SAMPLE CONTENT

HOLISTIC

MHT-CET

ROADMAP TO SUCCESS

- Based on latest paper pattern
- Important Formulae & Shortcuts
- Subtopic wise segregation
- Classwork/Homework segregation
- Previous Years' Questions

PHYSICS (STD.XII)

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HOLISTIC

MHT-CET

PHYSICS

MULTIPLE CHOICE QUESTIONS

Based on Std. XII Syllabus of MHT-CET

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CONTENTS

Textbook
Chapter No.

01 Rotational Dynamics

Subtopics

Riding on a vertical circular arc, this roller coaster fans experience a net force and acceleration that point towards the centre of the circle

Formulae

1. Angular velocity:

i. $\omega = \frac{v}{r}$ ii. $\omega = \frac{\theta}{t}$

iii. $\omega = 2\pi n$ iv. $\omega = \frac{2\pi}{T}$

2. Angular displacement:

i. $\theta = \omega t$ ii. $\theta = \frac{2\pi t}{T}$

iii. $\theta = 2\pi nt$

3. Angular acceleration:

i. $\alpha = \frac{\omega_2 - \omega_1}{t}$ ii. $\alpha = \frac{2\pi}{t}(n_2 - n_1)$

4. Linear velocity:

i. $v = r\omega$ ii. $v = 2\pi nr$

5. Centripetal acceleration or radial acceleration: $a = \frac{v^2}{r} = \omega^2 r$

6. Tangential acceleration: $\vec{a}_T = \vec{\alpha} \times \vec{r}$

7. Centripetal force:

i. $F_{CP} = \frac{mv^2}{r}$ ii. $F_{CP} = mr\omega^2$

iii. $F_{CP} = mr4\pi^2 n^2$ iv. $F_{CP} = \frac{4\pi^2 mr}{T^2}$

8. Centrifugal force: $F_{CF} = -F_{CP}$

9. Inclination of banked road: $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$

10. On unbanked road:

i. Maximum velocity of vehicle to avoid skidding on a curve unbanked road: $v_{max} = \sqrt{\mu rg}$

ii. Angle of leaning: $\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$

11. On banked road:

i. Upper speed limit: $v_{max} = \sqrt{rg\left[\frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta}\right]}$

ii. Lower speed limit: $v_{min} = \sqrt{rg\left[\frac{\tan\theta - \mu_s}{1 + \mu_s \tan\theta}\right]}$

iii. $v_{max} = \sqrt{rg \tan\theta}$ (in absence of friction)

12. Height of inclined road: $h = l \sin\theta$

13. Conical Pendulum:

i. Angular velocity of the bob of conical pendulum,

$$\omega = \sqrt{\frac{g}{L\cos\theta}}$$

ii. Period of conical pendulum

$$T = 2\pi\sqrt{\frac{L\cos\theta}{g}}$$

14. For mass tied to string:

i. Minimum velocity at lowest point to complete V.C.M: $v_L = \sqrt{5rg}$

ii. Minimum velocity at highest point to complete V.C.M: $v_H = \sqrt{rg}$

iii. Minimum velocity at midway point to complete in V.C.M: $v_M = \sqrt{3rg}$

iv. Tension at highest point in V.C.M:

$$T_H = \frac{mv_H^2}{r} - mg$$

v. Tension at midway point in V.C.M:

$$T_M = \frac{mv_m^2}{r}$$

vi. Tension at lowest point in V.C.M:

$$T_L = \frac{mv_L^2}{r} + mg$$

vii. Difference between tension at lower most and uppermost point:

$T_L - T_H = 6\ mg$

15. Moment of Inertia: $I = \sum_{i=1}^{n} m_i r_i^2 = \int dmr^2$

16. Radius of gyration: $K = \sqrt{\frac{I}{M}}$

17. Kinetic energy:

i. $K.E_{rotational} = \frac{1}{2} I\omega^2 = \frac{1}{2} I (2\pi n)^2$

ii. $K.E_{translational} = \frac{1}{2} Mv^2$

iii. $K.E_{rolling} = \frac{1}{2}[Mv^2 + I\omega^2] = \frac{1}{2} Mv^2\left[1+\frac{K^2}{R^2}\right]$

18. From principle of parallel axes: $I_o = I_c + Mh^2$

19. From principle of perpendicular axes:

$I_Z = I_X + I_Y$

20. Angular momentum of a body: $L = I\omega = I(2\pi n)$

21. From principle of conservation of angular momentum:

i. $I_1\omega_1 = I_2\omega_2$ ii. $I_1 n_1 = I_2 n_2$

22. Torque acting on a body:

i. $\tau = I\alpha = \frac{dL}{dt}$

ii. $\tau = I\frac{d\omega}{dt} = 2\pi I\left(\frac{n_2 - n_1}{t}\right)$

23. Velocity of rolling body: $v = \sqrt{\frac{2gh}{1+\frac{K^2}{R^2}}}$

24. Acceleration of rolling body: $a = \frac{g\sin\theta}{1+\frac{K^2}{R^2}}$

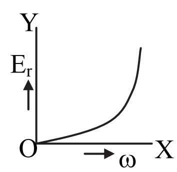
Table 1: Analogy of translational motion and rotational motion

Linear or Translational motion		S.I. Unit	Rotational motion		S.I. Unit
Displacement	s	m	Angular Displacement	θ	rad
Speed	v	ms^{-1}	Angular Speed	ω	rad s^{-1}
Velocity	$v = \frac{ds}{dt}$	ms^{-1}	Angular velocity	$\omega = \frac{d\theta}{dt}$	rad s^{-1}
Acceleration	$a = \frac{dv}{dt}$	ms^{-2}	Angular acceleration	$\alpha = \frac{d\omega}{dt}$	rad s^{-2}
Mass	m	kg	M.I.	$I = mr^2$	kg m^2
Force	$F = \frac{dP}{dt} = ma$	N	Torque or couple	$\tau = I\alpha = \frac{dL}{dt}$	Nm
Momentum	$P = mv$	$kgms^{-1}$	Angular momentum	$L = I\omega$	kg m^2 s^{-1}
Work	$W = Fs$	J	Work	$W = \tau\theta$	J
Kinetic energy	$E_k = \frac{1}{2}mv^2$	J	Rotational Energy	$E_{Rot} = \frac{1}{2}I\omega^2 = \frac{1}{2}LI$	J
Power	$P = Fv$ or $\vec{F}\cdot\vec{v}$	W	Power	$P = \tau\omega$ or $\vec{\tau}\cdot\vec{\omega}$	W

Table 2: Moment of inertia of different bodies

No.	Shape of regular body	Axis of rotation	Moment of Inertia
i.	Rod of mass M and length L (thin rod)	Centre of rod and perpendicular to length.	$\frac{ML^2}{12}$
		One end and perpendicular to length.	$\frac{ML^2}{3}$
ii.	Circular ring of mass M and radius R	Line passing through its centre and perpendicular to its plane.	MR^2
		Any diameter.	$\frac{1}{2}MR^2$
		Any tangent in the plane of the ring.	$\frac{3}{2}MR^2$
		Any tangent perpendicular to the plane of the ring.	$2\ MR^2$
iii.	Circular disc of mass M and radius R	Through centre, perpendicular to plane of disc.	$\frac{1}{2}MR^2$
		Any diameter.	$\frac{1}{4}MR^2$
		Tangent in the plane of the disc.	$\frac{5}{4}MR^2$
		Tangent perpendicular to plane of disc.	$\frac{3}{2}MR^2$
iv.	Solid sphere of mass M and radius R	Any diameter.	$\frac{2}{5}MR^2$
		Any tangent.	$\frac{7}{5}MR^2$
v.	Hollow sphere of mass M and radius R	Any diameter	$\frac{2}{3}MR^2$
vi.	Solid cylinder of mass M, radius R and length L	Axis passing through its centre and parallel to its length.	$\frac{1}{2}MR^2$
		Through centre perpendicular to length.	$M\left(\frac{R^2}{4}+\frac{L^2}{12}\right)$
vii.	Hollow cylinder of mass M, radius R	Axis passing through its centre and parallel to its length	MR^2
viii.	Annular ring or thick walled hollow cylinder	Axis passing through its centre and perpendicular to its plane	$I = \frac{1}{2}M\left(r_2^2 + r_1^2\right)$
ix.	Uniform symmetric spherical shell	Any diameter	$I = \frac{2}{5}M\frac{\left(r_2^5 - r_1^5\right)}{\left(r_2^3 - r_1^3\right)}$
x.	Uniform plate or rectangular parallelepiped	Axis passing through its centre of the side and perpendicular to its plane	$I = \frac{1}{12}M(L^2 + b^2)$

Table 3: Table representing the graphs of different parameters of rotational motion

Sr. No.	Graph of	Formula	Graph
1.	K.E.$_{rotational}$ v/s ω where, ω = angular velocity	$K.E._{rot} = \frac{1}{2}I\omega^2$ i.e. $K.E._{rot} \propto \omega^2$ if I is constant	

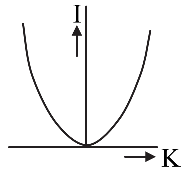
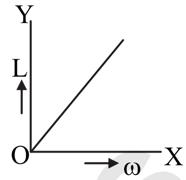
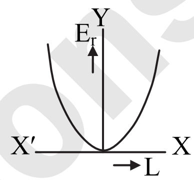
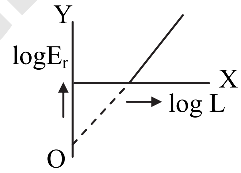
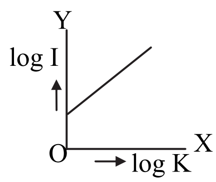
2.	I v/s K where, K = radius of gyration	$I = MK^2$ i.e. $I \propto K^2$	
3.	L v/s ω where, L = angular momentum	$L = I\omega$ i.e. $L \propto \omega$	
4.	$K.E._{rotational}$ v/s L	$K.E._{rot} = \frac{L^2}{2I}$ i.e. $K.E._{rot} \propto L^2$ if I is constant	
5.	log ($K.E._{rot}$) v/s log (L)	$K.E._{rot} = \frac{L^2}{2I}$ i.e. $\log(K.E._{rot}) = 2\log(L) - \log(2I)$	
6.	log (I) v/s log (K)	$I = MK^2$ i.e. $\log(I) = \log(M) + 2\log(K)$	

Table 4: Kinetic energy distribution table for different rolling bodies

Body	$\frac{K^2}{R^2}$	Translational $(K_T) = \frac{1}{2}mv^2$	Rotational $(K_R) = \frac{1}{2}mv^2\frac{K^2}{R^2}$	Rolling $(K_{Roll}) = \frac{1}{2}mv^2\left(1+\frac{K^2}{R^2}\right)$
Ring and Cylindrical shell	1	$\frac{1}{2}mv^2$	$\frac{1}{2}mv^2$	mv^2
Disc and solid cylinder	$\frac{1}{2}$	$\frac{1}{2}mv^2$	$\frac{1}{4}mv^2$	$\frac{3}{4}mv^2$
Solid sphere	$\frac{2}{5}$	$\frac{1}{2}mv^2$	$\frac{1}{5}mv^2$	$\frac{7}{10}mv^2$
Hollow sphere	$\frac{2}{3}$	$\frac{1}{2}mv^2$	$\frac{1}{3}mv^2$	$\frac{5}{6}mv^2$

Table 5: Velocity, Acceleration and Time of descent for Different Bodies

Body	Velocity $v = \sqrt{\frac{2gh}{1+\frac{K^2}{R^2}}}$	Acceleration $a = \frac{g\sin\theta}{\left(1+\frac{K^2}{R^2}\right)}$	Time of descent t $= \frac{1}{\sin\theta}\sqrt{\frac{2h}{g}\left(1+\frac{K^2}{R^2}\right)}$
Ring or Hollow cylinder	$\sqrt{gh}$	$\frac{1}{2}g\sin\theta$	$\frac{1}{\sin\theta}\sqrt{\frac{4h}{g}}$
Disc or solid cylinder	$\sqrt{\frac{4gh}{3}}$	$\frac{2}{3}g\sin\theta$	$\frac{1}{\sin\theta}\sqrt{\frac{3h}{g}}$

Solid sphere	$\sqrt{\frac{10}{7}gh}$	$\frac{5}{7}g\sin\theta$	$\frac{1}{\sin\theta}\sqrt{\frac{14}{5}\frac{h}{g}}$
Hollow sphere	$\sqrt{\frac{6}{5}gh}$	$\frac{3}{5}g\sin\theta$	$\frac{1}{\sin\theta}\sqrt{\frac{10}{3}\frac{h}{g}}$

Table 6: Rolling, Sliding and Falling bodies

Motion	Velocity	Acceleration	Time
Rolling	$\sqrt{\frac{2gh}{1+\frac{K^2}{R^2}}}$	$\frac{g\sin\theta}{\left(1+\frac{K^2}{R^2}\right)}$	$\frac{1}{\sin\theta}\sqrt{\frac{2h}{g}\left(1+\frac{K^2}{R^2}\right)}$
Sliding	$\sqrt{2gh}$	g sin θ	$\frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$
Falling	$\sqrt{2gh}$	g	$\sqrt{\frac{2h}{g}}$

Notes

1. *In U.C.M., angular velocity* $\left(\vec{\omega}\right)$ *is only constant vector but angular acceleration* $\left(\vec{\alpha}\right)$ *and angular displacement* $\left(\vec{\theta}\right)$ *are variable vectors.*
2. *The value of ω of earth about its axis is* 7×10^{-5} *rad/s or 360° per day.*
3. *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.*
4. *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.*
5. *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.*
6. *Centripetal force and Centrifugal force are not action-reaction forces as action-reaction forces act on different bodies.*
7. *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.*
8. *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.*
9. *Whenever a car is taking a horizontal turn, the normal reaction is at the inner wheel.*
10. *While taking a turn, when car overturns, its inner wheels leave the ground first.*
11. *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.*
    $[\because F_{cp} \propto \frac{1}{r}]$
12. *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* $\sqrt{\mu rg}$ *.*
13. *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.*
14. *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.*

15. *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.*

16. *For non uniform circular motion*
$\vec{a} = \vec{\alpha} \times \vec{r} + \vec{\omega} \times \vec{v}$

17. *When a bucket full of water is rotated in a vertical circle, water will not spill only if velocity of bucket at the highest point is* $\geq \sqrt{gr}$.

18. *If velocity imparted to body at the lowest position is equal to* $\sqrt{2rg}$*, then it will oscillate in a semicircle.*

19. *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.*

20. *If ice on poles starts melting, then both moment of inertia and length of the day (T) will increase, because* $I\omega = I \times \frac{2\pi}{T}$ *= constant.*

21. *Moment of inertia of the body will be minimum along the axis passing through its centre of mass.*

22. *M.I. of cube is minimum about its diagonal.*

23. *For same mass and dimensions, moment of inertia of a hollow body is more than moment of inertia of solid body.*

24. *For a given L, lesser the moment of inertia, more is the rotational kinetic energy.*

25. *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.*

26. *Angular momentum has same direction as that of angular velocity.*

Mindbenders

1. A flywheel is a rotating mechanical device that is used to store rotational energy. Flywheels, on account of a significant moment of inertia, resist changes in rotational speed. The amount of energy stored in a flywheel is proportional to the square of its rotational speed. Energy is transferred to a flywheel by applying torque to it, thereby increasing its rotational speed and hence its stored energy. Conversely, a flywheel releases stored energy by applying torque to a mechanical load, thereby decreasing its rotational speed.

2. In a reciprocating engine, the dead centre is the position of a piston in which it is farthest from, or nearest to, the crankshaft.
In general, the dead centre is any position of a crank where the applied force is straight along its axis, meaning no turning force can be applied. A few examples of crank driven machines are bicycles, tricycles, various types of machine presses, gasoline engines, diesel engines, steam locomotives and other steam engines. Crank-driven machines rely on the energy stored in a flywheel to overcome the dead centre. A steam locomotive is an example in which the connecting rods are arranged such that the dead centre for each cylinder occurs out of phase with the other one (or two) cylinders.

3. If the Earth suddenly stops rotating, then duration of day decreases. According to law of conservation of angular momentum,
$I\omega$ = constant or $\frac{I \times 2\pi}{T}$ = constant
∴ $T \propto I$. Here T represents the length of the day. When the earth contracts, the distribution of mass comes near to the axis of rotation. So I decreases. Consequently, T decreases i.e. the duration of the day will be decreased.

4. A swimmer executing a somersault takes the help of principle of conservation of angular momentum to increase his spin motion.
According to principle of conservation of angular momentum, $I\omega$ = constant or $\omega \propto \frac{1}{I}$.
Thus, angular velocity increases when moment of inertia decreases. To decrease the moment of inertia, he folds her arms and brings the stretched leg close to the other leg. Thus, angular velocity increases and hence the spin becomes faster

Shortcuts

1. In U.C.M., if central angle or angular displacement is given, then simply apply $dv = 2v \sin\frac{\theta}{2}$ to determine change in velocity.

2. There are two types of acceleration; a_r (radial) and a_t (tangential) acceleration.
Formula for $a_r = \omega^2 r$ and $a_t = \frac{dv}{dt}$ or $r\alpha$

3. To find out number of revolutions, always apply the formula,
Number of revolutions $= \frac{\theta}{2\pi} = \frac{\omega t}{2\pi} = \frac{2\pi n t}{2\pi} = nt$

4. The minimum safe velocity for not overturning is $v = \sqrt{\frac{gdr}{2h}}$

5. While rounding a curve on a level road, centripetal force required by the vehicle is provided by force of friction between the tyres and the road.

$\frac{mv^2}{r} = F = \mu R = \mu mg$

6. The maximum velocity with which a vehicle can go without toppling, is given by

$v = \sqrt{rg\frac{d}{2h}} = \sqrt{rg\tan\theta}$

where, $\tan\theta = \frac{d}{2h}$

d = distance between the wheels

h = height of centre of gravity from the road

g = acceleration due to gravity

7. Skidding of an object placed on a rotating platform:
The maximum angular velocity of rotation of the platform so that object will not skid on it is

$\omega_{max} = \sqrt{(\mu g / r)}$

8. If earth suddenly contracts to $\left(\frac{1}{n}\right)^{th}$ of its present size without changes in its mass, then duration of new day = $\frac{24}{n^2}$ hours.

9. If an inclined plane ends into a circular loop of radius r, then height from which a body must start from rest to complete the loop is given by $h = \frac{5}{2}r$

Hence h is independent of mass of the body.

10. When a small body of mass m slides down from the top of a smooth hemispherical surface of radius R, then height at which the body loses the contact with surface, $h = \frac{2R}{3}$

11. The angle of banking (θ) is given by,

$\tan\theta = \frac{v^2}{rg} = \frac{h}{\sqrt{l^2 - h^2}}$

where h is height of the outer edge above the inner edge and l is length of the road.

12. On the same basis, a cyclist has to bend through an angle θ from his vertical position while rounding a curve of radius r with velocity v such that $\tan\theta = \frac{v^2}{rg}$

If θ is very very small, then

$\tan\theta = \sin\theta = \frac{v^2}{rg}$

$\frac{v^2}{rg} = \frac{h}{l}$

where h is height of the outer edge from the inner edge and l is the distance between the tracks or width of the road.

13. Always remember the formulae for velocity of the body at the top, bottom and at the middle of a circle with two distinct cases:

i. path is convex

ii. path is concave

Remember in both the cases, formula will be different.

i. $\frac{mv^2}{r} = mg - N$ where N is normal reaction.

ii. $\frac{mv^2}{r} = N - mg$

Remember if in the question, it is given that body falls from a certain point then at that point N = 0.

14. In horizontal circle, tension will be equal to centripetal force i.e. $T = \frac{mv^2}{r}$

i. The minimum velocity of projection at the lowest point of vertical circle so that the string slacken at the highest point, is given by $v_L = \sqrt{5gr}$

ii. velocity at the highest point is $v_H = \sqrt{gr}$

15. When

i. $v_L = \sqrt{2gr}$, the body moves in a vertical semicircle about the lowest point L,

ii. $v_L < \sqrt{2gr}$, then the body oscillates in a circular arc smaller than the semicircle.

iii. For a motor cyclist to loop a vertical loop, $v_L > \sqrt{5gr}$ and $v_H > \sqrt{gr}$

16. The distance travelled by the particle performing uniform circular motion in t seconds is given by the formula, $d = \frac{2\pi r}{T}t$.

17. If a rod falls, apply the formula,

$\frac{1}{2}I\omega^2 = mg \times \left(\frac{L}{2}\right)$ where L is the length of the rod because when the rod falls, centre of mass travels a vertical distance of $\frac{L}{2}$ and I will be equal to $\frac{mL^2}{3}$.

18. If there is a change in mass or distribution of mass for example, for a piece of wax falling on rotating rod, apply the formula, $I_1\omega_1 = I_2\omega_2$.

19. Whenever the body falls from an inclined plane, apply $mgh = \frac{1}{2}I\omega^2 + \frac{1}{2}mv^2$ and always remember, acceleration of a rolling body is given by $\frac{g\sin\theta}{\left(1+\frac{K^2}{R^2}\right)}$. Therefore, body for which $\left(\frac{K^2}{R^2}\right)$ is smallest, will fall first.

20. The condition for a body to roll down the inclined plane without slipping:

$\mu \geq \left[\frac{K^2}{K^2+R^2}\right]\tan\theta$

where μ = coefficient of limiting friction (μ)

21. A body cannot roll down the inclined plane when the friction is absent.

For this situation, the relative values of μ for rolling without slipping down the inclined plane are:

$\mu_{ring} > \mu_{shell} > \mu_{disc} > \mu_{solid\ sphere}$

22. The ratio of moments of inertia of two discs of the same mass and same thickness but of different densities is given by $\frac{I_1}{I_2} = \frac{R_1^2}{R_2^2} = \frac{d_2}{d_1}$

23. To find ratios of different K.E., use

i. $\frac{\text{Rotational K.E.}}{\text{Total K.E.}} = \frac{\frac{K^2}{R^2}}{\left(1+\frac{K^2}{R^2}\right)}$

ii. $\frac{\text{Linear K.E.}}{\text{Total K.E.}} = \frac{1}{\left(1+\frac{K^2}{R^2}\right)}$

Classwork

1.2 Characteristics of Circular Motion

1. Angular speed of hour hand of a clock in degree per second is **[MHT CET 2016]**

(A) $\frac{1}{30}$ (B) $\frac{1}{60}$

(C) $\frac{1}{120}$ (D) $\frac{1}{720}$

2. The ratio of angular speed of a second-hand to the hour-hand of a watch is

(A) 3600 : 1 (B) 720 : 1

(C) 72 : 1 (D) 60 : 1

3. The difference between angular speed of minute hand and second hand of a clock is **[MH CET 2015]**

(A) $\frac{59\pi}{900}$ rad / s (B) $\frac{59\pi}{1800}$ rad / s

(C) $\frac{59\pi}{2400}$ rad / s (D) $\frac{59\pi}{3600}$ rad / s

4. The angular separation between the minute hand and the hour hand of a clock at 12:20 pm is **[MH CET 2019]**

(A) 120° (B) 90°

(C) 110° (D) 100°

5. The relation between linear speed v, angular speed ω and angular acceleration α in circular motion is **[MH CET 2010]**

(A) $\alpha = \frac{a\omega}{v}$ (B) $\alpha = \frac{av}{\omega}$

(C) $\alpha = \frac{v\omega}{a}$ (D) $\alpha = \frac{\omega}{av}$

6. The angle between velocity and acceleration of a particle describing uniform circular motion is

(A) 180° (B) 90°

(C) 45° (D) 60°

7. For a particle in uniform circular motion, the acceleration $\vec{a}$ at a point P(R, θ) on the circle of radius R is (Here θ is measured from the x-axis)

(A) $\frac{v^2}{R}\hat{i}+\frac{v^2}{R}\hat{j}$

(B) $-\frac{v^2}{R}\cos\theta\hat{i}+\frac{v^2}{R}\sin\theta\hat{j}$

(C) $-\frac{v^2}{R}\sin\theta\hat{i}+\frac{v^2}{R}\cos\theta\hat{j}$

(D) $-\frac{v^2}{R}\cos\theta\hat{i}-\frac{v^2}{R}\sin\theta\hat{j}$

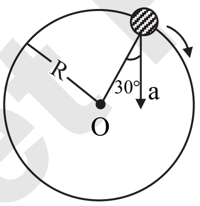
8. Two cars of masses m_1 and m_2 are moving in circles of radii r_1 and r_2 respectively. Their speeds are such that they make complete circles in the same time t. The ratio of their centripetal acceleration is
(A) $m_1r_1 : m_2r_2$ (B) $m_1 : m_2$
(C) $r_1 : r_2$ (D) 1 : 1

9. A particle moves in a circle of radius 25 cm at two revolutions per second. The acceleration of the particle in m/s^2 is
(A) π^2 (B) $8\pi^2$ (C) $4\pi^2$ (D) $2\pi^2$

10. 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) **[MHT CET 2018]**
(A) $\frac{\alpha^2 r^2}{v}$ (B) $\frac{\alpha^2 r}{v^2}$
(C) $\frac{\alpha r^2}{v^2}$ (D) $\frac{v^2}{r^2\alpha}$

11. A particle moves in a circle of radius 5 cm with constant speed and time period 0.2 π.s. the acceleration of the particle is
(A) 15 m/s^2 (B) 25 m/s^2
(C) 36 m/s^2 (D) 5 m/s^2

12. In the given figure, a = 15 m/s^2 represents the total acceleration of a particle moving in the clockwise direction in a circle of radius R = 2.5 m at a given instant of time. The speed of the particle is
(A) 6.2 m/s
(B) 4.5 m/s
(C) 5.0 m/s
(D) 5.7 m/s



13. Which of the following statements is false? Centripetal force and centrifugal force **[MH CET 2019]**
(A) are equal in magnitude.
(B) constitute an action - reaction pair.
(C) act on the same body.
(D) act along the radius.

14. One end of string of length l is connected to a particle of mass 'm' and the other end is connected to a small peg on a smooth horizontal table. If the particle moves in circle with speed 'v', the net force on the particle (directed towards centre) will be (T represents the tension in the string)
(A) T (B) $T+\frac{mv^2}{l}$
(C) $T-\frac{mv^2}{l}$ (D) Zero

15. A particle of mass m is executing uniform circular motion on a path of radius r. If p is the magnitude of its linear momentum, the radial force acting on the particle is
(A) pmr (B) $\frac{rm}{p}$
(C) $\frac{mp^2}{r}$ (D) $\frac{p^2}{rm}$

16. A toy cart is tied to the end of an unstretched string of length 'l'. When revolved, the toy cart moves in horizontal circle with radius '$2l$' and time period T. If it is speeded until it moves in horizontal circle of radius '$3l$' with period T_1, relation between T and T_1 is (Hooke's law is obeyed) **[MH CET 2015]**
(A) $T_1 = \frac{2}{\sqrt{3}}T$ (B) $T_1 = \sqrt{\frac{3}{2}}T$
(C) $T_1 = \sqrt{\frac{2}{3}}T$ (D) $T_1 = \frac{\sqrt{3}}{2}T$

17. Two stones of masses m and 2 m are whirled in horizontal circles, the heavier one in a radius $\frac{r}{2}$ and lighter one in radius r. The tangential speed of lighter stone is n times that of the value of heavier stone when they experience same centripetal forces. The value of n is :
(A) 1 (B) 2
(C) 3 (D) 4

18. A coin is placed on a rotating turn table rotated with angular speed ω. The coin just slips if it is placed at 4 cm from the center of the table. If angular velocity is doubled, at what distance will coin starts to slip. **[MH CET 2010]**
(A) 1 cm (B) 4 cm
(C) 9 cm (D) 16 cm

19. Two particles A and B are moving in uniform circular motion in concentric circles of radii r_A and r_B with speed v_A and v_B respectively. Their time period of rotation is the same. The ratio of angular speed of A to that of B will be:
(A) $r_B : r_A$ (B) 1 : 1
(C) $r_A : r_B$ (D) $v_A : v_B$

1.3 Applications of Uniform Circular Motion

20. 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) $\sqrt{gR\frac{\mu_s+\tan\theta}{1-\mu_s\tan\theta}}$

21. A railway track is banked for a speed v, by making the height of the outer rail h higher than that of the inner rail. If the distance between the rails is l and the radius of curvature of the track is r, then

(A) $\frac{h}{l}=\frac{v^2}{rg}$

(B) $\tan\left\{\sin^{-1}\left(\frac{h}{l}\right)\right\}=\frac{v^2}{rg}$

(C) $\tan^{-1}\left(\frac{h}{l}\right)=\frac{v^2}{rg}$

(D) $\frac{h}{r}=\frac{v^2}{lg}$

22. The maximum safe speed for which a banked road is intended, is to be increased by 20 %. If the angle of banking is not changed, then the radius of curvature of the road should be changed from 30 m to

(A) 36.3 m (B) 21.1 m
(C) 43.2 m (D) 63.2 m

23. A car of mass 1000 kg negotiates a banked curve of radius 90 m on a frictionless road. If the banking angle is 45°, the speed of the car is

(A) 20 ms^{-1} (B) 30 ms^{-1}
(C) 5 ms^{-1} (D) 10 ms^{-1}

24. A block of mass 10 kg is in contact against the inner wall of a hollow cylindrical drum of radius 1 m. The coefficient of friction between the block and the inner wall of the cylinder is 0.1. The minimum angular velocity needed for the cylinder to keep the block stationary when the cylinder is vertical and rotating about its axis, will be ($g = 10 m/s^2$)

(A) 10 rad/s (B) 10 π rad/s
(C) $\sqrt{10}$ rad/s (D) $\frac{10}{2\pi}$ rad/s

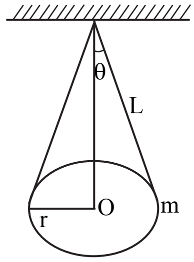
25. A particle of mass 'm' is suspended from a ceiling through a string of length 'L'. If the particle moves in a horizontal circle of radius 'r' as shown in the figure, then the speed of the particle is

(A) $r\sqrt{\frac{g}{\sqrt{L^2-r^2}}}$

(B) $g\sqrt{\frac{r}{\sqrt{L^2-r^2}}}$

(C) $r\sqrt{\frac{g}{L^2-r^2}}$

(D) $g\sqrt{\frac{r}{L^2-r^2}}$



1.4 Vertical Circular Motion

26. For a particle moving in vertical circle, the total energy at different positions along the path **[MHT CET 2017]**

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

27. 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) $\sqrt{2gR}$

28. 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) **[MHT CET 2018]**

(A) g (B) 3 g (C) 4 g (D) 6 g

29. In vertical circular motion, the ratio of kinetic energy of a particle at highest point to that at lowest point is **[MHT CET 2016]**

(A) 5 (B) 2
(C) 0.5 (D) 0.2

30. 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

1.5 Moment of Inertia as an Analogous Quantity for Mass

31. A disc of radius 'R' and thickness $\frac{R}{6}$ has moment of inertia 'I' about an axis passing through its centre and perpendicular to its plane. Disc is melted and recast into a solid sphere. The moment of inertia of a sphere about its diameter is **[MHT CET 2016]**

(A) $\frac{I}{5}$ (B) $\frac{I}{6}$ (C) $\frac{I}{32}$ (D) $\frac{I}{64}$

32. 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 **[MH CET 2014]**

(A) $\frac{4\pi}{3}$ (B) $\frac{8\pi^2}{3}$ (C) $\frac{5\pi}{3}$ (D) $\frac{8\pi^2}{5}$

33. 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 **[MHT CET 2018]**

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

34. There are four point masses m each on the corners of a square of side length l about one of its diagonals, the moment of inertia of the system is
(A) $2\ ml^2$ (B) ml^2 (C) $4\ ml^2$ (D) $6\ ml^2$

35. 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 **[MH CET 2019]**
(A) L = 3R (B) L = 2R
(C) $L = R\sqrt{2}$ (D) $L = R\sqrt{3}$

36. A solid sphere of mass m and radius R is rotating about its diameter. A solid cylinder of the same mass and same radius is also rotating about its geometrical axis with an angular speed twice that of the sphere. The ratio of their kinetic energies of rotation ($E_{sphere}/E_{cylinder}$) will be
(A) 3:1 (B) 2:3 (C) 1:5 (D) 1:4

37. Three objects, A : (a solid sphere), B : (a thin circular disk) and C : (a circular ring), each have the same mass M and radius R. They all spin with the same angular speed ω about their own symmetry axes. The amounts of work (W) required to bring them to rest, would satisfy the relation
(A) $W_C > W_B > W_A$ (B) $W_A > W_B > W_C$
(C) $W_B > W_A > W_C$ (D) $W_A > W_C > W_B$

38. Two discs of same moment of inertia rotating about their regular axis passing through centre and perpendicular to the plane of disc with angular velocities ω_1 and ω_2. They are brought into contact face to face coinciding the axis of rotation. The expression for loss of energy during this process is:

(A) $\frac{1}{2}I(\omega_1+\omega_2)^2$ (B) $\frac{1}{4}I(\omega_1-\omega_2)^2$
(C) $I(\omega_1-\omega_2)^2$ (D) $\frac{I}{8}(\omega_1-\omega_2)^2$

1.6 Radius of Gyration

39. Four particles each of mass (M) are held rigidly by a very light circular frame of radius b. The radius of gyration of the system for an axis through the centre of the circle and perpendicular to the plane is
(A) b (B) 2b
(C) $b/\sqrt{2}$ (D) $\sqrt{2}\ b$

1.7 Theorem of Parallel Axes and Theorem of Perpendicular Axes

40. 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

41. A solid sphere of mass M and radius R having moment of inertia I about its diameter is recast into a solid disc of radius r and thickness t. The moment of inertia of the disc about an axis passing the edge and perpendicular to the plane remains I. Then R and r are related as

(A) $r = \sqrt{\frac{2}{15}}R$ (B) $r = \frac{2}{\sqrt{15}}R$

(C) $r = \frac{2}{15}R$ (D) $r = \frac{\sqrt{2}}{15}R$

42. A circular disc X of radius R made from iron plate of thickness 't' and another disc Y of radius 4R made from an iron plate of thickness $\frac{t}{4}$. Then the relation between the moments of inertia I_X and I_Y is
(A) $I_Y = 32\ I_X$
(B) $I_Y = 16\ I_X$
(C) $I_Y = I_X$
(D) $I_Y = 64\ I_X$

43. 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 **[MH CET 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) $\frac{MR^2}{4}+\frac{Ml^2}{12}$

44. The moment of inertia of a solid cylinder of mass M, length 2 R and radius R about an axis passing through the centre of mass and perpendicular to the axis of the cylinder is I_1 and about an axis passing through one end of the cylinder and perpendicular to the axis of cylinder is I_2, then

(A) $I_2 < I_1$ (B) $I_2 - I_1 = MR^2$

(C) $\frac{I_2}{I_1} = \frac{19}{12}$ (D) $\frac{I_2}{I_1} = \frac{7}{6}$

45. 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 **[MH CET 2010]**

(A) $\frac{7ML^2}{48}$ (B) $\frac{ML^2}{9}$

(C) $\frac{ML^2}{12}$ (D) $\frac{ML^2}{3}$

46. A light rod of length l has two masses m_1 and m_2 attached to its two ends. The moment of inertia of the system about an axis perpendicular to the rod and passing through the centre of mass is

(A) $\sqrt{m_1 m_2} l^2$ (B) $\frac{m_1 m_2}{m_1 + m_2} l^2$

(C) $\frac{m_1 + m_2}{m_1 m_2} l^2$ (D) $(m_1 + m_2) l^2$

47. From a disc of radius R and mass M, a circular hole of diameter R, whose rim passes through the centre is cut. What is the moment of inertia of the remaining part of the disc about a perpendicular axis, passing through the centre?

(A) $11 MR^2/32$ (B) $9 MR^2/32$

(C) $15 MR^2/32$ (D) $13 MR^2/32$

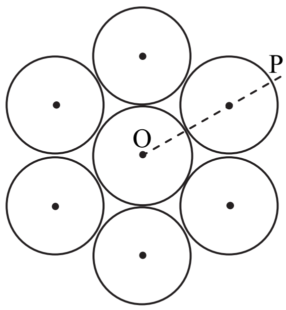
48. Seven identical circular planar disks, each of mass M and radius R are welded symmetrically as shown. The moment of inertia of the arrangement about the axis normal to the plane and passing through the point P is

(A) $\frac{73}{2} MR^2$

(B) $\frac{181}{2} MR^2$

(C) $\frac{19}{2} MR^2$

(D) $\frac{55}{2} MR^2$



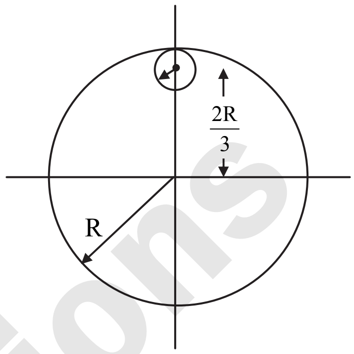
49. From a uniform circular disc of radius R and mass 9M, a small disc of radius $\frac{R}{3}$ is removed as shown in the figure. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through centre of disc is:

(A) $10 MR^2$

(B) $\frac{37}{9} MR^2$

(C) $4 MR^2$

(D) $\frac{40}{9} MR^2$



50. 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 **[MH CET 2010]**

(A) 4 I (B) 5 I

(C) 6 I (D) I

51. Three identical uniform thin metal rods form the three sides of an equilateral triangle. If the moment of inertia of the system of these three rods about an axis passing through the centroid of the triangle and perpendicular to the plane of the triangle is 'n' times the moment of inertia of one rod separately about an axis passing through the centre of the rod and perpendicular to its length, the value of 'n' is

(A) 3 (B) 6

(C) 9 (D) 12

52. The moment of inertia of an uniform cylinder of length l and radius R about its perpendicular bisector is I. What is the ratio $\frac{l}{R}$ such that the moment of inertia is minimum?

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

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

1.8 Angular Momentum or Moment of Linear Momentum

53. 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.

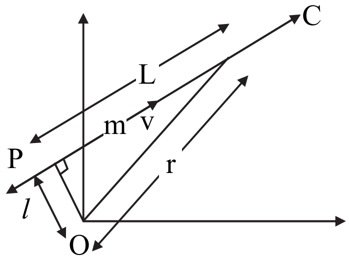
54. A particle of mass m moves along line PC with velocity v as shown. What is the angular momentum of the particle about O?

(A) mvL

(B) mv$l$

(C) mvr

(D) Zero



55. Two rotating bodies A and B of masses m and 2 m with moments of inertia I_A and I_B ($I_B > I_A$) have equal kinetic energy of rotation. If L_A and L_B be their angular momenta respectively, then

(A) $L_A > L_B$ (B) $L_A = \frac{L_B}{2}$

(C) $L_A = 2L_B$ (D) $L_B > L_A$

56. A solid sphere and a thin spherical shell of same radius rotate about their diameters with same angular momentum but with different angular velocities. If M_1 and M_2 are the masses of solid sphere and hollow sphere and if their angular velocities are in the ratio 1 : 2, then $\left(\frac{M_1}{M_2}\right)$ is

(A) $\frac{10}{3}$ (B) $\frac{5}{3}$

(C) $\frac{1}{3}$ (D) 3

57. 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.

1.9 Expression for Torque in Terms of Moment of Inertia

58. Which of the following is not correct?

[MH CET 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

59. A disc is rotating with angular velocity $\vec{\omega}$. A force $\vec{F}$ acts at a point whose position vector with respect to the axis of rotation is $\vec{r}$. The power associated with the torque due to the force is given by

(A) $(\vec{r} \times \vec{F}).\vec{\omega}$ (B) $(\vec{r} \times \vec{F}) \times \vec{\omega}$

(C) $\vec{r}.(\vec{F} \times \vec{\omega})$ (D) $\vec{r} \times (\vec{F}.\vec{\omega})$

60. A fly wheel of moment of inertia 3×10^2 kg m^2 is rotating with uniform angular speed of 4.6 rad s^{-1}. If a torque of 6.9×10^2 Nm retards the wheel, then the time in which the wheel comes to rest is

(A) 1.5 s (B) 2 s

(C) 0.5 s (D) 1 s

61. A string is wound round the rim of a mounted flywheel of mass 20 kg and radius 20 cm. A steady pull of 25 N is applied on the cord. Neglecting friction and mass of the string, the angular acceleration of the wheel is

(A) 50 s^{-2} (B) 25 s^{-2}

(C) 12.5 s^{-2} (D) 6.25 s^{-2}

62. A rope is wound around a hollow cylinder of mass 3 kg and radius 40 cm. What is the angular acceleration of the cylinder if the rope is pulled with a force of 30 N?

(A) 25 m/s^2 (B) 0.25 rad/s^2

(C) 25 rad/s^2 (D) 5 m/s^2

63. The instantaneous angular position of a point on a rotating wheel is given by the equation $\theta(t) = 2t^3 - 6t^2$. The torque on the wheel becomes zero at

(A) t = 2 s (B) t = 1 s

(C) t = 0.2 s (D) t = 0.25 s

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

(A) 25 N (B) 50 N

(C) 78.5 N (D) 157 N

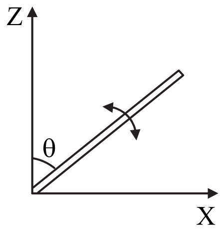
65. A slender uniform rod of mass M and length l is pivoted at one end so that it can rotate in a vertical plane (see figure). There is negligible friction at the pivot. The free end is held vertically above the pivot and then released. The angular acceleration of the rod when it makes an angle θ with the vertical is

(A) $\frac{3g}{2l}\cos\theta$

(B) $\frac{2g}{3l}\cos\theta$

(C) $\frac{3g}{2l}\sin\theta$

(D) $\frac{2g}{3l}\sin\theta$



1.10 Conservation of Angular Momentum

66. 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

67. 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.

68. 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 **[MHT CET 2018]**
   (A) $\frac{I\omega^2}{2}$ (B) $\frac{I\omega^2}{4}$
   (C) $\frac{I\omega^2}{6}$ (D) $\frac{I\omega^2}{8}$

69. A thin circular ring of mass M and radius r is rotating about its axis with a constant angular velocity ω. Four objects each of mass m, are kept gently to the opposite ends of two perpendicular diameters of the ring. The angular velocity of the ring will be
   (A) $\frac{M\omega}{M+4m}$ (B) $\frac{(M+4m)\omega}{M}$
   (C) $\frac{(M-4m)\omega}{M+4m}$ (D) $\frac{M\omega}{4m}$

70. 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 ω. Another disc of same thickness and radius but mass $\frac{1}{8}$ M is placed gently on the first disc co-axially. The angular velocity of the system is now
   (A) $\frac{8}{9}\omega$ (B) $\frac{5}{9}\omega$
   (C) $\frac{1}{3}\omega$ (D) $\frac{2}{9}\omega$

71. 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 **[MHT CET 2017; Similar in CBSE PMT 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) $\frac{1}{2}\left[\frac{I_1I_2}{I_1+I_2}\right]\omega_1^2$

72. 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 **[MH CET 2019]**
   (A) 100 rpm (B) 60 rpm
   (C) 150 rpm (D) 120 rpm

1.11 Rolling Motion

73. If a hollow cylinder and a solid cylinder are allowed to roll down an inclined plane, which will take more time to reach the bottom?
   (A) Hollow cylinder
   (B) Solid cylinder
   (C) Same for both
   (D) One whose density is more

74. 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

75. A solid sphere is in rolling motion. In rolling motion, a body possesses translational kinetic energy (K_t) as well as rotational kinetic energy (K_r) simultaneously, The ratio $K_t : (K_t + K_r)$ for the sphere is
(A) 7 : 10 (B) 5 : 7
(C) 10 : 7 (D) 2 : 5

76. The ratio of the accelerations for a solid sphere (mass m and radius R) rolling down an incline of angle 'θ' without slipping and slipping down the incline without rolling is
(A) 5 : 7 (B) 2 : 3
(C) 2 : 5 (D) 7 : 5

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

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

79. A disc of radius 2 m and mass 100 kg rolls on a horizontal floor. Its centre of mass has speed of 20 cm/s. How much work is needed to stop it?
(A) 2 J (B) 1 J
(C) 3 J (D) 30 kJ

80. A solid cylinder of mass 2 kg and radius 50 cm rolls up an inclined plane of angle of inclination 30°. The centre of mass of the cylinder has speed of 4 m/s. The distance travelled by the cylinder on the inclined surface will be, [take $g = 10\ m/s^2$]
(A) 2.4 m (B) 2.2 m
(C) 1.6 m (D) 1.2 m

81. 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) $v_S > v_D > v_R$

82. Three bodies a ring (R), a solid cylinder (C) and a solid sphere (S) having same mass and same radius roll down the inclined plane without slipping. They start from rest, if v_R, v_C and v_S are velocities of respective bodies on reaching the bottom of the plane, then
(A) $v_R = v_C = v_S$ (B) $v_R > v_C > v_S$
(C) $v_R < v_C < v_S$ (D) $v_R = v_C > v_S$

Miscellaneous

83. If K.E. of the particle of mass m performing U.C.M. in a circle of radius r is E. The acceleration of the particle is **[MH CET 2010]**
(A) $\frac{2E}{mr}$ (B) $\left(\frac{2E}{mr}\right)^2$ (C) 2Emr (D) $\frac{4E}{mr}$

84. A particle of mass M is moving in a horizontal circle of radius R with uniform speed v. When the particle moves from one point to a diametrically opposite point, its
(A) momentum does not change
(B) momentum changes by 2Mv
(C) kinetic energy changes by $\frac{Mv^2}{4}$
(D) kinetic energy changes by Mv^2

85. 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 **[MH CET 2015]**
(A) $m^2 K^2 r^2 t^2$ (B) $mK^2 r^2 t$
(C) $m K^2 r t^2$ (D) $m K r^2 t$

86. A simple pendulum of length L swings in a vertical plane. The tension of the string when it makes an angle θ with the vertical and the bob of mass m moves with a speed v is (g is the gravitational acceleration
(A) mv^2/L (B) $mg\cos\theta + mv^2/L$
(C) $mg \cos\theta - mv^2/L$ (D) $mg \cos\theta$

87. A particle with charge Q coulomb, tied at the end of an inextensible string of length R metre, revolves in a vertical plane. At the centre of the circular trajectory, there is a fixed charge of magnitude Q coulomb. The mass of the moving charge M is such that $Mg = \frac{Q^2}{4\pi\varepsilon_0 R^2}$. If at the highest position of the particle, the tension of the string just vanishes, the horizontal velocity at the lowest point has to be
(A) 0 (B) $2\sqrt{gR}$
(C) $\sqrt{2gR}$ (D) $\sqrt{5gR}$

88. A simple pendulum of length L carriers a bob of mass m. When the bob is at its lowest position, it is given the minimum horizontal speed necessary for it to move in a vertical circle about the point of suspension. When the string is horizontal the net force on the bob is

(A) $\sqrt{10}$ mg (B) $\sqrt{5}$ mg
(C) 4 mg (D) 1mg

89. 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 second revolution, after the revolution has started then the tangential acceleration is **[MHT CET 2016]**

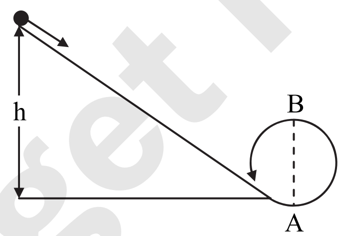
(A) $\frac{v^2}{8\pi r}$ (B) $\frac{v^2}{6\pi r}$
(C) $\frac{v^2}{4\pi r}$ (D) $\frac{v^2}{2\pi r}$

90. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration, if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion?

(A) 0.18 m/s^2 (B) 0.2 m/s^2
(C) 0.1 m/s^2 (D) 0.15 m/s^2

91. A body initially at rest and sliding along a frictionless track from a height h (as shown in the figure) just completes a vertical circle of diameter AB = D. The height h is equal to

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



92. A uniform circular disc of radius 50 cm at rest is free to turn about an axis which is perpendicular to its plane and passes through its centre. It is subjected to a torque which produces a constant angular acceleration of 2.0 rad s^{-2}. Its net acceleration in ms^{-2} at the end of 2.0 s is approximately

(A) 6.0 (B) 3.0 (C) 8.0 (D) 7.0

93. When W joule of work is done on a flywheel, its frequency of rotation increases from v_1 Hz to v_2 Hz. The moment of inertia of the flywheel about its axis of rotation is given by

(A) $\frac{W}{2\pi^2(v_2^2 - v_1^2)}$ (B) $\frac{W}{2\pi^2(v_2^2 + v_1^2)}$
(C) $\frac{W}{4\pi^2(v_2^2 - v_1^2)}$ (D) $\frac{W}{4\pi^2(v_2^2 + v_1^2)}$

94. A particle is moving with a uniform speed in a circular orbit of radius R in a central force inversely proportional to the nth power of R. If the period of rotation of the particle is T, then:

(A) $T \propto R^{(n+1)/2}$
(B) $T \propto R^{n/2}$
(C) $T \propto R^{3/2}$ for any n
(D) $T \propto R^{\frac{n}{2}+1}$

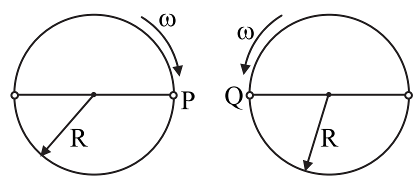
95. A particle is moving in a circular path of radius a under the action of an attractive potential $U = -\frac{k}{2r^2}$. Its total energy is:

(A) Zero (B) $-\frac{3}{2}\frac{k}{a^2}$
(C) $-\frac{k}{4a^2}$ (D) $\frac{k}{2a^2}$

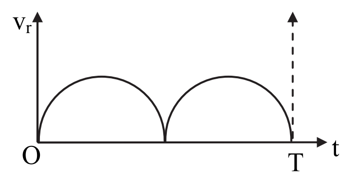
96. A point object moves along an arc of a circle of radius 'R'. Its velocity depends upon the distance covered 'S' as $V = K\sqrt{S}$ where 'K' is a constant. If 'θ' is the angle between the total acceleration and tangential acceleration, then

(A) $\tan\theta = \sqrt{\frac{S}{R}}$ (B) $\tan\theta = \sqrt{\frac{S}{2R}}$
(C) $\tan\theta = \frac{S}{2R}$ (D) $\tan\theta = \frac{2S}{R}$

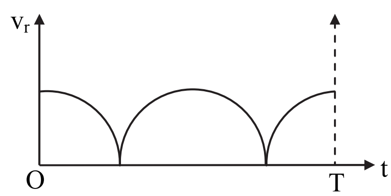
97. Two identical discs of same radius R are rotating about their axes in opposite directions with the same constant angular speed ω. The discs are in the same horizontal plane. At time t = 0, the points P and Q are facing each other as shown in the figure. The relative speed between the two points P and Q is v_r. As a function of time, it is best represented by



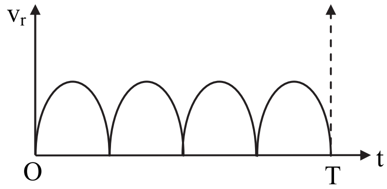
(A)



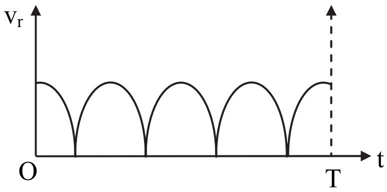
(B)



(C)



(D)

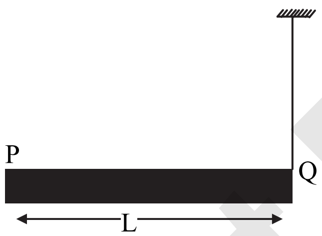


98. A wheel of circumference C is at rest on the ground. When the wheel rolls forward through half a revolution, then the displacement of initial point of contact will be

(A) $C\sqrt{\frac{1}{\pi^2}+\frac{1}{4}}$ (B) $\frac{C}{2}$

(C) $\pi\sqrt{C^2+4}$ (D) $C\sqrt{\frac{1}{\pi}+\frac{1}{2}}$

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



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

100. A hoop of radius r and mass m rotating with an angular velocity ω_0 is placed on a rough horizontal surface. The initial velocity of the centre of the hoop is zero. What will be the velocity of the centre of the hoop when it ceases to slip?

(A) $\frac{r\omega_0}{4}$ (B) $\frac{r\omega_0}{3}$

(C) $\frac{r\omega_0}{2}$ (D) $r\omega_0$

101. 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'? **[MHT CET 2018]**

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

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

102. 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 **[MHT CET 2017]**

(A) 24 rad (B) 48 rad

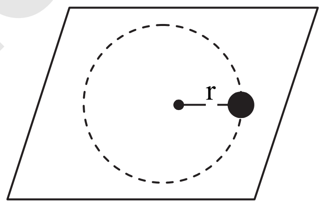
(C) 72 rad (D) 96 rad

103. 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 **[MHT CET 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

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



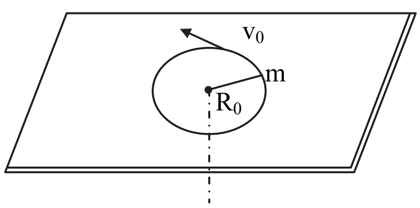
(A) increase by a factor of 4.

(B) decrease by a factor of 2.

(C) remain constant.

(D) increase by a factor of 2.

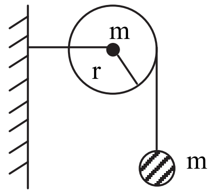
105. A mass m moves in a circle on a smooth horizontal plane with velocity v_0 at a radius R_0. The mass is attached to a string which passes through a smooth hole in the plane as shown.



The tension in the string is increased gradually and finally m moves in a circle of radius $\frac{R_0}{2}$. The final value of the kinetic energy is

(A) mv_0^2 (B) $\frac{1}{4}mv_0^2$

(C) $2mv_0^2$ (D) $\frac{1}{2}mv_0^2$

106. 

As shown in the figure, a bob of mass m is tied by a massless string whose other end portion is wound on a fly wheel (disc) of radius r and mass m. When released from rest the bob starts falling vertically. When it has covered a distance of h, the angular speed of the wheel will be:

(A) $r\sqrt{\frac{3}{2gh}}$ (B) $r\sqrt{\frac{3}{4gh}}$

(C) $\frac{1}{r}\sqrt{\frac{4gh}{3}}$ (D) $\frac{1}{r}\sqrt{\frac{2gh}{3}}$

107. A solid sphere of mass 100 kg and radius 10 m moving in a space becomes a circular disc of radius 20 m in one hour. Then the rate of change of moment of inertia in the process is

(A) $\frac{40}{9}$ kg m^2s^{-1} (B) $\frac{10}{9}$ kg m^2s^{-1}

(C) $\frac{50}{9}$ kg m^2s^{-1} (D) $\frac{25}{9}$ kg m^2s^{-1}

108. A wheel is rotating freely at an angular speed on a shaft. A second wheel with twice the moment of inertia of the first and initially at rest, is suddenly coupled to the first shaft. If K is the original rotational kinetic energy and ΔK is the loss in rotational kinetic energy, then $\frac{\Delta K}{K}$ is

(A) $\frac{1}{4}$ (B) $\frac{3}{4}$ (C) $\frac{3}{5}$ (D) $\frac{2}{3}$

109. 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 **[MH CET 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) $\left[\frac{mgh}{I+mr^2}\right]^{\frac{1}{2}}$

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

(A) $\frac{2g}{3}$ (B) $\frac{g}{2}$ (C) $\frac{5g}{6}$ (D) g

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

(A) Both cylinders P and Q reach the ground at the same time.
(B) Cylinder P has larger linear acceleration than cylinder Q.
(C) Both cylinders P and Q reach the ground with same translational kinetic energy.
(D) Cylinder Q reaches the ground with larger angular speed.

112. A body at rest starts from top of a smooth inclined plane and requires 4 second to reach bottom. How much time does it take, starting from rest at top, to cover one-fourth of a distance? **[MH CET 2014]**

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

113. 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 = $\frac{2}{3}MR^2$) **[MH CET 2015]**

(A) $\frac{R\omega}{4S}$ (B) $\frac{R^2\omega^2}{4S}$

(C) $\frac{R\omega}{2S}$ (D) $\frac{R^2\omega^2}{2S}$

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

(A) 2.86 kg m^2 s^{-2} (B) 6.66 kg m^2 s^{-2}
(C) 8.58 kg m^2 s^{-2} (D) 10.86 kg m^2 s^{-2}

115. 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) **[MHT CET 2017]**

(A) $\frac{4n}{15}$ (B) $\frac{8n}{15}$
(C) $\frac{16n}{15}$ (D) $\frac{32n}{15}$

116. 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 **[MH CET 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) $\frac{W}{2\pi^2\left(n_2^2+n_1^2\right)}$

117. A solid cylinder of mass 2 kg and radius 4 cm is rotating about its axis at the rate of 3 rpm. The torque required to stop after 2π revolutions is
(A) 12×10^{-4} Nm (B) 2×10^{6} Nm
(C) 2×10^{-6} Nm (D) 2×10^{-3} Nm

118. A truck is stationary and has a bob suspended by a light string, in a frame attached to the truck. The truck suddenly moves to the right with an acceleration of a. The pendulum will tilt
(A) to the left and angle of inclination of the pendulum with the vertical is $\tan^{-1}\left(\frac{g}{a}\right)$
(B) to the left and angle of inclination of the pendulum with the vertical is $\sin^{-1}\left(\frac{g}{a}\right)$
(C) to the left and angle of inclination of the pendulum with the vertical is $\tan^{-1}\left(\frac{a}{g}\right)$
(D) to the left and angle of inclination of the pendulum with the vertical is $\sin^{-1}\left(\frac{a}{g}\right)$

Homework

1.2 Characteristics of Circular Motion

1. The angular displacement in circular motion is
(A) dimensional quantity.
(B) dimensionless quantity.
(C) unitless and dimensionless quantity.
(D) unitless quantity.

2. Direction of $\vec{\alpha} \times \vec{r}$ is
(A) tangent to path.
(B) perpendicular to path.
(C) parallel to the path.
(D) along the path.

3. The vector relation between linear velocity $\vec{v}$, angular velocity $\vec{\omega}$ and radius vector $\vec{r}$ is given by
(A) $\vec{v} = \vec{\omega} \times \vec{r}$ (B) $\vec{v} = \vec{r} + \vec{\omega}$
(C) $\vec{v} = \vec{\omega} \cdot \vec{r}$ (D) $\vec{v} = \vec{r} - \vec{\omega}$

4. What is the angular speed of the seconds hand of a watch?
(A) 60 rad/s (B) π rad/s
(C) $\pi/30$ rad/s (D) 2 rad/s

5. What is the angular velocity of the earth?
(A) $\frac{2\pi}{86400}$ rad/s (B) $\frac{2\pi}{3600}$ rad/s
(C) $\frac{2\pi}{24}$ rad/s (D) $\frac{2\pi}{6400}$ rad/s

6. The ratio of angular speeds of minute hand and hour hand of a watch is
(A) 1 : 12 (B) 60 : 1
(C) 1 : 60 (D) 12 : 1

7. The angular velocity of a particle rotating in a circular orbit 100 times per minute is
(A) 1.66 rad/s (B) 10.47 rad/s
(C) 10.47 deg/s (D) 60 deg/s

8. A body of mass 100 g is revolving in a horizontal circle. If its frequency of rotation is 3.5 r.p.s. and radius of circular path is 0.5 m, the angular speed of the body is
(A) 18 rad/s (B) 20 rad/s
(C) 22 rad/s (D) 24 rad/s

9. An electric motor of 12 horse-power generates an angular velocity of 125 rad/s. What will be the frequency of rotation?
(A) 20 Hz (B) $20/\pi$ Hz
(C) $20/2\pi$ Hz (D) 40 Hz

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

11. 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}

12. A wheel has circumference C. If it makes f r.p.s., the linear speed of a point on the circumference is
(A) $2\pi fC$ (B) fC
(C) $fC/2\pi$ (D) fC/60

13. A body is whirled in a horizontal circle of radius 20 cm. It has angular velocity of 10 rad/s. What is its linear velocity at any point on circular path?
(A) 10 m/s (B) 2 m/s
(C) 20 m/s (D) $\sqrt{2}$ m/s

14. In uniform circular motion,
(A) both velocity and acceleration are constant.
(B) velocity changes and acceleration is constant.
(C) velocity is constant and acceleration changes.
(D) both velocity and acceleration change.

15. A particle performing uniform circular motion has
(A) radial velocity and radial acceleration.
(B) radial velocity and transverse acceleration.
(C) transverse velocity and radial acceleration.
(D) transverse velocity and transverse acceleration.

16. **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.

17. 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.

18. 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.

19. **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.

20. A particle is moving on a circular path with constant speed, then its acceleration will be
(A) zero.
(B) external radial acceleration.
(C) internal radial acceleration.
(D) constant acceleration.

21. 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.

22. Select the WRONG statement.
(A) In U.C.M. linear speed is constant.
(B) In U.C.M. linear velocity is constant.
(C) In U.C.M. magnitude of angular momentum is constant.
(D) In U.C.M. angular velocity is constant.

23. If a particle moves in a circle describing equal angles in equal intervals of time, the velocity vector
(A) remains constant.
(B) changes in magnitude only.
(C) changes in direction only.
(D) changes both in magnitude and direction.

24. A particle moves along a circle with a uniform speed v. After the position vector has made an angle of 30° with the reference position, its speed will be
(A) $v\sqrt{2}$ (B) $\frac{v}{\sqrt{2}}$
(C) $\frac{v}{\sqrt{3}}$ (D) v

25. 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.

26. The acceleration of a particle in U.C.M. directed towards centre and along the radius is called
(A) centripetal acceleration.
(B) centrifugal acceleration.
(C) gravitational acceleration.
(D) tangential acceleration.

27. If the angle between tangential acceleration and resultant acceleration in non U.C.M. is α, then direction of the resultant acceleration will be
(A) $\tan^{-1}\left(\frac{a_t}{a_r}\right)$ (B) $\tan^{-1}\left(\frac{a_r}{a_t}\right)$
(C) $\tan^{-1}\left(\frac{a_r}{a_\alpha}\right)$ (D) $\tan^{-1}\left(\frac{a_t}{a_\alpha}\right)$

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

29. Select the WRONG statement.
(A) Centrifugal force has same magnitude as that of centripetal force.
(B) Centrifugal force is along the radius, away from the centre.
(C) Centrifugal force exists in inertial frame of reference.
(D) Centrifugal force is called pseudo force, as its origin cannot be explained.

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

31. 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.

32. 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.

33. 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.

34. If p is the magnitude of linear momentum of a particle executing a uniform circular motion, then the ratio of centripetal force acting on the particle to its linear momentum is given by
(A) $\frac{r}{v}$ (B) $\frac{v^2}{mr}$ (C) $\frac{v}{r}$ (D) vr

35. Two particles of equal masses are revolving in circular paths of radii r_1 and r_2 respectively with the same speed. The ratio of their centripetal forces is
(A) $\frac{r_2}{r_1}$ (B) $\sqrt{\frac{r_2}{r_1}}$
(C) $\left(\frac{r_1}{r_2}\right)^2$ (D) $\left(\frac{r_2}{r_1}\right)^2$

36. A 10 kg object attached to a nylon cord outside a space vehicle is rotating at a speed of 5 m/s. If the force acting on the cord is 125 N, its radius of path is
(A) 2 m (B) 4 m (C) 6 m (D) 1 m

37. The breaking tension of a string is 50 N. A body of mass 1 kg is tied to one end of a 1 m long string and whirled in a horizontal circle. The maximum speed of the body should be
(A) $5\sqrt{2}$ m/s (B) 10 m/s
(C) 7.5 m/s (D) 5 m/s

38. 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

39. The safety speed of a vehicle on a curve horizontal road is
(A) μrg (B) $\sqrt{\mu rg}$
(C) $\mu r^2 g$ (D) $\mu/(rg)^2$

40. 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.

41. 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.

42. The angle of banking of the road does not depend upon
(A) acceleration due to gravity.
(B) radius of curvature of the road.
(C) mass of the vehicle.
(D) speed of the vehicle.

43. 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.

44. 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.

45. When the bob of a conical pendulum is moving in a horizontal circle at constant speed, which quantity is fixed?
(A) Velocity (B) Acceleration
(C) Centripetal force (D) Kinetic energy

46. The period of a conical pendulum is
(A) equal to that of a simple pendulum of same length l.
(B) more than that of a simple pendulum of same length l.
(C) less than that of a simple pendulum of same length l.
(D) independent of length of pendulum.

47. Consider a simple pendulum of length 1 m. Its bob performs a circular motion in horizontal plane with its string making an angle 60° with the vertical. The centripetal acceleration experienced by the bob is
(A) 17.3 m/s^2 (B) 5.8 m/s^2
(C) 10 m/s^2 (D) 5 m/s^2

48. A particle of mass 1 kg is revolved in a horizontal circle of radius 1 m with the help of a string. If the maximum tension the string can withstand is $16\pi^2$ N, then the maximum frequency with which the particle can revolve is
(A) 3 Hz (B) 2 Hz
(C) 4 Hz (D) 5 Hz

49. A racing car of mass 10^2 kg goes around a circular track (horizontal) of radius 10 m. The maximum thrust that track can withstand is 10^5 N. The maximum speed with which car can go around is
(A) 10 m/s (B) 100 m/s
(C) 50 m/s (D) 20 m/s

50. 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

51. When a particle is moved in a vertical circle,
(A) it has constant radial and tangential acceleration.
(B) it has variable tangential and radial acceleration.
(C) it has only constant radial acceleration.
(D) it has only constant tangential acceleration.

52. 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.

53. If a stone is tied to one end of the string and whirled in vertical circle, then the tension in the string at the lowest point is equal to
(A) centripetal force.
(B) the difference between centripetal force and weight of the stone.
(C) the addition of the centripetal force and weight of the stone.
(D) weight of the stone.

54. 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.

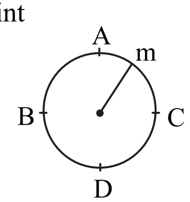
55. A body of mass m is suspended from a string of length l. What is minimum horizontal velocity that should be given to the body in its highest position so that it may complete one full revolution in the vertical plane with the point of suspension as the centre of the circle
(A) $v = \sqrt{lg}$ (B) $v = \sqrt{2lg}$
(C) $v = \sqrt{4lg}$ (D) $v = \sqrt{5lg}$

56. **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.

57. 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) $\frac{v^2g}{r}$

58. 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

59. 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

60. 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) $\frac{mu^2}{l} + mg(3\cos\theta - 2)$

61. 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

62. 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.

63. A couple produces
(A) linear motion.
(B) rotational motion.
(C) both linear as well as rotational motion.
(D) circular motion.

64. 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.

65. Select the WRONG statement.
(A) The moment of inertia is the torque acting per unit angular acceleration.
(B) The S.I. unit of moment of inertia is kg m^2.
(C) The dimensions of moment of inertia are $[M^1L^2T^0]$.
(D) The moment of inertia for a given body is a constant.

66. If the position of axis of rotation of a body is changed, then which of the following quantities will change?
(A) Torque
(B) Moment of inertia
(C) Momentum
(D) Force

67. 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.

68. 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.

69. 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

70. 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.

71. The new dimensional formula for the moment of inertia of a body is
(A) $[M^1L^0T^{-2}]$ (B) $[M^1L^2T^0]$
(C) $[M^1L^1T^0]$ (D) $[M^2L^3T^0]$

72. 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.

73. 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.

74. 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 $\vec{\tau}$

75. The physical significance of mass in translational motion is same as which of the following in rotational motion?
(A) Moment of inertia
(B) Angular momentum
(C) Torque
(D) Angular acceleration

76. The physical quantity in translatory motion corresponding to torque in rotatory motion is
(A) force (B) mass
(C) work (D) momentum

77. **Assertion:** A judo fighter in order to throw his opponent onto the mattress, he 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.

78. 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) $(\text{periodic time})^{-2}$

79. 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

80. 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

81. 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.

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

83. The dimensional formula for the radius of gyration of a body is
(A) $[M^0L^0T^0]$ (B) $[M^0L^1T^0]$
(C) $[M^1L^1T^0]$ (D) $[M^2L^0T^{-1}]$

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

85. 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) $\frac{R}{\sqrt{2}}$

86. 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

87. 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.

88. 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) $I_y + I_z = I_x$

89. 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) $I_C = I_O + Md^2$

90. 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

91. 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) $\frac{3}{4}MR^2$

92. 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) $2MR^2$

93. 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) $M\left[\frac{L^2}{12}+\frac{R^2}{2}\right]$

94. 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

1.8 Angular Momentum or Moment of Linear Momentum

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

96. 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.

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

98. 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.

99. Direction of angular momentum of rotating body in vertical plane is
(A) vertical (B) tangential
(C) horizontal (D) radial

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

101. 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

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

103. Torque/moment of inertia equals to
(A) angular velocity.
(B) angular acceleration.
(C) angular momentum.
(D) force.

104. 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.

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

106. 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) $\frac{\vec{F}}{\vec{r}}$

107. The dimensions of torque are the same as that of
(A) power
(B) angular momentum
(C) impulse
(D) rotational kinetic energy

108. 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) $\frac{1}{4}MK^2\alpha^2$

109. 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

110. 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

111. 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

112. 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) $\vec{\tau} = \vec{L} \times \vec{\omega}$

113. 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

1.11 Rolling Motion

114. 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.

115. 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.

116. 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

117. 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

118. 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

Miscellaneous

119. $\frac{L^2}{2I}$ represents
   (A) rotational kinetic energy of a particle.
   (B) potential energy of a particle.
   (C) torque on a particle.
   (D) power.

120. A flywheel of M.I. 0.32 kg m^2 is rotated steadily at 120 rad/s by a 50 W electric motor. The value of the frictional couple opposing rotation is
   (A) 0.025 Nm
   (B) 0.42 Nm
   (C) 0.042 Nm
   (D) 0.25 Nm

121. A motor rotates at a constant speed of 25 rev/s. The power delivered by the motor, if it supplies a torque of 60 Nm, is
   (A) 2500 W (B) 1500πW
   (C) 1250 W (D) 3000π W

Previous Years' Questions

1. 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) **[MHT CET 2020]**
   (A) 1 (B) 3 (C) 4 (D) 2

2. Let M and L be the mass and length of thin uniform rod respectively. In 1^{st} case, axis of rotations is passing through centre and perpendicular to its length. In 2^{nd} case, axis of rotation is passing through one end and perpendicular to its length. The ratio of radius of gyration in first case to second case is **[MHT CET 2020]**
   (A) 1 : 3 (B) 3 : 1
   (C) 1 : 2 (D) 2 : 1

3. The angular speed of the minute hand of a clock in degrees per second is **[MHT CET 2020]**
   (A) 0.01 (B) 10
   (C) 1 (D) 0.1

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

5. The moment of inertia of a thin uniform rod about a perpendicular axis passing through one of its ends is 'I'. Now, the rod is bent in a ring and its moment of inertia about diameter is 'I_1'. Then $\frac{I}{I_1}$ is **[MHT CET 2020]**
   (A) $\frac{4\pi^2}{3}$ (B) $\frac{11\pi^2}{3}$
   (C) $\frac{8\pi^2}{3}$ (D) $\frac{\pi^2}{3}$

6. Two stones of masses m and 3m are whirled in horizontal circles, the heavier one in radius $\left(\frac{r}{3}\right)$ and lighter one in radius 'r'. The tangential speed of lighter stone is 'n' times that of the value of heavier stone, when they experience same centripetal force. The value of n is **[MHT CET 2020]**
   (A) 4 (B) 1
   (C) 2 (D) 3

7. Two bodies 'A' and 'B' have their moments of inertia 'I' and '2I' respectively about their axis of rotation. If their kinetic energies of rotation are equal, their angular momenta (of body A to that of B) will be in the ratio **[MHT CET 2021]**
   (A) $1 : \sqrt{2}$ (B) 1 : 2
   (C) 2 : 1 (D) $\sqrt{2} : 1$

8. 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) **[MHT CET 2021]**
   (A) 36 rad s^{-1} (B) 4 rad s^{-1}
   (C) 8 rad s^{-1} (D) 18 rad s^{-1}

9. An object of mass 40 gram moves uniformly along a circular path with linear speed of 20 ms^{-1}. If the angular speed of object is 4 $rads^{-1}$, the centripetal force acting on it will be **[MHT CET 2021]**
   (A) 1.6 N (B) 12.8 N
   (C) 6.4 N (D) 3.2 N

10. 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 **[MHT CET 2022]**

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

11. 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, $g = 10\ m/s^2$) **[MHT CET 2022]**

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

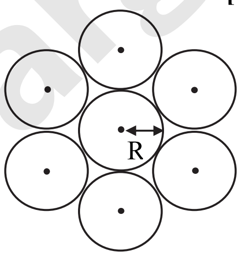
12. The relative angular speed of hour hand and second hand of a clock is (in rad/s) **[MHT CET 2022]**

(A) $\frac{421\pi}{11600}$ (B) $\frac{119\pi}{15600}$
(C) $\frac{719\pi}{21600}$ (D) $\frac{311\pi}{578}$

13. 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 **[MHT CET 2023]**

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

14. Seven identical discs each of mass M and radius R are arranged in a hexagonal plane pattern so as to touch each neighbour disc as shown in the figure. The moment of inertia of the system of seven discs about an axis passing through the centre of central disc and normal to the plane of all discs is **[MHT CET 2023]**



(A) $\frac{7}{2}MR^2$ (B) $\frac{13}{2}MR^2$
(C) $\frac{29}{2}MR^2$ (D) $\frac{55}{2}MR^2$

15. A particle of mass 'm' is rotating along a circular path of radius 'r' having angular momentum 'L'. The centripetal force acting on the particle is given by **[MHT CET 2023]**

(A) $\frac{L^2}{mr}$ (B) $\frac{L^2}{mr^2}$ (C) $\frac{mL^2}{r}$ (D) $\frac{L^2}{mr^3}$

16. 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) **[MHT CET 2023]**

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

17. Four point masses m, 2m, 3m and 4m are kept at the corners A, B, C and D respectively of a square ABCD of side 'b'. The moment of inertia of the system about an axis perpendicular to the plane of the square and passing through the point D is **[MHT CET 2023]**

(A) $5mb^2$ (B) $8mb^2$
(C) $10mb^2$ (D) $12mb^2$

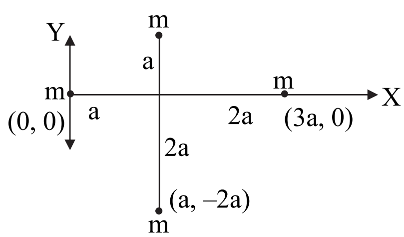
18. A thin uniform circular disc of mass 'M' and radius 'R' is rotating with angular velocity 'ω', in a horizontal plane about an axis passing through its centre and perpendicular to its plane. Another disc of same radius but of mass $\left(\frac{M}{2}\right)$ is placed gently on the first disc co-axially. The new angular velocity will be **[MHT CET 2023]**

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

19. 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 **[MHT CET 2023]**

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

20. Four point masses, each of mass 'm' are arranged in X - Y plane as shown in the figure. The moment of inertia of this system about X - axis is **[MHT CET 2024]**



(A) $3\ ma^2$ (B) $4\ ma^2$
(C) $5\ ma^2$ (D) $6\ ma^2$

21. The ratio of radius of gyration of a thin ring of mass 'M' and radius 'R' about its own axis to the radius of gyration of a uniform disc of same mass and radius about its diameter, is **[MHT CET 2024]**

(A) $1:\sqrt{2}$ (B) $1:2$

(C) $\sqrt{2}:1$ (D) $2:1$

22. An annular ring has mass 10 kg and inner and outer radii are 10m and 5m respectively. Its moment of inertia about an axis passing through its centre and perpendicular to its plane is **[MHT CET 2024]**

(A) 525 kgm^2 (B) 625 kgm^2

(C) 525 gcm^2 (D) 625 gcm^2

23. In case of rotational dynamics, which one of the following statements is correct?
[$\vec{\omega}$ = angular velocity, $\vec{v}$ = linear velocity
$\vec{r}$ = radius vector, $\vec{\alpha}$ = angular acceleration
$\vec{a}$ = linear acceleration, $\vec{L}$ = angular momentum
$\vec{p}$ = linear momentum, $\vec{\tau}$ = torque,
$\vec{f}$ = centripetal force] **[MHT CET 2024]**

(A) $\vec{v}=\vec{r}\times\vec{\omega}, \vec{\alpha}=\vec{r}\times\vec{a}, \vec{L}=\vec{r}\times\vec{p}, \vec{\tau}=\vec{f}\times\vec{r}$

(B) $\vec{v}=\vec{\omega}\times\vec{r}, \vec{\alpha}=\vec{a}\times\vec{r}, \vec{L}=\vec{p}\times\vec{r}, \vec{\tau}=\vec{r}\times\vec{f}$

(C) $\vec{v}=\vec{\omega}\times\vec{r}, \vec{\alpha}=\vec{a}\times\vec{r}, \vec{L}=\vec{r}\times\vec{p}, \vec{\tau}=\vec{r}\times\vec{f}$

(D) $\vec{v}=\vec{\omega}\times\vec{r}, \vec{\alpha}=\vec{a}\times\vec{r}, \vec{L}=\vec{p}\cdot\vec{r}, \vec{\tau}=\vec{r}\times\vec{f}$

24. A rotating body has angular momentum 'L'. If its frequency is doubled and kinetic energy is halved, its angular momentum will be **[MHT CET 2024]**

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

(C) 2 L (D) 4 L

25. Three thin rods, each of mass '2M' and length 'L' are placed along x, y and z axis which are mutually perpendicular. One end of each rod is at origin. Moment of inertia of the system about x - axis is **[MHT CET 2024]**

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

(B) $\frac{ML^2}{12}$

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

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

Answer Key

Classwork

1.	(C)	2.	(B)	3.	(B)	4.	(C)	5.	(A)	6.	(B)	7.	(D)	8.	(C)	9.	(C)	10.	(C)
11.	(D)	12.	(D)	13.	(B)	14.	(A)	15.	(D)	16.	(D)	17.	(B)	18.	(A)	19.	(B)	20.	(D)
21.	(B)	22.	(C)	23.	(B)	24.	(A)	25.	(A)	26.	(A)	27.	(B)	28.	(B)	29.	(D)	30.	(A)
31.	(A)	32.	(B)	33.	(A)	34.	(B)	35.	(D)	36.	(C)	37.	(A)	38.	(B)	39.	(A)	40.	(C)
41.	(B)	42.	(D)	43.	(D)	44.	(B)	45.	(B)	46.	(B)	47.	(D)	48.	(B)	49.	(C)	50.	(C)
51.	(B)	52.	(C)	53.	(A)	54.	(B)	55.	(D)	56.	(A)	57.	(C)	58.	(D)	59.	(A)	60.	(B)
61.	(C)	62.	(C)	63.	(B)	64.	(D)	65.	(C)	66.	(D)	67.	(D)	68.	(B)	69.	(A)	70.	(A)
71.	(D)	72.	(B)	73.	(A)	74.	(D)	75.	(B)	76.	(A)	77.	(B)	78.	(D)	79.	(C)	80.	(A)
81.	(D)	82.	(C)	83.	(A)	84.	(B)	85.	(B)	86.	(B)	87.	(B)	88.	(A)	89.	(A)	90.	(C)
91.	(D)	92.	(C)	93.	(A)	94.	(A)	95.	(A)	96.	(D)	97.	(A)	98.	(A)	99.	(A)	100.	(C)
101.	(B)	102.	(D)	103.	(C)	104.	(A)	105.	(C)	106.	(C)	107.	(A)	108.	(D)	109.	(C)	110.	(B)
111.	(D)	112.	(B)	113.	(B)	114.	(B)	115.	(C)	116.	(A)	117.	(C)	118.	(C)				

Homework

1.	(B)	2.	(A)	3.	(A)	4.	(C)	5.	(A)	6.	(D)	7.	(B)	8.	(C)	9.	(A)	10.	(C)
11.	(A)	12.	(B)	13.	(B)	14.	(D)	15.	(C)	16.	(D)	17.	(C)	18.	(C)	19.	(D)	20.	(C)
21.	(A)	22.	(B)	23.	(C)	24.	(D)	25.	(D)	26.	(A)	27.	(B)	28.	(A)	29.	(C)	30.	(A)
31.	(B)	32.	(B)	33.	(C)	34.	(C)	35.	(A)	36.	(A)	37.	(A)	38.	(C)	39.	(B)	40.	(A)
41.	(C)	42.	(C)	43.	(B)	44.	(A)	45.	(D)	46.	(C)	47.	(A)	48.	(B)	49.	(B)	50.	(C)
51.	(B)	52.	(C)	53.	(C)	54.	(C)	55.	(A)	56.	(C)	57.	(A)	58.	(B)	59.	(B)	60.	(D)
61.	(C)	62.	(C)	63.	(B)	64.	(C)	65.	(D)	66.	(B)	67.	(A)	68.	(C)	69.	(D)	70.	(A)
71.	(B)	72.	(D)	73.	(A)	74.	(C)	75.	(A)	76.	(A)	77.	(A)	78.	(D)	79.	(B)	80.	(C)
81.	(A)	82.	(B)	83.	(B)	84.	(B)	85.	(D)	86.	(D)	87.	(C)	88.	(C)	89.	(B)	90.	(B)
91.	(D)	92.	(C)	93.	(C)	94.	(A)	95.	(C)	96.	(B)	97.	(C)	98.	(D)	99.	(C)	100.	(D)
101.	(B)	102.	(B)	103.	(B)	104.	(C)	105.	(A)	106.	(A)	107.	(D)	108.	(B)	109.	(D)	110.	(A)
111.	(D)	112.	(A)	113.	(B)	114.	(C)	115.	(C)	116.	(A)	117.	(A)	118.	(D)	119.	(A)	120.	(B)
121.	(D)																		

Previous Years' Questions

1.	(D)	2.	(C)	3.	(D)	4.	(C)	5.	(C)	6.	(D)	7.	(A)	8.	(C)	9.	(D)	10.	(B)
11.	(A)	12.	(C)	13.	(B)	14.	(D)	15.	(D)	16.	(A)	17.	(A)	18.	(A)	19.	(A)	20.	(C)
21.	(D)	22.	(B)	23.	(C)	24.	(A)	25.	(A)										

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