7. Rotational Motion – Multiple Choice Questions

1. Centre of Mass

1. A 2 *kg* body and a 3 *kg* body are moving along the x–axis. At a particular instant the 2 *kg* body has a velocity of 3 ms^{-1} and the 3 *kg* body has the velocity of 2 ms^{-1}. The velocity of the centre of mass at that instant is

(a) $5ms^{-1}$ (b) $1ms^{-1}$

(c) 0 (d) None of these

2. The distance between the carbon atom and the oxygen atom in a carbon monoxide molecule is 1.1 Å. Given, mass of carbon atom is 12 *a.m.u.* and mass of oxygen atom is 16 *a.m.u.*, calculate the position of the center of mass of the carbon monoxide molecule

(a) 6.3 Å from the carbon atom

(b) 1 Å from the oxygen atom

(c) 0.63 Å from the carbon atom

(d) 0.12 Å from the oxygen atom

3. Three identical metal balls each of radius *r* are placed touching each other on a horizontal surface such that an equilateral triangle is formed, when centres of three balls are joined. The centre of the mass of system is located at

(a) Horizontal surface

(b) Centre of one of the balls

(c) Line jointing centres of any two balls

(d) Point of intersection of the medians

4. Two particles of masses m_1 and m_2 initially at rest start moving towards each other under their mutual force of attraction. The speed of the centre of mass at any time *t*, when they are at a distance *r* apart, is

(a) Zero (b) $\left(G\frac{m_1m_2}{r^2}\cdot\frac{1}{m_1}\right)t$

(c) $\left(G\frac{m_1m_2}{r^2}\cdot\frac{1}{m_2}\right)t$ (d) $\left(G\frac{m_1m_2}{r^2}\cdot\frac{1}{m_1+m_2}\right)t$

5. Two persons of masses 55 *kg* and 65 *kg* respectively, are at the opposite ends of a boat. The length of the boat is 3.0 *m* and weighs 100 *kg*. The 55 *kg* man walks up to the 65 *kg* man and sits with him. If the boat is in still water the centre of mass of the system shifts by

(a) 3.0 *m* (b) 2.3 *m*

(c) Zero (d) 0.75 *m*

6. Three masses are placed on the $x-axis$: $300\,g$ at origin, $500\,g$ at $x = 40\,cm$ and $400\,g$ at $x = 70\,cm$. The distance of the centre of mass from the origin is

(a) $40\,cm$ (b) $45\,cm$

(c) $50\,cm$ (d) $30\,cm$

7. Two bodies of mass 1 *kg* and 3 *kg* have position vectors $\hat{i}+2\hat{j}+\hat{k}$ and $-3\hat{i}-2\hat{j}+\hat{k}$, respectively. The centre of mass of this system has a position vector

(a) $-2\hat{i}+2\hat{k}$ (b) $-2\hat{i}-\hat{j}+\hat{k}$

(c) $2\hat{i}-\hat{j}-\hat{k}$ (d) $-\hat{i}+\hat{j}+\hat{k}$

8. Three masses of 2 *kg*, 4 *kg* and 4 *kg* are placed at the three points (1, 0, 0), (1, 1, 0) and (0, 1, 0) respectively. The position vector of its center of mass is

(a) $\frac{3}{5}\hat{i}+\frac{4}{5}\hat{j}$ (b) $(3\hat{i}+\hat{j})$

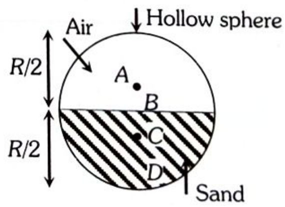
(c) $\frac{2}{5}\hat{i}+\frac{4}{5}\hat{j}$ (d) $\frac{1}{5}\hat{i}+\frac{4}{5}\hat{j}$

9. For which of the following does the centre of mass lie outside the body

(a) A pencil (b) A shotput

(c) A dice (d) A bangle

10. Which of the following points is the likely position of the centre of mass of the system shown in figure



(a) *A* (b) *B*

(c) *C* (d) *D*

11. Four particle of masses *m*, 2*m*, 3*m* and 4*m* are arranged at the corners of a parallelogram with each side equal to *a* and one of the angle between two adjacent sides is 60°. The parallelogram lies in the *x*-*y* plane with mass *m* at the origin and 4*m* on the *x*-axis. The centre of mass of the arrangement will be located at

(a) $\left(\frac{\sqrt{3}}{2}a, 0.95a\right)$ (b) $\left(0.95a, \frac{\sqrt{3}}{4}a\right)$

(c) $\left(\frac{3a}{4}, \frac{a}{2}\right)$ (d) $\left(\frac{a}{2}, \frac{3a}{4}\right)$

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

(a) $10/3$ (b) $5/2$

(c) $1/2$ (d) $2/5$

13. A cart of mass M is tied by one end of a massless rope of length $10\ m$. The other end of the rope is in the hands of a man of mass M. The entire system is on a smooth horizontal surface. The man is at $x=0$ and the cart at $x=10\ m$. If the man pulls the cart by the rope, the man and the cart will meet at the point

(a) $x = 0$ (b) $x = 5m$

(c) $x = 10m$ (d) They will never meet

14. A man of 50 kg mass is standing in a gravity free space at a height of 10m above the floor. He throws a stone of 0.5 kg mass downwards with a speed of 2m/s. When the stone reaches the floor, the distance of the man above the floor will be

(a) 20m (b) 9.9m

(c) 10.1m (d) 10m

15. A straight rod of length L has one of its ends at the origin and the other at $x = L$. If the mass per unit length of the rod is given by Ax where A is constant, where is its mass centre

(a) $L/3$ (b) $L/2$

(c) $2L/3$ (d) $3L/4$

16. A small disc of radius 2 cm is cut from a disc of radius 6 cm. If the distance between their centres is 3.2 cm, what is the shift in the centre of mass of the disc

(a) 0.4 cm (b) 2.4 cm

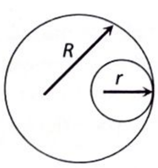
(c) 1.8 cm (d) 1.2 cm

17. The density of a non-uniform rod of length $1m$ is given by $\rho(x) = a(1+bx^2)$ where, a and b are constants and $0 \le x \le 1$. The centre of mass of the rod will be at

(a) $\frac{3(2+b)}{4(3+b)}$ (b) $\frac{4(2+b)}{3(3+b)}$

(c) $\frac{3(3+b)}{4(2+b)}$ (d) $\frac{4(3+b)}{3(2+b)}$

18. A spherical cavity of radius r is carved out of a uniform solid sphere of radius R as shown in the figure. The distance of the center of mass of the resulting body from that of the solid sphere is given by



(a) $\frac{R-r}{2}$

(b) 0

(c) $\frac{R+r}{2}$

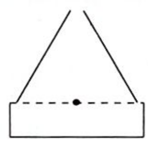
(d) $\frac{-r^3}{R^2+Rr+r^3}$

19. Two masses m_1 and m_2 are connected by a massless spring of spring constant k and unstretched length l. The masses are placed on a frictionless straight channel which we consider our x – axis. They are initially at rest at $x=0$ and $x=l$, respectively. At $t=0$, a velocity of v_0 is suddenly imparted to the first particle. At a later time t_0, the centre of mass of the two masses is at.

(a) $x = \frac{m_2 l}{m_1+m_2}$ (b) $x = \frac{m_1 l}{m_1+m_2} + \frac{m_2 v_0 t}{m_1+m_2}$

(c) $x = \frac{m_2 l}{m_1+m_2} + \frac{m_2 v_0 t}{m_1+m_2}$ (d) $x = \frac{m_2 l}{m_1+m_2} + \frac{m_1 v_0 t}{m_1+m_2}$

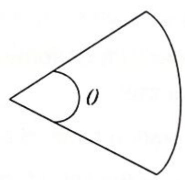
20. Two uniform plates of the same thickness and area but of different materials. One shaped like an isosceles triangle and the other shaped. Like a rectangle are joined together to form a composite body as shown in the figure. If the centre of mass of the composite body is located at the midpoint of their common side, the ratio between masses of the triangle to that of the rectangle is



(a) $1:1$ (b) $4:3$

(c) $3:4$ (d) $2:1$

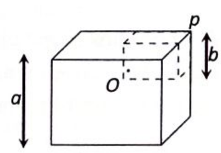
21. The distance between the vertex and the center of mass of a uniform solid planar circular segment of angular size θ and radius R is given by



(a) $\frac{4}{3}R\frac{\sin(\theta/2)}{\theta}$ (b) $R\frac{\sin(\theta/2)}{\theta}$

(c) $\frac{4}{3}R\cos\left(\frac{\theta}{2}\right)$ (d) $\frac{2}{3}R\cos(\theta)$

22. A smaller cube with side b (depicted by dashed lines) is excised from a bigger uniform cube with side a as shown below such that both cubes have a common vertex P. Let $X = a/b$. If the centre of mass of the remaining solid is at the vertex O of smaller cube then X satisfies



(a) $X^3 - X^2 - X - 1 = 0$

(b) $X^2 - X - 1 = 0$

(c) $X^3 + X^2 - X - 1 = 0$

(d) $X^3 - X^2 - X + 1 = 0$

2. Angular Displacement, Velocity and Acceleration

1. A point P on the rim of wheel is initially at rest and in contact with the ground. Find the displacement of the point P if the radius of the wheel is 5 m and the wheel rolls forward through half a revolution

(a) 5 m (b) 10 m

(c) 2.5 m (d) $5(\sqrt{(\pi^2+4)})m$

2. A car is moving at a speed of 72 km/hr. The radius of its wheels is 0.25 m. If the wheels are stopped in 20 rotations by applying brakes, then angular retardation produced by the brakes is

(a) –25.5 rad/s^2 (b) –29.5 rad/s^2

(c) –33.5 rad/s^2 (d) –45.5 rad/s^2

3. The rotor's velocity of a helicopter engine changes from 330 *rev/min* to 110 *rev/min* in 2 *minutes*. How long does the rotor blades take to stop?

(a) 2 *min* (b) 4 *min*

(c) 5 *min* (d) 6 *min*

4. A wheel turning with angular speed of $30\,rev/s$ is brought to rest with a constant acceleration. It turns $60\,rev$ before it stops. The time that elapses before it stops is

(a) $2s$ (b) $4s$

(c) $5s$ (d) $6s$

5. When a disc rotates with uniform angular velocity, which of the following is not true

(a) The sense of rotation remains same

(b) The orientation of the axis of rotation remains same

(c) The speed of rotation is non-zero and remains same

(d) The angular acceleration is non-zero and remains same

6. A particle moves along a circle of radius $\frac{20}{\pi}$ m with constant tangential acceleration. If the velocity of the particle is 80 m/s at the end of the second revolution after motion has begin, the tangential acceleration is

(a) 640 $\pi\, m/s^2$ (b) 160 $\pi\, m/s^2$

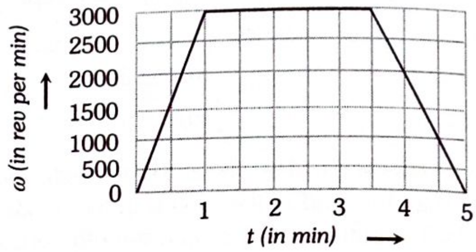
(c) 40 $\pi\, m/s^2$ (d) 40 m/s^2

7. A wheel has a speed of 1200 revolutions per *minute* and is made to slow down at a rate of 4 *radians/second*^{2}. The number of revolutions it makes before coming to rest is

(a) 143 (b) 272

(c) 314 (d) 722

8. As a part of a maintenance inspection the compressor of a jet engine is made to spin according to the graph as shown. The number of revolutions made by the compressor during the test is



(a) 9000 (b) 16570

(c) 12750 (d) 11250

9. What is the value of linear velocity, if $\vec{\omega}=3\hat{i}-4\hat{j}+\hat{k}$ and $\vec{r}=5\hat{i}-6\hat{j}+6\hat{k}$

(a) $6\hat{i}-2\hat{j}+3\hat{k}$ (b) $6\hat{i}-2\hat{j}+8\hat{k}$

(c) $4\hat{i}-13\hat{j}+6\hat{k}$ (d) $-18\hat{i}-13\hat{j}+2\hat{k}$

10. The linear velocity of a rotating body is given by $\vec{v}=\vec{\omega}\times\vec{r}$, where $\vec{\omega}$ is the angular velocity and $\vec{r}$ is the radius vector. The angular velocity of a body is $\vec{\omega}=\hat{i}-2\hat{j}+2\hat{k}$ and the radius vector $\vec{r}=4\hat{j}-3\hat{k}$, then $|\vec{v}|$ is

(a) $\sqrt{29}$ *units* (b) $\sqrt{31}$ *units*

(c) $\sqrt{37}$ *units* (d) $\sqrt{41}$ *units*

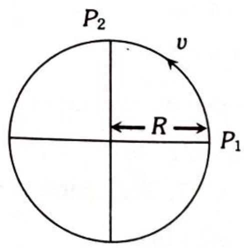
11. Figure below shows a body of mass M moving with the uniform speed on a circular path of radius, R. What is the change in acceleration in going from P_1 to P_2

(a) Zero

(b) $v^2/2R$

(c) $2v^2/R$

(d) $\frac{v^2}{R}\times\sqrt{2}$



12. When a ceiling fan is switched off its angular velocity reduces to 50% while it makes 36 rotations. How many more rotation will it make before coming to rest (Assume uniform angular retardation)?

(a) 18 (b) 12

(c) 36 (d) 48

3. Moment of Inertia

1. 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

(a) 1 $kg\text{-}m^2$ (b) 0.1 $kg\text{-}m^2$

(c) 2 $kg\text{-}m^2$ (d) 0.2 $kg\text{-}m^2$

2. A circular disc is to be made by using iron and aluminium, so that it acquires maximum moment of inertia about its geometrical axis. It is possible with

(a) Iron and aluminium layers in alternate order

(b) Aluminium at interior and iron surrounding it

(c) Iron at interior and aluminium surrounding it

(d) Either (a) or (c)

3. Radius of gyration of a body depends on

(a) Mass and size of body

(b) Mass distribution and axis of rotation

(c) Size of body

(d) Mass of body

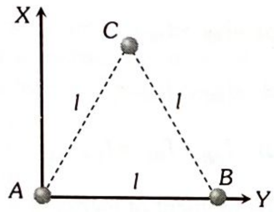
4. Three particles, each of mass m gram, are situated at the vertices of an equilateral triangle ABC of side l cm (as shown in the figure). The moment of inertia of the system about a line AX perpendicular to AB and in the plane of ABC, in $gram - cm^2$ units will be

(a) $\frac{3}{4}ml^2$

(b) $2ml^2$

(c) $\frac{5}{4}ml^2$

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



5. The moment of inertia of a metre scale of mass 0.6 kg about an axis perpendicular to the scale and located at the 20 cm position on the scale in $kg\ m^2$ is (Breadth of the scale is negligible)

(a) 0.074 (b) 0.104

(c) 0.148 (d) 0.208

6. A wheel of mass 10 kg has a moment of inertia of 160 $kg\text{-}m^2$ about its own axis, the radius of gyration will be

(a) 10 m (b) 8 m

(c) 6 m (d) 4 m

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

(a) $\frac{7}{5}R$ (b) $\frac{3}{5}R$

(c) $\left(\sqrt{\frac{7}{5}}\right)R$ (d) $\left(\sqrt{\frac{3}{5}}\right)R$

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

(a) $10\ g\text{-}cm^2$ (b) $100\ g\text{-}cm^2$

(c) $6\ g\text{-}cm^2$ (d) $1\ g\text{-}cm^2$

9. Radius of gyration of uniform thin rod of length L about an axis passing normally through its centre of mass is

(a) $\frac{L}{\sqrt{12}}$ (b) $\frac{L}{12}$

(c) $\sqrt{12}L$ (d) $12L$

10. The moment of inertia of a uniform circular disc of radius 'R' and mass 'M' about an axis touching the disc at its diameter and normal to the disc is

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

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

11. 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

(a) $\sqrt{2}:1$ (b) $\sqrt{2}:\sqrt{3}$

(c) $\sqrt{3}:\sqrt{2}$ (d) $1:\sqrt{2}$

12. (1) Centre of gravity (C.G.) of a body is the point at which the weight of the body acts

(2) Centre of mass coincides with the centre of gravity if the earth is assumed to have infinitely large radius

(3) To evaluate the gravitational field intensity due to any body at an external point, the entire mass of the body can be considered to be concentrated at its C.G

(4) The radius of gyration of any body rotating about an axis is the length of the perpendicular dropped from the C.G. of the body to the axis

Which one of the following pairs of statements is correct?

(a) (4) and (1) (b) (1) and (2)

(c) (2) and (3) (d) (3) and (4)

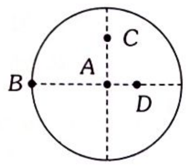
13. The moment of inertia of a uniform circular disc is maximum about an axis perpendicular to the disc and passing through

(a) B

(b) C

(c) D

(d) A



14. Two rods each of mass m and length l are joined at the centre to form a cross. The moment of inertia of this cross about an axis passing through the common centre of the rods and perpendicular to the plane formed by them, is

(a) $ml^2/12$ (b) $ml^2/6$

(c) $ml^2/3$ (d) $ml^2/2$

15. A uniform rod of length '2L' has mass per unit length 'm'. The moment of inertia of the rod about an axis passing through its centre and perpendicular to its length is

(a) $\frac{2}{3}mL^2$ (b) $\frac{1}{3}mL^2$

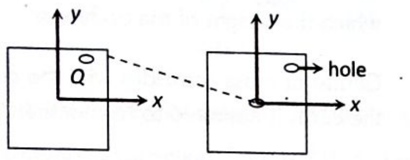
(c) $\frac{2}{3}mL^3$ (d) $\frac{4}{3}mL^3$

16. 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

(a) $I_0 + ML^2$ (b) $I_0 + \frac{ML^2}{2}$

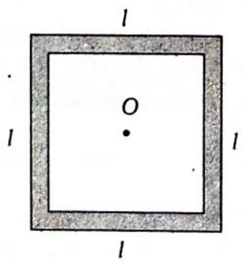
(c) $I_0 + \frac{ML^2}{4}$ (d) $I_0 + 2ML^2$

17. A uniform square plate has a small piece Q of an irregular shape removed and glued to the centre of the plate leaving a hole behind in figure. The moment of inertia about the z-axis is then,



(a) Increases
(b) Decreased
(c) The same
(d) Changed in unpredicted manner

18. 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



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

(b) $\frac{Ml^2}{3}$

(c) $\frac{Ml^2}{6}$

(d) $\frac{2}{3}Ml^2$

19. From a uniform wire, two circular loops are made (i) P of radius r and (ii) Q of radius nr. If the moment of inertia of Q about an axis passing through its centre and perpendicular to its plane is 8 times that of P about a similar axis, the value of n is (diameter of the wire is very much smaller than r or nr)

(a) 8 (b) 6

(c) 4 (d) 2

20. 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

(a) $\frac{l}{\sqrt{2}}$ (b) $\frac{l}{2}$

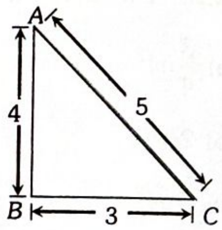
(c) l (d) $(\sqrt{2})l$

21. Moment of inertia of a disc about its own axis is I. Its moment of inertia about a tangential axis in its plane is

(a) $\frac{5}{2}I$ (b) $3I$

(c) $\frac{3}{2}I$ (d) $2I$

22. 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?



(a) I_{CA} is maximum

(b) $I_{AB} > I_{BC}$

(c) $I_{BC} > I_{AB}$

(d) $I_{AB} + I_{BC} = I_{CA}$

23. The moment of inertia of a uniform thin rod of length L and mass M about an axis passing through a point at a distance of $\frac{L}{3}$ from one of its ends and perpendicular to the rod is

(a) $\frac{7ML^2}{48}$ (b) $\frac{ML^2}{9}$

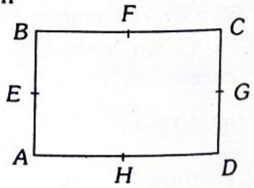
(c) $\frac{ML^2}{12}$ (d) $\frac{ML^2}{3}$

24. A rod of length L is composed of a uniform length $\frac{1}{2}L$ of wood whose mass is m_w and a uniform length $\frac{1}{2}L$ of brass whose mass is m_b. The moment of inertia I of the rod about an axis perpendicular to the rod and through its centre is equal to

(a) $(m_w + m_b)\frac{L^2}{12}$ (b) $(m_w + m_b)\frac{L^2}{6}$

(c) $(m_w + m_b)\frac{L^2}{3}$ (d) $(m_w + m_b)\frac{L^2}{2}$

25. In a rectangle $ABCD$ ($BC = 2\ AB$). The moment of inertia along which axes will be minimum



(a) BC
(b) BD
(c) HF
(d) EG

26. 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

(a) 2 : 3 (b) 2 : 1

(c) $\sqrt{5} : \sqrt{6}$ (d) $1 : \sqrt{2}$

27. From a circular disc of radius R and mass 9 M, 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

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

(c) $4MR^2$ (d) $\frac{4}{9}MR^2$

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

(a) I (b) $\frac{2I}{8}$

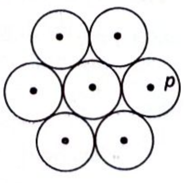
(c) $\frac{I}{5}$ (d) $\frac{I}{10}$

29. The moment of inertia of a solid disc made of thin metal of radius R and mass M about one of its diameters is given by $\frac{MR^2}{4}$. What will be the moment of inertia about this axis if the disc is folded in half about this diameter?

(a) $\frac{MR^2}{8}$ (b) $\frac{MR^2}{2}$

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

30. Seven identical coins are rigidly arranged on a flat table in the pattern shown below so that each coin touches its neighbours. Each coin is a thin disc of mass m and radius r.



Note that the moment of inertia of an individual coin about an axis passing through center and perpendicular to the plane of the coin is $\frac{mr^2}{2}$. The moment of inertia of the system of seven coins about an axis that passes through the point P (the centre of the coin positioned directly to the right of the central coin) and perpendicular to the plane of the coins is

(a) $\frac{55}{2}mr^2$ (b) $\frac{127}{2}mr^2$

(c) $\frac{111}{2}mr^2$ (d) $55mr^2$

31. The moments of inertial of a non – uniform circular disc (of mass M and radius R) about four mutually perpendicular tangents $AB, BC\,CD, DA$ are I_1, I_2, I_3 and I_4 respectively (the square $ABCD$ circumscribes the circle). The distance of the centre of mass of the disc from its geometrical centre is given by

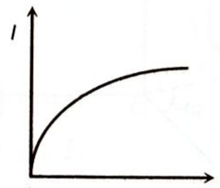
(a) $\frac{1}{4MR}\sqrt{(I_3 - I_3)^2 + (I_2 - I_4)^2}$

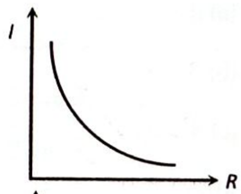
(b) $\frac{1}{12MR}\sqrt{(I_3 - I_3)^2 + (I_2 - I_4)^2}$

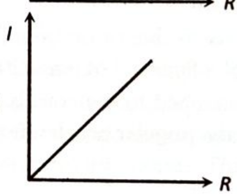
(c) $\frac{1}{3MR}\sqrt{(I_1 - I_2)^2 + (I_2 - I_4)^2}$

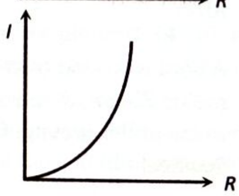
(d) $\frac{1}{2MR}\sqrt{(I_1 + I_3)^2 + (I_2 + I_4)^2}$

32. Moment of inertia of a sphere of mass M and radius R is I. Keeping M constant if a graph is plotted between I and R, then its form would be

(a)


(b)


(c)


(d)


4. Torque and Couple

1. A tap can be operated easily using two fingers because

(a) The force available for the operation will be more

(b) This helps application of angular forces

(c) The rotational effect is caused by the couple formed

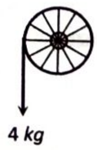
(d) The force by one finger overcomes friction and other finger provides the force for the operation

2. A 10 kg body hangs at rest from a rope wrapped around a cylinder 0.2 m in diameter. The torque applied about the horizontal axis of the cylinder is

(a) 98 N-m (b) 19.6 N-m

(c) 196 N-m (d) 9.8 N-m

3. A wheel of radius 0.4 m can rotate freely about its axis as shown in the figure. A string is wrapped over its rim and a mass of 4 kg is hung. An angular acceleration of 8 rad-s^{-2} is produced in it due to the torque. Then, moment of inertia of the wheel is $(g = 10ms^{-2})$



(a) $2\,kg - m^2$

(b) $1\,kg - m^2$

(c) $4\,kg - m^2$

(d) $8\,kg - m^2$

4. A constant torque of 1000*N-m* turns a wheel of moment of inertia 200kg-m^2 about an axis through its centre. Its angular velocity after 3*sec* is

(a) 1 rad/sec (b) 5 rad/sec

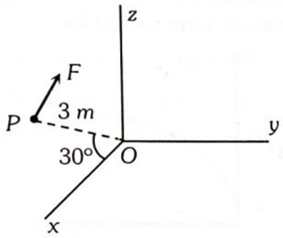
(c) 10 rad/sec (d) 15 rad/sec

5. A torque of 30 *N–m* is applied on a 5 *kg* wheel whose moment of inertia is $2 kg - m^2$ for 10 *sec*. The angle covered by the wheel in 10 *sec* will be

(a) 750 *rad*. (b) 1500 *rad*.

(c) 3000 *rad*. (d) 6000 *rad*

6. A force $F = 2.0\,N$ acts on a particle *P* in the *xz*-plane. The force *F* is parallel to *x*-axis. The particle *P* (as shown in the figure) is at a distance 3 *m* and the line joining *P* with the origin makes angle 30° with the *x*-axis. The magnitude of torque on *P* with respect to origin *O* (in *N-m*) is



(a) 2

(b) 3

(c) 4

(d) 5

7. A cord is wound over the rim of a flywheel of mass 20 *kg* and radius 25 *cm*. A mass 2.5 *kg* attached to the cord is allowed to fall under gravity. Calculate the angular acceleration of the flywheel

(a) $25\,rad/s^2$ (b) $20\,rad/s^2$

(c) $10\,rad/s^2$ (d) $5\,rad/s^2$

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

(a) $\frac{2\pi}{15}$ *N-m* (b) $\frac{\pi}{12}$ *N-m*

(c) $\frac{\pi}{15}$ *N-m* (d) $\frac{\pi}{18}$ *N-m*

9. A ladder rests against a frictionless vertical wall, with its upper end 6*m* above the ground and the lower end 4*m* away from the wall. The weight of the ladder is 500 *N* and its C. G. at 1/3rd distance from the lower end. Wall's reaction will be, (in *newton*)

(a) 111 (b) 333

(c) 222 (d) 129

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

(a) 50 s^{-2} (b) 25 s^{-2}

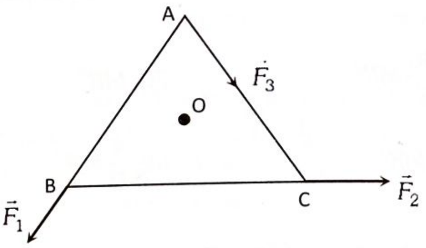
(c) 12.5 s^{-2} (d) 6.25 s^{-2}

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

(a) $t = 2\,s$ (b) $t = 1\,s$

(c) $t = 0.2\,s$ (d) $t = 0.25\,s$

12. *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 then the magnitude of $\vec{F}_3$ is



(a) $F_1 + F_2$ (b) $F_1 - F_2$

(c) $\frac{F_1 + F_2}{2}$ (d) $2(F_1 + F_2)$

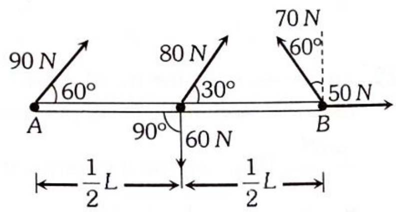
13. The total torque about pivot *A* provided by the forces shown in the figure, for $L = 3.0\,m$, is

(a) $210\,Nm$

(b) $140\,Nm$

(c) $95\,Nm$

(d) $75\,Nm$

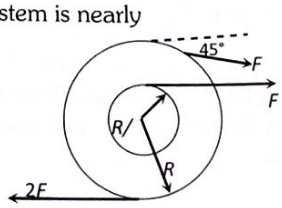


14. A solid cylinder of mass 50 *kg* and radius 0.5 *m* is free to rotate about the horizontal axis. A massless string is wound round the cylinder with one end attached to it and other hanging freely. Tension in the string required to produce an angular acceleration of 2 revolutions s^{-2} is

(a) 78.5 *N* (b) 157 *N*

(c) 25 *N* (d) 50 *N*

15. A wheel of radius *R* with an axle of radius $R/2$ is shown in the figure and is free to rotate about a frictionless axis through its centre and perpendicular to the page. Three forces (*F*, *F*, 2*F*) are exerted tangentially to the respective rims as shown in the figure. The magnitude of the net torque acting on the system is nearly



(a) 3.5*FR* (b) 3.2*FR*

(c) 3.5*FR* (d) 1.5*FR*

16. Consider two masses with $m_1 > m_2$ connected by a light inextensible string that passes over a pulley of radius R and moment of inertia I about its axis of rotation. The string does not slip on the pulley and the pulley turns without friction. The two masses are released from rest separated by a vertical distance $2h$. When the two masses pass each other, the speed of the masses is proportional to

(a) $\sqrt{\dfrac{m_1 - m_2}{m_1 + m_2 + \dfrac{I}{R^2}}}$ (b) $\sqrt{\dfrac{(m_1 + m_2)(m_1 - m_2)}{m_1 + m_2 + \dfrac{I}{R^2}}}$

(c) $\sqrt{\dfrac{m_1 + m_2 + \dfrac{I}{R^2}}{m_1 - m_2}}$ (d) $\sqrt{\dfrac{\dfrac{I}{R^2}}{m_1 + m_2}}$

5. Angular Momentum

1. A uniform heavy disc is rotating at constant angular velocity ω about a vertical axis through its centre 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

(a) ω (b) ω and L both

(c) L only (d) Neither ω nor L

2. The principle of conservation of angular momentum, states that angular momentum

(a) Always remains conserved

(b) Is the product of moment of inertia and velocity

(c) Remains conserved until the torque acting on it remains constant

(d) None of these

3. When a man stands on a turn-table stretching with two equal loads in hand and rotates. Then he folds his arm. Which of the following statement is correct?

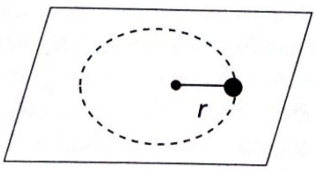
(a) Linear momentum is conserved

(b) Kinetic energy increases

(c) Angular momentum increases

(d) Angular velocity increases

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



(a) Increase by a factor of 4 (b) Decrease by a factor of 2

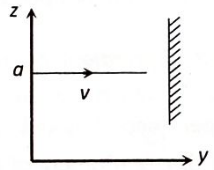
(c) Remain constant (d) Increase by a factor of 2

5. A round disc of moment of inertia I_2 about its axis perpendicular to its plane and passing, through its centre is placed over another disc of moment of inertia I_1 rotating with an angular velocity ω about the same axis. The final angular velocity of the combination of discs is

(a) $\dfrac{I_2\omega}{I_1 + I_2}$ (b) ω

(c) $\dfrac{I_1\omega}{I_1 + I_2}$ (d) $\dfrac{(I_1 + I_2)\omega}{I_1}$

6. A particle of mass m is moving in yz-plane with a uniform velocity v with its trajectory running parallel to $+ve$ y-axis and intersecting z-axis at $z = a$ in figure. The change in its angular momentum about the origin as it bounces elastically from a wall at $y =$ constant is



(a) $mva\,\hat{e}_x$ (b) $2mva\,\hat{e}_x$

(c) $ymv\,\hat{e}_x$ (d) $2ymv\,\hat{e}_x$

7. A merry-go-round, made of a ring-like platform of radius R and mass M, is revolving with angular speed ω. A person of mass M is standing on it. At one instant, the person jumps off the round, radially away from the centre of the round (as seen from the round). The speed of the round of afterwards is

(a) 2ω (b) ω

(c) $\dfrac{\omega}{2}$ (d) 0

8. 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

(a) $\sqrt{\omega_2} : \sqrt{\omega_1}$ (b) $\sqrt{\omega_1} : \sqrt{\omega_2}$

(c) $\omega_1 : \omega_2$ (d) $\omega_2 : \omega_1$

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

(a) 6 hours (b) 12 hours

(c) 18 hours (d) 24 hours

10. 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

(a) π s (b) $\dfrac{3\pi}{2}$ s

(c) 2π s (d) $\dfrac{\pi}{2}$ s

11. A bar of length ℓ carrying a small mass m at one of its ends rotates with a uniform angular speed ω in a vertical plane about the mid-point of the bar. During the rotation, at some instant of time when the bar is horizontal, the mass is detached from the bar but the bar continues to rotate with same ω. The mass moves vertically up, comes back and reaches the bar at the same point. At that place, the acceleration due to gravity is g

(a) This is possible if the quantity $\frac{\omega^2 \ell}{2\pi g}$ is an integer

(b) The total time of flight of the mass is proportional to ω^2

(c) The total distance travelled by the mass in air is proportional to ω^2

(d) The total distance travelled by the mass in air and its total time of flight are both independent on its mass

12. A horizontal disk of moment of inertia $4.25 kg-m^2$ with respect to its axis of symmetry is spinning counter clockwise at 15 revolutions per second about its axis, as viewed from above. A second disk of moment of inertia $1.80 kg-m^2$ with respect to its axis of symmetry is spinning clockwise at 25 revolutions per second as viewed from above about the same axis and is dropped on top of the first disk. The two disks stick together and rotate as one about their axis of symmetry. The new angular velocity of the system as viewed from above is close to

(a) 18 revolutions/second and clockwise

(b) 18 revolutions/second and counter clockwise

(c) 3 revolutions/second and clockwise

(d) 3 revolutions/second and counter clockwise

6. Work, Energy and Power

1. 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

(a) $\frac{K^2}{R^2}$ (b) $\frac{K^2}{K^2+R^2}$

(c) $\frac{R^2}{K^2+R^2}$ (d) $\frac{K^2+R^2}{R^2}$

2. A solid spherical ball rolls on an inclined plane without slipping. The ratio of rotational energy and total energy is

(a) 2/5 (b) 2/7

(c) 3/5 (d) 3/7

3. The M.I. of a body about the given axis is $1.2\ kg \times m^2$ initially the body is at rest. In order to produce a rotational kinetic energy of 1500 J, an angular acceleration of $25\ rad/sec^2$ musr be applied about that axis for duration of

(a) 4 *sec* (b) 2 *sec*

(c) 8 *sec* (d) 10 *sec*

4. An automobile engine develops 100 *kW* when rotating at a speed of 1800 rev/*min*. What torque does it deliver?

(a) 350 *N-m* (b) 440 *N-m*

(c) 531 *N-m* (d) 628 *N-m*

5. Two bodies have their moments of inertia I and $2I$ respectively about their axis of rotation. If their kinetic energies of rotation are equal, their angular momentum will be in the ratio

(a) 1 : 2 (b) $\sqrt{2}:1$

(c) 2 : 1 (d) $1:\sqrt{2}$

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

(a) Disc (b) Sphere

(c) Cylinder (d) Ring

7. The total kinetic energy of rolling solid sphere having translational velocity v is

(a) $\frac{7}{10}mv^2$ (b) $\frac{1}{2}mv^2$

(c) $\frac{2}{5}mv^2$ (d) $\frac{10}{7}mv^2$

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

(a) 8 *m/s* (b) 0.5 *m/s*

(c) 2 *m/s* (d) 1 *m/s*

9. The moment of inertia of a body about a given axis is 2.4 kg–m^2. To produce a rotational kinetic energy of 750 J, an angular acceleration of 5 rad/s^2 must be applied about that axis for

(a) 6 *sec* (b) 5 *sec*

(c) 4 *sec* (d) 3 *sec*

10. A solid homogeneous sphere is moving on a rough horizontal surface partly rolling and partly sliding. During this kind of motion of the sphere

(a) Total kinetic energy is conserved

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

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

(d) Angular momentum about the centre of mass is conserved

11. 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

(a) 25 (b) 5/4

(c) 5 (d) 1/4

12. A hollow sphere of diameter 0.2 m and mass 2 kg is rolling on an inclined plane with velocity $\upsilon = 0.5\ m/s$. The kinetic energy of the sphere is

(a) 0.1 J (b) 0.3 J

(c) 0.5 J (d) 0.42 J

13. If rotational kinetic energy is 50% of translational kinetic energy, then the body is

(a) Ring (b) Cylinder

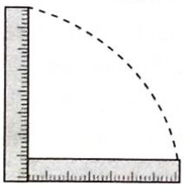
(c) Hollow sphere (d) Solid sphere

14. 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

(a) $\frac{1}{2}\frac{I_b I_t}{(I_t + I_b)}\omega_i^2$ (b) $\frac{1}{2}\frac{I_b^2}{(I_t + I_b)}\omega_i^2$

(c) $\frac{1}{2}\frac{I_t^2}{(I_t + I_b)}\omega_i^2$ (d) $\frac{I_b - I_t}{(I_t + I_b)}\omega_i^2$

15. A metre stick is held vertically with one end on the floor and is then allowed to fall. If the end touching the floor is not allowed to slip, the other end will hit the ground with a velocity of ($g = 9.8 m/s^2$)



(a) 3.2 m/s

(b) 5.4 m/s

(c) 7.6 m/s

(d) 9.2 m/s

16. A metre stick of mass 400 g is pivoted at one end and displaced through an angle 60°. The increase in its potential energy is

(a) 2 J (b) 3 J

(c) 0 J (d) 1 J

17. A uniform rod of length $2L$ 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

(a) $\omega = \sqrt{\frac{3g \sin \alpha}{2L}}$ (b) $\omega = \sqrt{\frac{2L}{3g \sin \alpha}}$

(c) $\omega = \sqrt{\frac{6g \sin \alpha}{L}}$ (d) $\omega = \sqrt{\frac{L}{g \sin \alpha}}$

18. A thin uniform rod mass m and length l is hinged at the lower end to a level floor and stands vertically. It is now allowed to fall, then its upper end will strike the floor with a velocity given by

(a) $\sqrt{2gl}$ (b) $\sqrt{3gl}$

(c) $\sqrt{5gl}$ (d) $\sqrt{mgl}$

7. Rolling on Inclined Plane

1. 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?

(a) $\sqrt{\frac{3}{4}gh}$ (b) $\sqrt{\frac{4}{3}gh}$

(c) $\sqrt{4gh}$ (d) $\sqrt{2gh}$

2. The speed of a homogeneous solid sphere after rolling down an inclined plane of vertical height h, form rest without sliding, is

(a) $\sqrt{\frac{10}{7}gh}$ (b) $\sqrt{gh}$

(c) $\sqrt{\frac{6}{5}gh}$ (d) $\sqrt{\frac{4}{3}gh}$

3. 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

(a) 5.29 m/sec (b) $4.1 \times 10^3\ m/sec$

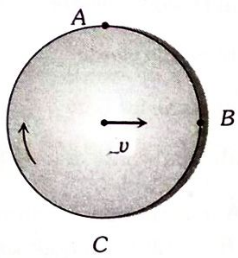
(c) 51 m/sec (d) 51 cm/sec

4. A wheel is rolling along the ground with a speed of 2 ms^{-1}. The magnitude of the velocity of the points at the extremities of the horizontal diameter of the wheel is equal to

(a) $2\sqrt{10}\ ms^{-1}$ (b) $2\sqrt{3}\ ms^{-1}$

(c) $2\sqrt{2}\ ms^{-1}$ (d) $2 ms^{-1}$

5. A solid disc rolls clockwise without slipping over a horizontal path with a constant speed υ. Then the magnitude of the velocities of points A, B and C (see figure) with respect to a standing observer are respectively



(a) υ, υ and υ

(b) $2\upsilon, \sqrt{2}\upsilon$ and zero

(c) $2\upsilon, 2\upsilon$ and zero

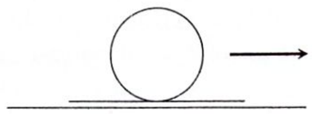
(d) $2\upsilon, \sqrt{2}\upsilon$ and $\sqrt{2}\upsilon$

6. A solid sphere of mass 1kg, radius 10cm rolls down an inclined plane of height 7m. The velocity of its centre as it reaches the ground level is

(a) $7m/s$ (b) $10m/s$

(c) $15m/s$ (d) $20m/s$

7. A ball rests upon a flat piece of paper on a table top. The paper is pulled horizontally but quickly towards right as shown. Relative to its initial position with respect to the table, the ball



(1) Remains stationary if there is no friction between the paper and the ball.

(2) Moves to the left and starts rolling backwards, *i.e.*, to the left if there is a friction between the paper and the ball.

(3) Moves forward, *i.e.*, in the direction in 'which the paper is pulled.

Here, the correct statement/s is/are

(a) Both (1) and (2) (b) Only (3)

(c) Only (1) (d) Only (2)

8. A sphere rolls down on an inclined plane of inclination θ. What is the acceleration as the sphere reaches bottom

(a) $\frac{5}{7}g\sin\theta$ (b) $\frac{3}{5}g\sin\theta$

(c) $\frac{2}{7}g\sin\theta$ (d) $\frac{2}{5}g\sin\theta$

9. A solid sphere rolls down two different inclined planes of same height, but of different inclinations. In both cases

(a) Speed and time of descent will be same

(b) Speed will be same, but time of descent will be different

(c) Speed will be different, but time of descent will be same

(d) Speed and time of descent both are different

10. If a hollow cylinder and a solid cylinder are allowed to roll down an inclined plane, which will take more time to reach the bottom

(a) Hollow cylinder

(b) Solid cylinder

(c) Same for both

(d) One whose density is more

11. A uniform non – deformable cylinder of mass m and radius R is rolling without slipping on a horizontal rough surface. The force of friction is

(a) μmg, where μ is the coefficient of sliding friction

(b) Zero

(c) Increases with time

(d) Decreases with time

12. A solid uniform sphere having a mass M, radius R, and moment of inertia of $\frac{2}{5}MR^2$ rolls down a plane inclined at an angle θ to the horizontal starting from rest. The coefficient of static friction between the sphere and the plane is μ. Then

(a) The sphere will always roll without slipping

(b) The sphere will always slide

(c) The sphere will roll without slipping only if $\theta \le \sin\frac{7\mu}{2}$

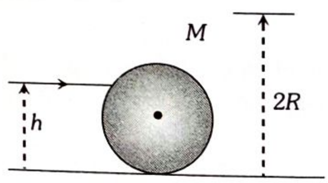
(d) The sphere will roll without slipping only if $\theta \le \tan^{-1}\frac{7\mu}{2}$

13. A cubical box of side a sitting on a rough table – top is pushed horizontally with a gradually increasing force until the box moves. If the force is applied at a height from the table top which is greater than a critical height H, the box topples first. If it is applied at a height less than H, the box starts sliding first. Then the coefficient of friction between the box and the table top is

(a) $\frac{a}{2H}$ (b) $\frac{2H}{a}$

(c) $\frac{a}{H}$ (d) $\frac{H}{a}$

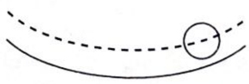
14. A bullet of mass m is fired horizontally into a large sphere of mass M and radius R resting on a smooth horizontal table. The bullet hits the sphere at a height h from the table and sticks to its surface. If the sphere starts rolling without slipping immediately on impact, then



(a) $\frac{h}{R}=\frac{4m+3M}{2(m+M)}$ (b) $\frac{h}{R}=\frac{m+3M}{m+2M}$

(c) $\frac{h}{R}=\frac{10m+7M}{5(m+M)}$ (d) $\frac{h}{R}=\frac{4m+3M}{m+M}$

15. A ball is rolling without slipping in a spherical shallow bowl (radius R) as shown in the figure and is executing simple harmonic motion. If the radius of the ball is doubled, the period of oscillation



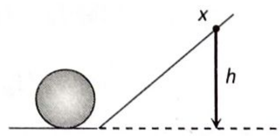
(a) Increases slightly

(b) Is reduced by a factor of 1/2

(c) Is increased by a factor of 2

(d) Decreases slightly

16. A solid sphere rolls without slipping, first horizontal and then up to a point X at height h on an inclined plane before rolling down, as shown. The initial horizontal speed of the sphere is



(a) $\sqrt{\frac{10gh}{7}}$ (b) $\sqrt{\frac{7gh}{5}}$

(c) $\sqrt{\frac{5gh}{7}}$ (d) $\sqrt{2gh}$

17. A solid cylinder P rolls without slipping from rest down an inclined plane attaining a speed V_p at the bottom. Another smooth solid cylinder Q of same mass and dimensions slides without friction from rest down the inclined plane attaining a speed V_q at the bottom. The ratio of the speeds $\left(\frac{V_p}{V_q}\right)$ is

(a) $\left(\sqrt{\frac{3}{4}}\right)$ (b) $\left(\sqrt{\frac{3}{2}}\right)$

(c) $\left(\sqrt{\frac{2}{3}}\right)$ (d) $\left(\sqrt{\frac{4}{3}}\right)$

18. A solid sphere spinning about a horizontal axis with an angular velocity ω is placed on a horizontal surface. Subsequently it rolls without slipping with an angular velocity of

(a) $\frac{2\omega}{5}$ (b) $\frac{7\omega}{5}$

(c) $\frac{2\omega}{7}$ (d) ω

19. A uniform ring of radius R is moving on a horizontal surface with speed υ and then climbs up a ramp of inclination 30° to a height h. There is no slipping in the entire motion. The h is

(a) $\upsilon^2/2g$ (b) υ^2/g

(c) $3\upsilon^2/2g$ (d) $2\upsilon^2/g$

8. IIT-JEE/AIEEE

1. Two particles A and B initially at rest move towards each other under a mutual force of attraction. At the instant when the speed of A is υ and the speed of B is 2υ, the speed of centre of mass of the system is **[1982]**

(a) Zero (b) υ

(c) 1.5υ (d) 3υ

2. A body A of mass M while falling vertically downwards under gravity breaks into two parts; a body B of mass $1/3M$ and a body C of mass $2/3M$. The centre of mass of bodies B and C taken together shifts compared to that of body A towards **[2005]**

(a) Body C

(b) Body B

(c) Depends on height of breaking

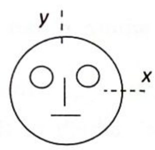
(d) Does not shift

3. Two spherical bodies of mass M and $5M$ and radii R and $2R$ respectively are released in free space with initial separation between their centres equal to $12R$. If they attract each other due to gravitational force only, then the distance covered by the smaller body just before collision is **[2003]**

(a) 1.5 R (b) 2.5 R

(c) 4.5 R (d) 7.5 R

4. Look at the drawing given in the figure which has been drawn with ink of uniform line-thickness. The mass of ink used to draw each of the two inner circles, and each of the two line segments is m. The mass of the ink used to draw the outer circle is 6 m. The coordinates of the centres of the different parts are : outer circle (0, 0), left inner circle $(-a, a)$, right inner circle (a, a), vertical line (0, 0) and horizontal line $(0, -a)$. The y-coordinate of the centre of mass of the ink in this drawing is **[2009]**



(a) $a/10$ (b) $a/8$

(c) $a/12$ (d) $a/3$

5. Consider a system of two particles having masses m_1 and m_2. If the particle of mass m_1 is pushed towards the centre of mass of particles through a distance d, by what distance would be particle of mass m_2 move so as to keep the centre of mass of particles at the original position **[2006]**

(a) $\frac{m_1}{m_1+m_2}d$ (b) $\frac{m_1}{m_2}d$

(c) d (d) $\frac{m_2}{m_1}d$

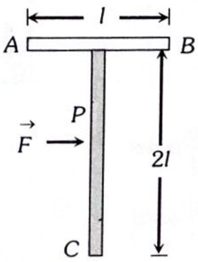
6. A 'T' shaped object with dimensions shown in the figure, is lying on a smooth floor. A force '$\vec{F}$' is applied at the point P parallel to AB, such that the object has only the translational motion without rotation. Find the location of P with respect to C **[2005]**

(a) $\frac{4}{3}l$

(b) l

(c) $\frac{2}{3}l$

(d) $\frac{3}{2}l$



7. An isolated particle of mass m is moving in a horizontal plane (X-Y) along the X-axis at a certain height above the ground. It suddenly explodes into two fragments of masses $m/4$ and $3m/4$. An instant later, the smaller fragment is at $y = 15$ cm. The larger fragment at this instant is at **[1997]**

(a) $y = -5$ cm (b) $y = +20$ cm

(c) $y = +5$ cm (d) $y = -20$ cm

8. A circular disc of radius R is removed from a bigger circular disc of radius $2R$ such that the circumferences of the discs coincide. The centre of mass of the new disc is αR from the centre of the bigger disc. The value of α is **[2007]**

(a) 1/3 (b) 1/2

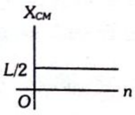
(c) 1/6 (d) 1/4

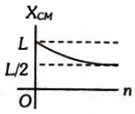
9. Distance of the centre of mass of a solid uniform cone form its vertex is z_0. If the radius of its base is R and its height is h the z_0 is equal to **[2015]**

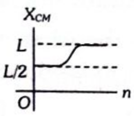
(a) $\frac{h^2}{4R}$ (b) $\frac{3h}{4}$

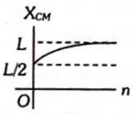
(c) $\frac{5h}{8}$ (d) $\frac{3h^2}{8R}$

10. A thin rod of length 'L' lying along the x-axis with its ends at $x = 0$ and $x=L$. Its linear density (mass/length) varies with x as $k\left(\frac{x}{L}\right)^n$, where n can be zero or any positive number. If the position x_{cm} of the centre of mass of the rod is plotted against 'n', which of the following graphs best approximates the dependence of x_{cm} on n **[2008]**

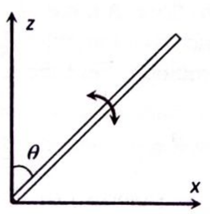
(a) 

(b) 

(c) 

(d) 

11. 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



[2017]

(a) $\frac{2g}{3l}\cos\theta$ (b) $\frac{3g}{2l}\sin\theta$

(c) $\frac{2g}{3l}\sin\theta$ (d) $\frac{3g}{2l}\cos\theta$

12. 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 **[2004]**

(a) $I_A = I_B$ (b) $I_A > I_B$

(c) $I_A < I_B$ (d) $I_A / I_B = d_A / d_B$

where d_A and d_B are their densities.

13. A solid sphere of mass M, radius R and having moment of inertia about an axis passing through the centre of mass as I, is recast into a disc of thickness t, whose moment of inertia about an axis passing through its edge and perpendicular to its plane remains I. Then, radius of the disc will be **[2006]**

(a) $\frac{2R}{\sqrt{15}}$ (b) $R\sqrt{\frac{2}{15}}$

(c) $\frac{4R}{\sqrt{15}}$ (d) $\frac{R}{4}$

14. The moment of inertia of semicircular ring about an axis which is perpendicular to the plane of the ring and passes through the centre **[2002]**

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

(c) $\frac{MR^2}{4}$ (d) None of these

15. 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 **[2008]**

(a) $\frac{1}{12}ma^2$ (b) $\frac{7}{12}ma^2$

(c) $\frac{2}{3}ma^2$ (d) $\frac{5}{6}ma^2$

16. From a solid sphere of mass M and radius R a cube of maximum possible volume is cut. Moment of inertia of cube about an axis passing through its centre and perpendicular to one of its faces is **[2015]**

(a) $\frac{MR^2}{32\sqrt{2}\pi}$ (b) $\frac{MR^2}{16\sqrt{2}\pi}$

(c) $\frac{4MR^2}{9\sqrt{3}\pi}$ (d) $\frac{4MR^2}{3\sqrt{3}\pi}$

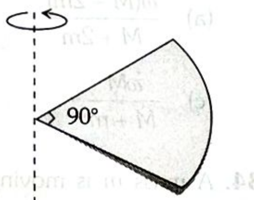
17. One quarter sector is cut from a uniform circular disc of radius R. This sector has mass M. It is made to rotate about a line perpendicular to its plane and passing through the centre of the original disc. Its moment of inertia about the axis of rotation is **[2001]**

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

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

(c) $\frac{1}{8}MR^2$

(d) $\sqrt{2}\,MR^2$



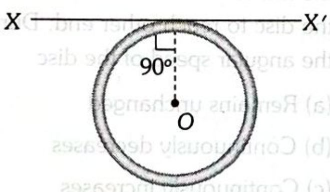
18. A thin wire of length L and uniform linear mass density ρ is bent into a circular loop with centre at O as shown. The moment of inertia of the loop about the axis XX' is **[2000]**

(a) $\frac{\rho L^3}{8\pi^2}$

(b) $\frac{\rho L^3}{16\pi^2}$

(c) $\frac{5\rho L^3}{16\pi^2}$

(d) $\frac{3\rho L^3}{8\pi^2}$

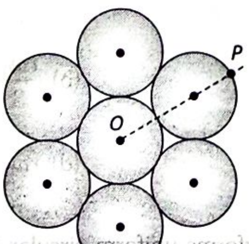


19. Let I be the moment of inertia of a uniform square plate about an axis AB that passes through its centre and is parallel to two of its sides. CD is a line in the plane of the plate that passes through the centre of the plate and makes an angle θ with AB. The moment of inertia of the plate about the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

(a) I (b) $I\sin^2\theta$

(c) $I\cos^2\theta$ (d) $I\cos^2\frac{\theta}{2}$

20. Seven identical circular planer 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

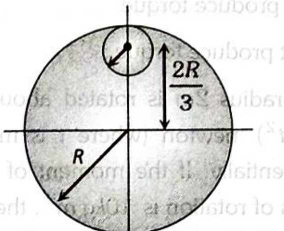


[2018]

(a) $\frac{73}{2}MR^2$ (b) $\frac{181}{2}MR^2$

(c) $\frac{19}{2}MR^2$ (d) $\frac{55}{2}MR^2$

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



[2018]

(a) $10MR^2$ (b) $\frac{37}{9}MR2$

(c) $4MR^2$ (d) $\frac{40}{9}MR^2$

22. 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 **[2017]**

(a) $\frac{3}{\sqrt{2}}$ (b) $\sqrt{\frac{3}{2}}$

(c) $\frac{\sqrt{3}}{2}$ (d) 1

23. Let $\vec{F}$ be the force acting on a particle having position vector $\vec{r}$ and $\vec{T}$ be the torque of this force about the origin. Then **[2003]**

(a) $\vec{r}.\vec{T}=0$ and $\vec{F}.\vec{T}=0$ (b) $\vec{r}.\vec{T}=0$ and $\vec{F}.\vec{T}\neq 0$

(c) $\vec{r}.\vec{T}\neq 0$ and $\vec{F}.\vec{T}=0$ (d) $\vec{r}.\vec{T}\neq 0$ and $\vec{F}.\vec{T}\neq 0$

24. A force of $-F\hat{k}$ acts on O, the origin of the coordinate system. The torque about the point (1, –1) is **[2006]**

(a) $-F(\hat{i}+\hat{j})$ (b) $F(\hat{i}+\hat{j})$

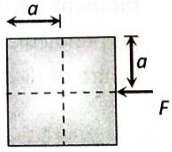
(c) $-F(\hat{i}-\hat{j})$ (d) $F(\hat{i}-\hat{j})$

25. 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 **[2005]**

(a) 1 (b) R_1/R_2

(c) R_2/R_1 (d) $(R_1/R_2)^2$

26. A horizontal force F is applied such that the block remains stationary then which of the following statement is false **[2005]**



(a) $f = mg$ [where f is the friction force]

(b) $F = N$ [where N is the normal force]

(c) F will not produce torque

(d) N will not produce torque

27. 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 **[2011]**

(a) Less than 3

(b) More than 3 but less than 6

(c) More than 6 but less than 9

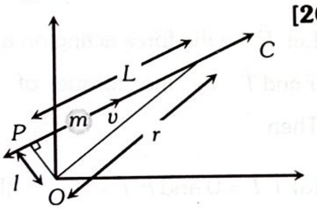
(d) More than 9

28. 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 **[2014]**

(a) $\frac{3}{2}g$ (b) g

(c) $\frac{2}{3}g$ (d) $\frac{g}{3}$

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



(a) mvL

(b) mvl

(c) mvr

(d) Zero

30. A solid sphere is rotating in free space. If the radius of the sphere is increased keeping mass same which one of the following will not be affected **[2004]**

(a) Moment of inertia (b) Angular momentum

(c) Angular velocity (d) Rotational kinetic energy

31. Angular momentum of the particle rotating with a central force is constant due to **[2007]**

(a) Constant Forces

(b) Constant linear momentum

(c) Zero Torque

(d) Constant Torque

32. A particle undergoes uniform circular motion. About which point on the plane of the circle, will the angular momentum of the particle remain conserved **[2003]**

(a) Centre of the circle

(b) On the circumference of the circle

(c) Inside the circle

(d) Outside the circle

33. 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 will now rotate with an angular velocity **[1983]**

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

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

34. 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 **[1985]**

(a) Zero (b) Remains constant

(c) Goes on increasing (d) Goes on decreasing

35. A thin horizontal circular disc is rotating about a vertical axis passing through its centre. An insect is at rest at a point near the rim of the disc. The insect now moves along a diameter of the disc to reach other end. During the journey of the insect, the angular speed of the disc **[2011]**

(a) Remains unchanged

(b) Continuously decreases

(c) Continuously increases

(d) First increases and then decreases

36. A thin and circular disc of mass M and radius R is rotating in a horizontal plane about an axis passing through its centre and perpendicular to its plane with an angular velocity ω. If another disc of same dimensions but of mass $M/4$ is placed gently on the first disc co-axially, then the new angular velocity of the system is **[2002]**

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

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

37. A hoop of radius r and mass m rotating with an angular velocity ω_0 is placed on a rough horizontal surface. The initial velocity of the centre of the hoop is zero. What will be the velocity of the centre of the hoop when it ceases to slip? **[2013]**

(a) $\frac{r\omega_0}{4}$ (b) $\frac{r\omega_0}{3}$

(c) $\frac{r\omega_0}{2}$ (d) $r\omega_0$

38. A particle performs uniform circular motion with an angular momentum L. If the frequency of a particle's motion is doubled and its kinetic energy is halved, the angular momentum becomes **[2003]**

(a) $2L$ (b) $4L$

(c) $L/2$ (d) $L/4$

39. 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 $\omega\, rad/s$ about the vertical. About the point of suspension **[2014]**

(a) Angular momentum is conserved

(b) Angular momentum changes in magnitude but not in direction

(c) Angular momentum changes in direction but not in magnitude

(d) Angular momentum changes both in direction and magnitude

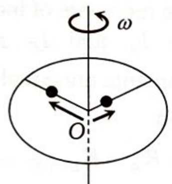
40. A ring of mass M and radius R is rotating with angular speed ω about a fixed vertical axis passing through its centre O with two point masses each of mass $\frac{M}{8}$ at rest at O. These masses can move radially outwards along two massless rods fixed on the ring as shown in the figure. At some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

(a) $\frac{2}{3}R$

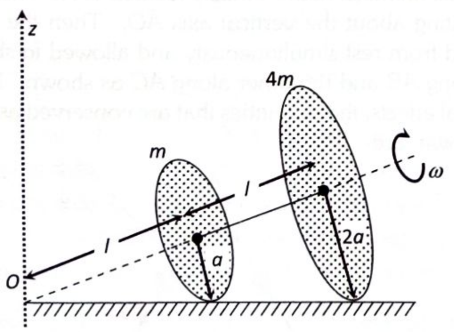
(b) $\frac{1}{3}R$

(c) $\frac{3}{5}R$

(d) $\frac{4}{5}R$



41. Two thin circular discs of mass m and $4m$, having radii of a and $2a$, respectively, are rigidly fixed by a massless, rigid rod of length $l = \sqrt{24}a$ through their centers. This assembly is laid on a firm and flat surface, and set rolling without slipping on the surface so that the angular speed about the axis of the rod is ω. The angular momentum of the entire assembly about the point 'O' is $\vec{L}$ (see the figure). Which of the following statement(s) is (are) true



[2016]

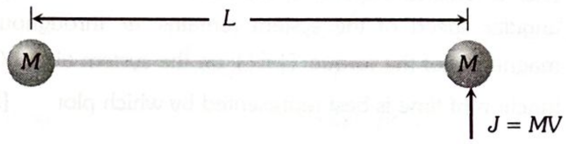
(a) The magnitude of angular momentum of the assembly about its center of mass is $17ma^2\omega/2$

(b) The magnitude of the z-component of $\vec{L}$ is $55ma^2\omega$

(c) The magnitude of angular momentum of center of mass of the assembly about the point O is $81ms^2\omega$

(d) The center of mass of the assembly rotates about the z-axis with an angular speed of $\omega/5$

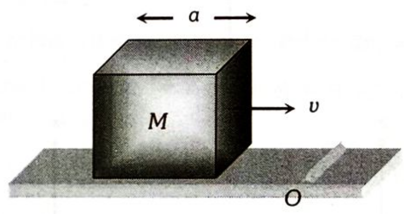
42. Consider a body, shown in figure, consisting of two identical balls, each of mass M connected by a light rigid rod. If an impulse $J = MV$ is imparted to the body at one of its ends, what would be its angular velocity **[2003]**



(a) V/L (b) $2V/L$

(c) $V/3L$ (d) $V/4L$

43. 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 **[1999]**



(a) $3v/4a$ (b) $3v/2a$

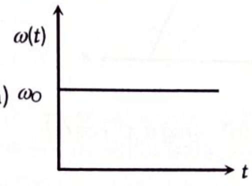
(c) $\frac{\sqrt{3}v}{\sqrt{2}a}$ (d) Zero

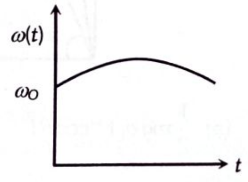
44. A smooth sphere A is moving on a frictionless horizontal plane with angular speed ω and centre of mass velocity v. It collides elastically and head-on with an identical sphere B at rest. Neglect friction everywhere. After the collision, their angular speeds are ω_A and ω_B respectively. Then **[1999]**

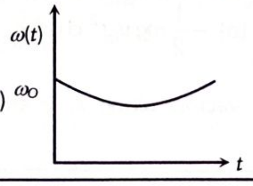
(a) $\omega_A < \omega_B$ (b) $\omega_A = \omega_B$

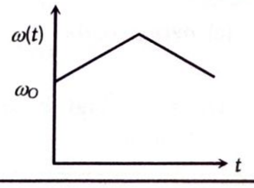
(c) $\omega_A = \omega$ (d) $\omega = \omega_B$

45. A circular platform is free to rotate in a horizontal plane about a vertical axis passing through its centre. A tortoise is sitting at the edge of the platform. Now, the platform is given an angular velocity ω_0. When the tortoise moves along a chord of the platform with a constant velocity (with respect to the platform), the angular velocity of the platform $\omega(t)$ will vary with time t as **[2002]**

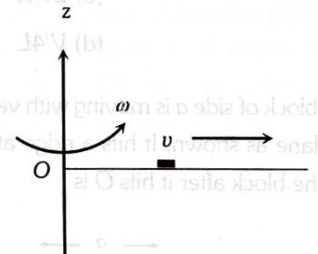
(a)


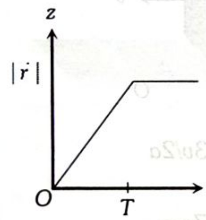
(b)


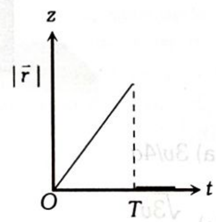
(c)


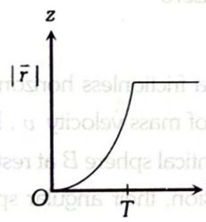
(d)


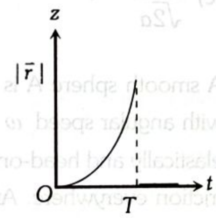
46. A thin uniform rod, pivoted at O, is rotating in the horizontal plane with constant angular speed ω, as shown in the figure. At time, $t = 0$, a small insect starts from O and moves with constant speed v with respect to the rod towards the other end. It reaches the end of the rod at $t = T$ and stops. The angular speed of the system remains ω throughout. The magnitude of the torque ($|\vec{\tau}|$) on the system about O, as a function of time is best represented by which plot **[2012]**



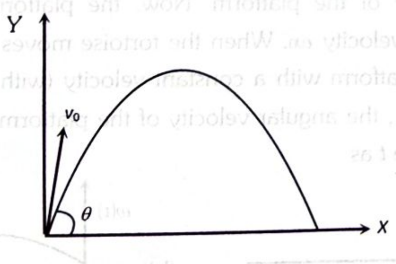
(a)


(b)


(c)


(d)


47. A small particle of mass m is projected at an angle θ with the x-axis with an initial velocity v_0 in the x-y plane as shown in the figure. At a time $t < \frac{v_0 \sin\theta}{g}$, the angular momentum of the particle is **[2010]**

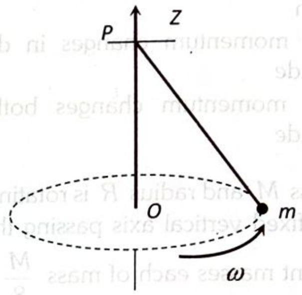


(a) $\frac{1}{2} mg v_0 t^2 \cos\theta\, \hat{i}$ (b) $-mg v_0 t^2 \cos\theta\, \hat{j}$

(c) $mg v_0 t \cos\theta\, \hat{k}$ (d) $-\frac{1}{2} mg v_0 t^2 \cos\theta\, \hat{k}$

where $\hat{i}, \hat{j}$ and $\hat{k}$ are unit vectors along x, y and z-axis respectively

48. A small mass m is attached to a massless string whose other end is fixed at P as shown in the figure. The mass is undergoing circular motion in the $x-y$ plane with centre at O and constant angular speed ω. If the angular momentum of the system, calculated about O and P are denoted by $\vec{L}_O$ and $\vec{L}_P$ respectively, then **[2012]**



(a) $\vec{L}_O$ and $\vec{L}_P$ do not vary with time

(b) $\vec{L}_O$ varies with time while $\vec{L}_P$ remains constant

(c) $\vec{L}_O$ remains constant while $\vec{L}_P$ varies with time

(d) $\vec{L}_O$ and $\vec{L}_P$ both vary with time

49. The moments of inertia of two freely rotating bodies A and B are I_A and I_B respectively. $I_A > I_B$ and their angular momenta are equal. If K_A and K_B are their kinetic energies, then **[2002]**

(a) $K_A = K_B$ (b) $K_A > K_B$

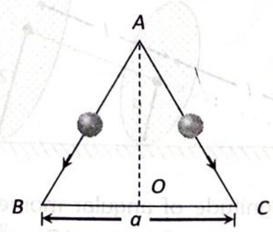
(c) $K_A < K_B$ (d) $K_A = 2K_B$

50. A child is standing with folded hands at the centre of a platform rotating about its central axis. The kinetic energy of the system is K. The child now stretches his arms so that the moment of inertia of the system doubles. The kinetic energy of the system now is **[2004]**

(a) $2K$ (b) $K/2$

(c) $K/4$ (d) $4K$

51. 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



(a) Angular velocity and total energy (kinetic and potential)

(b) Total angular momentum and total energy

(c) Angular velocity and moment of inertia about the axis of rotation

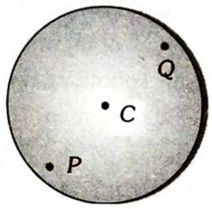
(d) Total angular momentum and moment of inertia about the axis of rotation

52. 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 centre of mass rises to a maximum height of **[2009]**

(a) $\frac{1}{3}\frac{l^2\omega^2}{g}$ (b) $\frac{1}{6}\frac{l\omega}{g}$

(c) $\frac{1}{2}\frac{l^2\omega^2}{g}$ (d) $\frac{1}{6}\frac{l^2\omega^2}{g}$

53. A disc is rolling (without slipping) on a horizontal surface. C is its center and Q and P are two points equidistant from C. Let v_P, v_Q and v_C be the magnitude of velocities of points P, Q and C respectively, then **[2004]**



(a) $v_Q > v_C > v_P$

(b) $v_Q < v_C < v_P$

(c) $v_Q = v_P, v_C = \frac{v_P}{2}$

(d) $v_Q < v_C > v_P$

54. 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. Then maximum acceleration down the plane is for (no rolling) **[2002]**

(a) Solid sphere (b) Hollow sphere

(c) Ring (d) All same

55. 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 **[2007]**

(a) $\frac{g\sin\theta}{1+\frac{I}{MR^2}}$ (b) $\frac{g\sin\theta}{1+\frac{MR^2}{I}}$

(c) $\frac{g\sin\theta}{1-\frac{I}{MR^2}}$ (d) $\frac{g\sin\theta}{1-\frac{MR^2}{I}}$

56. Two solid cylinders P and Q of same mass and same radius start rolling down a fixed inclined plane from the same height at the same time. Cylinder P has most of its mass concentrated near its surface, while Q has most of its mass concentrated near the axis. Which statement (s) is (are) correct **[2012]**

(a) Both cylinders P and Q reach the ground at the same time

(b) Cylinder P has larger linear acceleration than cylinder Q

(c) Both cylinder P and Q reaches the ground with same translational kinetic energy

(d) Cylinder Q reaches the ground with larger angular speed

57. A small object of uniform density rolls up a curved surface with an initial velocity v. It reaches up to a maximum height of $\frac{3v^2}{4g}$ with respect to the initial position. The object is **[2007]**

(a) Ring (b) Solid sphere

(c) Hollow sphere (d) Disc

58. 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 **[2002]**

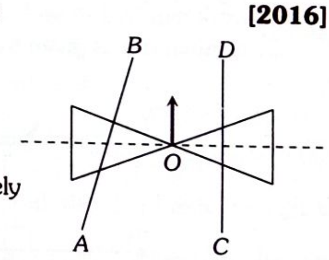
(a) Up the incline while ascending and down the incline while descending

(b) Up the incline while ascending as well as descending

(c) Down the incline while ascending and up the incline while descending

(d) Down the incline while ascending as well as descending

59. 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 **[2016]**



(a) Turn right

(b) Go straight

(c) Turn left and right alternately

(d) Turn left

9. NEET/AIPMT

1. Two spherical bodies of mass M and $5M$ and radii R and $2R$ released in free space with initial separation between their centres equal to $12R$. If they attract each other due to gravitational force only, then the distance covered by the smaller body before collision is **[2015]**

(a) 4.5 R (b) 7.5 R

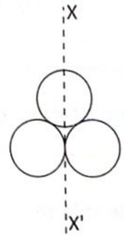
(c) 1.5 R (d) 2.5 R

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

(a) $25 m/s^2$ (b) $0.25 rad/s^2$

(c) $25 rad/s^2$ (d) $5 m/s^2$

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



(a) $3mr^2$

(b) $\frac{16}{5}mr^2$

(c) $4mr^2$

(d) $\frac{11}{5}mr^2$

4. From a disc of radius R and mass M, a circular hole of diameter R, whose rim passes through the centre is cut. What is the moment of inertia of the remaining part of the disc about a perpendicular axis, passing through the centre? **[2016]**

(a) $15MR^2/32$ (b) $13MR^2/32$

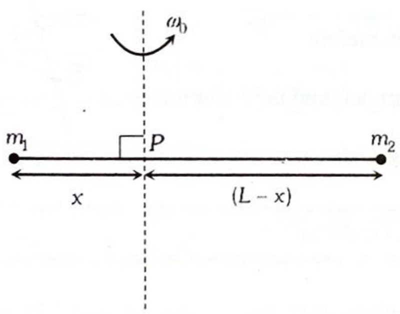
(c) $11MR^2/32$ (d) $9MR^2/32$

5. 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 **[2018]**

(a) Angular velocity (b) Moment of inertia

(c) Rotational kinetic energy (d) Angular momentum

6. 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



[2015]

(a) $x = \frac{m_1}{m_2}L$ (b) $x = \frac{m_2}{m_1}L$

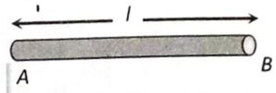
(c) $x = \frac{m_2 L}{m_1 + m_2}$ (d) $x = \frac{m_1 L}{m_1 + m_2}$

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

(a) $\sqrt{m_1 m_2 l^2}$ (b) $\frac{m_1 m_2}{m_1 + m_2} l^2$

(c) $\frac{m_1 + m_2}{m_1 m_2} l^2$ (d) $(m_1 + m_2)l^2$

8. A uniform rod AB of length l and mass m is free to rotate about point A. The rod is released from rest in horizontal position. Given that the moment of inertia of the rod about A is $\frac{ml^2}{3}$ the initial angular acceleration of the rod will be **[2013]**



(a) $\frac{2g}{3l}$ (b) $mg\frac{l}{2}$

(c) $\frac{3}{2}gl$ (d) $\frac{3g}{2l}$

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

(a) $8.58\,kg\,m^2s^{-2}$ (b) $10.86\,kg\,m^2s^{-2}$

(c) $2.86\,kg\,m^2s^{-2}$ (d) $6.66\,kg\,m^2s^{-2}$

10. A road 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 **[2015]**

(a) $\frac{Wd}{x}$ (b) $\frac{W(d-x)}{x}$

(c) $\frac{W(d-x)}{d}$ (d) $\frac{Wx}{d}$

11. Which of the following statements are correct

(A) Centre of mass of a body always coincides with the centre of gravity of the body

(B) Centre of mass of a body is the point at which the total gravitational torque on the body is zero

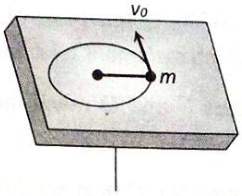
(C) A couple on a body produce both translational and rotational motion in a body

(D) Mechanical advantage greater then one means that small effort can be used to lift a large load

(a) (B) and (D) (b) (A) and (B)

(c) (B) and (C) (d) (C) and (D)

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



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

(c) $\frac{1}{2}mv_0^2$ (d) mv_0^2

13. 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 **[2016]**

(a) $L_A > L_B$ (b) $L_A = \frac{L_B}{2}$

(c) $L_A = 2L_B$ (d) $L_B > L_A$

14. Three objects, A : (a solid sphere), B : (a thin circular disk) and C = (a circular ring), each have the same mass M and radius R. They all spin with the same angular speed ω about their own symmetry axes. The amounts of work (W) required to bring them to rest, would satisfy the relation **[2018]**

(a) $W_C > W_B > W_A$ (b) $W_A > W_B > W_C$

(c) $W_B > W_A > W_C$ (d) $W_A > W_C > W_B$

15. A solid sphere is in rolling motion. In rolling motion a body possesses translational kinetic energy (K_t) as well as rotational kinetic energy (K_r) simultaneously. The ratio $K_t : (K_t + K_r)$ for the sphere is **[2018]**

(a) 7 : 10 (b) 5 : 7

(c) 10 : 7 (d) 2 : 5

16. 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? **[2016]**

(a) Disk

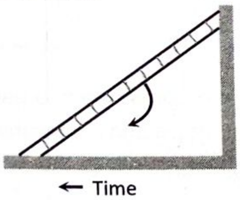
(b) Sphere

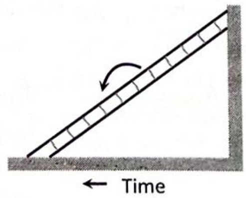
(c) Both reach at the same time

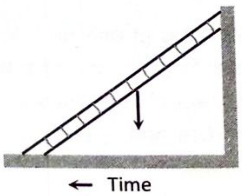
(d) Depends on their masses

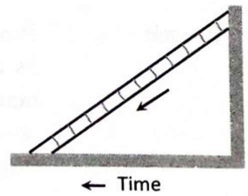
10. AIIMS

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

(a)


(b)


(c)


(d)


2. A wheel has angular acceleration of 3.0 *rad/sec*^{2} and an initial angular speed of 2.00 *rad*/sec. In a time of 2 *sec* it has rotated through an angle (In radian) of **[2008]**

(a) 6 (b) 10

(c) 12 (d) 4

3. The direction of the angular velocity vector is along **[2004]**

(a) The tangent to the circular path

(b) The inward radius

(c) The outward radius

(d) The axis of rotation

4. If the equation for the displacement of a particle moving on a circular path is given by $(\theta) = 2t^3 + 0.5$, where θ is in radians and t in seconds, then the angular velocity of the particle after 2 *sec* from its start is **[1998]**

(a) 8 rad/sec (b) 12 rad/sec

(c) 24 rad/sec (d) 36 rad/sec

5. 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 **[1995]**

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

(c) $3/4\,ma^2$ (d) $2/3\,ma^2$

6. Four point masses, each of value *m*, are placed at the corners of a square ABCD of side *l*. The moment of inertia of this system about an axis passing through A and parallel to BD is **[2008]**

(a) $\sqrt{3}\,ml^2$ (b) $3\,ml^2$

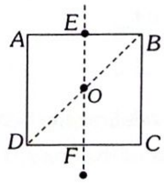
(c) ml^2 (d) $2ml^2$

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

(a) $\frac{1}{48}ML^2$ (b) $\frac{1}{12}ML^2$

(c) $\frac{1}{24}ML^2$ (d) $\frac{ML^2}{8\sqrt{3}}$

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



(a) $\sqrt{2}I_{AC} = I_{EF}$

(b) $I_{AD} = 3I_{EF}$

(c) $I_{AC} = I_{EF}$

(d) $I_{AC} = \sqrt{2}I_{EF}$

9. A uniform cylinder has a radius R and length L. If the moment of inertia of this cylinder about an axis passing through its centre and normal to its circular face is equal to the moment of inertia of the same cylinder about an axis passing through its centre and perpendicular to its length, then **[2010]**

(a) $L = R$ (b) $L = \sqrt{3}R$

(c) $L = \frac{R}{\sqrt{3}}$ (d) $L = \sqrt{\frac{3}{2}}R$

10. A constant torque of 31.4 N–m is exerted on a pivoted wheel. If angular acceleration of wheel is $4\pi rad/sec^2$, then the moment of inertia of the wheel is **[2001]**

(a) 2.5 kg–m^2 (b) 3.5 kg–m^2

(c) 4.5 kg–m^2 (d) 5.5 kg–m^2

11. A horizontal platform is rotating with uniform angular velocity around the vertical axis passing through its centre. At some instant of time a viscous fluid of mass 'm' is dropped at the centre and is allowed to spread out and finally fall. The angular velocity during this period **[2005]**

(a) Decreases continuously

(b) Decreases initially and increases again

(c) Remains unaltered

(d) Increases continuously

12. In an orbital motion, the angular momentum vector is **[2004]**

(a) Along the radius vector

(b) Parallel to the linear momentum

(c) In the orbital plane

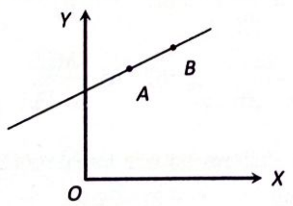
(d) Perpendicular to the orbital plane

13. A constant torque acting on a uniform circular wheel changes its angular momentum from A_0 to $4A_0$ in 4 *seconds*. The magnitude of this torque is **[1997]**

(a) $\frac{3A_0}{4}$ (b) A_0

(c) $4A_0$ (d) $12A_0$

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



(a) $L_A > L_B$

(b) $L_A = L_B$

(c) The relationship between L_A and L_B depends upon the slope of the line AB

(d) $L_A < L_B$

15. The motion of planets in the solar system is an example of the conservation of **[2003]**

(a) Mass (b) Linear momentum

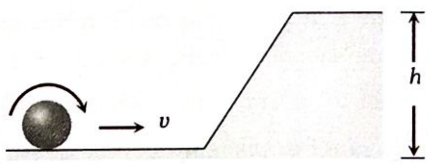
(c) Angular momentum (d) Energy

16. A body of mass m slides down an incline and reaches the bottom with a velocity v. If the same mass were in the form of a ring which rolls down this incline, the velocity of the ring at bottom would have been **[1995]**

(a) v (b) $\sqrt{2}\,v$

(c) $\frac{1}{\sqrt{2}}v$ (d) $\sqrt{\frac{2}{5}}\,v$

17. A solid sphere is rolling on a frictionless surface, shown in figure with a transnational velocity v m/s. If sphere climbs up to height h then value of v should be **[2005]**



(a) $\geq \sqrt{\frac{10}{7}gh}$ (b) $\geq \sqrt{2gh}$

(c) $2gh$ (d) $\frac{10}{7}gh$

11. Assertion & Reason

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

(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.

(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.

(c) If assertion is true but reason is false.

(d) If the assertion and reason both are false.

(e) If assertion is false but reason is true.

1. Assertion : The centre of mass of a two particle system lies on the line joining the two particles, being closer to the heavier particle.

Reason : Product of mass of one particle and its distance from centre of mass is numerically equal to product of mass of other particle and its distance from centre of mass.

2. Assertion : The centre of mass of an isolated system has a constant velocity.

Reason : If centre of mass of an isolated system is already at rest, it remains at rest.

3. Assertion : A particle is moving on a straight line with a uniform velocity, its angular momentum is always zero.

Reason : The momentum is zero when particle moves with a uniform velocity.

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

Reason : Centre of mass of a body lies always at the centre of the body

5. Assertion : A judo fighter in order to throw his opponent on to the mattress he initially bend his opponent and then rotate him around his hip.

Reason : As the mass of the opponent is brought closer to the fighter's hip, the force required to throw the opponent is reduced.

6. Assertion : At the centre of earth, a body has centre of mass, but no centre of gravity.

Reason : Acceleration due to gravity is zero at the centre of earth.

7. Assertion : It is harder to open and shut the door if we apply force near the hinge.

Reason : Torque is maximum at hinge of the door.

8. Assertion : If earth shrink (without change in mass) to half its present size, length of the day would become 6 hours.

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

9. Assertion : Radius of gyration of body is a constant quantity.

Reason : The radius of gyration of a body about an axis of rotation may be defined as the root mean square distance of the particle from the axis of rotation.

10. Assertion : A ladder is more apt to slip, when you are high up on it than when you just begin to climb.

Reason : At the high up on a ladder, the torque is large and on climbing up the torque is small.

11. Assertion : The speed of whirlwind in a tornado is alarmingly high.

Reason : If no external torque acts on a body, its angular velocity remains conserved.

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

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

13. Assertion : A wheel moving down a perfectly frictionless inclined plane will undergo slipping (not rolling motion).

Reason : For perfect rolling motion, work done against friction is zero.

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

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

15. Assertion : A light body and heavy body have same momentum. Then they also have same kinetic energy.

Reason : Kinetic energy does not depend on mass of the body.

7. Rotational Motion Theory – Answers Keys

1. Centre of Mass

1	d	2	c	3	d	4	a	5	c
6	a	7	b	8	a	9	d	10	c
11	b	12	b	13	b	14	c	15	c
16	a	17	a	18	d	19	d	20	c
21	a	22	a						

2. Angular Displacement, Velocity and Acceleration

1	d	2	a	3	a	4	b	5	d
6	d	7	c	8	d	9	d	10	a
11	d	12	b						

3. Moment of Inertia

1	b	2	b	3	b	4	c	5	b
6	d	7	c	8	c	9	a	10	a
11	d	12	a	13	a	14	b	15	c
16	c	17	b	18	a	19	d	20	a
21	a	22	c	23	b	24	a	25	d
26	c	27	a	28	c	29	c	30	c
31	a	32	d						

4. Torque and Couple

1	c	2	b	3	a	4	d	5	a
6	b	7	c	8	c	9	a	10	c
11	b	12	a	13	d	14	b	15	a
16	a								

5. Angular Momentum

1	c	2	d	3	bd	4	a	5	c
6	b	7	a	8	a	9	a	10	c
11	acd	12	d						

6. Work, Energy and Power

1	b	2	b	3	b	4	c	5	d
6	d	7	a	8	d	9	b	10	b
11	c	12	d	13	b	14	a	15	b
16	d	17	a	18	b				

7. Rolling on Inclined Plane

1	b	2	a	3	a	4	c	5	b
6	b	7	a	8	a	9	b	10	a
11	b	12	d	13	a	14	c	15	d
16	a	17	b	18	c	19	b		

8. IIT-JEE/AIEEE

1	a	2	d	3	d	4	a	5	b
6	a	7	a	8	a	9	b	10	d
11	b	12	c	13	a	14	a	15	c
16	c	17	a	18	d	19	a	20	b
21	c	22	b	23	a	24	b	25	b
26	d	27	b	28	c	29	b	30	b
31	c	32	a	33	b	34	b	35	d
36	c	37	c	38	d	39	c	40	d
41	ad	42	a	43	a	44	c	45	b
46	b	47	d	48	c	49	c	50	b
51	b	52	d	53	a	54	d	55	a
56	d	57	d	58	b	59	d		

9. NEET/AIPMT

1	b	2	c	3	c	4	b	5	d
6	c	7	b	8	d	9	d	10	c
11	b	12	b	13	a	14	a	15	b
16	b								

10. AIIMS

1	c	2	b	3	d	4	c	5	c
6	b	7	b	8	c	9	b	10	a
11	b	12	d	13	a	14	b	15	c
16	c	17	b						

11. Assertion and Reason

1	a	2	b	3	d	4	d	5	a
6	a	7	c	8	a	9	e	10	a
11	c	12	a	13	b	14	a	15	d