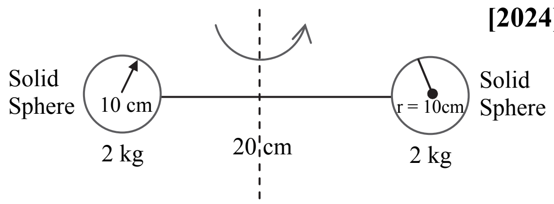


(A) $\frac{mL^2}{3}$ (B) $\frac{10\ mL^2}{3}$
(C) $\frac{mL^2}{12}$ (D) $\frac{mL^2}{24}$

73. In case of well of death which is a vertical cylindrical wall of radius 'r' inside which vehicle is driven in horizontal circles. If 'm' is mass of vehicle, 'V' is the velocity and 'μ_s' is the coefficient of static friction between the wheels of vehicle and walls then correct relation is [g = acceleration due to gravity] **[2024]**

(A) $V^2 \le \frac{rg}{\mu_s}$ (B) $V \le \frac{rg}{\mu_s}$
(C) $V^2 \geqslant \frac{rg}{\mu_s}$ (D) $V \geqslant \frac{rg}{\mu_s}$

74. Find moment of inertia about an axis shown, which is equidistant from both the spheres. **[2024]**

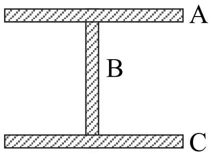


(A) 88×10^{-3} kgm^2 (B) 176×10^{-3} kgm^2
(C) 17.6×10^{-3} kgm^2 (D) 88×10^{-4} kgm^2

75. A metre stick is held vertically with one end on the floor and is allowed to fall. Assuming that the end on the floor does not slip, the angular velocity of the rod when it hits the ground is Where g = acceleration due to gravity) **[2024]**

(A) $\sqrt{2\ g}$ (B) $\sqrt{3gl}$
(C) $\sqrt{3\ g}$ (D) $\sqrt{\frac{3}{g}}$

76. Three rods of equal length 'L' and equal mass 'M' are connected as shown. The system is rotated such that the rod B is the axis of rotation. The moment of inertia of the system is **[2024]**



(A) $\frac{ML^2}{6}$

(B) $\frac{ML^2}{3}$

(C) $\frac{2ML^2}{3}$

(D) $\frac{4ML^2}{3}$

77. A sphere having moment of inertia 'I' and radius 'R' is rotating with angular velocity 'ω' about an axis passing through its centre and coinciding with its diameter. If it is converted into circular ring of same radius 'R', it will rotate about same axis with an angular velocity **[2024]**

(A) ω (B) 2ω (C) $\frac{2}{3}\omega$ (D) $\frac{2}{5}\omega$

78. A wheel has an angular acceleration of $3\ rad/s^2$ & an initial angular speed of $2\ rad/s$. In $2s$, it has rotated through an angle (in rad) of **[2024]**

(A) 10 (B) 12 (C) 4 (D) 6

79. A disc and a ring both have same mass and radius. The ratio of moment of inertia of the disc about its diameter to that of a ring about a tangent in its plane is **[2024]**

(A) $1:2$ (B) $1:4$ (C) $1:6$ (D) $1:8$

80. Two solid spheres (A and B) are made of metals having densities ρ_A and ρ_B respectively. If there masses are equal then ratio of their moments of inertia $\left(\frac{I_B}{I_A}\right)$ about their respective diameter is **[2024]**

(A) $\left(\frac{\rho_B}{\rho_A}\right)^{2/3}$ (B) $\left(\frac{\rho_A}{\rho_B}\right)^{2/3}$

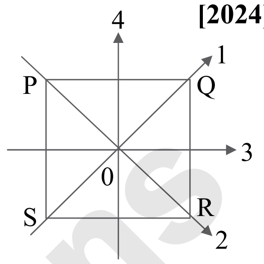
(C) $\frac{\rho_A}{\rho_B}$ (D) $\frac{\rho_B}{\rho_A}$

81. A carpet of mass 'M' made of a material is rolled along its length in the form of a cylinder of radius 'R' and kept above the rough floor. If the carpet is unrolled without sliding to a radius '$R/2$'. The change in potential energy is ($g =$ acceleration due to gravity) **[2024]**

(A) MgR (B) $\frac{7}{8}$MgR

(C) $\frac{5}{7}$MgR (D) $\frac{3}{4}$MgR

82. The moment of inertia of thin square plate PQRS of uniform thickness, about an axis passing through centre 'O' and perpendicular to the plane of the plate is (I_1, I_2, I_3, I_4 are respectively the moments of inertia about axis $1, 2, 3, 4$ which are in the plane of the plate as shown in figure) **[2024]**



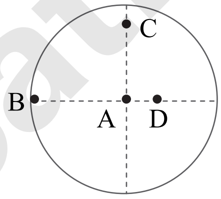
(A) $I_1 + I_2 + I_3$

(B) $I_1 + I_3 + I_4$

(C) $I_1 + I_2 + I_3 + I_4$

(D) $I_1 + I_3$

83. The moment of inertia of uniform circular disc is maximum about an axis perpendicular to the disc and passing through point **[2024]**



(A) A (B) B (C) C (D) D

84. Three thin rods, each of mass 'M' and length 'L' are placed along X, Y and Z axes which are mutually perpendicular. One end of each rod is at origin. M. I. of the system about Z axis is **[2024]**

(A) $\frac{3ML^2}{4}$ (B) $\frac{2ML^2}{5}$

(C) $\frac{2ML^2}{3}$ (D) $\frac{3ML^2}{5}$

85. The power (P) is supplied to a rotating body having moment of inertia 'I' and angular acceleration 'α'. Its instantaneous angular velocity 'ω' is **[2024]**

(A) $P(I\alpha)^{-1}$ (B) $P^{-1}(I\alpha)^{-1}$

(C) $P\alpha^{-1}I$ (D) $PI\alpha$

86. A body performing uniform circular motion of radius 'R' has frequency 'n'. Its centripetal acceleration per unit radius is proportional to $(n)^x$. The value of x is **[2024]**

(A) 1 (B) 2

(C) −1 (D) −2

Answer Key

Classical Thinking

1.2:	1. (A)	2. (C)	3. (D)	4. (A)	5. (D)	6. (C)	7. (C)	8. (D)	9.(A)	10. (D)
	11. (A)	12. (A)	13. (B)	14. (B)	15. (C)	16. (C)				
1.3:	1. (A)	2. (C)	3. (B)	4. (A)	5. (D)	6. (C)				
1.4:	1. (C)	2. (C)	3. (B)	4. (C)	5. (A)	6. (A)	7. (A)	8. (B)	9. (B)	10. (D)
	11. (C)									
1.5:	1. (C)	2. (C)	3. (A)	4. (C)	5. (D)	6. (A)	7. (D)	8. (A)	9. (C)	10. (A)
	11. (D)	12. (B)	13. (C)							
1.6:	1. (A)	2. (B)	3. (B)	4. (D)	5. (D)					
1.7:	1. (C)	2. (C)	3. (B)	4. (B)	5. (D)	6. (C)	7. (C)	8. (A)	9. (B)	10. (C)
1.8:	1. (B)	2. (D)	3. (C)	4. (D)	5. (A)	6. (C)	7. (C)	8. (B)		
1.9:	1. (B)	2. (C)	3. (A)	4. (A)	5. (B)	6. (D)	7. (A)	8. (D)		
1.10:	1. (A)	2. (C)	3. (D)	4. (D)	5. (B)	6. (A)				
1.11:	1. (C)	2. (C)	3. (D)	4. (A)	5. (A)	6. (D)	7. (A)	8. (D)	9. (D)	

MHT-CET Previous Years' Questions

1. (D)	2. (B)	3. (C)	4. (D)	5. (B)	6. (D)	7. (B)	8. (C)	9. (B)	10. (D)
11. (D)	12. (D)	13. (C)	14. (C)	15. (C)	16. (B)	17. (B)	18. (B)	19. (B)	20. (D)
21. (B)	22. (A)	23. (B)	24. (C)	25. (B)	26. (B)	27. (C)	28. (D)	29. (C)	30. (A)
31. (B)	32. (A)	33. (A)	34. (D)	35. (D)	36. (C)	37. (B)	38. (D)	39. (D)	40. (A)
41. (C)	42. (B)	43. (A)	44. (D)	45. (C)	46. (A)	47. (B)	48. (D)	49. (A)	50. (B)
51. (A)	52. (A)	53. (A)	54. (B)	55. (A)	56. (A)	57. (D)	58. (B)	59. (A)	60. (B)
61. (D)	62. (D)	63. (C)	64. (B)	65. (D)	66. (B)	67. (D)	68. (C)	69. (B)	70. (A)
71. (C)	72. (B)	73. (C)	74. (B)	75. (C)	76. (A)	77. (D)	78. (A)	79. (C)	80. (B)
81. (B)	82. (D)	83. (B)	84. (C)	85. (A)	86. (B)				

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