Exercise-1

ONLY ONE OPTION CORRECT TYPE

SECTION (A) : KINEMATICS

1. If angular displacement of a particle moving on a curved path be given as, $\theta = 1.5\,t + 2t^2$, where t is in sec, the angular velocity at t = 2 sec, will be
(1) 1.5 (2) 2.5 (3) 9.5 (4) 8.5

2. A wheel starts rotating from rest (with constant α) and attains an angular velocity of 60 rad/sec in 5 seconds. The total angular displacement in radians will be
(1) 60 (2) 80 (3) 100 (4) 150

3. All the particles of a rigid body in a rotatory motion have axis of rotation:
(1) Passing from any point inside the object (2) Passing from any point outside the object
(3) Passing from any point (4) Passing from centre of mass of object

4. A wheel has angular acceleration of 3.0 rad/s^2 and an initial angular speed of 2.0 rad/s. In a time of 2s it has rotated through an angle (in radian) of **[RPMT-2008]**
(1) 6 (2) 10 (3) 12 (4) 4

5. A fan is running at 3000 rpm. It is switched off. It comes to rest by uniformly decreasing its angular speed in 10 seconds. The total number of revolution in this period.
(1) 150 (2) 250 (3) 350 (4) 300

6. A block hangs from a string wrapped on a disc of radius 20 cm free to rotate about its axis which is fixed in a horizontal position. If the angular speed of the disc is 10 rad/s at some instant, with what speed is the block going down at that instant?
(1) 4 m/s (2) 3 m/s (3) 2 m/s (4) 5 m/s

7. A sphere is rotating about a diameter.
(1) The particle on the surface of the sphere do not have any linear acceleration
(2) The particles on the diameter mentioned above do not have any linear acceleration
(3) Different particles on the surface have different angular speeds.
(4) All the particles on the surface have same linear speed

SECTION (B) : MOMENT OF INERTIA

1. A stone of mass 4kg is whirled in a horizontal circle of radius 1m and makes 2 rev/sec. The moment of inertia of the stone about the axis of rotation is
(1) 64 kg × m^2 (2) 4 kg × m^2 (3) 16 kg × m^2 (4) 1 kg × m^2

2. Two spheres of same mass and radius are in contact with each other. If the moment of inertia of a sphere about its diameter is I, then the moment of inertia of both the spheres about the tangent at their common point would be
(1) 3 I (2) 7I (3) 4 I (4) 5 I

3. From the theorem of perpendicular axes. If the lamina is in X- Y plane
(1) $I_x - I_y = I_z$ (2) $I_x + I_z = I_y$ (3) $I_x + I_y = I_z$ (4) $I_y + I_z = I_x$

4. The moment of inertia of a body depends upon
(1) mass only (2) angular velocity only
(3) distribution of particles only (4) mass and distribution of mass about the axis

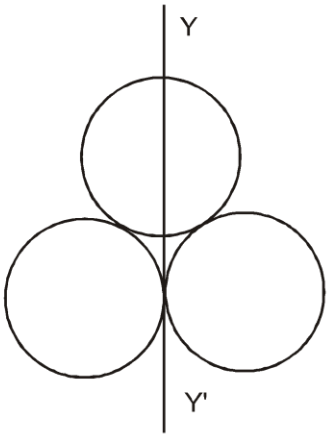
5. A wheel of mass 10 kg has a moment of inertia of 160 kg m^2 about its own axis, the radius of gyration will be **[Pb. PMT 2001]**
(1) 10 m (2) 8 m (3) 6 m (4) 4 m

6. Analogue of mass in rotaional motion is **[DCE 2000, 01]**
(1) Moment of inertia (2) Angular momentum (3) Torque (4) None of these

7. The moment of inertia of a uniform ring of mass M and radius r about a tangent lying in its own plane is **[MP PMT 1997; RPET 2001]**

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

8. Three rings each of mass M and radius R are arranged as shown in the figure. The moment of inertia of the system about YY' will be **[MP PET 2000]**



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

9. Radius of gyration of a body depends on **[RPET 2000]**

(1) Mass and size of body (2) Mass distribution and axis of rotation
(3) Size of body (4) Mass of body

10. The moment of inertia of body comes into play **[AFMC-1979]**

(1) In motion along a curved path (2) In linear motion
(3) In rotational motion (4) None of the above

11 Moment of inertia of a ring of mass M and radius R about an axis passing through the centre and perpendicular to the plane is **[CPMT-1982]**

(1) $1/2\ MR^2$ (2) MR^2 (3) $1/4\ MR^2$ (4) $3/4\ MR^2$

12 The moment of inertia of a straight thin rod of mass M and length l about an axis perpendicular to its length and passing through its one end, is **[RPMT 1996; MPPMT 1996; MPPET 2002]**

(1) $Ml^2/12$ (2) $Ml^2/3$ (3) $Ml^2/2$ (4) Ml^2

13. Three rods each of length L and mass M are placed along X. Yand Z axes in such a way that one end of each of the rod is at the origin. The moment of inertia of this system about Z axis is **[AMU 1995]**

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

14. Three point masses each of mass m are placed at the corners of an equilateral triangle of side 'a'. Then the moment of inertia of this system about an axis passing along one side of the triangle is **[AIIMS 1995]**

(1) ma^2 (2) $3ma^2$ (3) $3/4\ ma^2$ (4) $2/3\ ma^2$

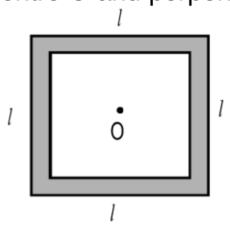
15. The moment of inertia of a uniform thin rod of length L and mass M about an axis passing through a point at a distance of L/3 on the rod from one of its ends and perpendicular to the rod is **[PMT 1995]**

(1) $\frac{7ML^2}{48}$ (2) $\frac{ML^2}{9}$ (3) $\frac{ML^2}{12}$ (4) $\frac{ML^2}{3}$

16. Two rings have their moments of inertia in the ratio 2 : 1 and their diameters are in the ratio 2 : 1. The ratio of their masses will be **[MP PMT/PET 1998]**

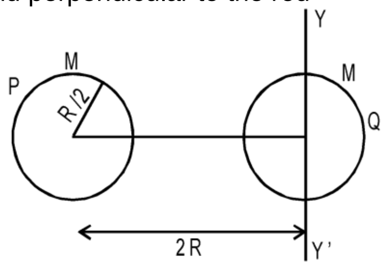
(1) 2 : 1 (2) 1 : 2 (3) 1 : 4 (4) 1 : 1

17. Four thin rods of same mass M and same length l, form a square as shown in figure. Moment of inertia of this system about an axis through centre O and perpendicular to its plane is **[MP PMT 2002]**



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

18. Two spheres each of mass M and radius R/2 are connected with a massless rod of length 2R as shown in the-figure. What will be the moment of inertia of the -system about an axis passing through the centre of one of the spheres and perpendicular to the rod **[Raj. PMT 1996]**



(1) $\frac{21}{5}$ MR^2 (2) $\frac{2}{5}$ MR^2 (3) $\frac{5}{2}$ MR^2 (4) $\frac{5}{21}$ MR^2

19. The moment of inertia of a disc of mass M and radius R about a tangent to its rim in its plane is : **[AIPMT-1999]**

(1) $\frac{2}{3}$ MR_2 (2) $\frac{3}{2}$ MR_2 (3) $\frac{4}{5}$ MR_2 (4) $\frac{5}{4}$ MR_2

20. 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**[Raj. PET 1996]**

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

21. The moment of inertia of a sphere of mass M and radius R about an axis passing through its centre is $\frac{2}{5}MR^2$. The radius of gyration of the sphere about a parallel axis to the above and tangent to the sphere is **[EAMCET (Engg.) 2000]**

(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. Four particles each of mass m are placed at the corners of a square of side length l. The radius of gyration of the system about an axis perpendicular to the square and passing through its centre is **[EAMCET (Med.) 2001]**

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

23. One circular ring and one circular disc, both are having the same mass and radius. The ratio of their moments of inertia about the axes passing through their centres and perpendicular to their planes. will be **[DCE 2000]**

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

24. The radius of gyration of a disc of mass 100 g and radius 5 cm about an axis passing through centre of gravity and perpendicular to the plane is **[MH CET 2000]**

(1) 3.54 cm (2) 1.54 cm (3) 4.54 cm (4) 2.5 cm

25. The moment of inertia of a solid sphere about its tangential axis will be : **[RPMT_2004]**

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

26. The moment of inertia in rotational motion will be equivalent to …… as in linear motion :**[RPMT-2004]**

(1) mass (2) velocity (3) momentum (4) force

27. 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

28. Five particles of mass 2 kg 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 plane is : **[RPMT-2006]**

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

29. 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 ? **[RPMT-2009]**

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

30. The moment of inertia of a uniform semicircular wire of mass M and radius R about a line perpendicular to the plane of the wire through the centre is

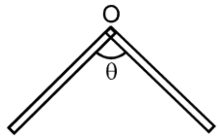
(1) MR^2 (2) $\frac{1}{2}MR^2$ (3) $\frac{1}{4}MR^2$ (4) $\frac{2}{5}MR^2$

31. Let I_A and I_B be moments of inertia of a body about two axes A and B respectively, The axis A passes through the centre of mass of the body but B does not.

(1) $I_A < I_B$ (2) If $I_A < I_B$, the axes are parallel.

(3) If the axes are parallel, $I_A < I_B$ (4) If the axes are not parallel, $I_A \geq I_B$.

32. A thin rod of length L and mass M is bend at the middle point O as shown in figure. Consider an axis passing through two middle point O and perpendicular to the plane of the bent rod. Then moment of inertia about this axis is :

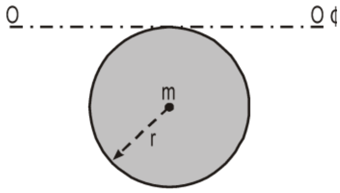


(1) 2/3 mL^2 (2) 1/3 mL^2 (3) 1/12 mL^2 (4) 1/24 mL^2

33. The moment of inertia of a uniform circular disc about its diameter is 200 gm cm^2. Then its moment of inertia about an axis passing through its center and perpendicular to its circular face is

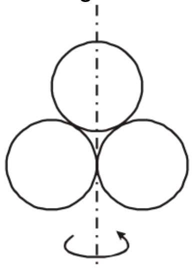
(1) 100 gm cm^2 (2) 200 gm cm^2 (3) 400 gm cm^2 (4) 1000 gm cm^2

34. Moment of inertia of a uniform disc about O O′ is:



(1) $\frac{3\,m\,r^2}{2}$ (2) $\frac{m\,r^2}{2}$ (3) $\frac{5\,m\,r^2}{2}$ (4) $\frac{5\,m\,r^2}{4}$

35. Three rings each of mass m and radius r are so placed that they touch each other. The radius of gyration of the system about the axis as shown in the figure is :



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

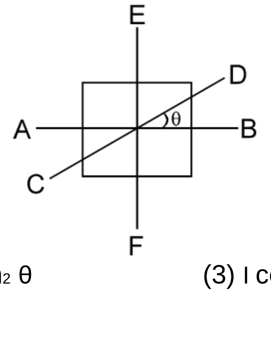
36. Let ℓ be the moment of inertia of a uniform square plate about an axis AB that passes through its centre and is parallel to two of its sides. CD is a line in the plane of the plate that passes through the centre of the plate and makes an angle θ with AB. The moment of inertia of the plate about the axis CD is then equal to **[IIT 1998; JIPMER 2000]**

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

37. A circular disc is to be made using iron and aluminium. To keep its moment of inertia maximum about a geometrical axis, it should be so prepared that :- **[AIPMT_2002]**

(1) aluminium at interior and iron surrounds it
(2) iron at interior and aluminium surrounds it
(3) aluminium and iron layers in alternate order
(4) sheet of iron is used at both external surfaces and aluminium sheet as inner material

38. 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 as shown in figure. The moment of inertia of the plate about the axis CD is then equal to



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

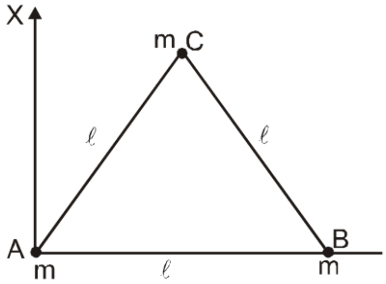
39. Moment of inertia of a circular wire of mass M and radius R about its diameter is :**[AIEEE 4/300 2002]**

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

40. The ratio of the radii of gyration of a circular disc about a tangential axis in the plane of the disc and of a circular ring of the same radius about a tangential axis in the plane of the ring is **[AIPMT-2004]**

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

41. Three particles, each of mass m grams 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 : **[AIPMT_2004]**



(1) (3/4) $m\ell^2$ (2) 2 $m\ell^2$ (3) (5/4) $m\ell^2$ (4) (3/2) $m\ell^2$

42. The moment of inertia of a uniform circular disc of radius R and mass M about an axis passing from the edge of the disc and normal to the disc is : **[AIPMT_2005]**

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

43. 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 **[AIPMT 2008]**

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

44. A thin rod of length L and mass M is bent at its midpoint into two halves so that the angle between them is 90º. 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 **[AIPMT_2008]**

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

45. 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 : **[AIEEE 4/300 2004]**

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

where d_A and d_B are their densities.

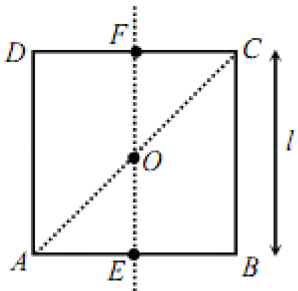
46. The moment of inertia of uniform semicircular disc of mass M and radius r about a line perpendicular to the plane of the disc through the centre is : **[AIEEE 4/300 2005]**

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

47. Four point masses, each of value m, are placed at the corners of a square ABCD of side ℓ. The moment of inertia about an axis passing through A and parallel to BD is : **[AIEEE-2006, 4½//180]**

(1) $m\ell^2$ (2) $2m\ell^2$ (3) $\sqrt{3}\,m\ell^2$ (4) $3m\ell^2$

48. For the given uniform square lamina ABCD, whose centre is O, **[AIEEE-2007; 3/120]**



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

49. 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 : **[AIEEE-2008, 3/105]**

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

SECTION (C) : TORQUE

1. The product of moment of inertia and angular acceleration is
(1) force (2) torque (3) angular momentum (4) rotational kinetic energy

2. A disc of radius 2m and mass 200kg is acted upon by a torque 100N-m. Its angular acceleration would be
(1) 1 rad/sec^2 (2) 0.25 rad/sec^2 (3) 0.5 rad/sec^2 (4) 2 rad/sec^2

3. Rotational power in rotational motion is
(1) $\vec{\omega} \cdot \vec{\tau}$ (2) $\vec{\omega} \times \vec{\tau}$ (3) $\vec{\tau} \cdot \vec{\alpha}$ (4) $\vec{\tau} \times \vec{\alpha}$

4. A constant torque of 31.4 N-m is exerted on a pivoted wheel. If angular acceleration of wheel is 4π rad/see^2, then the moment of inertia of the wheel is **[AIIMS 2001]**
(1) 2.5 kg-m^2 (2) 3.5 kg-m^2 (3) 4.5 kg-m^2 (4) 5.5 kg-m^2

5. A body whose moment of inertia is 3 kg-m^2 is in rest. It is rotated for 20 sec by a torque of 6 Nm, angular displacement of the body will be : **[RPMT_2005]**
(1) 400 radian (2) 200 radian (3) 100 radian (4) 250 radian

6. A force $\vec{F} = 4\hat{i} - 10\hat{j}$ acts on a body at a point having position vector $-5\hat{i} - 3\hat{j}$ relative to origin of co-ordinates on the axis of rotation . The torque acting on the body is :
(1) $38\hat{k}$ (2) $-25\hat{k}$ (3) $62\hat{k}$ (4) none of these

7. A force F = $2\hat{i} + 3\hat{j} - \hat{k}$ acts at a point (2, –3, 1). Then magnitude of torque about point (0, 0, 2) will be:
(1) 6 (2) $3\sqrt{5}$ (3) $6\sqrt{5}$ (4) none of these

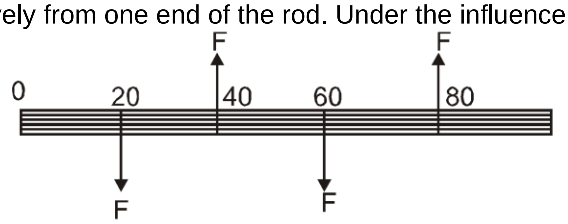
8. In case of torque of a couple if the axis is changed by displacing it parallel to itself, torque will :aa
(1) Increase (2) Decrease (3) Remain constant (4) None of these

9. A torque of 30 N-m is acting on a wheel of mass 5 kg and moment of inertia 2 kg-m^2. If wheel starts rotating from rest then, its angular displacement in 10 seconds will be : **[RPMT_2002]**
(1) 750 rad (2) 1500 rad (3) 3000 rad (4) 6000 rad

10. Let $\vec{F}$ be the force acting on a particle having position vector $\vec{r}$ and $\vec{\tau}$ be the torque of this force about the origin. Then : **[AIEEE 4/300 2003]**
(1) $\vec{r} \cdot \vec{F} = 0$ and $\vec{F} \cdot \vec{\tau} \neq 0$ (2) $\vec{r} \cdot \vec{\tau} \neq 0$ and $\vec{F} \cdot \vec{\tau} = 0$
(3) $\vec{r} \cdot \vec{\tau} \neq 0$ and $\vec{F} \cdot \vec{\tau} \neq 0$ (4) $\vec{r} \cdot \vec{\tau} = 0$ and $\vec{F} \cdot \vec{\tau} = 0$

SECTION (D) : ROTATIONAL EQUILIBRIUM

1. Four equal and parallel forces are acting on a rod (as shown in figure) at distances of 20 cm, 40 cm, 60 cm and 80 cm respectively from one end of the rod. Under the influence of these forces the rod :

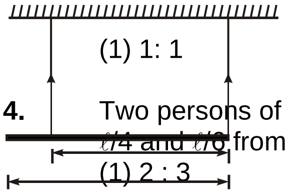


(1) Is at rest (2) Experiences a torque
(3) Experiences a linear motion (4) Experiences a torque and also a linear motion

2. If a rigid body is subjected to two forces $\vec{F}_1$ = 2i + 3j + 4k acting at (3,3,4) and $\vec{F}_2$ = –2i – 3j – 4k acting at (1, 0, 0) then which of the following is (are) true? **[REE - 94]**
(1) The body is in equilibrium.
(2) The body is under the influence of a couple only.

(3) The body is under the influence of a single force.
(4) the body is under the influence of a force together with a couple.

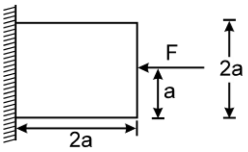
3. A uniform rod of mass m and length L is suspended with two massless strings as shown in the figure. If the rod is at rest in a horizontal position the ratio of tension in the two strings T_1/T_2 is:



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

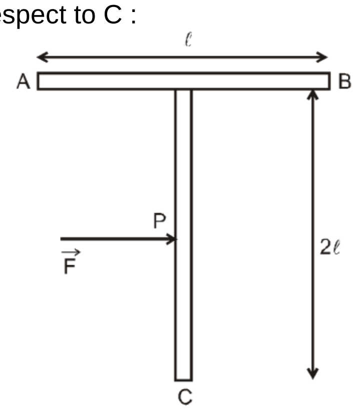
4. Two persons of equal height are carrying a long uniform wooden beam of length ℓ. They are at distance $\ell/4$ and $\ell/6$ from nearest ends of the rod. The ratio of normal reactions at their heads is:
(1) 2 : 3 (2) 1 : 3 (3) 4 : 3 (4) 1 : 2

5. A block of mass m is held fixed against a wall by applying a horizontal force F. Which of the following option is incorrect. **[JEE Scr. 2005, 3/84]**



(1) friction force = mg
(2) normal will not produce torque
(3) F will not produce torque
(4) normal reaction = F

6. A '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 : **[AIEEE 4/300 2005]**



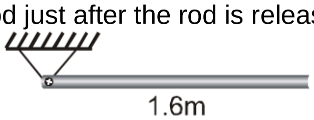
(1) $\frac{2}{3}\ell$ (2) $\frac{3}{2}\ell$ (3) $\frac{4}{3}\ell$ (4) ℓ

SECTION (E) : ROTATION ABOUT FIXED AXIS ($\tau_H = I_H\alpha$)

1. 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

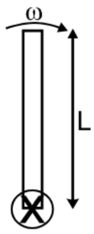
(1) $m\omega^2\ell$ (2) zero (3) mg (4) $\frac{1}{2}m\omega^2\ell$

2. The uniform rod of mass 20 kg and length of 1.6 m is pivoted at its end and swings freely in the vertical plane. Angular acceleration of rod just after the rod is released from rest in the horizontal position.



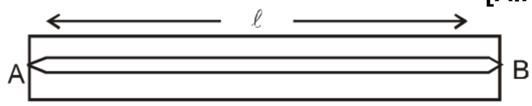
(1) $\frac{15g}{16}$ (2) $\frac{17g}{16}$ (3) $\frac{16g}{15}$ (4) $\frac{g}{15}$

3. A uniform rod hinged at its one end is allowed to rotate in vertical plane. Rod is given an angular velocity ω in its vertical position as shown in figure. The value of ω for which the force exerted by the hinge on rod is zero in this position is :



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

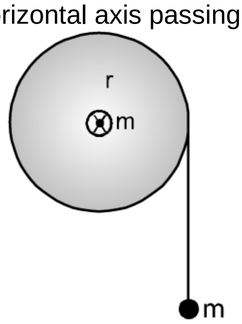
4. A uniform rod of length ℓ and mass m is free to rotate in a vertical plane about A. The rod initially in horizontal position is released.The initial angular acceleration of the rod is (Moment of inertia of rod about A is $\frac{M\ell^2}{3}$) : **[AIPMT_2006]**



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

5. Two men support a uniform horizontal rod at its two ends. If one of them suddenly lets go, the force exerted by the rod on the other man will:
(1) remain unaffected (2) increase
(3) decrease
(4) become unequal to the force exerted by him on the beam.

6. A uniform disc of mass m and radius r and a point mass m are arranged as shown in the figure. The acceleration of point mass is: (Assume there is no slipping between pulley and thread and the disc can rotate smoothly about a fixed horizontal axis passing through its centre and perpendicular to its plane)



(1) $\frac{g}{2}$ (2) $\frac{g}{3}$ (3) $\frac{2g}{3}$ (4) none of these

SECTION (F) : ROTATION ABOUT FIXED AXIS (ENERGY CONSERVATION)

1. The rotational kinetic energy is:
(1) $\frac{1}{2}m\omega^2$ (2) $\frac{1}{2}I\alpha^2$ (3) $\frac{1}{2}I\omega^2$ (4) $\frac{1}{2}mv^2$

2. The M.I. of a body about the given axis is 1.2 kgm^2 initially the body is at rest. In order to produce a rotational kinetic energy of 1500 joule an angular acceleration of 25 rad/sec^2 must be applied about that axis for a duration of **[CPMT-96,2002; RPET 1999]**
(1) 4 sec (2) 2 sec (3) 8 sec (4) 10 sec

3. A uniform rod of length L is placed with one end in contact with the horizontal and is then inclined at an angle α to the horizontal and allowed to fall without slipping at contact point. When it becomes horizontal. its angular velocity Will be **[UPSEAT 2001]**
(1) $\omega = \sqrt{\frac{3g\sin\alpha}{L}}$ (2) $\omega = \sqrt{\frac{2L}{3g\sin\alpha}}$ (3) $\omega = \sqrt{\frac{6g\sin\alpha}{L}}$ (4) $\omega = \sqrt{\frac{L}{g\sin\alpha}}$

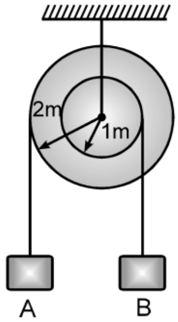
4. A cord is wound round the circumference of wheel of radius r. The fixed axis of the wheel is horizontal and moment of inertia about it is I. A weight mg is attached to the end of the cord and falls from rest. After falling through a distance h, the angular velocity of the wheel will be

[MP PMT 1994; Delhi PMT 2001]

(1) $\sqrt{\frac{2gh}{I+mr}}$ (2) $\left[\frac{2mgh}{I+mr^2}\right]^{1/2}$ (3) $\left[\frac{2mgh}{I+2mr^2}\right]^{1/2}$ (4) $\sqrt{2gh}$

5. A tap can be operated easily using two fingers because **[Manipal MEE 1995; BVP 2003]**
(1) The force available for the operation will be more
(2) This helps application of angular forces
(3) The rotational effect is caused by the couple formed
(4) The force by one finger overcomes friction and other finger provides the force for the operation

6. In the pulley system (stick to each other) shown, if radii of the bigger and smaller pulley are 2 m and 1 m respectively and the acceleration of block A is 5 m/s2 in the downward direction, then the acceleration of block B will be:



(1) 0 m/s2 (2) 5 m/s2 (3) 10 m/s2 (4) 5/2 m/s2

7. A uniform thin rod of mass 'm' and length ℓ is held horizontally by two vertical strings attached to the two ends. One of the string is cut. Find the angular acceleration soon after it is cut :

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

8. A wheel having moment of inertia 2 kg-m2 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 : **[AIPMT_2004]**

(1) $\frac{2\pi}{15}N-m$ (2) $\frac{\pi}{12}N-m$ (3) $\frac{\pi}{15}N-m$ (4) $\frac{\pi}{18}N-m$

9. A fan is moving around its axis. What will be its motion regarded as ? **[RPMT_2006]**
(1) Pure rolling (2) Rolling with slipping (3) Skidding (4) Pure rotations

10. A mass m hangs with the help of a string wrapped around a pulley on a frictionless bearing. The pulley has mass m and radius R. Assuming pulley to be a perfect uniform circular disc, the acceleration of the mass m, if the string does not slip on the pulley, is : **[AIEEE - 2011, 1-May; 4/120, –1]**

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

11. A rod can rotate about a fixed vertical axis. The mass is non-uniformly distributed along the length of the rod. A horizontal force of constant magnitude and always perpendicular to the rod is applied at the end. Which of the following quantity (after one rotation) will not depend on the information that through which end the axis passes ? (Assuming initial angular velocity to be zero)
(1) angular momentum (2) kinetic energy
(3) angular velocity (4) none of these

12. A platform is revolving in horizontal plane about a fixed axis and a boy is sitting at centre. The initial kinetic energy of system is K. If the boy stretches his arms then moment of inertia of system becomes double. Final kinetic energy of system is : **[JEE Sc. 2004' 3/84]**

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

SECTION (G) : ANGULAR MOMENTUM & ITS CONSERVATION

1. On account of melting of ice at the north pole the moment of inertia of spinning earth
(1) increases (2) decreases (3) remains unchanged (4) depends on the time

2. Which of the following quantity is direction less
(1) moment of momentum (2) Moment of force
(3) Moment of charge (4) Moment of inertia

3. Two rigid bodies A and B rotate with rotational kinetic energies E_A and E_B respectively. The moments of inertia of A and B about the axis of rotation are I_A and I_B respectively. If $I_A = I_B/4$ and $E_A = 100\ E_B$ the ratio of angular momentum (L_A) of A to the angular momentum (L_B) of B is **[JIPMER 2001,2002]**
(1) 25 (2) 5/4 (3) 5 (4) 1/4

4. The moments of inertia of two rotating bodies A and B are I_A and I_B ($I_A > I_B$) and their angular momentum are equal. If their kinetic energies be K_A and K_B, respectively, then
(1) $\frac{K_A}{K_B} > 1$ (2) $\frac{K_B}{K_A} > 1$ (3) $\frac{K_A}{K_B} = 1$ (4) $\frac{K_A}{K_B} = \frac{1}{2}$

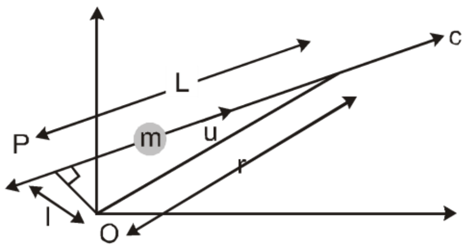
5. When a body rotates about an axis the quantity which remains same for all its particles, is
(1) linear velocity (2) angular velocity (3) linear acceleration (4) angular momentum

6. The time rate of change of angular momentum is called
(1) angular velocity (2) angular acceleration (3) force (4) torque

7. The torque applied to a ring revolving about its own axis so as to change its angular momentum by 2 J-s. in 5 s, is
(1) 10N-m (2) 2.5 N-m (3) 0.1N-m (4) 0.4 N-m

8. When a mass is rotating in a plane about a fixed point, its angular momentum is directed along
(1) radius (2) the tangent to the orbit
(3) a line perpendicular to the plane of rotation (4) none of the above

9. A particle of mass m moves along line PC with velocity u as shown. What is the angular momentum of the particle about O **[AIEEE 2002]**



(1) muL (2) mul (3) mur (4) zero

10. The angular speed of a body changes from ω_1 to ω_2 without applying a torque but due to change in its moment of inertia. The ratio of radii of gyration in the two cases is **[BHU 2002]**
(1) $\sqrt{\omega_2} : \sqrt{\omega_1}$ (2) $\sqrt{\omega_1} : \sqrt{\omega_2}$ (3) $\omega_1 : \omega_2$ (4) $\omega_2 : \omega_1$

11. If the radius of the earth suddenly contracts to half of its present value, then the duration of day will be of **[RPMT 1999; Kerala 2002; AMU (Med.) 1999]**
(1) 6 hours (2) 12 hours (3) 18 hours (4) 24 hours

12. If the earth is treated as a sphere of radius R and mass M. Its angular momentum about the axis of rotation with period T is **[Pb, PET 2004]**
(1) $\frac{\pi MR^3}{T}$ (2) $\frac{MR^2\pi}{T}$ (3) $\frac{2\pi MR^2}{5T}$ (4) $\frac{4\pi MR^2}{5T}$

13. 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 ring now rotates with an angular velocity **[IIT 1983; MP PMT 1994]**

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

14. What remains constant in the field of central force **[RPET 1996]**

(1) Potential energy (2) Kinetic energy (3) Angular momentum (4) Linear momentum

15. If a gymnast, sitting on a rotation stool with his arms outstretched, suddenly lowers his hands **[RPMT-2000]**

(1) The angular velocity decreases (2) His moment of inertia decreases
(3) The angular velocity stays constnat (4) The angular momentum increases

16. A uniform heavy disc is rotating at constant angular velocity ω about a vertical axis through its eentre and perpendicular to the plane of the disc. Let L be its angular momentum. A lump of plasticine is dropped vertically on the disc and sticks to it. Which will be constant **[AMU (Me d.) 2001]**

(1) ω (2) ω and L both (3) L only (4) Neither ω nor L

17. A disc is rotating with an angular speed of ω. If a child sits on it, which of the following is conserved **[CBSE 2002]**

(1) Kinetic energy (2) Potential energy (3) Linear momentum (4) Angular momentum

18. A homogeneous disc of mass 2 kg and radius 15 cm is rotating about its axis (which is fixed) with an angular velocity of 4 radian/s. The linear momentum of the disc is **[CPMT 1989]**

(1) 1.2kg-m/s (2) 1.0 kg-m/s (3) 0.6 kg-m/s (4) None of the above

19. A mass M is moving with a constant velocity along a line parallel to x-axis. Its angular momentum with respect to origin or z-axis is **[IIT 1985, 97 (Cancelled); MP PET 1996; MP PMT 1997; Raj. PET 2000]**

(1) Zero (2) Remains constant (3) Goes on increasing (4) Goes on decreasing

20. The moment of momentum is called **[RPET-2000]**

(1) Couple (2) Torque (3) Impulse (4) Angular momentum

21. A flywheel rotating about a fixed axis has a kinetic energy of 360 joule when its angular speed is 30 rad/sec. The moment of inertia of the wheel about the axis of rotation is **[CBSE 1990]**

(1) 0.6 kg x m_2 (2) 0.15 kg x m_2 (3) 0.8 kg x m_2 (4) 0.75 kg x m_2

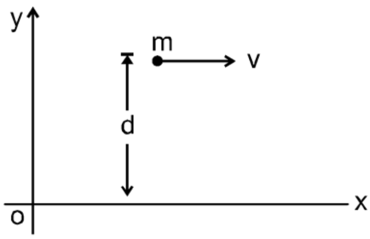
22. A particle of mass m is rotating in a plane in circular path of radius r. Its angular momentum is L. The centripetal force acting on the particle is **[MP PMT 2001]**

(1) L_2/mr (2) L_2m/r_2 (3) L_2/m_2r_2 (4) L_2/mr_3

23. The position of a particle is given by $\vec{r} = (\hat{i} + 2\hat{j} - \hat{k})$ and momentum $\vec{P} = (3\hat{i} + 4\hat{j} - 2\hat{k})$. The angular momentum is perpendicular to **[CPMT 2000]**

(1) X-axis (2) Y-axis
(3) Z-axis (4) Line at equal angles to all the three axes

24. A mass m is moving with constant velocity along a line parallel to x-axis beyond origin. Its angular momentum about the origin : **[RPMT-2004]**



(1) remains constant (2) is zero (3) increases (4) decreases

25. A solid sphere is rotating about a diameter at an angular velocity ω. If it cools so that its radius reduces to $\frac{1}{n}$ of its original value, its angular velocity becomes **[RPMT-2007]**

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

26. A particle performing uniform circular motion has angular momentum L. If its angular frequency is doubled and its kinetic energy is halved, then the new angular momentum is : **[RPMT-2008]**

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

27. A body is rotating with angular momentum L. If I is its moment of inertia about the axis of rotation, its kinetic energy of rotation is **[RPMT-2011]**

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

28. A constant torque actingon a uniform circular wheel changes its angular momentum from A_0 to $4A_0$ in 4 sec. the magnitude of this torque is :

(1) $4A_0$ (2) A_0 (3) $3A_0/4$ (4) $12A_0$

29. 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.

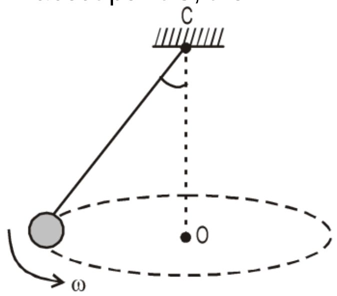
30. A particle performs uniform circular motion with an angular momentum L. If the frequency of particle's motion is doubled and its kinetic energy is halved, the angular momentum becomes :

(1) 2L (2) 4L (3) L/2 (4) L/4

31. A person sitting firmly over a rotating stool has his out stretched. If he folds his arms, his angular momentum about the axis of rotation

(1) increases (2) decreases (3) remains unchanged (4) doubles

32. A conical pendulum consists of a simple pendulum moving in a horizontal circle as shown. C is the pivot, O the centre of the circle in which the pendulum bob moves and ω the constant angular velocity of the bob. If $\vec{L}$ is the angular momentum about point C, then



(1) $\vec{L}$ is constant (2) only direction of $\vec{L}$ is constant
(3) only magnitude of $\vec{L}$ is constant (4) none of the above.

33. In the above problem if $\vec{L}$ is the angular momentum about the axis CO, then,

(1) $\vec{L}$ is constant (2) only direction of $\vec{L}$ is constant
(3) only magnitude of $\vec{L}$ is constant (4) none of the above.

34. The motion of planets in the solar system is an example of the conservation of **[AIIMS 2003; DEC 2003]**

(1) Mass (2) Linear momentum
(3) Angular momentum (4) Energy

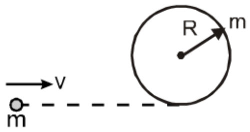
35. A particle is in uniform circular motion in a horizontal plane. Its angular momentum is constant when the origin is taken at : **[JEE Sc. 2003' 3/84]**

(1) centre of the circle (2) any point on the circumference of the circle
(3) any point inside the circle (4) any point outside the circle

36. A particle of mass m is projected with a velocity v making an angle 45º with the horizontal. The magnitude of the angular momentum of the projectile about the point of projection when the particle is at its maximum height h, is :-

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

37. A circular wooden loop of mass m and radius R rests flat on a horizontal frictionless surface. A bullet, also of mass m, and moving with a velocity V, strikes the loop and gets embedded in it. The thickness of the loop is much smaller than R. The angular velocity with which the system rotates just after the bullet strikes the loop is



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

SECTION (H) : COMBINED TRANSLATIONAL + ROTATION MOTION (KINEMATICS)

1. A solid spherical ball rolls on an inclined plane without slipping. The ratio of rotational energy and total energy is **[CBSE 1993; BHU 1997; MP PET 2002; UPSEAT 2002]**

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

2. When a sphere of moment of inertia I about its centre of gravity and mass 'm' rolls from rest down an inclined plane without slipping. its kinetic energy is **[Delhi PMT 1993; Raj. PET 2001]**

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

3. A ring of mass 1 kg and diameter 1m is rolling on a plane road with a speed 2m/s. Its kinetic energy would be

(1) 1 joule (2) 4 joule (3) 2 joule (4) 0.5 joule

4. A solid cylinder starts rolling from a height h on an inclined plane. At some instant t, the ratio of its rotational K.E. and the total K.E. would be

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

5. A solid homogeneous sphere is moving on a rough horizontal surface partly rolling and partly sliding. During this kind of motion of the sphere **[CBSE PMT 1992]**

(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 is conserved

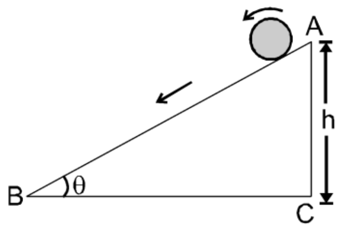
6. A solid cylinder 30 cm in diameter at the top of an inclined plane 2.0 m high is released and rolls down the incline without loss of energy due to friction. Its linear speed at the bottom is **[PMT 1999]**

(1) 5.29 m/sec (2) $4.1 \times 10_3$ m/sec (3) 51 m/sec (4) 51 cm/sec

7. The total energy of disc of mass M and velocity υ rolling an inclined plane without slipping is : **[RPMT_2004]**

(1) $\frac{3}{4} M\upsilon_2$ (2) $\frac{2}{5} M\upsilon_2$ (3) $\frac{3}{2} M\upsilon_2$ (4) $1\ \frac{1}{3} M\upsilon_2$

8. If a sphere rolling on an inclined plane with velocity υ without slipping, the vertical height of the incline in terms of velocity will be : **[RPMT_2004]**



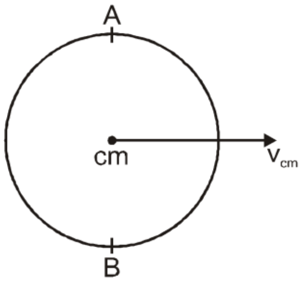
(1) $\frac{7\upsilon}{10g}$ (2) $\frac{7\upsilon^2}{10g}$ (3) $\frac{2\upsilon^2}{5g}$ (4) $\frac{3\upsilon}{5g}$

9. A sphere of diameter 0.2 m and mass 2 kg is rolling on an inclined plane with velocity v = 0.5 m/s. The kinetic energy of the sphere is : **[RPMT-2006]**
(1) 0.1 J (2) 0.3 J (3) 0.5 J (4) 0.42 J

10. A solid sphere rolls down on two different inclined planes of same height, but of different inclinations. In both cases **[RPMT-2007]**
(1) speed and time of descent will be same
(2) speed will be same but time of descent will be different
(3) speed will be different, but time of descent will be same
(4) speed and time of descent both are different

11. A smooth sphere A is moving on a frictionless horizontal plane with angular speed ω and centre of mass velocity v. It collides elastically and head on with an identical sphere B at rest. Neglect friction everywhere. After the collision, their angular speeds are ω_A & ω_B respectively. Then:
(1) $\omega_A < \omega_B$ (2) $\omega_A = \omega_B$ (3) $\omega_A = \omega$ (4) $\omega_B = \omega$

12. A wheel of bicycle is rolling without slipping on a level road. The velocity of the centre of mass is v_{cm}; then true statement is : **[AIPMT-2001]**



(1) The velocity of point A is $2v_{cm}$ and velocity of point B is zero
(2) the velocity of point A is zero and velocity of point B is $2v_{cm}$
(3) the vleocity of point A is $2v_{cm}$ and velocity of point B is v_{cm}
(4) the velocities of both A and B are v_{cm}

13. P is the point of contact of a wheel and the ground. The radius of wheel is 1m. The wheel rolls on the ground without slipping. The displacement of point P when wheel completes half rotation is :- **[AIPMT-2002]**
(1) 2 m (2) $\sqrt{\pi^2+4}$ m (3) π m (4) $\sqrt{\pi^2+2}$ m

14. A disc is rolling on an inclined plane. What fraction of its total energy will be as rotational energy : **[RPMT_2002]**
(1) 4/3 (2) 1/3 (3) 1/2 (4) 2/3

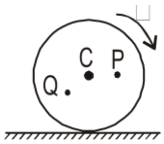
15. If rotational kinetic energy is 50% of translational kinetic energy, then the body is **[RPMT 2003]**
(1) Ring (2) Cylinder (3) Hollow sphere (4) Solid sphere

16. A solid sphere is rolling without slipping on a horizontal surface. The ratio of its rotational kinetic energy and translational kinetic energy is **[RPMT-2003]**
(1) $\frac{2}{9}$ (2) $\frac{2}{5}$ (3) $\frac{2}{7}$ (4) $\frac{7}{2}$

17. A solid sphere, a hollow sphere and a ring are released from top of an inclined plane (frictionless) so that they slide down the plane. The maximum acceleration down the plane is for (no rolling) : **[AIEEE 4/300 2002]**

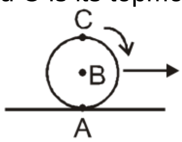
(1) solid sphere (2) hollow sphere (3) ring (4) all same

18. A disc is moving without slipping on ground then the relation between magnitude of velocity of points P, C and Q is [distance CP = CQ] **[JEE Sc. 2004' 3/84]**



(1) Q > C > P (2) P > C > Q (3) C > Q > P (4) All will be same

19. A sphere is rolling without slipping on a fixed horizontal plane surface. In the figure, A is the point of contact, B is the centre of the sphere and C is its topmost point. Then, **[JEE 2009, 4/160, –1]**



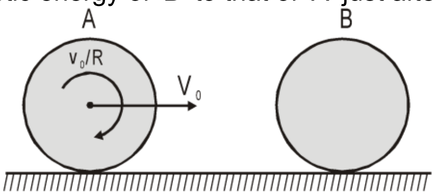
(1) $\vec{V}_C - \vec{V}_A = 2(\vec{V}_B - \vec{V}_C)$ (2) $\vec{V}_B - \vec{V}_C \neq \vec{V}_B - \vec{V}_A$

(3) $|\vec{V}_C - \vec{V}_A| = 2\ |\vec{V}_B - \vec{V}_C|$ (4) None of these

20. The centre of a wheel rolling with out slipping in a plane surface moves with speed υ_0. A particle on the rim of the wheel at the same level as the centre will be moving at speed

(1) zero (2) υ_0 (3) $\sqrt{2}\upsilon_0$ (4) $2\upsilon_0$

21. A hollow smooth uniform sphere A of mass 'm' rolls without sliding on a smooth horizontal surface. It collides elastically and headon with another stationary smooth solid sphere B of the same mass m and same radius. The ratio of kinetic energy of 'B' to that of 'A' just after the collision is :



(1) 5 : 2 (2) 1 : 1 (3) 2 : 3 (4) 3 : 2

22. A solid sphere, a hollow sphere and a disc, all having same mass and radius, are placed at the top of an incline and released. The friction coefficients between the objects and the incline are same and not sufficient to allow pure rolling. The smallest kinetic energy at the bottom of the incline will be achieved by

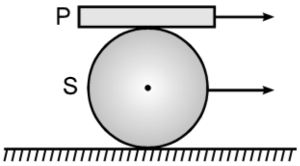
(1) the solid sphere (2) the hollow sphere
(3) the disc (4) all will achieve same kinetic energy.

23. A hollow sphere and a solid sphere having same mass and same radii are rolled down (without sliding) a rough inclined plane.
(1) The hollow sphere reaches the bottom first
(2) The solid sphere reaches the bottom with greater speed.
(3) The solid sphere reaches the bottom with greater kinetic energy
(4) The two spheres will reach the bottom with same linear momentum

24. A solid sphere, a hollow sphere and a disc, all having same mass and radius, are placed at the top of an incline and released. The friction coefficients between the objects and the incline are same and not sufficient to allow pure rolling. Least time will be taken in reaching the bottom by

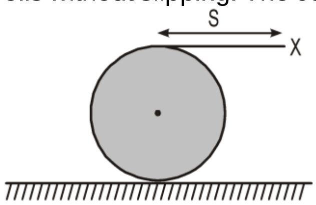
(1) the solid sphere (2) the hollow sphere (3) the disc (4) all will take same time.

25. A plank P is placed on a solid cylinder S, which rolls on a horizontal surface. The two are of equal mass. There is no slipping at any of the surfaces in contact. The ratio of the kinetic energy of P to the kinetic energy of S is:



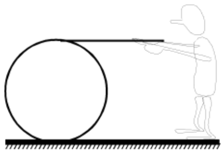
(1) 1: 1 (2) 2: 1 (3) 8: 3 (4) 1: 4

26. A large spool of rope lies on the ground as shown in the fig. The end, labelled X is pulled a distance S in the horizontal direction. The spool rolls without slipping. The centre of mass of the spool moves a distance



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

27. A thin string is wrapped several times around a cylinder kept on a rough horizontal surface. A boy standing at a distance ℓ from the cylinder draws the string towards him as shown in figure. The cylinder rolls without slipping. The length of the string passed through the hand of the boy while the cylinder reaches his hand is



(1) ℓ (2) 2ℓ (3) 3ℓ (4) 4ℓ

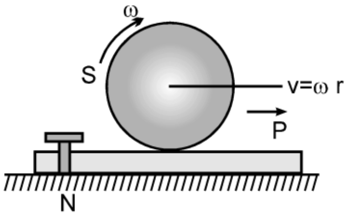
SECTION (I) : COMBINED TRANSLATIONAL & ROTATIONAL MOTION (DYNAMICS)

1. The velocity of centre of mass of a disc rolling on an inclined plane changes from V to 2V at any instant of time. If M is the mass of disc then increases in its kinetic energy will be
(1) (9/4) MV_2 (2) $MV_2/2$ (3) MV_2 (4) $3MV_2$

2. A solid sphere and a solid cylinder having the same mass and radius, roll down the same incline.The ratio of their acceleration will be
(1) 15 : 14 (2) 14 : 15 (3) 5 : 3 (4) 3 : 5

3. A solid sphere and a hollow sphere are thrown horizontally from a cliff with equal velocities, respectively. Then which sphere reaches first on earth ? **[AIPMT-2000]**
(1) Solid sphere
(2) Hollow sphere
(3) Both sphere simultaneously
(4) We cannot say because masses of spheres are not given

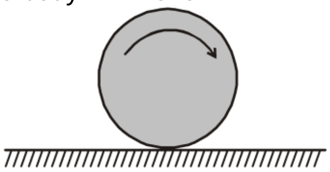
4. A sphere S rolls without slipping, moving with a constant speed on a plank P. The friction between the upper surface of P and the sphere is sufficient to prevent slipping, while the lower surface of P is smooth and rests on the ground. Initially, P is fixed to the ground by a pin N. If N is suddenly removed:



(1) S will begin to slip on P
(2) P will begin to move backwards
(3) the speed of S will decrease and its angular velocity will increase
(4) there will be no change in the motion of S and P will still be at rest.

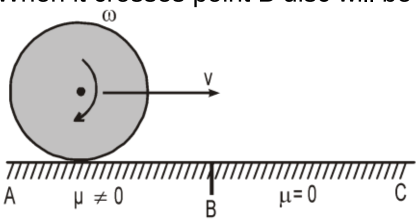
5. A body is given translational velocity and kept on a surface that has sufficient friction. Then:
(1) body will move forward before pure rolling (2) body will move backward before pure rolling
(3) body will start pure rolling immediately (4) none of these

6. A body of mass m and radius r is rotated with angular velocity ω as shown in the figure & kept on a surface that has sufficient friction then the body will move :



(1) backward first and then move forward (2) forward first and then move backward
(3) will always move forward (4) none of these

7. As shown in the figure, a disc of mass m is rolling without slipping with an angular velocity ω. The portion AB is rough and BC is smooth. When it crosses point B disc will be in :

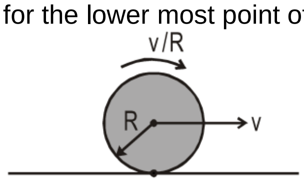


(1) translational motion only (2) pure rolling motion
(3) rotational motion only (4) none of these

8. 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 :
[JEE - 02 (Scr.) 3/90]
(1) Up the incline while ascending and down the incline while 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.

9. A solid uniform disc of mass m rolls without slipping down an inclined plane with an acceleration a. The frictional force on the disc due to surface of the plane is
(1) 2 ma (2) $\frac{3}{2}$ ma (3) ma (4) $\frac{1}{2}$ ma

10. 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



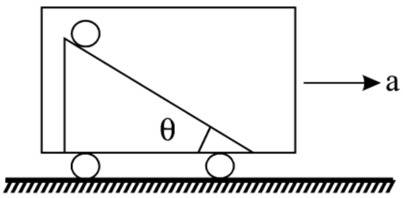
(1) Velocity is v, acceleration is zero
(2) Velocity is zero, acceleration is zero
(3) velocity is v, acceleration is $\frac{v^2}{R}$.
(4) velocity is zero, acceleration is $\frac{v^2}{R}$

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

12. 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 : **[AIEEE 4/300 2005]**
(1) $\frac{R_2}{R_1}$
(2) $\left(\frac{R_1}{R_2}\right)^2$
(3) 1
(4) $\frac{R_1}{R_2}$

13. A round uniform body of radius R, mass M and moment of inertia I rolls down (without slipping) an inclined plane making an angle θ ? with the horizontal. Then its acceleration is :**[AIEEE-2007; 3/120]**
(1) $\frac{g\sin\theta}{1+I/MR^2}$
(2) $\frac{g\sin\theta}{1+MR^2/I}$
(3) $\frac{g\sin\theta}{1-I/MR^2}$
(4) $\frac{g\sin\theta}{1-MR^2/I}$

14. A smooth inclined plane fixed in a car accelerating on a horizontal road is shown in figure. The angle of incline θ is related to the acceleration a of the car as a = g tanθ. If the sphere is set in pure rolling on the incline



(1) it will continue pure rolling
(2) it will slip up the plane
(3) its angular velocity will increase
(4) its angular velocity will decrease.

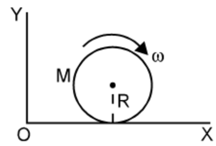
SECTION (J) : CONSERVATION OF ANGULAR MOMENTUM (COMBINED TRANSLATION & ROTATIONAL MOTION)

1. A uniform sphere is released on a smooth inclined plane from the top. When it moves down its angular momentum is:
(1) conserved about every point
(2) conserved about the point of contact only
(3) conserved about the centre of the sphere only
(4) conserved about any point on a fixed line parallel to the inclined plane and passing through the centre of the ball.

2. A uniform thin ring of mass 0.4 kg rolls without slipping on a horizontal surface with a linear velocity of 10 cm/s. The kinetic energy of the ring is : **[RPMT-2011]**
(1) 4×10^{-3} joules
(2) 4×10^{-2} joules
(3) 2×10^{-3} joules
(4) 2×10^{-2} joules

3. A wheel and an axle is made to rotate about a horizontal axis with the help of a body of mass 5 kg attached to a string wound around the axle. The radius of the axle is 10 cm. The body falls vertically throught 5 m is 10 s starting from rest. The moment of inertial of the wheel and axle is **[RPMT-2014]**
(1) 3.85 kg m^2
(2) 4.85 kg m^2
(3) 5.85 kg m^2
(4) 2.85 kg m^2

4. A disc of mass M and radius R is rolling with angular speed ω on a horizontal plane as shown. The magnitude of angular momentum of the disc about the origin O is **[JEE - 99' 2/200]**



(1) $(1/2)MR^2\omega$ (2) $MR^2\omega$ (3) $(3/2)MR^2\omega$ (4) $2MR^2\omega$

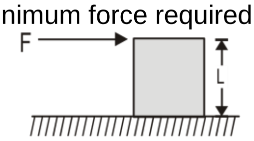
5. A sphere is released on a smooth inclined plane from the top. When it moves down its angular momentum is:
(1) conserved about every point
(2) conserved about the point of contact only
(3) conserved about the centre of the sphere only
(4) conserved about any point on a fixed line parallel to the inclined plane and passing through the centre of the ball.

SECTION (K) : TOPPLING

1. A uniform cube of side a and mass m rests on a rough horizontal table. A horizontal force 'F' is applied normal to one of the faces at a point that is directly above the centre of the face, at a height $\frac{3a}{4}$ above the base. The minimum value of 'F' for which the cube begins to tilt about the edge is ....(assume that the cube does not slide). **[JEE - 84]**

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

2. A cubical block of side L rests on a rough horizontal surface with coefficient of friction μ . A horizontal force F is applied on the block as shown If the coefficient of friction is sufficiently high so that the block does not slide before toppling, the minimum force required to topple the block is **[JEE - 2000 (Scr' 1/35]**



(1) Infinitesimal (2) $\frac{mg}{4}$ (3) mg/2 (4) $mg(1-\mu)$

Exercise-2

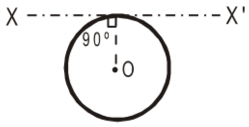
1. The moment of inertia of a uniform semicircular wire of mass M and radius r about a line perpendicular to the plane of the wire and passing through the centre of mass of the system

(1) $Mr^2\left(1-\frac{4}{\pi^2}\right)$ (2) $Mr^2\left(1+\frac{4}{\pi^2}\right)$ (3) $Mr^2\left(1-\frac{\pi^2}{4}\right)$ (4) $Mr^2\left(1+\frac{\pi^2}{4}\right)$

2. Find moment of inertia of a semi circular disc about axis passing through center of mass and perpendicular to its plane.

(1) $MR^2\left(\frac{1}{2}-\frac{16}{9\pi^2}\right)$ (2) $MR^2\left(\frac{1}{2}+\frac{16}{9\pi^2}\right)$ (3) $MR^2\left(\frac{1}{2}-\frac{9\pi^2}{16}\right)$ (4) $MR^2\left(\frac{1}{2}+\frac{9\pi^2}{16}\right)$

3. A thin wire of length L and linear mass density ρ is bent into a circular loop with centre at O as shown. The moment of inertia of the loop about the axis XX' is **[JEE - 2000 Scr' 1/35]**



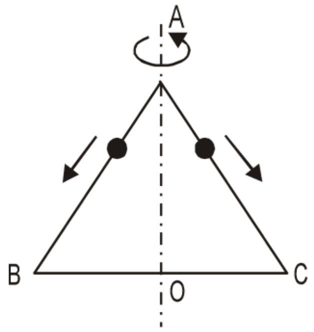
(1) $\frac{\rho L^3}{8\pi^2}$ (2) $\frac{\rho L^3}{16\pi^2}$ (3) $\frac{5\rho L^3}{16\pi^2}$ (4) $\frac{3\rho L^3}{8\pi^2}$

4. The beam and pans of a balance have negligible mass. An object weighs W_1 when placed in one pan and W_2 when placed in the other pan. The weight W of the object is :

(1) $\sqrt{W_1W_2}$ (2) $\sqrt{(W_1+W_2)}$ (3) $W_{12} + W_{22}$ (4) $(W_{1-1} + W_{2-1})/2$

5. A weightless ladder 20 ft. long rests against a frictionless wall at an angle of 60° from the horizontal. A 150 pound man is 4 ft from the bottom of the ladder. A horizontal force is needed to keep it from slipping. Choose the correct magnitude of force from the following : **[AIPMT-1998]**
(1) 17.3 pound (2) 100 pound (3) 120 pound (4) 150 pound

6. An equilateral triangle ABC formed from a uniform wire has two small identical beads initially located at A. The triangle is set rotating about the vertical axis AO. Then the beads are released from rest simultaneously and allowed to slide down, one along AB and the other along AC as shown. Neglecting frictional effects, the quantities that are conserved as the beads slide down, are **[JEE - 2000 Scr.' 1/35]**

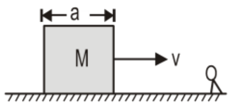


(1) Angular velocity and total energy (kinetic energy and potential energy)
(2) Total angular momentum and total energy
(3) Angular velocity and moment of inertia about the axis of rotation
(4) Total angular momentum and moment of inertia about axis AO

7. If $\tau \times L = 0$ for a rigid body, where τ = resultant torque & L = angular momentum about a point and both are non-zero. Then :
(1) L = constant (2) $|L|$ = constant (3) $|L|$ will increase (4) $|L|$ may increase

8. A uniform ring of radius R is given a back spin of angular velocity $V_0/2R$ and thrown on a horizontal rough surface with velocity of center to be V_0. The velocity of the centre of the ring when it starts pure rolling will be
(1) $V_0/2$ (2) $V_0/4$ (3) $3V_0/4$ (4) 0

9. A cubical block of side a is moving with velocity v on a horizontal smooth plane, as shown It hits a ridge at point O. The angular speed of the block after it hits O is . **[JEE - 99' 2/200]**



(1) $\frac{3v}{4a}$ (2) $\frac{3v}{2a}$ (3) $\frac{\sqrt{3}v}{\sqrt{2}a}$ (4) zero

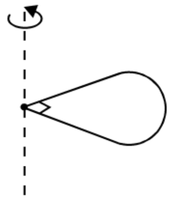
10. A solid sphere of radius R is placed on a smooth horizontal surface. A horizontal force F is applied at height h from the lowest point. For the maximum acceleration of the centre of mass : **[AIPMT_2002]**
(1) h = R (2) h = 2R
(3) h = 0 (4) the acceleration will be same whatever h may be

11. A solid cylinder of mass M and radius R rolls without slipping down an inclined plane of length L and height h. What is the speed of its centre of mass when the cylinder reaches its bottom ? **[AIPMT-2003]**
(1) $\sqrt{\frac{4}{3}gh}$ (2) $\sqrt{4gh}$ (3) $\sqrt{2gh}$ (4) $\sqrt{\frac{3}{4}gh}$

12. A circular disc X of radius R is made from an iron plate of thickness t, and another disc Y of radius 4R is made from an iron plate thickness t/4. Then the relation between the moment of inertia I_X and I_Y is :
[AIEEE 4/300 2003]

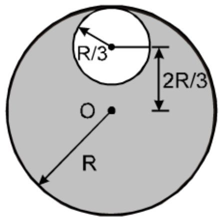
(1) $I_Y = 32I_X$ (2) $I_Y = 16I_X$ (3) $I_Y = I_X$ (4) $I_Y = 64\ I_X$

13. One quarter sector is cut from a uniform circular disc of radius R. This sector has mass M . It is made to rotate about a line perpendicular to its plane and passing through the centre of the original disc. Its moment of inertial about the axis of rotation is : **[JEE - 01 (Scr.)' 3/105]**



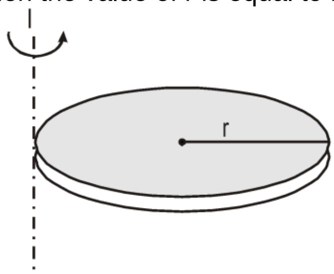
(1) $\frac{1}{2}MR^2$ (2) $\frac{1}{4}MR^2$ (3) $\frac{1}{8}MR^2$ (4) $\sqrt{2}\ MR^2$

14. A disc has mass 9m. A hole of radius $\frac{R}{3}$ is cut from it as shown in the figure. The moment of inertia of the remaining part about an axis passing through the centre 'O' of the disc and perpendicular to the plane of the disc is : **[JEE Scr. 2005 , 3/84]**



(1) $8\ mR^2$ (2) $4\ mR^2$ (3) $\frac{40}{9}\ mR^2$ (4) $\frac{37}{9}\ mR^2$

15. A solid sphere of radius R has moment of inertia I about its geometrical axis. If it is melted into a disc of radius r and thickness t. If it's moment of inertia about the tangential axis (which is perpendicular to plane of the disc), is also equal to I, then the value of r is equal to : **[JEE 2006 , 3/184]**



(1) $\frac{2}{\sqrt{15}}R$ (2) $\frac{2}{\sqrt{5}}R$ (3) $\frac{3}{\sqrt{15}}R$ (4) $\frac{\sqrt{3}}{\sqrt{15}}R$

16. **STATEMENT – 1 :** If there is no external torque on a body about its centre of mass, then the velocity of the center of mass remains constant. **[JEE-2007, 3/162]**
because
STATEMENT – 2 : The linear momentum of an isolated system remains constant.
(1) Statement-1 is True, Statement-2 is True; Statement-2 **is** a correct explanation for Statement-1
(2) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1
(3) Statement-1 is True, Statement-2 is False
(4) Statement-1 is False, Statement-2 is True.

17. **STATEMENT -1 :** Two cylinders, one hollow (metal) and the other solid (wood) with the same mass and identical dimensions are simultaneously allowed to roll without slipping down an inclined plane from the same height. The hollow cylinder will reach the bottom of the inclined plane first. **[JEE-2008, 3/163]**
and
STATEMENT -2 : By the principle of conservation of energy, the total kinetic energies of both the cylinders are identical when they reach the bottom of the incline. **[JEE-2008, 3/163]**

(1) STATEMENT -1 is True, STATEMENT -2 is True; STATEMENT -2 is a correct explanation for STATEMENT -1

(2) STATEMENT -1 is True, STATEMENT-2 is True; STATEMENT -2 is NOT a correct explanation for STATEMENT -1

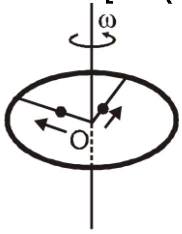
(3) STATEMENT -1 is True, STATEMENT -2 is False

(4) STATEMENT -1 is False, STATEMENT -2 is True.

18. If the resultant of all the external forces acting on a system of particles is zero, then from an inertial frame, one can surely say that **[JEE 2009, 4/160, –1]**

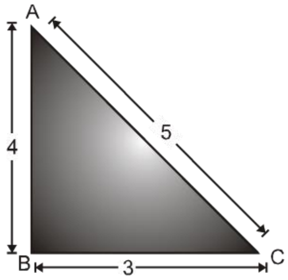
(1) linear momentum of the system does not change in time
(2) kinetic energy of the system does not changes in time
(3) angular momentum of the system does not change in time
(4) potential energy of the system does not change in time

19. A ring of mass M and radius R is rotating with angular speed ω about a fixed vertical axis passing through its centre O with two point masses each of mass $\frac{M}{8}$ at rest at O. These masses can move radially outwards along two massless rods fixed on the ring as shown in the figure. At some instant the angular speed of the system is $\frac{8}{9}\omega$ and one of the masses is ata distance of $\frac{3}{5}R$ from O. At this instant the distance of the other mass from O is : **[JEE(Advanced) 2015 ; 4/88, –2]**



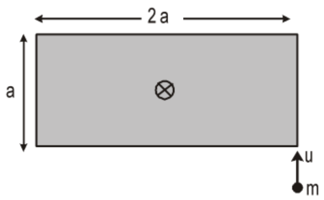
(1) $\frac{2}{3}R$ (2) $\frac{1}{3}R$ (3) $\frac{3}{5}R$ (4) $\frac{4}{5}R$

20. ABC is a triangular plate of uniform thickness. The sides are in the ratio shown in the figure. I_{AB}, I_{BC}, I_{CA} are the moments of inertia of the plate about AB, BC, CA respectively. Which one of the following relations is correct **[CBSE PMT 1995]**



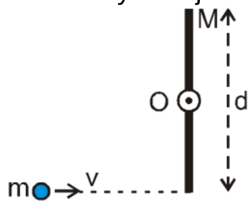
(1) I_{CA} is maximum (2) $I_{AB} > I_{BC}$ (3) $I_{BC} > I_{AB}$ (4) $I_{AB} + I_{BC} = I_{CA}$

21. A uniform rectangular plate of mass m which is free to rotate about the smooth vertical hinge passing through the centre and perpendicular to the plate, is lying on a smooth horizontal surface. A particle of mass m moving with speed 'u' collides with the plate and sticks to it as shown in figure. The angular velocity of the plate after collision will be :



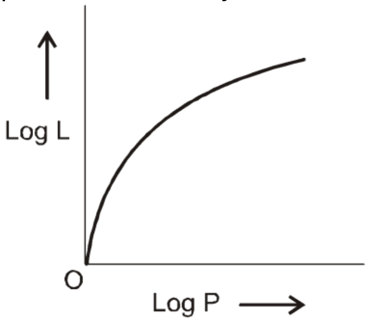
(1) $\frac{12}{5}\frac{u}{a}$ (2) $\frac{12}{19}\frac{u}{a}$ (3) $\frac{3}{2}\frac{u}{a}$ (4) $\frac{3}{5}\frac{u}{a}$

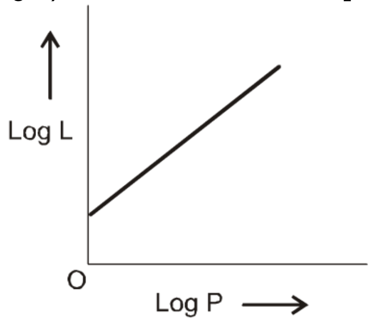
22. A particle of mass m is moving horizontally at speed v perpendicular to a uniform rod of length d and mass M = 6m . The rod is hinged at centre O and can freely rotate in horizontal plane about a fixed vertical axis passing through its centre O. The hinge is frictionless.The particle strikes and sticks to the end of the rod. The angular speed of the system just after the collision :

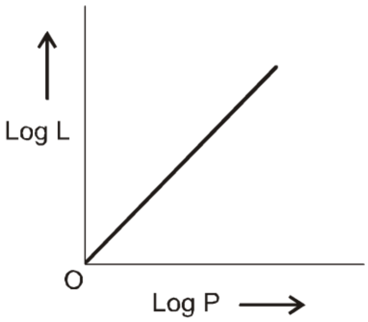


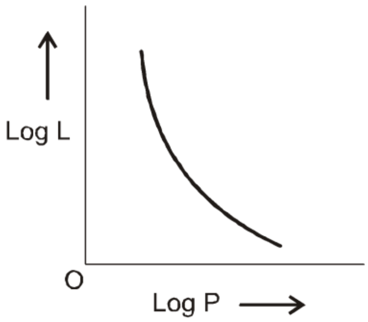
(1) 2v/3d (2) 3v/2d (3) v/3d (4) 2v/d

23. If ‘r’ is the radius vector and ‘P’ momentum, the angular momentum L is given by L = Pr. Which of the graphs shows correctly the variation of (log L) with (log P) ? **[RPMT-2014]**

(1)


(2)


(3)


(4)


24. A particle is projected at time t = 0 from a point P on the ground with a speed V_0, at an angle of 45° to the horizontal. What is the magnitude of the angular momentum of the particle about P at time t= v_0/g. **[JEE-1984 6 marks]**

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

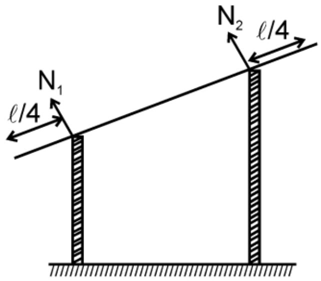
25. A ball rolls without slipping. The radius of gyration of the ball about an axis passing through its centre of mass is K. If radius of the ball be R, then the fraction of total energy associated with its rotational energy will be :- **[AIPMT-2003]**

(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) $\frac{K^2}{R^2}$

26. A circular disk of moment of inertia I_t is rotating in a horizontal plane, about its symmetry axis, with a constant angular speed ω_i. Another disk of moment of inertia I_b is dropped coaxially onto the rotating disk. Initially the second disk has zero angular speed. Eventually both the disks rotate with a constant angular speed ω_f. The energy lost by the initially rotating disc to friction is **[AIPMT (Screening)_2010]**

(1) $\frac{1}{2}\frac{I_b^2}{(I_t+I_b)}\omega_i^2$ (2) $\frac{1}{2}\frac{I_t^2}{(I_t+I_b)}\omega_i^2$ (3) $\frac{I_b-I_t}{(I_t+I_b)}\omega_i^2$ (4) $\frac{1}{2}\frac{I_bI_t}{(I_t+I_b)}\omega_i^2$

27. A uniform rod of length ℓ is placed symmetrically on two walls as shown in figure. The rod is in equilibrium. If N_1 and N_2 are the normal forces exerted by the walls on the rod then



(1) $N_1 > N_2$ (2) $N_1 > N_2$ (3) $N_1 = N_2$
(4) N_1 and N_2 would be in the vertical directions.

Exercise-3

PART - I : NEET / AIPMT QUESTION (PREVIOUS YEARS)

1. If is force acting on a particle having position vector and be the torque of this force about the origin, then **[AIPMT_2009]**

(1) $\vec{r}.\vec{\tau} \neq 0$ and $\vec{F}.\vec{\tau} = 0$ (2) $\vec{r}.\vec{\tau} > 0$ and $\vec{F}.\vec{\tau} < 0$
(3) $\vec{r}.\vec{\tau} = 0$ and $\vec{F}.\vec{\tau} = 0$ (4) $\vec{r}.\vec{\tau} = 0$ and $\vec{F}.\vec{\tau} \neq 0$

2. Four identical thin rods each of mass M and length ℓ, form a square frame. Moment of intertia of this frame about an axis through the centre of the square and perpendicular to its plane is **[AIPMT_2009]**

(1) $\frac{4}{3}M\ell^2$ (2) $\frac{2}{3}M\ell^2$ (3) $\frac{13}{3}M\ell^2$ (4) $\frac{1}{3}M\ell^2$

3. From a circular disc of radius R and mass 9M, a small disc of mass M and radius $\frac{R}{3}$ is removed concentrically. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through its centre is **[AIPMT (Mains)_2010]**

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

4. The instantaneous angular position of a point on a rotating wheel is given by the equation $\theta(t) = 2t^3 - 6t^2$. The torque on the wheel becomes zero at : **[AIPMT (Screening)_2011]**

(1) t = 1s (2) t = 0.5 s (3) t = 0.25 s (4) t = 2s

5. The moment of inertia of a thin uniform rod of mass M and length L about an axis passing through its midpoint and perpendicular to its length is I_0. Its moment of inertia about an axis passing through one of its ends and perpendicular to its length is : **[AIPMT (Screening)_2011]**

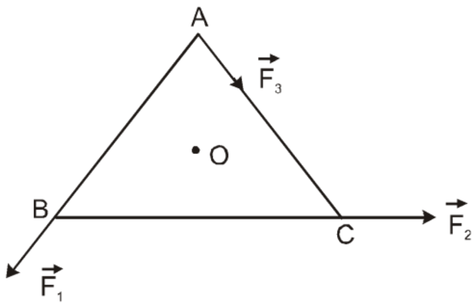
(1) $I_0 + ML^2/2$ (2) $I_0 + ML^2/4$ (3) $I_0 + 2ML^2$ (4) $I_0 + ML^2$

6. When a mass is rotating in a plane about a fixed point, its angular momentum is directed along :
(1) a line perpendicular to the plane of rotation **[RBD_ AIPMT_Pre_2012]**
(2) the line making an angle of 45° to the plane of rotation.
(3) the radius
(4) the tangent to the orbit.

7. A solid cylinder of mass 3 kg is rolling on a horizontal surface with velocity $4ms^{-1}$. It collides with a horizontal spring of force constant $200\ Nm^{-1}$. The maximum compression produced in the spring will be: **[AIPMT-Pre-2012]**

(1) 0.5 m (2) 0.6 m (3) 0.7 m (4) 0.2 m

8. ABC is an equilateral triangle with O as its centre. $\vec{F_1}$, $\vec{F_2}$ and $\vec{F_3}$ represent three forces acting along the sides AB, BC and AC respectively. If the total torque about O is zero the magnitude of $\vec{F_3}$ is : **[AIPMT_Pre_2012]**

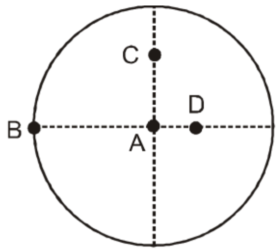


(1) $F_1 + F_2$ (2) $F_1 - F_2$ (3) $\frac{F_1 + F_2}{2}$ (4) $2 (F_1 + F_2)$

9. A circular platform is mounted on a frictionless vertical axle. Its radius R = 2m and its moment of inertia about the axle is 200 kgm^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 $1ms^{-1}$ relative to the ground. Time taken by the man to complete one revolution is : **[AIPMT 2012 (Mains)]**

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

10. The moment of inertia of a uniform circular disc is maximum about an axis perpendicular to the disc and passing through : **[AIPMT 2012 (Mains)]**

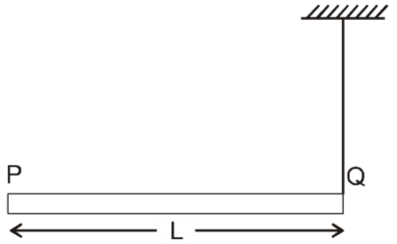


(1) B (2) C (3) D (4) A

11. A small object of uniform density rolls up a curved surface with an initial velocity 'v'. It reaches upto a maximum height of $\frac{3v^2}{4g}$ with respect to the initial position. The object is **[NEET_2013]**

(1) Solid sphere (2) Hollow sphere (3) Disc (4) Ring

12. A rod PQ of mass M and length L is hinged at end P. The rod is kept horizontal by a massless string tied to point Q as shown in figure. When string is cut, the initial angular acceleration of the rod is : **[NEET_2013]**



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

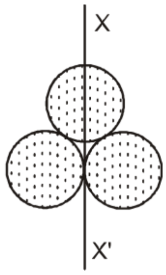
13. A solid cylinder of mass 50 kg and radius 0.5 m is free to rotate about horizontal axis. A massless string is wound round the cylinder with one end attached to it and other hanging freely. Tension in the string required to produce an angular acceleration of 2 revolutions s^{-2} **[AIPMT-2014]**

(1) 25 N (2) 50 N (3) 78.5 N (4) 157 N

14. 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]**

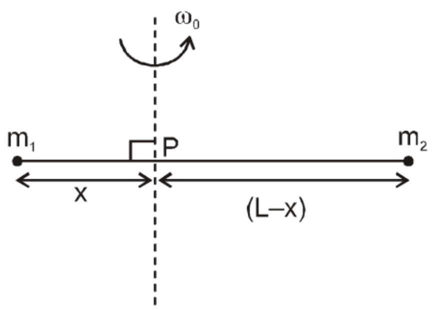
(1) $\frac{Wd}{x}$ (2) $\frac{W(d-x)}{\chi}$ (3) $\frac{W(d-x)}{d}$ (4) $\frac{Wx}{d}$

15. Three identical spherical shells, cach 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 sphereical shell about XX' axis is : **[AIPMT-2015]**



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

16. Point masses m_1 and m_2 are placed at the opposite ends of a rigid of length L, and negligible mass. The rod is to be set rotating about an axis perpendicular to it. The position of point P on this rod through which the axis should pass so that the work required to set the rod rotating with angular velocity ω_0 is minimum, is given by :



(1) $x=\frac{m_1}{m_2}L$ (2) $x=\frac{m_2}{m_1}L$ (3) $x=\frac{m_2L}{m_1+m_2}$ (4) $x=\frac{m_1L}{m_1+m_2}$

17. 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 :

(1) 2 (2) zero (3) 1 (4) –1

18. 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 at perpendicular axis, passing through the centre? **[AIPMT-2016]**

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

19. 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 ? **[AIPMT-2016]**

(1) Depends on their masses (2) Disk

(3) Sphere (4) both reach at the same time

20. A uniform circular disc of radius 50 cm at rest is free to turn about an axis which is perpendicular to its plane and passes through its centre. it is subjected to a torque which produces a constant angular acceleration of 2.0 rad s^{-2}. Its net acceleration in ms^{-2} at the end of 2.0 s is approximately: **[AIPMT-2016]**

(1) 3.0 (2) 8.0 (3) 7.0 (4) 6.0

21. Two rotating bodies A and B of masses m and 2m with moments of inertia I_A and I_B ($I_B > I_A$) have equal kinetic energy of rotation. If L_A and L_B be their angular momenta respectively, then **[NEET 2016]**

(1) $L_A > L_B$ (2) $L_A = \frac{L_B}{2}$ (3) $L_A = 2L_B$ (4) $L_B > L_A$

22. A solid sphere of mass m and radius R is rotating about its diameter. A solid cylinder of the same mass and same radius is also rotating about its geometrical axis with an angular speed twice that of the sphere. The ratio of their kinetic energies of rotation (E_{sphere} / E cylinder) will be : **[NEET 2016]**

(1) 3 : 1 (2) 2 : 3 (3) 1 : 5 (4) 1 : 4

23. A light rod of length l has two masses m_1 and m_2 attached to its two ends. The moment of inertia of the system about an axis perpendicular to the rod and passing through the centre of mass is :**[NEET 2016]**

(1) $\sqrt{m_1 m_2}\,\ell^2$ (2) $\frac{m_1 m_2}{m_1 + m_2}\ell^2$ (3) $\frac{m_1 m_2}{m_1 + m_2}\ell^2$ (4) $(m_1 + m_2)\ell^2$

24. 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 $K_t : (K_t + R_r)$ for the sphere is : **[NEET 2018]**

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

25. 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) Angular velocity (2) Angular momentum

(3) Rotational kinetic energy (4) Moment of inertia

26. A student measured the diameter of a small steel ball using a screw gauge of least count 0.001 cm. The main scale reading is 5 mm and zero of circular scale division coincides with 25 divisions above the reference level. If screw gauge has a zero error of –0.004 cm, the correct diameter of the ball is **[NEET 2018]**

(1) 0.521 cm (2) 0.529 cm (3) 0.053 cm (4) 0.525 cm

27. A solid cylinder of mass 2 kg and radius 4 cm rotating about its axis at the rate of 3 rpm. The torque required to stop after 2π revolutions is: **[NEET-2019-I]**

(1) 2×10^6 Nm (2) 2×10^{-6} Nm (3) 2×10^{-3} Nm (4) 12×10^{-4} Nm

28. 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-2019-I]**
(1) 1 J (2) 3 J (3) 30 kJ (4) 2 J

29. A solid cylinder of mass 2 kg and radius 50 cm rolls up an inclined plane of angle of inclination 30º. The centre of mass of the cylinder has speed of 4 m/s. The distance travelled by the cylinder on the inclined surface will be, [take g = 10 m/s^2] **[NEET-2019-II]**
(1) 2.2 m (2) 1.6 m (3) 1.2 m (4) 2.4 m

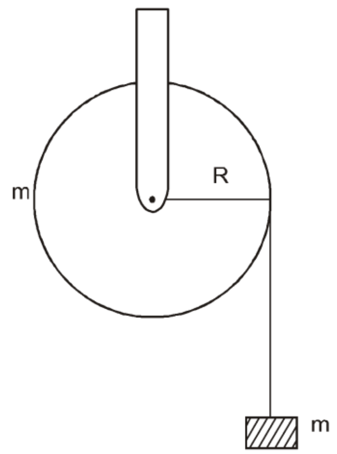
PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

1. A thin uniform rod of length ℓ and mass m is swinging freely about a horizontal axis passing through its end. Its maximum angular speed is ω. Its cenfre of mass rises to a maximum height of :
[AIEEE-2009, 4/144]
(1) $\frac{1}{6}\frac{\ell\ \ \omega}{g}$ (2) $\frac{1}{2}\frac{\ell^2\ \ \omega^2}{g}$ (3) $\frac{1}{6}\frac{\ell^2\ \ \omega^2}{g}$ (4) $\frac{1}{3}\frac{\ell^2\ \ \omega^2}{g}$

2. A thin horizontal circular disc is rotating about a vertical axis passing through its centre. An insect is at rest at a point near the rim of the disc. The insect now moves along a diameter of the disc to reach its other end. During the journey of the insect, the angular speed of the disc :
[AIEEE-2011, 1-May; 4/120, –1]
(1) remains unchanged (2) continuously decreases
(3) continuously increases (4) first increases and then decreases

3. A pulley of radius 2m is rotated about its axis by a force F = (20t – 5t$_2$) newton (where t is measured in seconds) applied tangentially. If the moment of inertia of the pulley about its axis of rotation is 10 kg m$_2$, the number of rotations made by the pulley before its direction of motion if reversed, is :
[AIEEE - 2011, 1-May; 4/120, –1]
(1) less than 3 (2) more than 3 but less than 6
(3) more than 6 but less than 9 (4) more than 9

4. A mass 'm' supported by a massless string wound around a uniform hollow cylinder of mass m and radius R. If the string does not slip on the cylinder, with what acceleration will the mass fall on release ?
[JEE (Main)-2014]



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

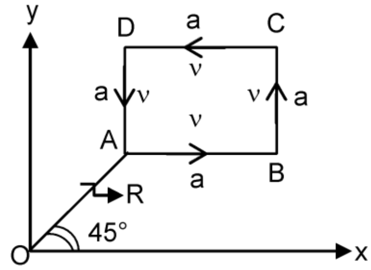
5. A bob of mass m attached to an inextensible string of length *l* is suspended from a vertical support. The bob rotates in a horizontal circle with a angular speed ω rad/s about the vertical. About the point of suspension : **[JEE (Main)_2014]**
(1) angular momentum is conserved.
(2) angular momentum changes in magnitude but not in direction
(3) angular momentum changes in direction but not in magnitude.

(4) angular momentum changes both in direction and magnitude.

6. Form 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 **[JEE(Main)-2015; 4/120, –1]**

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

7. A particle of mass m is moving along the side of square of side 'a' with a uniform speed ν in the x-y plane as shown in the figure : **[JEE Main 2016]**



Which of the following statements is false for the angular momentum $\vec{L}$ about the origin ?

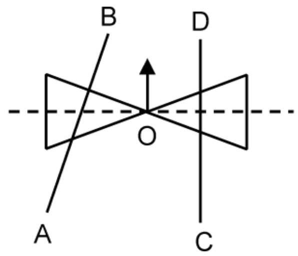
(1) $\vec{L} = m\nu\left[\frac{R}{\sqrt{2}} - a\right]\hat{k}$ when the particle is moving from C to D.

(2) $\vec{L} = m\nu\left[\frac{R}{\sqrt{2}} + a\right]\hat{k}$ when the particle is moving from B to C.

(3) $\vec{L} = \frac{m\nu}{\sqrt{2}}R\ \hat{k}$ when the particle is moving from D to A.

(4) $\vec{L} = -\frac{m\nu}{\sqrt{2}}R\ \hat{k}$ when the particle is moving from A to B.

8. A roller is made by joining together two cones at their vertices O. It is kept on two rails AB and CD which are placed asymmetrically (see figure), with its axis perpendicular to CD and its centre O at the centre of line joining AB and CD (see figure). It is given a light push so that it starts rolling with its centre O moving parallel to CD in the direction shown. As it moves, the roller will tend to : **[JEE Main 2016]**



(1) turn right (2) go straight

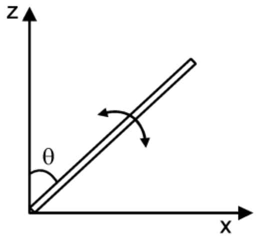
(3) turn left and right alternately (4) turn left.

9. The moment of inertia of a uniform cylinder of length l and radius R about its perpendicular bisector is I. What is the ratio l/R such that the moment of inertia is minimum? **[JEE Main 2017]**

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

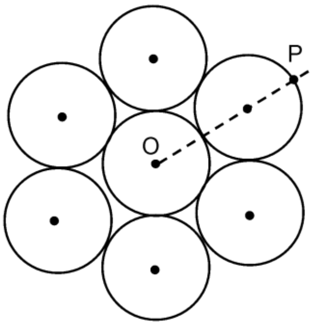
10. A slender uniform rod of mass M and length l is pivoted at one end so that it can rotate in a vertical plane (see figure). There is negligible friction at the pivot. The free end is held vertically above the pivot and then released. the angular acceleration of the rod when it makes an angle θ with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

[JEE Main 2017]



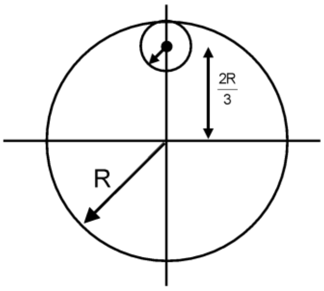
(1) $\frac{2g}{3l}\cos\theta$ (2) $\frac{3g}{2l}\sin\theta$ (3) $\frac{2g}{3l}\sin\theta$ (4) $\frac{3g}{2l}\cos\theta$

11. Seven identical circular planar disks, each of mass M and radius R are welded symmetrically as shown. The moment of inertia of the arrangement about the axis normal to the plane and passing through the point P is : **[JEE-Main-2018]**



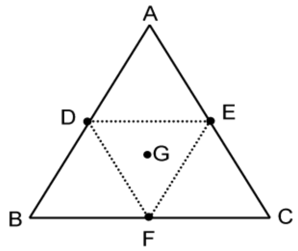
(1) $\frac{73}{2}MR^2$ (2) $\frac{181}{2}MR^2$ (3) $\frac{19}{2}MR^2$ (4) $\frac{55}{2}MR^2$

12. From a uniform circular disc of radius R and mass 9 M, a small disc of radius $\frac{R}{3}$ is removed as shown in the figure. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through centre of disc is : **[JEE-Main-2018]**



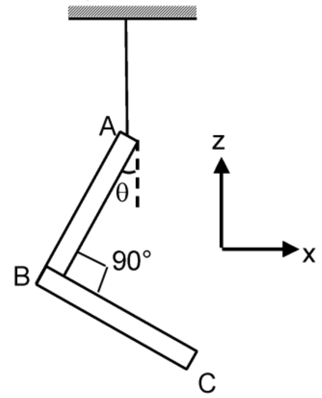
(1) 10 MR^2 (2) $\frac{37}{9}MR^2$ (3) 4 MR^2 (4) $\frac{40}{9}MR^2$

13. An equilateral triangle ABC is cut from a thin solid sheet of wood. (See figure) D, E and F are the mid-points of its sides as shown and G is the centre of the triangle. The moment of inertia of the triangle about an axis passing through G and perpendicular to the plane of the triangle is I_0. If the smaller triangle DEF is removed from ABC, the moment of inertia of the remaining figure about the same axis is I. Then : **[JEE-Main-2019]**



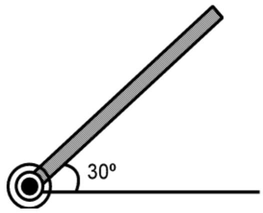
(1) $I = \frac{9}{16} I_0$ (2) $I = \frac{15}{16} I_0$ (3) $I = \frac{3}{4} I_0$ (4) $I = \frac{I_0}{4}$

14. An L-shaped object, made of thin rods of uniform mass density, is suspended with a string as shown in figure. If AB = BC, and the angle made by AB with downward vertical is θ, then : **[JEE-Main-2019]**



(1) $\tan\theta = \frac{1}{2}$ (2) $\tan\theta = \frac{1}{3}$ (3) $\tan\theta = \frac{1}{2\sqrt{3}}$ (4) $\tan\theta = \frac{2}{\sqrt{3}}$

15. A rod of length 50 cm is pivoted at one end. It is raised such that if makes an angle of 30º from the horizontal as shown and released from rest. Its angular speed when it passes through the horizontal (in rad s^{-1}) will be ($g = 10\ m/s^{-2}$) **[JEE-Main-2019]**



(1) $\sqrt{30}$ (2) $\frac{\sqrt{20}}{3}$ (3) $\frac{\sqrt{30}}{2}$ (4) $\frac{\sqrt{30}}{2}$

16. To mop-clean a floor, a cleaning machine presses a circular mop of radius R vertically down with a total force F and rotates it with a constant angular speed about its axis. If the force F is distributed uniformly over the mop and if coefficient of friction between the mop and the floor is μ, the torque, applied by the machine on the mop is : **[JEE-Main-2019]**

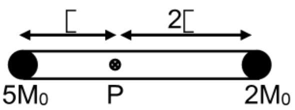
(1) $\frac{\mu FR}{3}$ (2) $\frac{2}{3}\mu FR$ (3) $\frac{\mu FR}{2}$ (4) $\frac{\mu FR}{6}$

17. A homogeneous solid cylindrical roller of radius R and mass M is pulled on a cricket pitch by a horizontal force. Assuming rolling without slipping, angular acceleration of the cylinder is :

[JEE-Main-2019]

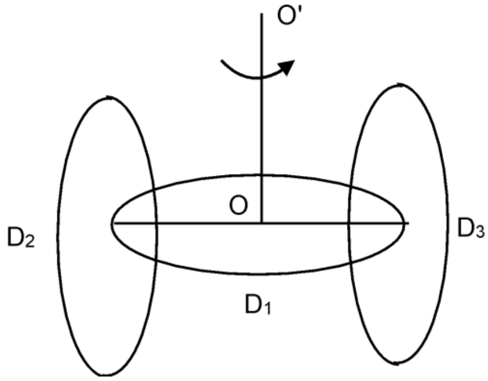
(1) $\frac{F}{3mR}$ (2) $\frac{F}{2mR}$ (3) $\frac{3F}{2mR}$ (4) $\frac{2F}{3mR}$

18. A rigid massless rod of length 3ℓ has two masses attached at eachend as shown in the figure. The rod is pivoted at pont P on the horizontal axis (see figure). When released from initial horizontal position, its instantaneous angluar acceleration will be : **[JEE-Main-2019]**



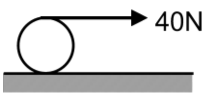
(1) $\frac{g}{3\ell}$ (2) $\frac{g}{13\ell}$ (3) $\frac{7g}{3\ell}$ (4) $\frac{g}{2\ell}$

19. A circular disc D_1 of mass M and radius R has two identical discs D_2 and D_3 of the same mass M and radius R attached rigidly at its opposite ends (see figure.) The moment of inertia of the system about the axis OO', passing through the centre of D_v as shown in the figure, will be: **[JEE-Main-2019]**



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

20. A string is wound around a hollow cylinder of mass 5 kg and radius 0.5 m. If the string is now pulled with a horizontal force of 40 N, and the cylinder is rolling without slipping on a horizontal surface (see figure), then the angular acceleration of the cylinder will be (Neglect the mass and thickness of the string): **[JEE-Main-2019]**

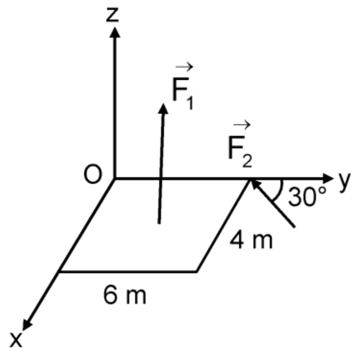


(1) 20 rad/s^2 (2) 16 rad/s^2 (3) 10 rad/s^2 (4) 12 rad/s^2

21. The magnitude of torque on a particle of mass 1 kg is 2.5 Nm about the origin. If the force acting on it is 1 N, and the distance of the particle from the origin is 5 m, the angle between the force and the position vector is (in radians) : **[JEE-Main-2019]**

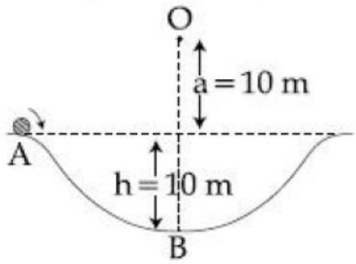
(1) $\frac{\pi}{6}$ (2) $\frac{\pi}{4}$ (3) $\frac{\pi}{8}$ (4) $\frac{\pi}{3}$

22. A slab is subjected to two forces $\vec{F}_1$ and $\vec{F}_2$ of same magnitude F as shown in the figure. Force $\vec{F}_2$ is in XY–plane while force F_1 acts along z–axis at the point $\left(2\vec{i}+3\vec{j}\right)$. The moment of these forces about point O will be **[JEE-Main-2019]**



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

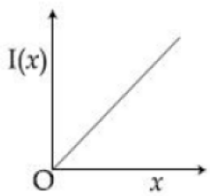
23. A particle of mass 20 g is released with an initial velocity 5 m/s along the curve from the point A, as shown in figure. The point A is at height h from point B. The particle sides along the frictionless surface. When the particle reaches point B, its angular momentum about O will be : **[JEE-Main-2019]**

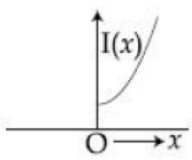


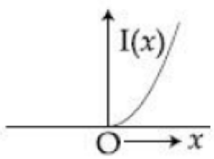
(1) 3 kg-m^2/s (2) 6 kg-m^2/s (3) 2 kg-m^2/s (4) 8 kg-m^2/s

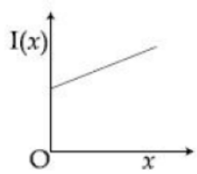
24. The moment of inertia of a solid sphere, about an axis parallel to its diameter and at a distance of x from it, is 'I(x)'. Which one of the graphs represents the variation of I(x) with x correctly?

[JEE-Main-2019]

(1) 

(2) 

(3) 

(4) 

25. Let the moment of inertia of a hollow cylinder of length 30 cm (inner radius 10 cm and outer radius 20 cm), about its axis be I. The radius of a thin cylinder of the same mass such that its moment of inertia about its axis is also I, is: **[JEE-Main-2019]**

(1) 14 cm (2) 16 cm (3) 18 cm (4) 12 cm

Answers

EXERCISE - 1

SECTION (A) :

1.	(3)	**2.**	(4)	**3.**	(3)	**4.**	(2)	**5.**	(2)	**6.**	(3)	**7.**	(2)

SECTION (B) :

1.	(2)	**2.**	(2)	**3.**	(3)	**4.**	(4)	**5.**	(4)	**6.**	(1)	**7.**	(2)
8.	(4)	**9.**	(2)	**10.**	(3)	**11**	(2)	**12**	(2)	**13.**	(1)	**14.**	(3)
15.	(2)	**16.**	(2)	**17.**	(1)	**18.**	(1)	**19.**	(4)	**20.**	(1)	**21.**	(3)
22.	(1)	**23.**	(2)	**24.**	(1)	**25.**	(2)	**26.**	(1)	**27.**	(4)	**28.**	(2)
29.	(1)	**30.**	(1)	**31.**	(3)	**32.**	(3)	**33.**	(3)	**34.**	(4)	**35.**	(4)
36.	(1)	**37.**	(1)	**38.**	(1)	**39.**	(1)	**40.**	(3)	**41.**	(3)	**42.**	(4)
43.	(2)	**44.**	(2)	**45.**	(3)	**46.**	(4)	**47.**	(4)	**48.**	(3)	**49.**	(3)

SECTION (C) :

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

SECTION (D) :

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

SECTION (E) :

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

SECTION (F) :

1.	(3)	**2.**	(2)	**3.**	(1)	**4.**	(2)	**5.**	(3)	**6.**	(4)	**7.**	(3)
8.	(3)	**9.**	(4)	**10.**	(3)	**11.**	(2)	**12.**	(2)				

SECTION (G) :

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

SECTION (H) :

1.	(2)	**2.**	(4)	**3.**	(2)	**4.**	(2)	**5.**	(2)	**6.**	(1)	**7.**	(1)
8.	(2)	**9.**	(2)	**10.**	(2)	**11.**	(3)	**12.**	(1)	**13.**	(2)	**14.**	(2)
15.	(2)	**16.**	(2)	**17.**	(4)	**18.**	(2)	**19.**	(3)	**20.**	(3)	**21.**	(4)
22.	(2)	**23.**	(2)	**24.**	(4)	**25.**	(3)	**26.**	(3)	**27.**	(2)		

SECTION (I) :

1.	(1)	**2.**	(1)	**3.**	(3)	**4.**	(4)	**5.**	(1)	**6.**	(3)	**7.**	(2)
8.	(2)	**9.**	(4)	**10.**	(4)	**11.**	(1)	**12.**	(4)	**13.**	(1)	**14.**	(1)

SECTION (J) :

1.	(4)	**2.**	(1)	**3.**	(2)	**4.**	(3)	**5.**	(4)

SECTION (K) :

1.	(1)	**2.**	(3)

EXERCISE # 2

1.	(1)	**2.**	(1)	**3.**	(4)	**4.**	(1)	**5.**	(1)	**6.**	(2)	**7.**	(4)
8.	(2)	**9.**	(1)	**10.**	(4)	**11.**	(1)	**12.**	(4)	**13.**	(1)	**14.**	(2)
15.	(1)	**16.**	(4)	**17.**	(4)	**18.**	(1)	**19.**	(4)	**20.**	(3)	**21.**	(4)
22.	(1)	**23.**	(2)	**24.**	(4)	**25.**	(1)	**26.**	(4)	**27.**	(3)		

EXERCISE # 3

PART – I

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

PART – II

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