LEVEL – I

CENTER OF MASS

1. The distance between the centres of the carbon and oxygen atoms in the carbon monoxide gas molecule is 1.12×10^{-8}cm. Calculate the centre of mass of the molecule with respect to the carbon atom.
(1) 0.48×10^{-8} cm (2) 0.64×10^{-8} cm (3) zero (4) 1.12×10^{-8}

2. The linear density of a rod of length L varies as $\lambda = A + Bx$. Then the position of its centre of mass is given by
(1) $X_{CM} = \frac{L(2A+BL)}{3(3A+2BL)}$ (2) $X_{CM} = \frac{L(3A+2BL)}{3(2A+BL)}$
(3) $X_{CM} = \frac{L(3A+2BL)}{3}$ (4) $X_{CM} = \frac{L(2A+3BL)}{3}$

3. The centre of mass of a system of particles does not depend upon:
(1) Masses of the particles (2) Forces on the particles
(3) Position of the particles (4) Relative distances between the particles

4. If $\vec{R}_{CM}$ is the position of the centre of mass of a system of two particles of masses m_1 and m_2, then $\vec{R}_{CM}$ is given by:
(1) $\frac{m_1 + m_2}{m_1\vec{r}_1 + m_2\vec{r}_2}$ (2) $\frac{m_1 m_2}{m_1\vec{r}_1 + m_2\vec{r}_2}$ (3) $\frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$ (4) $\frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 m_2}$

5. The centre of mass of a body is defined as the point at which the whole of its mass is supposed to be concentrated, while centre of gravity of a body is defined as the point at which whole of its weight is supposed to be concentrated then:
(1) Centre of gravity always coincides with the centre of mass
(2) Centre of gravity may lie slightly below the centre of mass
(3) Centre of gravity may lie slightly above the centre of mass
(4) None of these

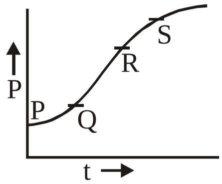
6. The position of centre of mass of a system consisting of two particles of masses m_1 and m_2 separated by a distance L apart, from m_1 will be:
(1) $\frac{m_1 L}{m_1 + m_2}$ (2) $\frac{m_2 L}{m_1 + m_2}$ (3) $\frac{m_2}{m_1}L$ (4) $\frac{L}{2}$

IMPULSE AND MOVENTUM

7. Parrot is in a cage which has openings and is hanging from a spring balance. Initially the parrot sits in the cage in the second instance the parrot flies about inside the cage:
(1) The reading of the balance will be greater when the parrot flies in the cage
(2) The reading of the balance remains unchanged
(3) The reading of the balance will be less when the parrot flies
(4) None of the above

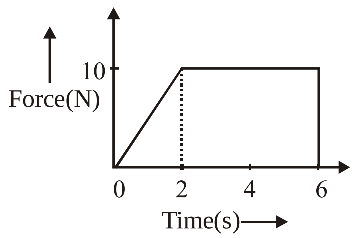
8. Two heavenly bodies S_1 and S_2 not far from each other are seen revolving in orbits :
(1) Around their common centre of mass (2) Which are arbitrary
(3) With S_1 fixed and S_2 moving round S_1 (4) With S_2 fixed and S_1 moving round S_2

9. The variation of momentum with time of one of the body in a two body collision is shown in figure. the instantaneous force is maximum corresponding to point :



(1) P (2) S (3) R (4) P & S

10. A body of mass 3 kg is acted upon by a force which varies as shown in the graph below. The momentum acquired is given by :



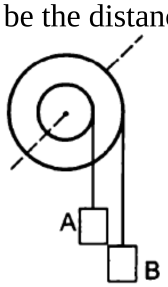
(1) Zero (2) 5 Ns (3) 30 Ns (4) 50 Ns

11. A particle of mass M is moving in a horizontal circle of radius R with uniform speed V. When it moves from one point to a diametrically opposite point, its
(1) Kinetic energy changes by $MV^2/4$ (2) Momentum does not change
(3) Momentum changes by 2 MV (4) Kinetic energy changes by MV^2

ANGULAR VARIABLES

12. A rigid body is rotating with variable angular velocity ($a - bt$) at any instant of time t. The total angle rotated by it before coming to rest will be: (a and b are constants)
(1) $\frac{(a-b)a}{2}$ (2) $\frac{a^2}{2b}$ (3) $\frac{a^2-b^2}{2b}$ (4) $\frac{a^2-b^2}{2a}$

13. Figure shows a small wheel fixed coaxially on abigger one of double the radius. The system rotatesabout the common axis. The strings supporting A and Bdo not slip on the wheels. If x and y be the distancestravelled by A and B in the same time interval, then



(1) x = 2y (2) y = 2x (3) x =y (4) none of these.

MOMENT OF INERTIA

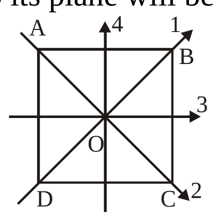
14. Three uniform thin rods, each of mass M and length l are placed along the three co-ordinate axes with one end of each rod at the origin. The moment of inertia of the system about any one of the co-ordinate axes is:

(1) $2\,Ml^2$ (2) $\frac{2}{3}Ml^2$ (3) $\frac{3}{2}Ml^2$ (4) $\frac{1}{2}Ml^2$

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

(1) $2I$ (2) $\frac{I}{2}$ (3) I (4) $\frac{I}{4}$

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

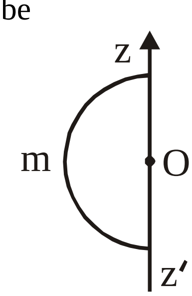


(1) $I_1 + I_2$ (2) $I_1 - I_3$ (3) $I_1 + I_2 + I_4$ (4) $I_1 + I_2 + I_3$

17. Two rotating bodies have same angular momentum but their moments of inertia are I_1 and I_2 respectively $(I_1 > I_2)$. Which body will have higher kinetic energy of rotation.

(1) first (2) second
(3) both will have same kinetic energy (4) not possible to predict

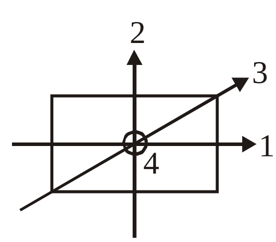
18. A thin wire of length l and mass m is bent in the form of a semicircle (Figure). Its moment of inertia about an axis joining its free ends will be



(1) zero (2) ml^2 (3) $\frac{ml^2}{\pi^2}$ (4) $\frac{ml^2}{2\pi^2}$

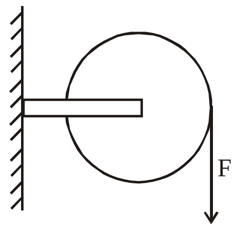
19. About which axis in the following figure the moment of inertia of the rectangular lamina is the maximum?

(1) 2 (2) 4
(3) 3 (4) 1



TORQUE

20. A uniform disc of mass M can rotate about a fixed smooth axis passing through its centre and perpendicular to its plane. A force F is applied on its rim. What is the tangential acceleration of the rim of the disc ?



(1) $\frac{2F}{M}$ (2) $\frac{F}{M}$ (3) $\frac{F}{2M}$ (4) $\frac{F}{4M}$

21. Torque per unit moment of inertia is equivalent to
(1) angular velocity (2) angular acceleration (3) radius of gyration (4) inertia

22. A constant torque acting on a uniform circular wheel changes its angular momentum from A_0 to $4A_0$ in 4 seconds. The value of torque is
(1) $4A_0$ (2) $12A_0$ (3) A_0 (4) $3A_0/4$

ANGULAR MOMENTUM

23. The angular momentum of a particle is
(1) parallel to its linear momentum (2) perpendicular to its linear momentum
(3) inclined to its linear momentum (4) a scalar quantity

24. If the rotational kinetic energy of a body is increased by 300% then the percentage increase in its angular momentum will be
(1) 600% (2) 150% (3) 100% (4) 1500%

25. A particle moves with a constant velocity parallel to the X-axis. Its angular momentum with respect to the origin
(1) is zero (2) remains constant (3) goes on increasing (4) goes on decreasing

CONSERVATION OF ANGULAR MOMENTUM AND MECHANICAL ENERGY

26. The angular speed of a body changes from ω_1 to ω_2 without application of a torque but due to changes in moment of inertia. The ratio of the radii of gyration in the two cases i.e., $k_1 : k_2$ to equal to
(1) $\sqrt{\omega_1} : \sqrt{\omega_2}$ (2) $\sqrt{\omega_2} : \sqrt{\omega_1}$ (3) $\sqrt{\omega_2^2} : \sqrt{\omega_1^2}$ (4) $\sqrt{\omega_2^3} : \sqrt{\omega_1^3}$

27. A girl is sitting near the edge of a rotating circular platform. If the girl moves from circumference toward the centre of the platform then the angular velocity of the platform will
(1) decrease (2) increase (3) remain same (4) become zero

28. A solid cylinder of diameter D is mounted on a fixed frictionless horizontal axle. A string is wrapped around it and a mass m is attached to the free end of the string. The mass is allowed to fall freely. If the speed of the mass m just before striking the ground is ν be, then:

(1) $\nu \propto D$ (2) $\nu \propto D^2$

(3) $\nu \propto 1/D$ (4) ν is independent of D

29. A uniform circular disc of mass M and radius R is rotating about its fixed axis such that a particle on the rim moves with uniform speed *v*. What is its kinetic energy ?

(1) Mv^2 (2) $(1/2)Mv^2$ (3) $(1/4)\,Mv^2$ (4) $(1/8)Mv^2$

ROLLING MOTION

30. The moment of inertia of a solid cylinder about its axis is *I*. It is allowed to roll down an inclined plane without slipping. If its angular velocity at the bottom be ω, then kinetic energy of the cylinder will be

(1) $\frac{1}{2}I\omega^2$ (2) $I\omega^2$ (3) $\frac{3}{2}I\omega^2$ (4) $2I\omega^2$

31. A circular ring of mass M and radius R is rolling on a horizontal surface with speed *v*. What is its kinetic energy ?

(1) Mv^2 (2) $(1/2)\,Mv^2$ (3) $(1/4)\,Mv^2$ (4) $(1/8)\,Mv^2$

32. A body slides down an inclined plane and reaches the bottom with velocity *v*. If a ring rolls down the same inclined plane without slipping, what will be its velocity on reaching the bottom ?

(1) v (2) $v/\sqrt{2}$ (3) $\sqrt{2}\,v$ (4) $v/2$

33. A solid sphere rolls down an inclined plane having inclination 30^o, without slipping. What will be its acceleration down the inclined plane ?

(1) g/2 (2) g/3 (3) 2g/3 (4) 5*g*/14

34. A ring of radius *R* slides down an inclined plane and reaches the bottom with speed *v*. If the radius of the ring is doubled keeping its mass constant, the speed at the bottom of the inclined plane will be :

(1) $2v$ (2) $\sqrt{2}v$ (3) $v/\sqrt{2}$ (4) v

35. A solid homogeneous sphere of mass *M* and radius *R* is moving on a rough horizontal surface, rolling with sliding. During this kind of motion of the sphere

(1) Total kinetic energy is conserved

(2) The angular momentum of the sphere about the point of contact with the plane is conserved

(3) Only the rotational kinetic energy about the centre of mass is conserved

(4) Angular momentum about the centre of mass of conserved

36. A body is rolling without slipping on a horizontal surface and its rotational kinetic energy is equal to the translational kinetic energy. The body is :

(1) Disc (2) Sphere (3) Spherical shell (4) Ring

37. A thick walled hollow sphere has outer radius R. It rolls down an inclined plane without slipping and its speed at the bottom is V. If the inclined plane is frictionless, its speed at the bottom will be $5V/4$. What is the radius of gyration of the sphere ?

(1) $\frac{R}{\sqrt{2}}$ (2) $\frac{R}{2}$ (3) $\frac{3R}{4}$ (4) $\frac{\sqrt{3}R}{4}$

38. A solid sphere of mass M rolls without slipping on an inclined plane of inclination 'θ'. What should be the minimum coefficient of friction, so that the ball rolls down without slipping ?

(1) $\frac{2}{5}\tan\theta$ (2) $\frac{2}{7}\tan\theta$ (3) $\frac{5}{7}\tan\theta$ (4) $\tan\theta$

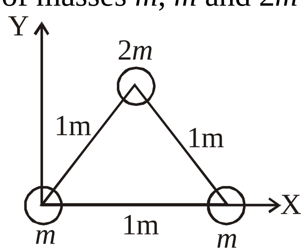
39. A solid cylinder of mass M and radius R rolls down an inclined plane of height h. The velocity of its centre of mass at the bottom of the plane will be

(1) $\sqrt{\frac{4g}{h}}$ (2) $\sqrt{\frac{3}{4}gh}$ (3) $\sqrt{\frac{4}{3}gh}$ (4) $\sqrt{2gh}$

LEVEL – II

CENTER OF MASS

1. Determine the x and y coordinates of the center of mass of the system shown in the figure. The system consists of masses m, m and $2m$ placed at the vertices of an equilateral triangle of side $1m$.



(1) (0.5, 0.866) (2) $(0.5, \sqrt{3})$ (3) (0.43, 0.5) (4) (0.5, 0.43)

2. If the centre of mass of three particles of masses 10, 20 and 30 units be at a point (1, –1, 3) where should a fourth particle of mass 40 units be placed so that the combined centre of mass may be at the point (1, 1, 1) ?

(1) 1, 5.5, –2 (2) 3, 5, 4 (3) 1.5, 0, –2 (4) None of these

3. Three identical spheres, each of mass 1 kg are placed touching each other with their centres on a straight line. Their centre are marked P, Q and R respectively. The distance of centre of mass of the system from P is:

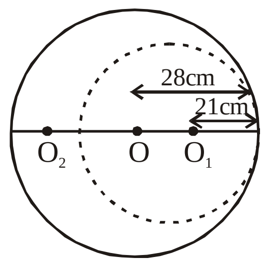
(1) $\frac{PQ+PR+QR}{3}$ (2) $\frac{PQ+PR}{3}$

(3) $\frac{PQ+QR}{3}$ (4) $\frac{PR+QR}{3}$

4. A uniform metal disc of radius R is taken and out of it a disc of diameter R is cut off from the end. The centre of mass of the remaining part will be:

(1) $\frac{R}{4}$ from the centre
(2) $\frac{R}{3}$ from the centre
(3) $\frac{R}{5}$ from the centre
(4) $\frac{R}{6}$ from the centre

5. A circular plate of uniform thickness has a diameter of 56 cm. A circular portion of diameter 42 cm is removed from one edge as shown in the figure. The centre of mass of the remaining portion from the centre of plate will be:



(1) 5 cm
(2) 7 cm
(3) 9 cm
(4) 11 cm

6. The two bodies of masses m_1 and m_2 ($m_1 > m_2$) respectively are tied to the ends of a string which passes over a light frictionless pulley. The masses are initially at rest and released. The acceleration of the centre of mass is:

(1) $\left(\frac{m_1 - m_2}{m_1 + m_2}\right)^2 g$
(2) $\left(\frac{m_1 - m_2}{m_1 + m_2}\right) g$
(3) g
(4) Zero

MOTION OF CENTER OF MASS

7. Two blocks of masses 3 m and *m* are connected by a massless and inextensible string which passes over a massless and frictionless pulley. Calculate the magnitude of acceleration of centre of mass of the system when the blocks are allowed to accelerate, given $g = 10 \text{ m/s}^2$

(1) 5 m/s^2
(2) 2.5 m/s^2
(3) 2 m/s^2
(4) zero

8. Two particles of masses 1 kg and 3 kg move towards each other under their mutual force of attraction. No other force acts on them. When the relative velocity of the two particles is 2 m/s, their centre of mass has a velocity of 0.5 m/s. But when the relative velocity of approach becomes 3 m/s, the velocity of the centre of mass is

(1) 0
(2) 0.5 m/s
(3) 1.5 m/s
(4) none of these

9. The particles attract each other and are permitted to move towards each other along the line joining their centres of mass. They are left at rest and at a particular moment of time their speeds are v and 2v. What is the speed of their common centre of mass at this instant?

(1) Zero
(2) 1.5v
(3) v
(4) 3v

10. Sailing of a boat is based on the principle of

(1) Momentum conservation
(2) Angular momentum conservation
(3) Energy conservation
(4) Mass conservation

ANGULAR VARIABLES

11. A rigid body rotates about a fixed axis with variable angular velocity equal to $\alpha - \beta t$ at time *t* where α and β are constants. Find the angle through which it rotates before it comes to stop?

(1) $\frac{\alpha^2}{2\beta}$ (2) $\frac{\alpha^2 - \beta^2}{2\alpha}$ (3) $\frac{\alpha^2 - \beta^2}{2\beta}$ (4) $\frac{(\alpha - \beta)\alpha}{2}$

12. A wheel is rotating at 900 r.p.m about its axis. When power is cut off it comes to rest in 1 minute. The angular retardation in rad/s^2 is

(1) $\pi / 2$ (2) $\pi / 4$ (3) $\pi / 6$ (4) $\pi / 8$

13. The angular velocity of second's hand of a watch is

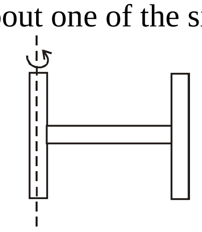
(1) 0.053 rad/s (2) 0.210 rad/s (3) 0.105 rad/s (4) 0.42 rad/s

MOMENT OF INERTIA

14. Four identical rods are joined end to end to form a square. The mass of each rod is M. The moment of inertia of the square about the diagonal is

(1) $\frac{2Ml^2}{3}$ (2) $\frac{13Ml^2}{3}$ (3) $\frac{Ml^2}{6}$ (4) $\frac{13Ml^2}{6}$

15. Three identical thin rods each of length *l* and mass M are joined together to form a letter H. What is the moment of inertia of the system about one of the sides of H?



(1) $\frac{Ml^2}{3}$ (2) $\frac{Ml^2}{4}$ (3) $\frac{2Ml^2}{3}$ (4) $\frac{4Ml^2}{3}$

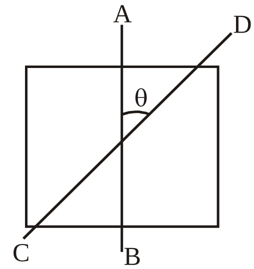
16. A uniform cylinder has a radius R and length L. If the moment of inertia of this cylinder about an axis passing through its centre and normal to its circular face is equal to the moment of inertia of the same cylinder about an axis passing through its centre and normal to its length; then:

(1) L = R (2) $L = \sqrt{3}R$ (3) $L = \frac{R}{\sqrt{3}}$ (4) L = 0

17. Three solid spheres , each of mass m and radius *l*, are placed at the corners of an equilateral triangle of side 2*l*. The moment of inertia of this system about an axis along one of side of the triangle is:

(1) $3ml^2$ (2) $\frac{65}{5}ml^2$ (3) $\frac{33}{4}ml^2$ (4) $\frac{21}{5}ml^2$

18. Let I be the moment of inertia of a uniform square plate about an axis AB that passes through its centre and is parallel to two of its sides. CD is a line in the plane of the plate that passes through the centre of the plate and makes an angle θ with AB. The moment of inertia of the plate about the axis CD is :



(1) I (2) $I \sin^2\theta$ (3) $I\cos^2\theta$ (4) $I \cos^2(\theta/2)$

19. The minimum moment of inertia of a solid sphere about any axis is $\frac{2}{5}MR^2$. Then its radius of gyration about an axis at a distance 2R from its centre is:

(1) 5R (2) $\sqrt{22/5}\,R$ (3) $\frac{5}{2}R$ (4) $\sqrt{12/5}R$

20. Two particles of masses m_1 and m_2 are connected by a rigid massless rod of length r to constitute a dumb-bell which is free to move in any plane. The moment of inertia of the dumb-bell about an axis perpendicular to the line joining the centres and passing through the centre of mass of the dumb bell is:

(1) $\frac{m_1m_2r^2}{m_1+m_2}$ (2) $(m_1+m_2)r^2$ (3) $\frac{m_1m_2r^2}{m_1-m_2}$ (4) $(m_1-m_2)r^2$

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

(1) 5 *I* (2) 3 *I* (3) 6 *I* (4) 4 *I*

22. Moment of inertia of a uniform annular disc of internal radius *r* and external radius *R* and mass *M* about an axis through its centre and perpendicular to its plane is

(1) $\frac{1}{2}M(R^2-r^2)$ (2) $\frac{1}{2}M(R^2+r^2)$ (3) $\frac{M(R^4+r^4)}{2(R^2+r^2)}$ (4) $\frac{1}{2}\frac{M(R^4+r^4)}{R^2-r^2}$

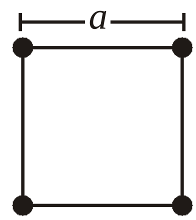
23. A fly-wheel rotating about a fixed axis has a kinetic energy of 360 joule when its angular speed is 30 radian per second. The moment of inertia of the fly-wheel about the axis of rotation is

(1) 0.6 kgm^2 (2) 0.15 kgm^2 (3) 0.8 kgm^2 (4) 0.75 kgm^2

24. The moment of inertia of a thin spherical shell of mass M and radius, r, about a diameter is $\frac{2}{3}Mr^2$. Its radius of gyration K, about tangent will be

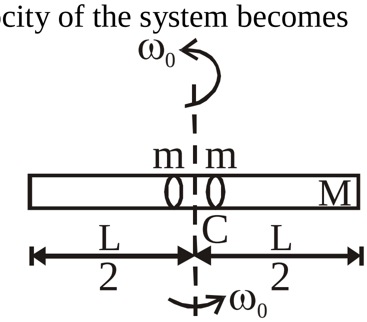
(1) $\frac{2}{3}r$ (2) $\sqrt{\frac{2}{3}}r$ (3) $\sqrt{\frac{5}{3}}r$ (4) $\sqrt{\frac{3}{5}}r$

25. Four spheres each having mass m and radius r are placed with their centres on the four corners of a square of side a. The moment of inertia of the system about an axis along one of the sides of the square, is



(1) $\frac{8}{5}mr^2$ (2) $\frac{8}{5}mr^2 + 2ma^2$ (3) $\frac{4}{5}mr^2 + 2ma^2$ (4) $\frac{4}{5}mr^2 + 4ma^2$

26. A smooth uniform rod of length L and mass M has two identical beads of negligible size, each of mass m, which can slide freely along the rod. Initially the two beads are at the centre of the rod and the system is given an angular velocity ω_0 about an axis perpendicular to rod and passing through the midpoint of rod (As shown in figure). There are no external forces. When the beads reach the ends of the rod the angular velocity of the system becomes

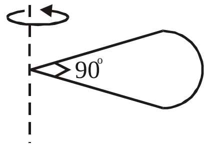


(1) $\frac{M}{M+3m}\omega_0$ (2) $\frac{M}{M+6m}\omega_0$ (3) $\frac{M+6m}{M}\omega_0$ (4) ω_0

27. The moment of Inertia of a solid cylinder of mass M and radius R about a line parallel to the axis of the cylinder but lying on the surface of the cylinder is

(1) $\frac{2}{5}MR^2$ (2) $\frac{3}{5}MR^2$ (3) $\frac{3}{2}MR^2$ (4) $\frac{5}{2}MR^2$

28. One quarter sector is cut from a uniform circular disc of mass *M* of radius *R*. It is made to rotate about a line perpendicular to its plane and passing through the centre of the original disc. Its moment of inertia about the axis of rotation is



(1) $\frac{1}{2}MR^2$ (2) $\frac{1}{4}MR^2$ (3) $\frac{1}{8}MR^2$ (4) $\sqrt{2}MR^2$

29. From a given sample of uniform wire, two circular loops *P* and *Q* are made, *P* of radius *r*, and *Q* of radius *nr*. If the M.I. of *Q* about its axis is 4 times that of *P* about its, axis the value of *n* is

(1) $(4)^{\frac{2}{3}}$ (2) $(4)^{\frac{1}{3}}$ (3) $(4)^{\frac{1}{2}}$ (4) $(4)^{\frac{1}{4}}$

30. The moment of inertia of a thin spherical shell of mass *M* and radius, *r*, about a diameter is $\frac{2}{3}Mr^2$. Its radius of gyration *K*, about tangent will be

(1) $\frac{2}{3}r$ (2) $\sqrt{\frac{2}{3}}r$ (3) $\sqrt{\frac{5}{3}}r$ (4) $\sqrt{\frac{3}{5}}r$

31. A body rolls down an inclined plane without slipping. The fraction of total energy associated with its rotation will be ($K \rightarrow$ Radius of gyration)

(1) $K^2 + R^2$ (2) $\frac{K^2}{R^2}$ (3) $\frac{K^2}{K^2+R^2}$ (4) $\frac{R^2}{K^2+R^2}$

CONSERVATION OF ANGULAR MOMENTUM

32. The rotational kinetic energy of a body is *E* and its moment of inertia is *I*. The angular momentum is

(1) *EI* (2) $2\sqrt{EI}$ (3) $\sqrt{2EI}$ (4) *E/I*

33. Before jumping in to water from above, swimmer bends his body to

(1) Increase moment of Inertia (2) decrease moment of Inertia
(3) decrease the angular momentum (4) reduce the angular velocity

ROLLING MOTION

34. A heavy disc is gently placed on a horizontal surface after it has been given angular velocity (V_0/R). It will start rolling without slipping when the speed of its centre reduces to:

(1) $\frac{V_0}{3}$ (2) $\frac{2V_0}{3}$ (3) $\frac{3V_0}{5}$ (4) $\frac{5V_0}{7}$

35. A solid sphere, a hollow sphere and a disc, all having same mass and radius, are placed at the top of a smooth incline and released. Least time will be taken in reaching the bottom by

(1) the solid sphere (2) the hollow sphere
(3) the disc (4) all will take same time

36. A solid sphere is rolling on a horizontal plane, Ratio of its translational K.E. and rotational energy is
(1) 1/5 (2) 5/2 (3) 3/5 (4) 5/7

37. A loop rolls down on inclined plane. The fraction of its total kinetic energy that is associated with rotational motion is
(1) 1 : 2 (2) 1 : 3 (3) 1 : 4 (4) 2 : 3

38. A fly-wheel rotating about a fixed axis has a kinetic energy of 360 J when its angular speed is 30 radian per second. The moment of inertia of the fly-wheel about the axis of rotation is
(1) 0.6 kgm^2 (2) 0.15 kgm^2 (3) 0.8 kgm^2 (4) 0.75 kgm^2

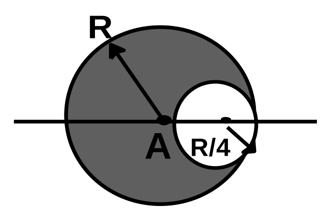
LEVEL – III

QUESTIONS BASED ON NEET LEVEL

CENTER OF MASS

1. The centre of mass of a body:
(1) Lies always at the geometrical centre (2) Lies always inside the body
(3) Lies always outside the body (4) Lies within or outside the body

2. The centre of mass of the shaded portion of the disc is:
(The mass is uniformly distributed in the shaded portion):



(1) $\frac{R}{20}$ to the left of A (2) $\frac{R}{12}$ to the left of A
(3) $\frac{R}{20}$ to the right of A (4) $\frac{R}{12}$ to the right of A

3. A thin uniform wire is bent to form the two equal sides AB and AC of triangle ABC, where $AB = AC = 5cm$ .The third side BC, of length 6 cm, is made from uniform wire of twice the density of the first. The distance of centre of mass from A is:
(1) $\frac{34}{11}$cm (2) $\frac{11}{34}$cm (3) $\frac{34}{9}$cm (4) $\frac{11}{45}$cm

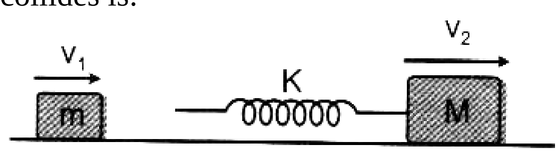
4. A body has its centre of mass at the origin. The $x-$coordinates of the particles
(1) May be all positive (2) May be all negative
(3) May be all non-negative (4) None of these

MOTION OF CENTER OF MASS

5. A bomb travelling in a parabolic path under the effect of gravity,explodes in mid air. The centre of mass of fragments will
(1) Move vertically upwards and then downwards
(2) Move vertically downwards
(3) Move in irregular path
(4) Move in the parabolic path which the unexploded bomb would have travelled.

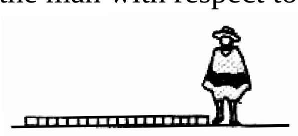
6. A body at rest breaks into two pieces of equal masses. The parts will move
(1) In same direction (2) Along different lines
(3) In opposite directions with equal speeds (4) In opposite directions with unequal speeds

7. Two blocks of masses m and M are moving with speeds v_1 and $v_2\left(v_1 > v_2\right)$ in the same direction on the frictionless surface respectively, M being ahead of m. An ideal spring of force constant k is attached to the backside of M (as shown). The maximum compression of the spring when the block collides is:



(1) $v_1\sqrt{\frac{m}{k}}$ (2) $v_2\sqrt{\frac{M}{k}}$
(3) $\left(v_1 - v_2\right)\sqrt{\frac{mM}{(M+m)K}}$ (4) None of above is correct

8. On a smooth horizontal plane, a uniform string of mass M and length is lying in the state of rest. A man of the same mass M is standing next to one end of the string. Now, the man starts collecting the string. Finally the man collects all the string and puts it in his pocket. What is the displacement of the man with respect to earth in the process of collection?



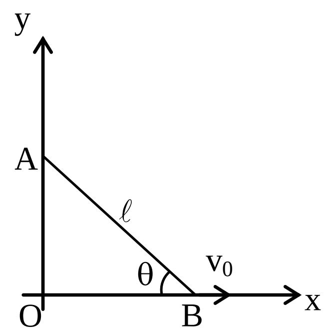
(1) $L/2$ (2) $L/4$ (3) $L/8$ (4) none

9. A bullet in motion hits and gets embedded in a solid block resting on a frictionless table. Which of the following is conserved?
(1) Momentum and KE (2) Kinetic energy alone
(3) Neither KE nor momentum (4) Momentum alone

10. A boy hits a baseball with a bat and imparts an impulse J to the ball. The boy hits the ball again with the same force, except that the ball and the bat are in contact for twice the amount of time as in the first hit. The new impulse equals:
(1) Half the original impulse (2) The original impulse
(3) Twice the original impulse (4) Four time the original impulse

ANGULAR VARIABLES

11. In the figure given below, the end B of the rod AB which makes angle θ with the floor is pulled with a constant velocity v_0 as shown. The length of rod is ℓ. At an instant when θ = 37º



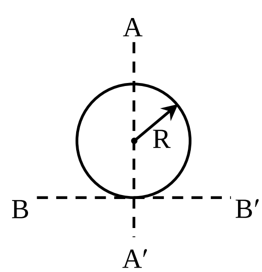
(1) Velocity of end A is $\frac{4v_0}{3}$
(2) angular velocity of rod is $\frac{5v_0}{6\ell}$
(3) angular velocity of rod is constant
(4) velocity of end A is constant

12. A particle moves along a circle of radius $\frac{20}{\pi}$ m with constant tangential acceleration. If the velocity of the particle is 80 m/s at the end of the second revolution after motion has begin, the tangential acceleration is
(1) $640\pi\,m/s^2$
(2) $160\pi\,m/s^2$
(3) $40\pi\,m/s^2$
(4) $40\,m/s^2$

13. The direction of the angular velocity vector is along
(1) The tangent to the circular path
(2) The inward radius
(3) The outward radius
(4) The axis of rotation

MOMENT OF INERTIA

14. Figure shows a sphere of mass M & radius 'R' let AA′ and BB′ be two axes as shown in figure then
(I) Parallel axes theorem is not applicable between axes AA′& BB′
(II) $I_{BB'} = I_{AA'} + MR^2$



(1) Both of statement - I and statement - II are correct
(2) Statement - I is correct but statement - II is false
(3) Statement - I is false but statement - II is correct
(4) Both of statement - I and statement - II are false

15. A uniform disc of mass radius R lies in the x – y plane, with its centre at origin. Its moment of inertia is $\frac{MR^2}{2}$ about the line y = x + c. The value of c will be

(1) –R/2 (2) $\pm\frac{R}{\sqrt{2}}$ (3) + R/4 (4) –R

16. A circular disc of radius R and thickness $\frac{R}{6}$ has moment of inertia I about an axis passing through its centre and perpendicular to its plane. It is melted and recasted into a solid sphere. The moment of inertia of the sphere about its diameter as axis of rotation is

(1) I (2) $\frac{2I}{8}$ (3) $\frac{I}{5}$ (4) $\frac{I}{10}$

17. Two discs of same thickness but of different radii are made of two different materials such that their masses are same. The densities of the materials are in ratio 1 : 3. The moment of inertia of these discs about the respective axes passing through their centres and perpendicular to their planes will be in the ratio

(1) 1:3 (2) 3:1 (3) 1:9 (4) 9:1

18. Two thin rods of mass m and length ℓ each are joined to form L shape as shown in the figure. The moment of inertia of rods about an axis passing through free end (O) of a rod and perpendicular to both the rod is

(1) $\frac{2}{7}m\ell^2$ (2) $\frac{m\ell^2}{6}$ (3) $m\ell^2$ (4) $\frac{5m\ell^2}{3}$

19. The moment of inertia of semicircular ring of mass m and radius R about an axis which is perpendicular to the plane of the ring and passes through the centre

(1) MR^2 (2) $\frac{MR^2}{2}$ (3) $\frac{MR^2}{4}$ (4) None of these

20. Four point masses, each of value m, are placed at the corners of a square ABCD (taken in order) of side l. The moment of inertia of this system about an axis passing through A and parallel to BD is

(1) $\sqrt{3}ml^2$ (2) $3ml^2$ (3) ml^2 (4) $2ml^2$

21. The moment of inertia of a sphere of mass M and radius R about an axis passing through its centre is $2/5MR^2$. The radius of gyration of the sphere about a parallel axis to the above and tangent to the sphere is

(1) $\frac{7}{5}R$ (2) $\frac{3}{5}R$ (3) $\left(\sqrt{\frac{7}{5}}\right)R$ (4) $\left(\sqrt{\frac{3}{5}}\right)R$

22. Consider a uniform square plate of side 'a' and mass 'm'. The moment of inertia of this plate about an axis perpendicular to its plane and passing through one of its corners is

(1) $\frac{1}{12}ma^2$ (2) $\frac{7}{12}ma^2$ (3) $\frac{2}{3}ma^2$ (4) $\frac{5}{6}ma^2$

23. Moment of inertia of a thin circular disc of mass M and radius R about any diameter is

(1) $\frac{MR^2}{4}$ (2) $\frac{2}{3}MR^2$ (3) $\frac{1}{2}MR^2$ (4) MR^2

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

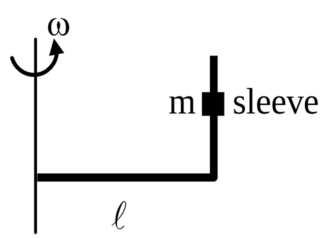
(1) 2m (2) 4m (3) 5m (4) 6m

25. One solid sphere *A* and another hollow sphere *B* are of same mass and same outer radii. Their moment of inertia about their diameters are respectively I_A and I_B such that

(1) $I_A = I_B$ (2) $I_A > I_B$ (3) $I_A < I_B$ (4) $I_A / I_B = d_A / d_B$

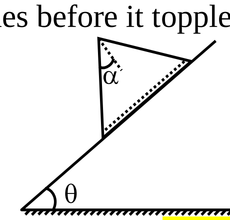
TORQUE

26. A L shaped rod whose one rod is horizontal and other is vertical is rotating about a vertical axis as shown with angular speed ω. The sleeve shown in figure has mass m and friction coefficient between rod and sleeve is μ. The minimum angular speed ω for which sleeve cannot sleep on rod is-



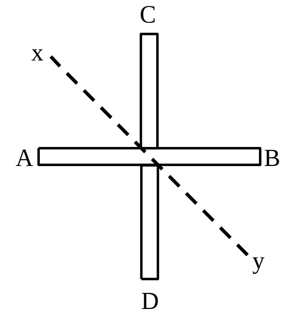
(1) $\omega = \sqrt{\frac{g}{\mu\ell}}$ (2) $\omega = \sqrt{\frac{\mu g}{\ell}}$ (3) $\omega = \sqrt{\frac{\ell}{\mu g}}$ (4) None of these

27. A right circular cone with semi vertical angle 'α' rest on a rough inclined plane. As angle of inclination θ increases, cone will slides before it topples over if coefficient of friction -



(1) $\mu < \tan\alpha$ (2) $\mu < \frac{3}{4}\tan\alpha$ (3) $\mu < 4\tan\alpha$ (4) $\mu < \frac{4}{3}\tan\alpha$

28. AB and CD are two identical rods each of length ℓ and masses m joined to form a cross. The moment of inertia of these two rods about a bisector of the angle between the rods (xy) is



(1) $\frac{m\ell^2}{6}$ (2) $\frac{m\ell^2}{3}$
(3) $\frac{m\ell^2}{12}$ (4) $\frac{2m\ell^2}{3}$

29. Let $\vec{F}$ be the force acting on a particle having position vector $\vec{r}$ and $\vec{T}$ be the torque of this force about the origin. Then
(1) $\vec{r}.\vec{T} = 0$ and $\vec{F}.\vec{T} = 0$ (2) $\vec{r}.\vec{T} = 0$ and $\vec{F}.\vec{T} \neq 0$
(3) $\vec{r}.\vec{T} \neq 0$ and $\vec{F}.\vec{T} = 0$ (4) $\vec{r}.\vec{T} \neq 0$ and $\vec{F}.\vec{T} \neq 0$

30. A couple produces
(1) Purely linear motion (2) Purely rotational motion
(3) Linear and rotational motion (4) No motion

31. When a torque acting upon a system is zero, then which of the following will be constant
(1) Force (2) linear momentum
(3) Angular momentum (4) linear impulse

32. A disc of moment of inertia $5\,kg-m^2$ is acted upon by a constant torque of 40 Nm. Starting from rest the time taken by it to acquire an angular velocity of 24 rad/sec is
(1) 3sec (2) 4 sec (3) 2.5 sec (4) 120 sec

33. One end of a uniform rod of mass m and length *l* is clamped. The rod lies on a smooth horizontal surface and rotates on it about the clamped end at a uniform angular velocity ω. The force exerted by the clamp on the rod has a horizontal component
(1) $m\omega^2 l$ (2) zero (3) mg (4) $\frac{1}{2}m\omega^2 l$ b

CONSERVATION OF ANGULAR MOMENTUM

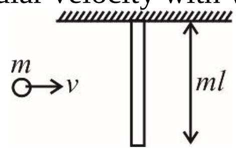
34. A man weighing 80 kg is standing at the centre of flat boat and he is 20 m from the shore. He walks 8m on the boat towards the shore and then halts. The boat weight 200 kg. How far is he from the shore at the end of this time?
(1) 11.2 m (2) 13.8 m (3) 14.3 m (4) 15.4 m

35. The angular momentum of a system of particles is conserved
(1) When no external force acts upon the system
(2) When no external torque acts on the system
(3) When no external impulse acts upon the system
(4) When axis of rotation remains same

36. If the radius of the earth suddenly contracts to half of its present value, then the duration of day will be of

(1) 6 hours (2) 12 hours (3) 18 hours (4) 24 hours

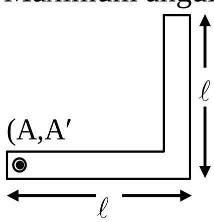
37. A bullet of mass m coming at a speed v hits at the center of a rod of mass m and length l and gets embedded in it. What will be the angular velocity with which it will start rotating?



(1) $\frac{6V}{7l}$ (2) $\frac{3V}{7l}$ (3) $\frac{3V}{2l}$ (4) $\frac{12V}{7l}$

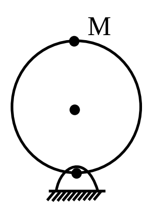
WORK ENERGY IN ROTATION

38. A L shaped rod of mass M is free to rotate in a vertical plane about axis AA′ as shown in figure. Maximum angular acceleration of rod is-



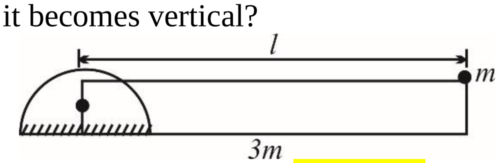
(1) $\frac{3g}{\sqrt{10}\ell}$ (2) $\frac{9g\ell}{10}$ (3) $\frac{9g\ell}{5}$ (4) $\frac{6g}{5\sqrt{2}\ell}$

39. A uniform disc of mass M and radius 'R' is supported vertically by a pivot at its periphery as shown. A particle of mass M is fixed to the rim and raised to highest point above the centre. The system is released from rest and it can rotate about pivot freely. The angular speed of system when it attached object is directly beneath the pivot, is -



(1) $\sqrt{\frac{24g}{11R}}$ (2) $\sqrt{\frac{8g}{11R}}$ (3) $\sqrt{\frac{8g}{3R}}$ (4) $\sqrt{\frac{3g}{8R}}$

40. A small mass m is stricken at the end of a rod of mass 3m and length l. This system is redeased to rotate about an axis coming out of page and passing through left end of rod. What will be 'ω' of the system at the instant when it becomes vertical?



(1) $\sqrt{\frac{3}{2}\frac{g}{l}}$ (2) $\sqrt{\frac{g}{2l}}$ (3) $\sqrt{\frac{5g}{2l}}$ (4) $\sqrt{\frac{5g}{4l}}$

ROLLING MOTION

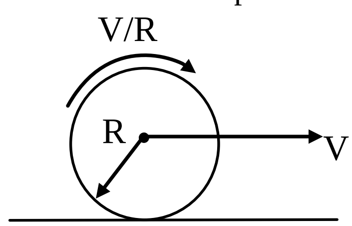
41. A spherical ball rolls on a table without slipping. Then the fraction of its total energy associated with rotation is -

(1) 2/5 (2) 2/7 (3) 3/5 (4) 3/7

42. A body of radius R and mass m is rolling horizontally without slipping with speed v. It then rolls up a hill to a maximum height $h = \frac{3v^2}{4g}$. The body might be a -

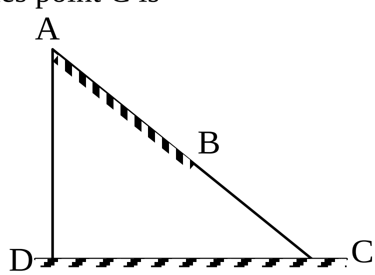
(1) solid sphere (2) hollow sphere (3) disc (4) ring

43. A disc is performing pure rolling on a smooth stationary surface with constant angular velocity as shown in figure. At any instant, for the lower most point of the disc.



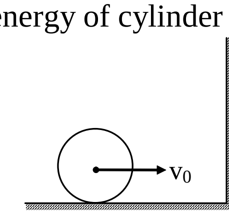
(1) Velocity is v, acceleration is zero
(2) Velocity is zero, acceleration is zero
(3) Velocity is v, acceleration is $\frac{v^2}{R}$
(4) Velocity is zero, acceleration is nonzero

44. Portion AB of the wedge shown in figure is rough and BC is smooth. A solid cylinder rolls without slipping from A to B. If AB = BC, then ratio of translational kinetic energy to rotational kinetic energy, when the cylinder reaches point C is –



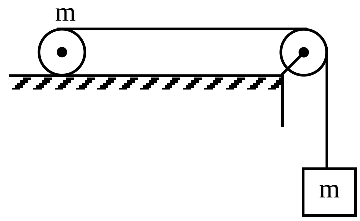
(1) 3/5 (2) 5 (3) 7/5 (4) 8/3

45. A cylinder is rolling over frictionless horizontal surface with velocity v_0 as shown in figure. Coefficient of friction between wall and cylinder is $\mu = \frac{1}{4}$. If the collision between cylinder and wall is completely inelastic, then kinetic energy of cylinder after collision -



(1) Zero (2) $\frac{mv_0^2}{32}$ (3) $\frac{mv_0^2}{4}$ (4) $\frac{3mv_0^2}{32}$

46. In the given figure a ring of mass m is kept on a horizontal surface while a body of equal mass 'm' attached through a string, which is wounded on the ring. When the system is released the ring rolls without slipping. Consider the following statements and choose the correct option-



(i) acceleration of the centre of mass of ring is $\frac{2g}{3}$

(ii) acceleration of the hanging particle is $\frac{4g}{3}$

(iii) frictional force (on the ring) acts along forward direction

(iv) frictional force (on the ring) acts along backward direction

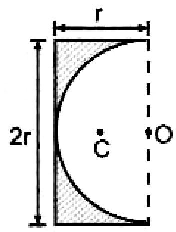
(1) statement (i) and (ii) only (2) statement (i) and (iii)only

(3) statement (ii) and (iv) only (4) none of these

QUESTIONS BASED ON AIIMS LEVEL

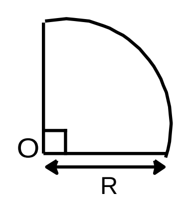
CENTER OF MASS

1. A semicircular portion of radius 'r' is cut from a uniform rectangular plate as shown in figure. The distance of centre of mass 'C' of remaining plate,



(1) $\frac{2r}{(3-\pi)}$ (2) $\frac{3r}{2(4-\pi)}$ (3) $\frac{2r}{(4+\pi)}$ (4) $\frac{2r}{3(4-\pi)}$

2. In the figure one fourth part of a uniform disc of radius R is shown. The distance of the centre of mass of this object from centre 'O' is



(1) $\frac{4R}{3\pi}$ (2) $\frac{2R}{3\pi}$

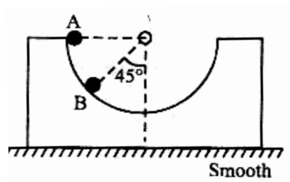
(3) $\sqrt{2}\frac{4R}{3\pi}$ (4) $\sqrt{2}\frac{2R}{3\pi}$

MOTION OF CENTER OF MASS

3. A shell is fired from a cannon with a velocity V at an angle θ with the direction. At the highest point in its path, it explodes into two pieces of equal masses. One of the pieces retraces its path to the cannon. The speed of the other piece immediately after the explosion is

(1) $3V\cos\theta$ (2) $2V\cos\theta$ (3) $\frac{3}{2}V\cos\theta$ (4) $V\cos\theta$

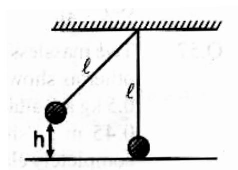
4. A ball of mass m is released from A inside a smooth wedge of mass m as shown in the figure. What is the speed of the wedge when the ball reaches point B?



(1) $\left(\frac{gR}{3\sqrt{2}}\right)^{1/2}$ (2) $\sqrt{2gR}$ (3) $\left(\frac{5gR}{2\sqrt{3}}\right)^{1/2}$ (4) $\sqrt{\frac{3}{2}gR}$

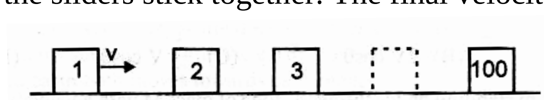
COLLISION

5. In the arrangement shown, the pendulum on the left is pulled aside. It is then released and allowed to collide with other pendulum which is at rest. A perfectly inelastic collision occurs and the system rises to a height $1/4$th. The ratio of the masses of the pendulum is



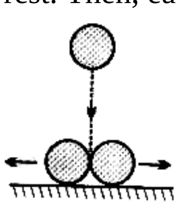
(1) 1 (2) 2 (3) 3 (4) 4

6. There are hundred identical sliders equally spaced on a frictionless track as shown in the figure. Initially all the sliders are at rest. Slider 1 is pushed with velocity v towards slider 2. In a collision the sliders stick together. The final velocity of the set of hundred stucked sliders will be



(1) $\frac{v}{99}$ (2) $\frac{v}{100}$ (3) zero (4) v

7. In the figure shown, the two identical balls of mass M and radius R each, are placed in contact with each other on the frictionless horizontal surface. The third ball of mass M and radius R/2, is coming down vertically and has a velocity $= v_0$ when it simultaneously hits the two balls and itself comes to rest. Then, each of the two bigger balls will move after collision with a speed equal to



(1) $4v_0/\sqrt{5}$ (2) $2v_0/\sqrt{5}$ (3) $v_0/\sqrt{5}$ (4) None

MOMENT OF INERTIA

8. Four small objects each of mass *m* are fixed at the corners of a rectangular wire-frame of negligible mass and of sides a and b (a>b). If the wire frame is now rotated about an axis passing along the side of length *b*, then the moment of inertia of the system for this axis of rotation is

(1) $2ma^2$ (2) $4ma^2$ (3) $2m\left(a^2+b^2\right)$ (4) $2m\left(a^2-b^2\right)$

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

(1) 2m (2) 4m (3) 5m (4) 6m

10. A solid sphere of mass M, radius R and having moment of inertia about an axis passing through the centre of mass as I, is recast into a disc of thickness t, whose moment of inertia about an axis passing through its edge and perpendicular to its plane remains I. Then, radius of the disc will be

(1) $\frac{2R}{\sqrt{5}}$ (2) $R\left(\sqrt{\frac{2}{5}}\right)$ (3) $\frac{4R}{\sqrt{5}}$ (4) $\frac{R}{4}$

11. From a solid sphere of mass *M* and radius *R* a cube of maximum possible volume is cut. Moment of inertia of cube about an axis passing through its centre and perpendicular to one of its faces is

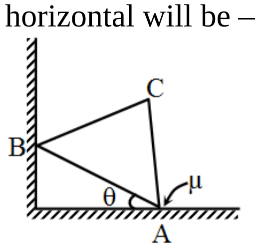
(1) $\frac{MR^2}{32\sqrt{2}\pi}$ (2) $\frac{MR^2}{16\sqrt{2}\pi}$ (3) $\frac{4MR^2}{9\sqrt{3}\pi}$ (4) $\frac{4MR^2}{3\sqrt{3}\pi}$

12. A uniform cylinder has a radius R and length *L*. If the moment of inertia of this cylinder about an axis passing through its centre and normal to its circular face is equal to the moment of inertia of the same cylinder about an axis passing through its centre and perpendicular to its length, then

(1) $L = R$ (2) $L = \sqrt{3}R$ (3) $L = \frac{R}{\sqrt{3}}$ (4) $L = \sqrt{\frac{3}{2}}R$

TORQUE

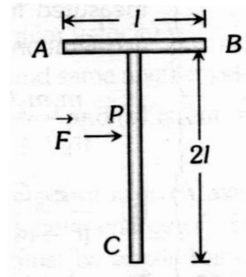
13. A thin uniform equilateral plate rests in vertical plane with one of its ends 'A' on a rough horizontal floor, and other end 'C' on smooth vertical wall. The least angle (θ) its base AC can make with horizontal will be –



(1) $\theta = \cot^{-1}\left(2\mu + \frac{1}{\sqrt{3}}\right)$ (2) $\theta = \tan^{-1}\left(2\mu + \frac{1}{\sqrt{3}}\right)$

(3) $\theta = \tan^{-1}\left(2\mu + \frac{1}{2\sqrt{3}}\right)$ (4) $\theta = \cot^{-1}\left(2\mu + \frac{1}{2\sqrt{3}}\right)$

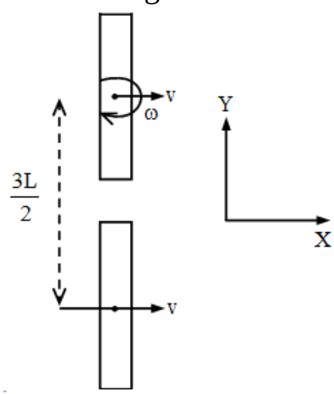
14. A uniform ‘T’ shaped object with dimensions shown in the figure, is lying on a smooth floor. A force '$\vec{F}$' is applied at the point P parallel to AB, such that the object has only the translational motion without rotation. Find the location of P with respect to C



(1) $\frac{4}{3}l$ (2) l (3) $\frac{2}{3}l$ (4) $\frac{3}{2}l$

CONSERVATION OF ANGULAR MOMENTUM

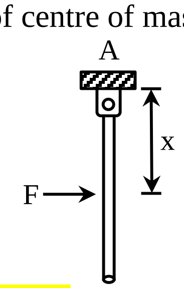
15. Two identical rods each of mass M and length 'L' are performing general plane motion in horizontal plane as shown in figure. If v is the velocity of circular motion of both rods and 'ω' is the angular speed about vertical axis, then angular momentum of rod 1 in the reference frame of centre of mass of rod 2 at given instant will be

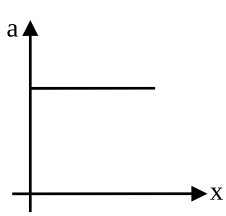
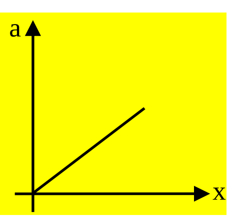
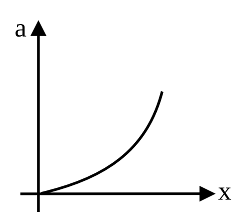
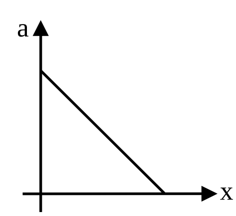


(1) $\left(Mv\frac{3L}{2}+\frac{ML^2}{12}\omega\right)(-\hat{k})$ (2) $Mv.\frac{3L}{2}(-\hat{k})$

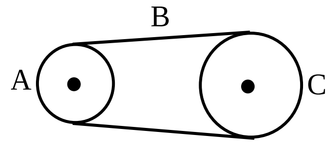
(3) $\left(\frac{ML^2}{12}\omega\right)(-\hat{k})$ (4) None

16. A rod of mass **m** and length ***l*** is hinged at one of its end A as shown in figure. A force F is applied at a distance x from A. The acceleration of centre of mass (1) varies with x as –



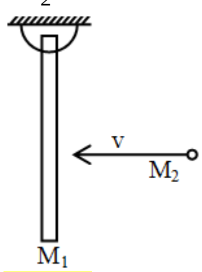
(1)  (2)  (3)  (4) 

17. As shown in figure, wheel A of radius r_A = 10 cm is coupled by belt B to wheel C of radius r_C = 25 cm. The angular speed of wheel A is increased from rest at a constant rate of 1.6 rad/s^2. Time after which wheel C reaches a rotational speed of 100 rpm, assuming the belt does not slip, is nearly



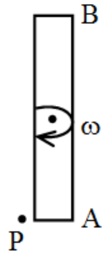
(1) 4 sec (2) 8 sec (3) 12 sec (4) 16 sec

18. A uniform rod of mass M_1 is hinged at its upper end. A particle of mass M_2 moving horizontally strikes the rod at its mid point elastically. If the particle comes to rest after collision, the value of $\frac{M_1}{M_2}$ is –



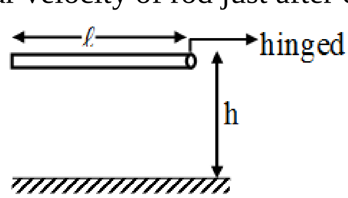
(1) $\frac{3}{4}$ (2) $\frac{4}{3}$ (3) $\frac{2}{3}$ (4) $\frac{3}{2}$

19. A rod of mass 'M' & length 'L' lying on a frictionless horizontal surface is initially given an angular velocity 'ω' about vertical axis with centre of mass at rest but circular motion is not fixed. Subsequently end A of rod collides with nail P, which is near to A such that end A becomes stationary immediately after impact. Velocity of end 'B' just after collision will be –



(1) ωL (2) $\frac{\omega L}{2}$ (3) $\frac{\omega L}{4}$ (4) $\frac{7\omega L}{3}$

20. A thin rod of mass m and length ℓ is hinged at one end point which is at a distance h (h < ℓ) above the horizontal surface. The rod is released from rest from the horizontal position. If e is the co-efficient of restitution, the angular velocity of rod just after collision will be (h = 1m, ℓ = 2m, e = 1) -

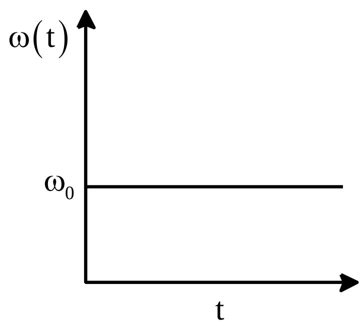


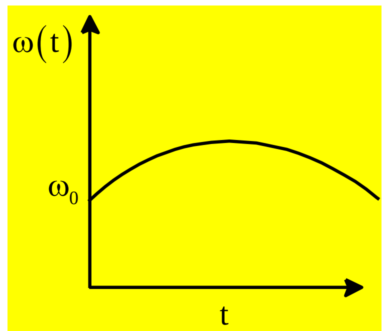
(1) $\frac{3\sqrt{3g}}{8}$ (2) $\frac{6\sqrt{3g}}{8}$ (3) $\frac{5\sqrt{3g}}{8}$ (4) none of these

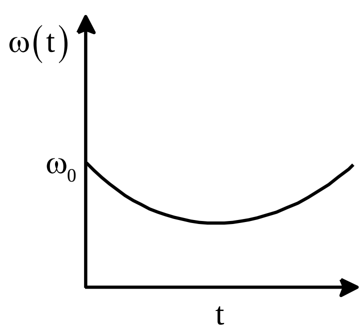
21. A thin circular ring of mass M and radius r is rotating about its axis with a constant angular velocity ω, Two objects, each of mass m, are attached gently to the opposite ends of a diameter of the ring. The wheel now rotates with an angular velocity

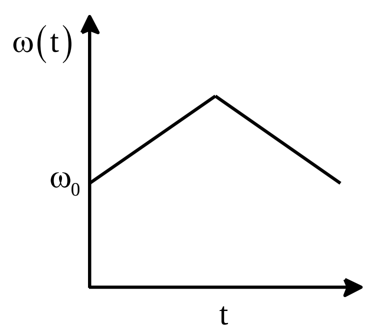
(1) $\frac{\omega M}{(M+m)}$ (2) $\frac{\omega(M-2m)}{(M+2m)}$ (3) $\frac{\omega M}{(M+2m)}$ (4) $\frac{\omega(M+2m)}{M}$

22. A circular platform is free to rotate in a horizontal plane about a vertical axis passing through its centre. A tortoise is sitting at the edge of the platform. Now the platform is given an angular velocity ω_0. When the tortoises move along a chord of the platform with a constant velocity (with respect to the platform), the angular velocity of the platform $\omega(t)$ will very with time t as

(1)


(2)


(3)


(4)


23. A particle is confined to rotate in a circular path decreasing linear speed, then which of the following is correct?
(1) $\vec{L}$ (angular momentum) is conserved about the centre
(2) only direction of angular momentum $\vec{L}$ is conserved about the center
(3) it spiral towards the centre
(4) its acceleration is towards the centre

24. A uniform sticks of mass m and length ℓ spins around on a frictionless horizontal plane, with its Centre of Mass stationary. A mass M is placed on the plane, and the sticks collide elastically with it, as shown (with the contact point being the end of the stick). If M the mass (in kg) so that after the collision the stick has translational moxion, but no rotational motion, then find the value of $\frac{M}{4}$.
(Take m = 24 kg)

(1) 3 (2) 5 (3) 9 (4) None of these

25. A thin and 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. If another disc of same dimensions but of mass M/4 is placed gently on the first disc co-axially, then the new angular velocity of the system is

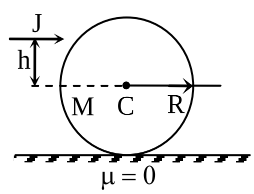
(1) $\frac{5}{4}\omega$ (2) $\frac{2}{3}\omega$ (3) $\frac{4}{5}\omega$ (4) $\frac{3}{2}\omega$

26. A gymnast spins on a smooth floor with angular speed ω and kinetic energy k about his vertical symmetric axis. He reduces his moment of inertia by half on pulling his hands closer. The kinetic energy of rotation finally is

(1) k (2) 2k (3) k/2 (4) k/4

ROLLING MOTION

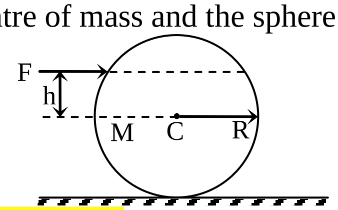
27. A solid sphere of mass M and radius R is placed on a smooth horizontal surface. It is given a horizontal impulse J at a height h above the centre of mass and sphere starts rolling then, the value of h and speed of centre of mass are –



(1) $h = \frac{2}{5}R$ and $v = \frac{J}{M}$ (2) $h = \frac{2}{5}R$ and $v = \frac{2}{5}\frac{J}{M}$

(3) $h = \frac{7}{5}R$ and $v = \frac{7}{5}\frac{J}{M}$ (4) $h = \frac{7}{5}R$ and $v = \frac{J}{M}$

28. A solid sphere of radius R and M is placed on a smooth horizontal floor. If it given a horizontal impulse F at a height h above centre of mass and the sphere starts rolling, then its angular speed ω is

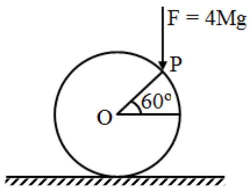


(1) $\omega = \frac{2F.h}{5R^2M}$ (2) $\omega = \frac{5}{2} \times \frac{Fh}{MR^2}$ (3) $\omega = \frac{F}{hM}$ (4) $\omega = \frac{7Fh}{5MR^2}$

29. In the figure shown two identical disc of radius R, each are placed on a smooth horizontal plane. Thread unwraps without slack from discs when they move away from each other. At any instant acceleration of centre of disc A & B are a_2 & a_1 respectively in opposite direction while their angular acceleration are α_2 & α_1 respectively. If string unwraps from discs without slipping then –

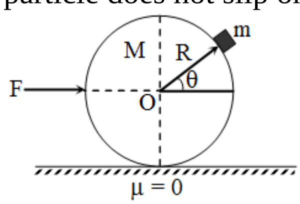
(1) $a_1 - R\alpha_1 = R\alpha_2 - a_2$
(2) $a_1 - a_2 = R\alpha_1 - R\alpha_2$
(3) $\frac{d^2\ell}{dt^2} = a_1 - a_2$
(4) $\frac{d^2\ell}{dt^2} = a_1 + a_2 - (R\alpha_1 + R\alpha_2)$

30. A solid sphere of mass M and radius R is lying on a rough horizontal plane. A constant force F = 4 Mg acts vertically at point P such that OP makes 600 with horizontal. Find the minimum value of coefficient of friction μ so that sphere starts pure rolling –



(1) $\frac{3}{7}$
(2) $\frac{4}{7}$
(3) $\frac{2}{7}$
(4) $\frac{2}{5}$

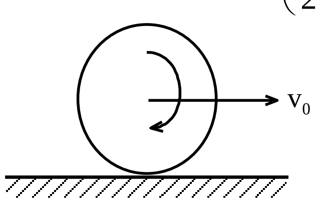
31. A smooth sphere of radius R and M is placed on the smooth horizontal floor. Another particle of mass m is placed on the sphere and a horizontal force F is applied on the sphere as shown. If the particle does not slip on the sphere, then the value of force F is –



(1) F = (m + M)g cot θ
(2) F = Mg cot θ
(3) F = (m + M) g tan θ
(4) None of these

32. A uniform disc of mass m and radius R is rolling down a rough inclined plane which makes an angle 30° with the horizontal. If the coefficients of static and kinetic friction are each equal to μ and the only force acting are gravitational and frictional, then the magnitude of the frictional force acting on the disc is -
(1) (mg/3) upwards
(2) (mg/3) downwards
(3) (mg/6) upwards
(4) (mg/6) downwards

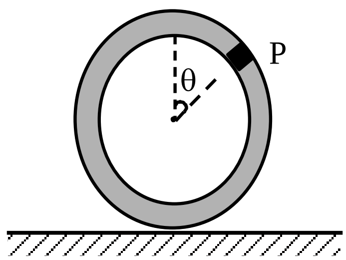
33. A solid cylinder is projected on a rough surface having coefficient of friction μ, with velocity v_0 and angular velocity $\omega_0 = \left(\frac{v_0}{2R}, \text{R is radius}\right)$, the time t at which rolling without slipping occurs is-



(1) $\frac{v_0}{3\mu g}$
(2) $\frac{v_0}{6\mu g}$
(3) $\frac{v_0}{2\mu g}$
(4) $\frac{v_0}{\mu g}$

34. A cylinder rolls up an inclined plane, reaches some height, and then rolls down (without slipping throughout these motions). The directions of the frictional force acting on the cylinder are
(1) up the incline while ascending and down the incline descending
(2) up the incline while ascending as well as descending
(3) down the incline while ascending and up the incline while descending
(4) down the incline while ascending as well as descending

35. A small block of mass m is rigidly attached at P to a ring of mass 3m and radius r. The system is released from the rest at $\theta = 90^0$ and rolls without sliding. The angular acceleration of loop just after release is



(1) g/4R (2) g/8R (3) g/3R (4) g/2R

36. An annular ring with inner and outer radii R_1 and R_2 is rolling without slipping with a uniform angular speed. The ratio of the forces experienced by the two particles situated on the inner and outer parts of the ring, $\frac{F_1}{F_2}$ is

(1) 1 (2) R_1/R_2 (3) R_2/R_1 (4) $(R_1/R_2)^2$

Assertion & Reason Questions

Read the assertion and reason carefully to mark the correct option out of the options given below:

(1) ***Assertion is True, Reason is True; Reason is a correct explanation for Assertion.***

(2) ***Assertion is True, Reason is True; Reason is NOT a correct explanation for Assertion.***

(3) ***Assertion is True, Reason is False.***

(4) ***Assertion is False, Reason is True.***

1. **Assertion :** In a two body collision, the momenta of the particle are equal and opposite to one another, before as well as after the collision when measured in the center of mass frame.

Reason : The momentum of the system is zero from the centre of mass frame.

2. **Assertion :** If no external force acts on a system of particles, then the centre of mass will not move in any direction.

Reason : If net external force is zero, then the linear momentum of the system remains constant.

3. **Assertion :** The centre of mass and centre of gravity of a body are two different positions in general.

Reason : The centre of mass and centre of gravity of a body coincide only if gravitational field is uniform.

4. **Assertion :** If linear momentum of a system of discrete particles is zero. The kinetic energy of the system of discrete particles will be zero.

Reason : If kinetic energy of a system of discrete particle is zero, the linear momentum of the system of discrete particles will be zero.

5. **Assertion :** The internal forces acting within the system can change the linear momentum of individual particles of the system.

Reason : The internal forces cannot change the linear momentum of the system.

6. **Assertion :** If there is no external torque on a body about its centre of mass, then the velocity of the centre of the mass remains constant.

Reason : The linear momentum of isolated system remains constant.

7. **Assertion :** A block is kept at the top of a smooth wedge which is kept on a smooth horizontal surface. As the block slides down the wedge, centre of the mass of system will be accelerated.

Reason : When external force acting on the system is zero, centre of mass is in rest.

8. **Assertion :** We apply the principle of conservation of linear momentum in collision and explosion phenomena even in the presence of external forces.

Reason : During collision and explosion net impulse on the system should be zero to apply the principle of conservation of linear momentum.

9. **Assertion :** If net force acting on a system is zero then centre of mass of system always remains at rest.

Reason : If net force acting on a system is zero then acceleration of centre of mass is zero.

10. **Assertion :** The position of centre of mass of a body does not depend upon shape and size of the body.

Reason : The centre of mass of a body may lie where there is no mass.

11. **Assertion :** The equation $\tau = I\alpha$ can be applied only about two points

(i) centre of mass and

(ii) point about which the body is rotating.

Reason : The equation $a = r\alpha$ can always be applied in case of rolling.

12. **Assertion :** In case of rolling friction force can act in forward and backward direction both.

Reason : The angular momentum of a system will be conserved only about that point about which external angular impulse is zero.

13. **Assertion :** For the purpose of calculation of moment of inertia, a body's mass can be thought to be concentrated at its centre of mass.

Reason : Moment of inertia is a measure of how the mass is distributed about a certain axis.

14. Assertion : Many great rivers flow toward the equator. The sediments that they carry, increases the time of rotation of the earth about its own axis.

Reason : The angular momentum of the earth about its rotation axis is conserved.

15. Assertion : The mass of a body cannot be considered to be concentrated at the centre of mass of the body for the purpose of computing its moment of inertia.

Reason : For then the moment of inertia of every body about an axis passing through its centre of mass would be zero.

16. Assertion : A ladder is more likely to slip when a person is near the top than when he is near the bottom.

Reason : The friction between the ladder and floor decreases as he climbs up.

17. Assertion : If a body (ball) is rolling on a surface without slipping, no frictional force acts on it.

Reason : In the case of rolling without slipping points of contact are relatively at rest.

18. Assertion : If Torque $(\vec{\tau})$ acting on a rigid body is defined as $\vec{\tau} = \vec{A} \times \vec{L}$, where $\vec{A}$ is a constant vector and $\vec{L}$ is the angular momentum of the body, the magnitude of the angular momentum of the body remains same.

Reason : $\vec{\tau}$ is perpendicular to $\vec{L}$ and hence torque does not deliver any power to the body.

19. Assertion : For a rigid body angular momentum $\vec{L}$ and $\vec{\omega}$ have same direction.

Reason : For rigid body about a symmetrical axis $\vec{L}$ and $\vec{\omega}$ have same direction.

20. Assertion : The moment of inertia of a rigid body is not unique; about a given axis.

Reason : The moment of inertia of a rigid body depends on axis about which it has to be calculated.

21. Assertion : A sphere rolling on a rough horizontal surface with constant velocity then it start going up on a smooth inclined plane. Rotational KE of sphere decreases continuously on horizontal and inclined surface.

Reason : Rotational KE decreases if torque due to friction opposes angular velocity of sphere.

22. Assertion : Minimum moment of inertia of a uniform body is I about an axis. The axis must be passing through COM of body.

Reason : Moment of inertia depends on distribution of mass about axis of rotation.

23. Assertion : A solid sphere rolling on a rough horizontal surface. Acceleration of contact point is zero.

Reason : A solid sphere can roll on the smooth surface.

24. Assertion : A disc is rolling on an inclined plane without slipping. The velocity of centre of mass is V. These other points on the disc having same speed as centre of mass lie on a circular arc.

Reason : When a disc is rolling on an inclined plane. The magnitude of velocities of all the point from the contact point is same, having distance equal to radius r.

25. **Assertion :** A sphere is performing pure rolling on a rough horizontal surface with constant angular velocity. Frictional force acting on the sphere is zero.

Reason : Velocity of contact point is zero.

26. **Assertion :** A non–uniform sphere is placed such that its centre is at the origin of co–ordinate system. If I_x and I_y be moment of inertia about x axis and y axis respectively then moment of inertia about z axis is $I_x + I_y$.

Reason : According to perpendicular axis theory $I_z = I_x + I_y$ when object is lying in x–y plane.

27. **Assertion :** Torque is equal to rate of change of angular momentum.

Reason : Angular momentum depends on moment of inertia and angular velocity.

28. **Assertion :** If earth shrink (without change in mass) to half it's present size. Length of the day would become 6 hours.

Reason : As size of earth changes its moment of inertia changes.

29. **Assertion :** A disc is rolling on a rough horizontal surface. The instantaneous speed of the point of contact during pure rolling is zero with respect to ground.

Reason : The force of friction can help in achieving pure rolling condition.

30. **Assertion :** When a diver dives, the rotational kinetic energy of diver increases, during several somersaults.

Reason : When diver pulls his limbs, the moment of inertia decreases and on account of conservation of angular momentum his angular speed increases.

31. **Assertion :** A ring moving down on a smooth inclined plane will be in slipping motion.

Reason : Work done by friction in pure rolling motion is zero.

32. **Assertion :** The velocity of a body at the bottom of an inclined place of given height, is more when it slides down the plane, compared to, when it rolling down the same plane.

Reason : In rolling down, a body acquires both, kinetic energy of translation and rotation.

33. **Assertion :** If rod is thrown upward with initial angular velocity and velocity of centre of mass then its momentum changes but angular velocity remains same.

Reason : Torque on rod about centre of mass due to gravitational force is zero.

34. **Assertion :** Moment of inertial of uniform disc and solid cylinder of equal mass and equal radius about an axis passing through centre and perpendicular to plane will be same.

Reason : Moment of inertia depends upon distribution of mass from the axis of rotation i.e., perpendicular distance from the axis.

35. **Assertion :** For a particle moving along circular path, centripetal force cancel centrifugal force.

Reason : They are equal in magnitude and opposite in direction.

36. **Assertion :** The force of friction in the case of a disc rolling without slipping down on inclined plane is $\frac{M}{3} g \sin\alpha$.

Reason : When the disc rolls without slipping, friction is required because for rolling condition velocity of point of contact is zero.

Previous Year's Questions

Centre of Mass

1. In the diagram shown below, m_1 and m_2 are the masses of two particles and x_1 and x_2 are the respectively distances from the origin O. The centre of mass of the system is **[J&K CET 2011]**

(1) $\frac{m_1x_2+m_2x_2}{m_1+m_2}$ (2) $\frac{m_1+x_2}{2}$ (3) $\frac{m_1x_1+m_2x_2}{m_1+m_2}$ (4) $\frac{m_1m_2+x_1x_2}{m_1+m_2}$

2. The centre of mass of a solid cone along the line form the centre of the base to the vertex is at **[DUMET 2011]**

(1) One-fourth of the height (2) One-third of the height
(3) One-third of the height (4) None of these

3. The centre of mass of a system of three particles of masses 1g, 2g, and 3g is taken as the origin of a coordinate system. The position vector of a fourth particle of mass 4g such that the centre of mass of the four particle system lies at the point (1, 2, 3) is $\alpha\left(\hat{i}+2\hat{j}+3\hat{k}\right)$, where α is a constant. The value of α is **[AMU 2010]**

(1) $\frac{10}{3}$ (2) $\frac{5}{2}$ (3) $\frac{1}{2}$ (4) $\frac{2}{5}$

4. A pulley fixed to the ceiling carries a string with blocks of masses m and 3m attached to its ends. The masses of string and pulley are negligible. When the system is released, the acceleration of centre of mass will be **[JCECE 2010]**

(1) zero (2) $-\frac{g}{4}$ (3) $\frac{g}{2}$ (4) $-\frac{g}{2}$

5. The centre of mass of three particle of masses 1 kg, 2 kg and 3 kg is at (3, 3, 3) with reference to a fixed coordinate system. Where should a fourth particle of mass 4 kg be placed, so that the centre of mass of the system of all particles shifts to a point (1, 1, 1)? **[JCECE 2010]**

(1) (–1, –1, –1) (2) (–2, –2, –2) (3) (2, 2, 2) (4) (1, 1, 1)

6. An object placed in stable equilibrium. If the object is given a slight push then initially the position of centre of gravity **[AMU 2008]**

(1) moves nearer to ground (2) rises higher above the ground
(3) remains as such (4) may remain at same level

7. Two bodies of different masses of 2 kg and 4 kg moving with velocities 2 ms^{-1} and 10 ms^{-1} towards each other due to mutual gravitational attraction. What is the velocity of their centre of mass? **[BHU 2008]**

(1) zero (2) 5 ms^{-1} (3) 8 ms^{-1} (4) 6 ms^{-1}

8. A system consisting of two masses connected by a massless rod lies along the x-axis. A 0.4 kg mass is at a distance x =2 m while a 0.6 kg mass is at a distance x = 7 m. The x-coordinate of the centre of mass is **[Kerala CEE 2008]**
(1) 5 m (2) 3.5 m (3) 4.5 m (4) 4 m
(5) 3 m

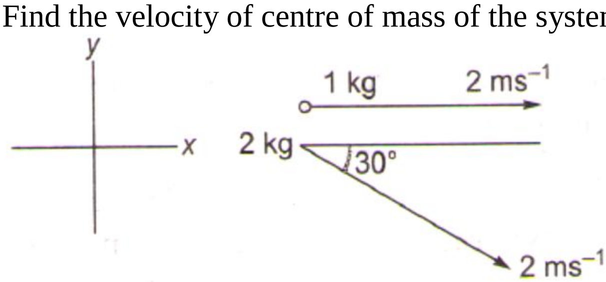
9. Identify the correct statement for the rotational motion of a rigid body. **[J&K GET 2008]**
(1) Individual particles of the body do not undergo accelerated motion
(2) The centre of mass of the body remains unchanged
(3) The centre of mass of the body moves uniformly in a circular path
(4) Individual particles and centre of mass the body undergo an accelerated motion

10. Four point masses P, Q, R and S with respective masses 1 kg, 1 kg, 2 kg and 2 kg form the corners of a square of side a. The centre of mass of the system will be farthest from **[Kerala CEE 2007]**
(1) P only (2) R and S (3) R only (4) P and Q

11. The motion of the centre of mass is the result of **[J&K GET 2007]**
(1) internal forces (2) external forces (3) attractive forces (4) repulsive forces

12. A small disc of radius 2 cm is cut from a disc of radius 6 cm. If the distance between their centres is 3.2 cm, what is the shift in the centre of mass of the disc? **[AFMC 2006]**
(1) 0.4 cm (2) 2.4 cm (3) 1.8 cm (4) 1.2 cm

13. Find the velocity of centre of mass of the system shown in the figure? **[AMU 2006]**



(1) $\left(\frac{2+2\sqrt{3}}{3}\right)\hat{i}-\frac{2}{3}\hat{j}$ (2) $4\hat{i}$ (3) $\left(\frac{2-2\sqrt{3}}{3}\right)\hat{i}-\frac{1}{3}\hat{j}$ (4) None of these

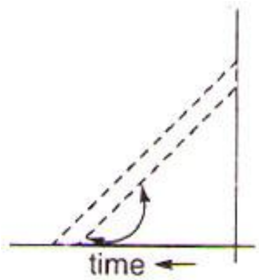
14. A straight rod of length L has one of its ends at the origin and the other at $x = L$. If the mass per unit length of the rod is given by Ax here A is constant, where is its mass centre? **[BHU 2006]**
(1) L/3 (2) L/2 (3) 2L/3 (4) L/4

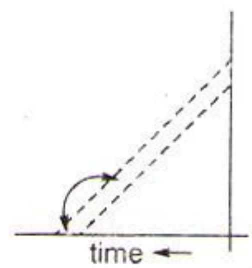
15. Four particles, each of mass 1 kg are placed at the corners of a square $OABC$ of side 1 m. O is at the origin of the coordinate system. OA and OC are aligned along positive X-axis and positive y-axis respectively. The position vector of the centre of mass is (in metre) **[EAMCET 2006]**
(1) $\hat{i}+\hat{j}$ (2) $\frac{1}{2}(\hat{i}+\hat{j})$ (3) $(\hat{i}-\hat{j})$ (4) $\frac{1}{2}(\hat{i}-\hat{j})$

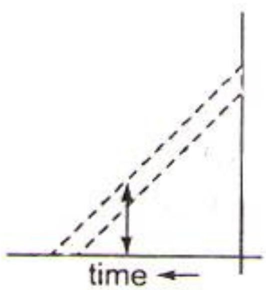
16. Three identical spheres of mass M each are placed at the cornels of an equilateral triangle of side $2m$. Taking one of the corner as the origin, the position vector of the centre of mass is **[J&K GET 2006]**

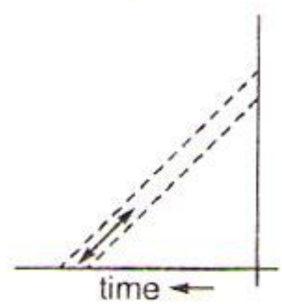
(1) $\sqrt{3}\left(\hat{i}-\hat{j}\right)$ (2) $\frac{\hat{i}}{\sqrt{3}}+\hat{j}$ (3) $\frac{\hat{i}+\hat{j}}{3}$ (4) $\hat{i}+\frac{\hat{j}}{\sqrt{3}}$

17. A ladder is leaned against a smooth wall and it is allowed to slip on a frictionless floor. Which figure represents the track of its centre of mass? **[AIIMS 2005]**

(1) 

(2) 

(3) 

(4) 

18. A cricket bat is cut at the location of its centre of mass as shown. Assuming the handle to be light, which of the following is correct? **[Kerala JEE 2005]**

(1) the two pieces will have the same mass
(2) the bottom piece will have larger mass
(3) the handle piece will have larger mass
(4) mass of handle piece is double the mass of bottom piece

19. Three particles each of mass 1 kg are placed at the corners of a right angled triangle AOB, O being the origin of the coordinate system $(OA$ and OB along positive X-direction and positive Y-direction). If $OA = OB = 1$ m, the positive vector of the centre of mass (in metre) is **[EAMCET 2005]**

(1) $\frac{\hat{i}+\hat{j}}{3}$ (2) $\frac{\hat{i}-\hat{j}}{3}$ (3) $\frac{2\left(\hat{i}+\hat{j}\right)}{3}$ (4) $\left(\hat{i}+\hat{j}\right)$

20. If linear density of a rod of length 3 m varies as $\lambda=2+x$, then the position of the centre of gravity of the rod is **[BCECE 2005]**

(1) $\frac{7}{3}m$ (2) $\frac{12}{7}m$ (3) $\frac{10}{7}m$ (4) $\frac{9}{7}m$

21. Consider a system of two particles having masses m_1 and m_2. If the particle of mass m_1 is pushed towards the mass centre of particles through a distance d, by what distance would the particle of mass m_2 move so as to keep the mass centre of particles at the original position?
[CBSE AIPMT 2004]
(1) $\frac{m_1}{m_1+m_2}d$ (2) $\frac{m_1}{m_2}d$ (3) d (4) $\frac{m_2}{m_1}d$

22. Four particles, each of mass 1 kg, are placed at the corners of a square of side 1 m in the X-Y plane. If the point of intersection of the diagonals of the square is taken as the origin, the coordinates of the centre of mass are **[EAMCE 2004]**
(1) (1, 1) (2) (–1, 1) (3) (1, –1) (4) (0, 0)

23. The centre of mass of a system of two particles divides the distance between them
[MHT CET 2004]
(1) in inverse ratio of square of masses of particles
(2) in direct ratio of square of masses of particles
(3) in inverse ratio of masses of particles
(4) in direct ratio of masses of particles

Rotational Variables

24. A car moves on a circular road. It describes equal angles about the centre in equal intervals of time. Which of the following statements about the velocity of the car is true? **[Punjab PMET 2009]**
(1) Magnitude of velocity is not constant
(2) Both magnitude and direction of velocity change
(3) Velocity is directed towards the centre of the circle
(4) Magnitude of velocity is constant but direction changes

25. A wheel has angular acceleration of 3.0 rad s^{-2} and initial angular speed of 2.00 rad s^{-1}. In a time of 2 s it has rotated through an angle (in radian) of **[AIIMS 2008]**
(1) 6 (2) 10 (3) 12 (4) 4

26. When a ceiling fan is switched off, its angular velocity reduces to half its initial value after it completing 36 rotations. The number of rotations it will further rotate before coming to rest is (Assuming the retardation to be uniform) **[Kerala CEE 2008]**
(1) 10 (2) 20 (3) 18 (4) 12

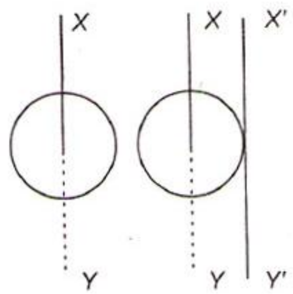
Moment of Inertia

27. The moment of inertia of a thin uniform rod of mass M and length L about an axis passing through its mid-point and perpendicular to its length is I_0. Its moment of inertia about an axis passing through one of its ends and perpendicular to its length is **[CBSE AIPMT 2011]**
(1) $I_0 + ML^2/4$ (2) $I_0 + 2ML^2$ (3) $I_0 + ML^2$ (4) $I_0 + ML^2/2$

28. Moment of inertia of a hollow cylinder of mass M and radius r about its own axis is
[Kerala CEE 2011]
(1) $\frac{2}{3}Mr^2$ (2) $\frac{2}{5}Mr^2$ (3) Mr^2 (4) $\frac{1}{2}Mr^2$

29. A constant torque of 3.14 Nm is exerted on a pivoted wheel. If the angular acceleration of the wheel is 4π rad s^{-2}, then the moment of inertia of the wheel is **[J&K CET 2011]**
(1) 0.25 kg-m^2 (2) 2.5 kg-m^2 (3) 4.5 kg-m^2 (4) 25 kg-m^2

30. The moment of inertia of a circular disc of radius 2 m and mass 1 kg about an axis passing through the centre of mass but perpendicular to the plane of the disc is 2 kg-m^2. Its moment of inertia about an axis parallel to this axis but passing through the edge of the disc is (see the given figure). **[KCET 2010]**



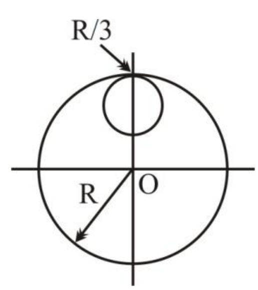
(1) 8 kg-m^2 (2) 4 kg-m^2 (3) 10 kg-m^2 (4) 6 kg-m^2

31. If the moment of inertia of a disc about an axis tangential and parallel to its surface be I, then what will be the moment of inertia about the axis tangential but perpendicular to the surface? **[VMMC 2010]**
(1) $\frac{6}{5}I$ (2) $\frac{3}{4}I$ (3) $\frac{3}{2}I$ (4) $\frac{5}{4}I$

32. A sphere of mass 10 kg and radius 0.5 m rotates about a tangent. The moment of inertia of the sphere is **[VMMC 2010]**
(1) 5 kg-m^2 (2) 2.7 kg-m^2 (3) 3.5 kg-m^2 (4) 4.5 kg-m^2

33. The moment of inertia of two equal masses each of mass m at separation L connected by a rod of mass M, about an axis passing through centre and perpendicular to length of rod is **[CMC 2010]**
(1) $\frac{(M+3m)L^2}{12}$ (2) $\frac{(M+6m)L^2}{12}$ (3) $\frac{ML^2}{4}$ (4) $\frac{ML^2}{12}$

34. From a circular disc of radius R and mass 9m, a small disc of radius $\frac{R}{3}$ is removed from the disc, the moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through O is **[AFMC 2010]**



(1) 4MR^2 (2) $\frac{40}{9}MR^2$ (3) 10 MR^2 (4) $\frac{37}{9}MR^2$

35. The ratio of the radii of gyration of a circular disc and a circular ring of the same radii about a tangential axis perpendicular to plane of disc or ring is **[AFMC 2010]**

(1) 1 : 2 (2) $\sqrt{5}:\sqrt{6}$ (3) 2 : 3 (4) $\frac{\sqrt{3}}{2}$

36. Radius of gyration of disc of mass 50 g and radius 5 cm about an axis passing through its centre of gravity and perpendicular to the plane is **[Punjab PMET 2010]**

(1) 6. 54 cm (2) 3.64 cm (3) 1.77 cm (4) 3.53 cm

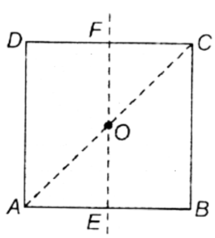
37. The ratio of the radii of gyration of a circular disc to that of a circular ring, each of same mass and radius, around their respective axes is **[CBSE AIPMT 2008]**

(1) $\sqrt{3}:\sqrt{2}$ (2) $1:\sqrt{2}$ (3) $\sqrt{2}:1$ (4) $\sqrt{2}:\sqrt{3}$

38. A thin rod of length L and mass M is bent at its mid-point into two halves so that the angle between them is 90°. The moment of inertia of the bent rod about an axis passing through the bending point and perpendicular to the plane defined by the two halves of the rod is **[CBSE AIPMT 2008]**

(1) $\frac{ML^2}{24}$ (2) $\frac{ML^2}{12}$ (3) $\frac{ML^2}{6}$ (4) $\frac{\sqrt{2}ML^2}{24}$

39. For the given uniform square lamina $ABCD$, whose centre is O **[AIIMS 2008]**



(1) $\sqrt{2}I_{AC}=I_{EF}$ (2) $I_{AD}=3I_{EF}$ (3) $I_{AD}=4I_{EF}$ (4) $I_{AD}=\sqrt{2}I_{EF}$

40. Moment of inertia of circular loop of radius R about the axis of rotation parallel to horizontal diameter at a distance $R/2$ from it is **[AMU 2008]**

(1) MR^2 (2) $\frac{1}{2}MR^2$ (3) $2MR^2$ (4) $\frac{3}{4}MR^2$

41. The radius of gyration of a rod of length L and mass M about an axis perpendicular to its length and passing through a point at a distance $L/3$ from one of its ends is **[Punjab PMET 2008]**

(1) $\frac{\sqrt{7}}{6}L$ (2) $\frac{L}{9}$ (3) $\frac{L}{3}$ (4) $\frac{\sqrt{5}}{3}L$

42. Two identical concentric rings each of mass m and radius R are placed perpendicularly. What is the moment of inertia about axis of one of the rings? **[DUMET 2008]**

(1) $\frac{3}{2}MR^2$ (2) $2MR^2$ (3) $3MR^2$ (4) $\frac{1}{4}MR^2$

43. Two spheres of equal masses, one of which is a thin spherical shell and the other a solid, have the same moment of inertia about their respective diameters. The ratio of their radii will be

[MHT CET 2008]

(1) 5 : 7 (2) 3 : 5 (3) $\sqrt{3}:\sqrt{5}$ (4) None

44. Moment of inertia of ring about its diameter is I. The: moment of inertia about an axis passing through centre perpendicular to its plane is **[BCECE 2008]**

(1) 2I (2) $\frac{I}{2}$ (3) $\frac{3}{2}I$ (4) I

45. The moment of inertia of a circular ring of mass 1kg about an axis passing through its centre an; perpendicular to its plane is 4 kg-m^2. The diameter of the ring is **[J&K CET 2008]**

(1) 2 m (2) 4m (3) 5 m (4) 6 m

46. The moment of inertia about an axis of a body which is rotating with angular velocity 1 rads^{-1} is numerical equal to **[J&K CET 2008]**

(1) one-fourth of its rotational kinetic energy (2) half of the rotational kinetic energy

(3) rotational kinetic energy (4) twice the rotational kinetic energy

47. The moment of inertia of a circular disc of radius 2m and mass 2 kg, about an axis passing through its centre of mass is 2 kg-m^2. Its moment of inertia about an axis parallel to this axis and passing through its edge (in kg-m^2) is **[J&K CET 2008]**

(1) 10 (2) 8 (3) 6 (4) 4

48. The moment of inertia of a flywheel having kinetic energy 360 J and angular speed of 20 rad s^{-1} is

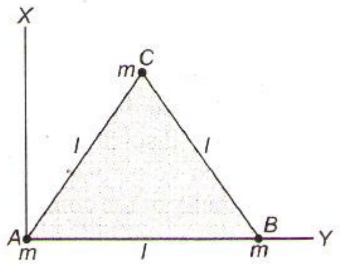
[Kerala CEE 2007]

(1) 18 kg-m^2 (2) 1.8 kg-m^2 (3) 2.5 kg-m^2 (4) 9 kg-m^2

49. The ratio of the radii of gyration of a circular disc and a circular ring about axes passing through their centers and perpendicular to their planes is **[Manipal 2007]**

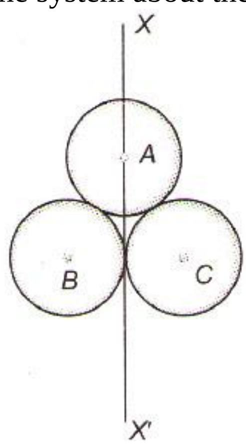
(1) 2 : 3 (2) 2 : 1 (3) $\sqrt{5}:\sqrt{6}$ (4) $1:\sqrt{2}$

50. Three particles, each of mass m gram situated at the vertices of an equilateral triangle ABC of side ℓ cm (as shown in the figure). The moment of inertia of the system about a line AX perpendicular to AB and in the plane of ABC, in gram-cm^2 units will be **[MP PMT 2007]**



(1) (3/4) mℓ^2 (2) 2 mℓ^2 (3) (5/4) mℓ^2 (4) (3/2) mℓ^2

51. Three rings each of mass M and radius R are arranged as shown in figure. The moment of inertia of the system about the XX′ will be **[CBSE AIPMT 2006]**



(1) $\frac{7}{2}MR^2$ (2) 3R^2 (3) $\frac{3}{2}MR^2$ (4) 5MR^2

52. The moment of inertia of a rod about an axis through its centre and perpendicular to it is $\frac{1}{12}$ ML^2(where M is the mass and L the length of the rod). The rod is bent in the middle so that the two halves make an angle of 60°. The moment of inertia of the bent rod about the same axis **[AIIMS 2006]**

(1) $\frac{1}{48}ML^2$ (2) $\frac{1}{12}ML^2$ (3) $\frac{1}{24}ML^2$ (4) $\frac{ML^2}{8\sqrt{3}}$

53. Moment of inertia of a body does not depend not depend upon its **[Kerala CEE 2006]**

(1) mass (2) axis of rotation
(3) shape (4) distribution of mass
(5) angular velocity

54. A uniform circular disc of radius R lies in the $X–Y$ plane with its centre coinciding with the origin of the coordinate system. Its moment of inertia about an axis, lying in the X-Y *plane*, parallel to the X-axis and passing through a point on the Y-axis at a distance $y = 2R$ is I_1. Its moment of inertia about an axis lying in a plane perpendicular to X–Y plane passing through a point on the X-axis at a distance x = d is I_2. If $I_1 = I_2$, the value of d is **[EAMCET 2006]**

(1) $\frac{\sqrt{19}}{2}R$ (2) $\frac{\sqrt{17}}{2}R$ (3) $\frac{\sqrt{15}}{2}R$ (4) $\sqrt{17}\left(\frac{R}{2}\right)$

55. Five particles of mass 2 kg each are attached to the rim of a circular disc of radius 0.1 m and negligible mass. Moment of inertia of the system about the axis passing through the centre of the disc and perpendicular to its place is **[Manipal 2006]**

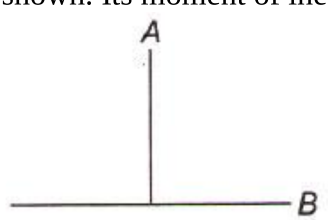
(1) 1 kg-m^2 (2) 0.1 kg-m^2 (3) 2 kg-m^2 (4) 0.2 kg-m^2

56. The moment of inertia of a solid sphere about an axis passing through centre of gravity is $\frac{2}{5}MR^2$, then its radius of gyration about a parallel axis at a distance 2R from first axis is

[MHT CET 2006]

(1) 5R (2) $\sqrt{\frac{22}{5}}R$ (3) $\frac{5}{2}$R (4) $\sqrt{\frac{12}{5}}$R

57. A T joint is formed by two identical rods A and B each of mass m and length L in the XY plane as shown. Its moment of inertia about axis coinciding with A is **[J&K CET 2006]**



(1) $\frac{2mL^2}{3}$ (2) $\frac{mL^2}{12}$ (3) $\frac{mL^2}{6}$ (4) None of these

58. **Assertion (A):** I_s and I_H are the moments of inertia about the diameters of a solid and thin walled hollow sphere respectively. If the radii and the masses of the above spheres are equal, $I_H > I_s$.
Reason (R): In solid sphere, the mass is continuously and regularly distributed about the centre whereas the mass, to a large extent, is concentrated on the surface of hollow sphere.

[EAMCET 2005]

(1) Assertion is True, Reason is True; Reason is a correct explanation for Assertion.
(2) Assertion is True, Reason is True; Reason is NOT a correct explanation for Assertion.
(3) Assertion is True, Reason is False.
(4) Assertion is False, Reason is True.

59. Moment of inertia of a disc about an axis which is a tangent and parallel to its plane is I. Then the moment of inertia of disc about a tangent, but perpendicular to its plane will be **[MHT CET 2005]**

(1) $\frac{3I}{4}$ (2) $\frac{5I}{6}$ (3) $\frac{3I}{2}$ (4) $\frac{6I}{5}$

60. Out of the given bodies (of same mass) for which the moment of inertia will be maximum about the axis passing through its centre of gravity and perpendicular to its plane? **[RPMT 2005]**
(1) Disc of radius a
(2) Ring of radius *a*
(3) Square lamina of side 2a
(4) Four rods of length 2a making a square

61. The angular speed of a body changes from ω_1 to ω_2 without applying a torque, but due to change in moment of inertia. The ratio of radii of gyration in the two cases is **[Haryana PMT 2005]**
(1) $\sqrt{\omega_1}:\sqrt{\omega_2}$
(2) $\sqrt{\omega_2}:\sqrt{\omega_1}$
(3) $\omega_2:\omega_1$
(4) $\omega_1:\omega_2$

62. Four spheres each of mass *M* and radius *R* are placed with their centres on the four corners *A*, *B*, *C* and *D* of a square of side *b*. The spheres *A* and *B* are hollow and C and *D* are solids. The moment of inertia of the system about side *AD* of square is **[J&K CET 2005]**
(1) $\frac{8}{3}MR^2+2Mb^2$
(2) $\frac{8}{5}MR^2+2Mb^2$
(3) $\frac{32}{15}MR^2+2Mb^2$
(4) $32MR^2+4Mb^2$

63. A round disc of moment of inertia I_2 about its axis perpendicular to its plane and passing through its centre is placed over another disc of moment of inertia I_1 rotating with an angular velocity ω about the same axis The final angular velocity of the combination of discs is **[CBSE AIPMT 2004]**
(1) $\frac{I_2\omega}{I_1+I_2}$
(2) ω
(3) $\frac{I_1\omega}{I_1+I_2}$
(4) $\frac{(I_1+I_2)\omega}{I_1}$

64. Let I be the moment of inertia of a uniform square plate about an axis *AB* that passes through its centre and is parallel to two of its sides. *CD* is a line in the plane of the plate that passes through the centre of the plate and makes an angle θ with *AB*. The moment of inertia of the plate about the axis *CD* is then equal to **[CBSE AIPMT 2004]**
(1) $I\sin^2\theta$
(2) $I\cos^2\theta$
(3) I
(4) $I\cos^2\left(\frac{\theta}{2}\right)$

65. Two circular loops *A* and *B* or radii r_A and r_B, respectively are made from a uniform wire. The ratio of their moments of inertia about axes passing through their centres and perpendicular to their planes is $\frac{I_B}{I_A}=8$ then $\left(\frac{r_B}{r_A}\right)$ equal to **[EAMCET 2003]**
(1) 2
(2) 4
(3) 6
(4) 8

Torque, Couple and Angular Momentum

66. The instantaneous angular position of a point on a rotating wheel is given by the equation
$Q(t) = 2t^3 - 6t^2$ **[CBSE AIPMT]**
The torque on the wheel becomes zero at
(1) t = 0.5 s
(2) t = 0.25 s
(3) t = 2 s
(4) t = 1 s

67. If *r* denotes the distance between the sun and the earth then the angular momentum of the earth around the sun is proportional to **[Kerala CEE 2011]**
(1) r^3/r
(2) r
(3) $\sqrt{r}$
(4) r^2
(5) r^3

68. A small object of mass m is attached to a light string which passes through a hollow tube. The tube is hold by one hand and the string by the other. The object is set into rotation in a circle of radius R and velocity v. The string is then pulled down, shortening the radius of path of r. What is conserved? **[UP CPMT 2010]**

(1) Angular momentum (2) Linear momentum
(3) Kinetic energy (4) None of these

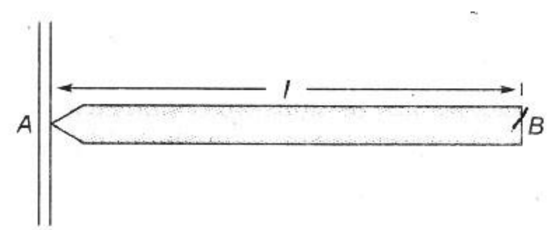
69. A particle with the position vector r has linear momentum p. Which of the following statements is true in respect of its angular momentum L about the origin? **[Kerala CEE 2010]**

(1) L acts along p (2) L acts along r
(3) L is maximum when p and r are parallel (4) L is maximum when p is perpendicular to r
(5) L is minimum when p is perpendicular to r

70. A particle of mass m is projected with a velocity v making an angle of 45° with the horizontal. The magnitude of angular momentum of the projectile about an axis of projection when the particle is at maximum height is **[BVP 2010]**

(1) zero (2) $\frac{mv^3}{4\sqrt{2}g}$ (3) $\frac{mv^2}{\sqrt{2}g}$ (4) m(2gh^3)

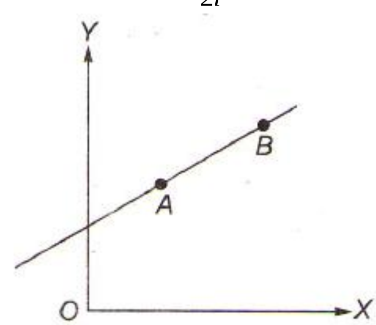
71. A uniform rod AB of length ℓ and mass m is free to rotate about point A. The rod is released from rest in the horizontal position. Given that the moment of inertia of the rod about A is $\frac{ml^2}{3}$, the initial angular acceleration of the rod will be



[CBSE AIPMT 2007]

(1) $\frac{2g}{3l}$ (2) $mg\frac{l}{2}$ (3) $\frac{3}{2}gl$ (4) $\frac{3g}{2l}$

72. A particle of mass m moves in the XY plane with a velocity v along the straight line AB. If the angular momentum of the particle with respect to origin O is L_A when it is at A and L_B when it is at B, then **[CBSE AIPMT 2007]**



(1) $L_A > L_B$ (2) $L_A = L_B$
(3) the relationship between L_A and L_B depends upon the slope of the line AB
(4) $L_A < L_B$

73. A thin rod of mass m and length 2ℓ is made to rotate about an axis passing through its centre and perpendicular to it. If its angular velocity changes from 0 to ω in time t, the torque acting on it is **[AMU 2007]**

(1) $\frac{ml^2\omega}{12t}$ (2) $\frac{ml^2\omega}{3t}$ (3) $\frac{ml^2\omega}{t}$ (4) $\frac{4ml^2\omega}{3t}$

74. A particle is projected with a speed v at 45° with the horizontal. The magnitude of angular momentum of the projectile about the point of projection when the particle is at its maximum height *h* is **[Kerala CEE 2007]**

(1) zero (2) $\frac{mvh^2}{\sqrt{2}}$ (3) $\frac{mv^2h}{2}$ (4) $\frac{mvh^3}{\sqrt{2}}$

(5) $\frac{mvh}{\sqrt{2}}$

75. A ring and a disc of different masses are rotating with the same kinetic energy. If we apply a retarding torque τ on the ring, it stops after completing *n* revolutions in all. If same torque is applied to the disc, how many revolutions would it complete in all before stopping? **[Manipal 2007]**

(1) 4n (2) 2n (3) n (4) $\frac{n}{2}$

76. A wheel having moment of inertia 2 kg-m^2 about its vertical axis, rotates at the rate of 60 rpm about this axis. The torque which can stop the wheel's rotation in one minute would be **[Manipal 2007]**

(1) $\frac{2\pi}{15} Nm$ (2) $\frac{\pi}{12} Nm$ (3) $\frac{\pi}{15} Nm$ (4) $\frac{\pi}{18} Nm$

77. A tube of length *L* is filled completely with an incompressible liquid of mass *M* and closed at both the ends. The tube is then rotated in a horizontal plane about one of its ends with a uniform angular velocity ω. The force exerted by the liquid at the other end is **[MP PMT 2007]**

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

78. A solid sphere is rotating about a diameter at an angular velocity ω. If it cools so that its radius reduces to 1/n of its original value, its angular velocity becomes **[RPMT 2007]**

(1) $\frac{\omega}{n}$ (2) $\frac{\omega}{n^2}$ (3) nω (4) $n^2\omega$

79. A particle performs uniform circular motion with an angular momentum *L*. If the frequency of particle motion is doubled and its KE is halved the angular momentum becomes **[AMU 2006]**

(1) 2L (2) 4L (3) $\frac{L}{2}$ (4) $\frac{L}{4}$

80. A disc of mass 2 kg and radius 0.2 m is rotating with angular velocity 30 rad s^{-1}. What is angular velocity, if a mass of 0.25 kg is put on periphery of the disc? **[DUMET 2006]**

(1) 24 rads^{-1} (2) 36 rads^{-1} (3) 15 rads^{-1} (4) 26 rads^{-1}

81. A particle of mass m = 5 units is moving with a uniform speed $v = 3\sqrt{2}$ units in the *XOY* plane along the line $y = x + 4$. The magnitude of the angular momentum of the particle about the origin is **[Manipal 2006]**

(1) 60 unit (2) $40\sqrt{2}$ unit (3) zero (4) 7.5 unit

82. The unit mass having $r = 8\hat{i} - 4\hat{j}$ and $v = 8\hat{i} + 4\hat{j}$ in its angular momentum is **[JCECE 2006]**
(1) 64 unit in $-\hat{k}$ direction
(2) 64 unit in $+\hat{k}$ direction
(3) 64 unit in $+\hat{j}$ direction
(4) 64 unit in $+\hat{i}$ direction

83. A horizontal platform is rotating with uniform angular velocity around the vertical axis passing through its centre. At some instant of time a viscous fluid of mass m is dropped at the centre and is allowed to spread out and finally fall, the angular velocity during this period **[AIIMS 2005]**
(1) decreases continuously
(2) decreases initially and increases again
(3) remains unaltered
(4) increases continuously

84. **Assertion** For a system of particles under central force field, the total angular momentum is conserved.
Reason The torque acting on such a system is zero.
(1) Assertion is True, Reason is True; Reason is a correct explanation for Assertion.
(2) Assertion is True, Reason is True; Reason is NOT a correct explanation for Assertion.
(3) Assertion is True, Reason is False.
(4) Assertion is False, Reason is True.

85. A uniform disc of mass *M* and radius *R* is mounted on an axle supported in frictionless bearings. A light cord is wrapped around the rim of the disc and a steady downward pull *T* is exerted on the cord. The angular acceleration of the disc is **[AMU 2005]**
(1) $\frac{MR}{2T}$
(2) $\frac{2T}{MR}$
(3) $\frac{T}{MR}$
(4) $\frac{MR}{T}$

86. The angular momentum of a rotating body changes from A_0 to $4A_0$ in 4 min. The torque acting on the body is **[BHU 2005]**
(1) $\frac{3}{4}A_0$
(2) 4 A_0
(3) 3 A_0
(4) $\frac{3}{2}A_0$

87. If torque is zero, then **[Punjab PMET 2005]**
(1) angular momentum is conserved
(2) linear momentum is conserved
(3) energy is conserved
(4) angular momentum is not conserved

88. A uniform cylindrical rod of mass *M* and length *L* is rotating with an angular speed ω. The axis of rotation is perpendicular to its axis of symmetry and passes through 1 of its end faces. If the room temperature increases by *t* and the coefficient of linear expansion of the rod is α, the magnitude of the change in its angular momentum is **[EAMCET 2005]**
(1) 2ωαt
(2) ωαt
(3) $\frac{3}{2}\omega\alpha t$
(4) $\frac{\omega\alpha t}{2}$

89. By keeping moment of inertia of a body constant, if we double the time period, then angular momentum of body **[MHT CET 2005]**
(1) remains constant
(2) becomes half
(3) doubles
(4) quadruples

90. Total angular momentum of a rotating body remains constant, if the net torque acting on the body is **[JCECE 2005]**
(1) zero (2) maximum (3) minimum (4) unit

91. Turning effect is produced by **[J&K CET 2005]**
(1) tangential component of force
(2) radial component of force
(3) transverse component of force
(4) None of the above

92. The angular momentum of a system of particles is not conserved **[DUMET 2004]**
(1) when a net external force acts upon the system
(2) when a net external torque is acting upon the system
(3) when a net external impulse is acting upon the system
(4) None of the above

93. If a particle of mass m is moving in horizontal uniform circular motion, then the angular momentum of the particle is constant about **[Manipal 2004]**
(1) radius of the circle
(2) centre of the circle
(3) tangent of the circle
(4) None of the above

Rotational Energy and Power

94. A body of mass 10 kg moves with a velocity v of 2 ms^{-1} along a circular path of radius 8 m. The power produced by the body will be **[Manipal 2010]**
(1) 10 Js^{-1} (2) 98 Js^{-1} (3) 49 Js^{-1} (4) zero

95. If a sphere is rolling, then the ratio of its rotational kinetic energy to the total kinetic energy is **[JCECE 2010]**
(1) 1 : 2 (2) 2 : 5 (3) 2 : 7 (4) 5 : 7

96. A coin is of mass 4.8 kg and radius 1 m rolling on a horizontal surface without sliding with angular velocity 600 rot/min. What is total kinetic energy of the coin? **[JCECE 2010]**
(1) 360 J (2) 1440 n^2J (3) 4000 π^2J (4) 600 π^2 J

97. A person, with outstretched arms, is spinning on a rotating stool. He suddenly brings his arms down to his sides. Which the following is true about his kinetic energy *K* and angular momentum *L*. **[AMU 2010]**
(1) Both *K* and *L* increase
(2) Both *K* and *L* remain unchanged
(3) *K* remains constant, *L* increases
(4) *K* increases but *L* remains constant

98. A body is rolling down an inclined plane. If KE of rotation is 40% of KE in translatory state, then the body is a **[DUMET 2008]**
(1) ring
(2) cylinder
(3) hollow sphere
(4) solid ball

99. Circular disc of mass 2 kg and radius 1 m is rotating about an axis perpendicular to its plane and passing through its centre of mass with a rotational kinetic energy of 8 J. The angular momentum in (Js) is **[EAMCET 2008]**
(1) 8 (2) 4 (3) 2 (4) 1

100. A ball rolls without slipping. The radius of gyration of the ball about an axis passing through its centre of mass is K. If radius of the ball be R, then the fraction of total energy associated with its rotational energy will be **[BHU 2007]**

(1) $\frac{K^2}{K^2+R^2}$ (2) $\frac{R^2}{K^2+R^2}$ (3) $\frac{K^2+R^2}{R^2}$ (4) $\frac{K^2}{R^2}$

101. A thin metal disc of radius of 0.25 m and mass 2 kg starts from rest and rolls down on an inclined plane. If its rotational kinetic energy is 4 J at the foot of inclined plane, then the linear velocity at the same point, is in ms^{-1} **[J&K CET 2007]**

(1) 2 (2) $2\sqrt{2}$ (3) $2\sqrt{3}$ (4) $3\sqrt{2}$

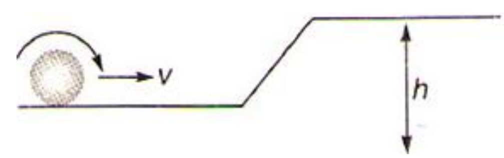
102. A sphere of diameter 0.2 m and mass 2 kg is rolling on an inclined plane with velocity v = 0.5 ms^{-1}. The kinetic energy of the sphere is **[Manipal 2006]**

(1) 0.1 J (2) 0.3 J (3) 0.5 J (4) None

103. Two bodies 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 will be in the ratio **[CBSE AIPMT 2005]**

(1) 1 : 2 (2) $\sqrt{2}:1$ (3) 2 : 1 (4) $1:\sqrt{2}$

104. A solid sphere is rolling on a frictionless surface, shown in figure with a translational velocity v ms^{-1}. If it is to climb the inclined surface then v should be **[AIIMS 2005]**



(1) $\geq\sqrt{\frac{10}{7}gh}$ (2) $\geq\sqrt{2gh}$ (3) 2gh (4) $\frac{10}{7}gh$

105. An object of mass m is attached to light string which passes through a hollow tube. The object is set into rotation in a horizontal circle of radius r_1. If the string is pulled shortening the radius to r_2, the ratio of new kinetic energy to the original kinetic energy is **[JCECE 2005]**

(1) $\left(\frac{r_2}{r_1}\right)^2$ (2) $\left(\frac{r_1}{r_2}\right)^2$ (3) $\frac{r_1}{r_2}$ (4) $\frac{r_2}{r_1}$

106. If the moments of inertia of two freely rotating bodies A and B are I_A and I_B respectively such that $I_A > I_B$ and their angular momenta are equal. If K_A and K_B are their kinetic energies, then **[CPMT 2004]**

(1) $K_a < K_b$ (2) $K_a > K_b$ (3) $K_a = K_b$ (4) $K_a = 2K_b$

107. A cylinder of 10 kg is rolling in a plane with an initial velocity of 10 ms^{-1}. If the coefficient of friction between the surface and cylinder is 0.5, then before stopping, it will cover (g = 10 ms^{-2}) **[Punjab PMET2004]**

(1) 2.5 m (2) 5 m (3) 7.5 m (4) None of these

108. A solid sphere and a hollow sphere, both of the same size and same mass roll down an inclined plane. Then **[Kerala CEE 2003]**
(1) solid sphere reaches the ground first
(2) hollow sphere reaches the ground first
(3) both spheres reach the ground at the same time
(4) the time at which the spheres reach the ground cannot be specified by the data given
(5) the hollow sphere will not roll down

109. A circular ring of mass *m* and radius *r* is rolling on a smooth horizontal surface with speed v. Its kinetic energy is **[Haryana PMT 2003]**
(1) $\frac{1}{8}mv^2$ (2) $\frac{1}{4}mv^2$ (3) $\frac{1}{4}m^2v$ (4) mv^2

Rolling Motion

110. If μ_s is coefficient of static friction, the maximum speed v_{max} with which a vehicle can negotiate an unbanked curved track having radius *R* and inclined at an angle θ with respect to horizontal plane is **[J&K CET 2011]**
(1) $v_{max} = \sqrt{Rg \tan\theta}$ (2) $v_{max} = \sqrt{\mu_s Rg}$ (3) $\sqrt{Rg}$ (4) $\sqrt{\tan\theta / Rg}$

111. The reduced mass of two particles having masses m and *2m* is **[DUMET 2011]**
(1) 2m (2) 3m (3) 2m/3 (4) m/2

112. When a uniform solid sphere and a disc of the same mass and of the same radius roll down an inclined smooth plane from rest to the same distance, then the ratio of the times taken by them is **[Haryana PMT 2010]**
(1) 15 : 14 (2) $15^2 : 14^2$ (3) $\sqrt{14} : \sqrt{15}$ (4) 14 : 15

113. **Assertion** The velocity of a body at the bottom of an inclined plane of given height is more when it slides down the plane, compared to, when it rolling down the same plane.
Reason In rolling down, a body acquires both, kinetic energy of translation and rotation. **[AIIMS 2008]**
(1) Assertion is True, Reason is True; Reason is a correct explanation for Assertion.
(2) Assertion is True, Reason is True; Reason is NOT a correct explanation for Assertion.
(3) Assertion is True, Reason is False.
(4) Assertion is False, Reason is True.

114. Two spheres of unequal mass but same radius are released on inclined plane. They rolls down with slipping. Which one will reach the ground first? **[DUMET 2008]**
(1) Lighter sphere (2) Heavier sphere
(3) Both will reach at the same time (4) None of the above

115. A cylinder is rolling down on an inclined plane of inclination 60°. What is its acceleration? **[DUMET 2008]**
(1) g/3 (2) $g/\sqrt{3}$ (3) $\sqrt{\frac{2g}{3}}$ (4) None of these

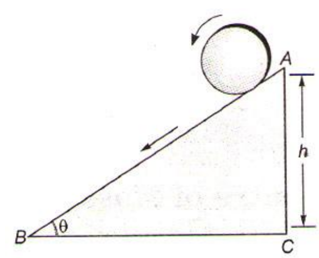
116. A solid cylinder is rolling down on an inclined plane of angle θ. The coefficient of static friction between the plane and cylinder is μ_s. Then condition for the cylinder not to slip is **[J&K CET 2008]**
(1) $\tan\theta \geq 3\mu_s$ (2) $\tan\theta > 3\mu_s$ (3) $\tan\theta \leq 3\mu_s$ (4) $\tan\theta < 3\mu_s$

117. A solid cylinder rolls down an inclined plane of height 3 m and reaches the bottom of plane with angular velocity, of $2\sqrt{2}$ rad s^{-1}. The radius of cylinder must be (Take g = 10 ms^{-2})
[Kerala CEE 2006]
(1) 5 cm (2) 0.5 cm (3) $\sqrt{10}cm$ (4) $\sqrt{5}m$
(5) 10 cm

118. A drum of radius *R* and mass *M*, rolls down without slipping along an inclined plane of angle θ. The frictional force **[CBSE AIPMT 2005]**
(1) converts translational energy to rotational energy
(2) dissipates energy as heat
(3) decreases the rotational motion
(4) decreases the rotational and translational motion

119. At any instant, a rolling body may be considered to be in pure rotation about an axis through the point of contact. This axis is translating forward with speed **[JCECE 2005]**
(1) equal to centre of mass (2) zero
(3) twice of centre of mass (4) no sufficient data

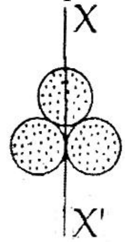
120. If a sphere rolling on an inclined plane with velocity v without slipping, the vertical height of the incline in terms of velocity will be **[RPMT 2004]**



(1) $\frac{7v}{10g}$ (2) $\frac{7v^2}{10g}$
(3) $\frac{2v^2}{5g}$ (4) $\frac{3v}{5g}$

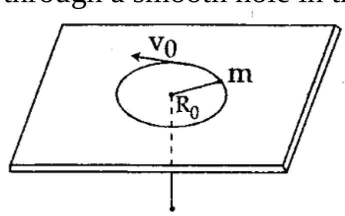
121. A circular platform is mounted on a frictionless vertical axle. Its radius R = 2m and its moment of inertia about the axel is 200 kg m^2. It is initially at rest. A 50 kg man stands on the edge of the platform and begins to walk along the edge at the speed of 1 ms^{-1} relative to the ground. Time taken by the man to complete one revolution on disc is **[AIPMT 2012]**
(1) 2π s (2) $\frac{\pi}{2}s$ (3) π s (4) $\frac{3\pi}{2}s$

122. Three identical spherical shells, each of mass m and radius r are placed as shown in figure. Consider an axis XX' which is touching to two shells and passing through diameter of third shell. Moment of inertia of the system consisting of these three spherical shells about XX' axis is **[AIPMT 2015]**



(1) $3\ mr^2$ (2) $\frac{16}{5}mr^2$ (3) $4mr^2$ (4) $\frac{11}{5}mr^2$

123. 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. **[AIPMT 2015]**



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:

(1) $\frac{1}{4}mv_0^2$ (2) $2mv_0^2$ (3) $\frac{1}{2}mv_0^2$ (4) mv_0^2

124. A rod of weight W is supported by two parallel knife edges A and B and is in equilibrium in a horizontal position. The knives are at a distance d from each other. The centre of mass of the rod is at distance x from A. The normal reaction on A is: **[AIPMT 2015]**

(1) $\frac{Wd}{x}$ (2) $\frac{W(d-x)}{x}$ (3) $\frac{W(d-x)}{d}$ (4) $\frac{Wx}{d}$

125. An automobile moves on a road with a speed of 54 km h^{-1}. The radius of its wheels is 0.45 m and the moment of inertia of the wheel about its axis of rotation is 3 kg m^2. IF the vehicle is brought to rest in 15 s, the magnitude of average torque transmitted by its brakes to the wheel is: **[RE AIPMT 2015]**

(1) 2.86 kg m^2s^{-2} (2) 6.66 kg m^2s^{-2} (3) 8.58 kg m^2s^{-2} (4) 10.86 kg m^2s^{-2}

126. A force $\vec{F} = \alpha\hat{i} + 3\hat{j} + 6\hat{k}$ is acting at a point $\vec{r} = 2\hat{i} - 6\hat{j} - 12\hat{k}$. The value of α for which angular momentum about origin is conserved is: **[RE AIPMT 2015]**

(1) 1 (2) –1 (3) 2 (4) zero

127. 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 ? **[NEET-I 2016]**

(1) $9\ MR^2/32$ (2) $15\ MR^2/32$ (3) $13\ MR^2/32$ (4) $11\ MR^2/32$

128. A disk 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 ? **[NEET-I 2016]**

(1) Depends on their masses (2) Disk
(3) Sphere (4) Both reach at the same time

129. A rope is wound around a hollow cylinder of mass 3 kg and radius 40 cm. What is the angular acceleration of the cylinder the rope is pulled with a force of 30 N? **[NEET 2017]**

(1) $25\,m/s^2$ (2) $0.25\,rad/s^2$ (3) $25\,rad/s^2$ (4) $5\,m/s^2$

130. Which of the following statements are correct? **[NEET 2017]**

(a) Centre of mass of a body always coincidens with the centre of gravity of the body.
(b) Centre of mass of a body is the point at which the total gravitational torque on the body is zero.
(c) A couple on a body produce both translational and rotational motion in a body.
(d) Mechanical advantage greater than one means that small effort can be used to lift a large load.

(1) (b) and (d) (2) (a) and (b) (3) (b) and (c) (4) (c) and (d)

131. 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: **[NEET 2017]**

(1) $\frac{1}{2}1(\omega_1+\omega_2)^2$ (2) $\frac{1}{4}1(\omega_1-\omega_2)^2$ (3) $1(\omega_1-\omega_2)^2$ (4) $\frac{1}{8}(\omega_1-\omega_2)^2$

132. 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? **[NEET 2018]**

(1) 10. : 7 (2) 2 : 5 (3) 5 : 7 (4) 7 : 10

133. 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? **[NEET 2018]**

(1) Rotational kinetic energy (2) Angular momentum
(3) Moment of inertia (4) Angular velocity

134. A moving block having mass m, collides with another stationary block having mass 4m. The lighter block comes to rest after collision. When the initial velocity of the lighter block is v, then the value of coefficient of restitution (e) will be **[NEET 2018]**

(1) 0.8 (2) 0.4 (3) 0.25 (4) 0.5

135. The moment of the force, $\vec{F}=4\hat{i}+5\hat{j}-6\hat{k}$ at (2, 0, –3), about the point (2, –2, –2), is given by **[NEET 2018]**

(1) $-7\hat{i}-8\hat{j}-4\hat{k}$ (2) $-7\hat{i}-4\hat{j}-8\hat{k}$ (3) $-4\hat{i}-\hat{j}-8\hat{k}$ (4) $-8\hat{i}-4\hat{j}-7\hat{k}$

136. A particle starting from rest, moves in a circle of radius 'r'. It attains a velocity of v_0 m/s in the n^{th} round.
Its angular acceleration will be **[NEET (Odisha) 2019]**
(1) $\frac{v_0}{n}\text{rad}/s^2$ (2) $\frac{v_0^2}{2\pi nr^2}\text{rad}/s^2$ (3) $\frac{v_0^2}{4\pi nr^2}\text{rad}/s^2$ (4) $\frac{v_0^2}{4\pi nr}\text{rad}/s^2$

137. A solid cylinder of mass 2 kg and radius 50 cm rolls up an inclined plane of angle inclination 30°. The
centre of mass of 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) **[NEET (Odisha) 2019]**
(1) 2.2 m (2) 1.6 m (3) 1.2 m (4) 2.4 m

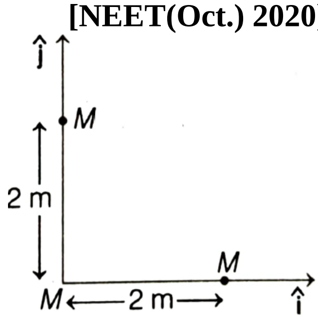
138. A disc of radius 2 m and mass 100 kg rolls on a horizontal floor. Its centre of mass has speed of 20 cm/s. How much work is needed to stop it? **[NEET (National) 2019]**
(1) 30 kJ (2) 2 J (3) 1 J (4) 3 J

139. 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 **[NEET (National) 2019]**
(1) $2\times10^{-3}\,N-m$ (2) $12\times10^{-4}\,N-m$ (3) $2\times10^{6}\,N-m$ (4) $2\times10^{-6}\,N-m$

140. Two particles of mass 5 kg and 10 kg respectively are attached to the two ends of a rigid rod of length 1 m with negligible mass.
The centre of mass of the system from the 5 kg particle is nearly at a distance of **[NEET (Sep) 2020]**
(1) 50 cm (2) 67 cm (3) 80 cm (4) 33 cm

141. Find the torque about the origin when a force of $3\hat{j}\,N$ acts on the particle whose position vector is $2\hat{k}\,m$. **[NEET (Sep.) 2020]**
(1) $6\hat{j}N-m$ (2) $-6\hat{i}N-m$ (3) $6\hat{k}N-m$ (4) $6\hat{i}N-m$

142. Three identical spheres, each of mass M, are placed at the corners of a right angle triangle with the mutually perpendicular sides equal to 2 m (see figure). Taking the point of intersection of the two mutually perpendicular sides as the origin, find the position vector of centre of mass.
[NEET(Oct.) 2020]

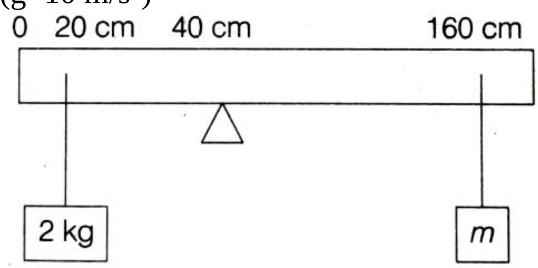


(1) $2(\hat{i}+\hat{j})$ (2) $(\hat{i}+\hat{j})$ (3) $\frac{2}{3}(\hat{i}+\hat{j})$ (4) $\frac{4}{3}(\hat{i}+\hat{j})$

143. The angular speed of the wheel of a vehicle is increased from 360 rpm to 1200 rpm in 14 s. ts angular acceleration is **[NEET (Oct.) 2020]**

(1) $2\pi\,rad/s^2$ (2) $28\pi\,rad/s^2$ (3) $120\pi\,rad/s^2$ (4) $1\,rad/s^2$

144. A uniform rod of length 200 cm and mass 500 g is balanced on a wedge placed at 40 cm mark. A mass of 2 kg is suspended form the rod at 20 cm and another unknown mass m is suspended from the rod at 160 cm mark as shown in the figure. Find the value of m such that the rod is in equilibrium. **[NEET 2021]**
($g=10\ m/s^2$)



(1) $\frac{1}{2}$kg (2) $\frac{1}{3}$kg (3) $\frac{1}{6}$kg (4) $\frac{1}{12}$kg

145. From a circular ring of mass M and radius R, an arc corresponding to a 90° sector is removed. The moment of inertia of the remaining part of the ring about an axis passing through the centre of the ring and perpendicular to the plane of the ring is K times MR^2. Then, the value of K is **[NEET 2021]**

(1) $\frac{3}{4}$ (2) $\frac{7}{8}$ (3) $\frac{1}{4}$ (4) $\frac{1}{8}$

146. A shell of mass m is at rest initially. It explodes into three fragments having mass in the ratio 2:2:1. If the fragments having equal mass fly off along mutually perpendicular directions with speed υ, the speed of the third (lighter) fragment is: **[NEET 2022]**

(1) $\sqrt{2}\upsilon$ (2) $2\sqrt{2}\upsilon$ (3) $3\sqrt{2}\upsilon$ (4) υ

147. Two objects of mass 10 kg and 20 kg respectively are connected to the two ends of a rigid rod of length 10 m with negligible mass. The distance of the centre of mass of the system from the 10 kg mass is: **[NEET 2022]**

(1) $\frac{20}{3}$m (2) 10m (3) 5m (4) $\frac{10}{3}$m

ANSWER KEY

LEVEL – I

1.	(2)	2.	(2)	3.	(2)	4.	(3)	5.	(2)
6.	(2)	7.	(3)	8.	(1)	9.	(3)	10.	(4)
11.	(3)	12.	(2)	13.	(2)	14.	(2)	15.	(2)
16.	(1)	17.	(2)	18.	(4)	19.	(2)	20.	(1)
21.	(2)	22.	(4)	23.	(2)	24.	(3)	25.	(2)
26.	(2)	27.	(2)	28.	(4)	29.	(3)	30.	(3)
31.	(1)	32.	(2)	33.	(4)	34.	(4)	35.	(2)
36.	(4)	37.	(3)	38.	(2)	39.	(3)		

LEVEL – II

1.	(4)	2.	(4)	3.	(2)	4.	(4)	5.	(3)
6.	(1)	7.	(2)	8.	(2)	9.	(1)	10.	(1)
11.	(1)	12.	(1)	13.	(3)	14.	(1)	15.	(4)
16.	(2)	17.	(4)	18.	(1)	19.	(2)	20.	(1)
21.	(3)	22.	(2)	23.	(3)	24.	(3)	25.	(2)
26.	(2)	27.	(3)	28.	(3)	29.	(2)	30.	(3)
31.	(3)	32.	(3)	33.	(2)	34.	(1)	35.	(1)
36.	(2)	37.	(1)	38.	(3)				

LEVEL – III

QUESTIONS BASED ON NEET LEVEL

1.	(4)	2.	(1)	3.	(1)	4.	(3)	5.	(4)
6.	(3)	7.	(3)	8.	(2)	9.	(4)	10.	(3)
11.	(1)	12.	(4)	13.	(4)	14.	(1)	15.	(2)
16.	(3)	17.	(2)	18.	(4)	19.	(1)	20.	(2)
21.	(3)	22.	(3)	23.	(1)	24.	(2)	25.	(3)
26.	(1)	27.	(3)	28.	(3)	29.	(1)	30.	(2)
31.	(3)	32.	(1)	33.	(4)	34.	(3)	35.	(2)
36.	(1)	37.	(1)	38.	(1)	39.	(1)	40.	(3)
41.	(2)	42.	(3)	43.	(4)	44.	(2)	45.	(4)
46.	(4)								

QUESTIONS BASED ON AIIMS LEVEL

1.	(4)	2.	(3)	3.	(1)	4.	(1)	5.	(1)
6.	(2)	7.	(3)	8.	(1)	9.	(2)	10.	(1)

11. (3)	12. (2)	13. (1)	14. (1)	15. (3)
16. (2)	17. (4)	18. (1)	19. (3)	20. (4)
21. (3)	22. (2)	23. (2)	24. (1)	25. (3)
26. (2)	27. (1)	28. (2)	29. (4)	30. (3)
31. (1)	32. (3)	33. (2)	34. (2)	35. (2)
36. (2)				

Assertion & Reason

1. (1)	2. (4)	3. (1)	4. (4)	5. (2)
6. (4)	7. (3)	8. (1)	9. (4)	10. (4)
11. (3)	12. (2)	13. (4)	14. (1)	15. (1)
16. (3)	17. (4)	18. (4)	19. (4)	20. (4)
21. (4)	22. (2)	23. (4)	24. (1)	25. (2)
26. (4)	27. (2)	28. (2)	29. (2)	30. (1)
31. (2)	32. (1)	33. (1)	34. (1)	35. (4)
36. (2)				

Previous Year's Questions

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

111. (3)	**112. (3)**	**113. (2)**	**114. (3)**	**115. (2)**
116. (3)	**117. (4)**	**118. (1)**	**119. (2)**	**120. (2)**
121. (1)	**122. (3)**	**123. (2)**	**124. (3)**	**125. (2)**
126. (2)	**127. (3)**	**128. (3)**	**129. (3)**	**130. (1)**
131. (2)	**132. (3)**	**133. (2)**	**134. (3)**	**135. (2)**
136. (3)	**137. (4)**	**138. (4)**	**139. (4)**	**140. (2)**
141. (2)	**142. (2)**	**143. (1)**	**144. (4)**	**145. (1)**
146. (2)	**147. (1)**			