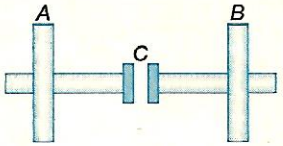
1. Disks $A$ and $B$ are mounted on a shaft as shown in the figure. Clutch $C$ is used to connect or disconnect the disks,

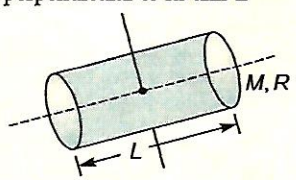



moment of inertia of $A$ is half of that of $B$. When the clutch is in disconnected position, the disk $A$ is brought up to an angular velocity $\omega_0$ with the help of an external torque. Then external torque is removed from $A$ and it is coupled to $B$ with the help of clutch. Neglect bearing friction in the shaft but due to coupling 150 J of heat is developed in the clutch. The initial kinetic energy (just before the connections are made) of the disk $A$ was (*Assume clutch and shaft are light*).
(a) 450 J (b) 300 J
(c) 225 J (d) None of these

2. A body is moving in circular motion of constant radius, then
(a) the net acceleration of the body may be towards the centre of the circle
(b) the net acceleration of the body may not be towards the centre of the circle
(c) the velocity of the body must change
(d) All of the above

3. A cylinder having moment of inertia, which is free to rotate about its axis, receives an angular impulse of $J$ kg-m$^2$/s initially, followed by similar impulse after every 4 s. What is the angular speed of the cylinder 30 s after the initial impulse? (*Cylinder is at rest initially*)
(a) $\frac{7J}{I}$ (b) $\frac{8J}{I}$
(c) $\frac{J}{I}$ (d) Zero

4. The moment of inertia of a solid cylinder about an axis passing through its centre and perpendicular to its axis is




(a) $\frac{MR^2}{4}$ (b) $\frac{MR^2}{4}+\frac{ML^2}{12}$
(c) $\frac{MR^2}{2}$ (d) $\frac{MR^2}{4}+\frac{ML^2}{3}$

5. A rope of negligible mass is wound round a hollow cylinder of mass 3 kg and radius 0.5 m. If the rope is pulled with a force of 50 N, the angular acceleration of the cylinder would be
(a) 50 rad/s$^2$ (b) 100 rad/s$^2$
(c) $\frac{50}{3}$ rad/s$^2$ (d) 10 rad/s$^2$

6. To maintain a rotor at uniform angular speed of 200 rad/s, an engine needs to transmit a torque of 180 N-m. What is the power required by engine? (*Assume efficiency of engine to be* 80%)
(a) 36 kW (b) 18 kW
(c) 45 kW (d) 54 kW

7. A disk and a ring, both of radius 10 cm are placed on a horizontal table simultaneously, with initial angular speed equal to $10\pi$ rad/s. Which of the two will start pure rolling earlier? (*Take* $\mu = 0.2$ *and* $g = 10\ m/s^2$)
(a) Disk
(b) Ring
(c) Both at the same time
(d) Pure rolling is not possible

8. Mark the correct statement(s) regarding circular motion of a particle.
(a) Particle is in equilibrium.
(b) Speed of particle is constant.
(c) Velocity of particle must change.
(d) Acceleration of particle may be constant.

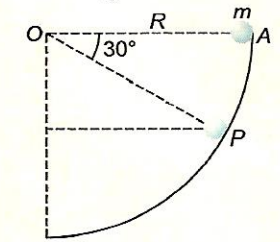
9. When a ball is whirled in a circle and the string supporting the ball is released, the ball flies off tangentially. This is due to
(a) the action of centrifugal force
(b) inertia for linear motion
(c) centripetal force
(d) some unknown cause

10. A disc revolves in a horizontal plane at a steady rate of 3 rad/s. A coin will remain on the disc if kept at a distance of 20 cm from the axis of rotation. The coefficient of friction is ($g = \pi^2$ m/s$^2$)
(a) 0.5 (b) 0.3
(c) 0.2 (d) 0.18

11. When a particle is moving in a verticle circle,
(a) its radial and tangential acceleration both are constant
(b) its radial and tangential acceleration both are varying
(c) its radial acceleration is constant but tangential acceleration is varying
(d) its radial acceleration is varying but tangential acceleration is constant

12. A particle is moving along a circular track of radius 100 m. The speed of the particle is increasing at a rate of 3 m/s$^2$, the acceleration of the particle at the instant when its speed is 20 m/s would be
(a) 3 m/s$^2$ (b) 4 m/s$^2$
(c) 7 m/s$^2$ (d) 5 m/s$^2$

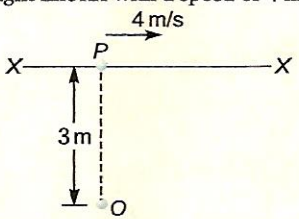
13. A particle of mass $m$ slides on a quarter part of smooth sphere of radius $R$ as shown in the figure.




It is released from rest at $A$, the normal contact force exerted by surface on particle when it reaches $P$ is
(a) $\frac{mg}{2}$ (b) $\frac{3mg}{2}$
(c) $mg\times\frac{\sqrt{3}}{2}+mg$ (d) $\frac{mg\sqrt{3}}{2}$

14. A horizontal rod of length 1 m is rotated about a vertical axis passing through one of its ends. The number of rev/sec at which the rod breaks is (*Breaking stress of material of rod* $= 3\times10^9\ N/m^2$ *and density of material of rod* $= 6000\ kg/m^3$)
(a) 159 (b) 1000
(c) 880 (d) 420

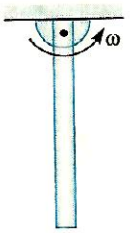
15. A particle $P$ is moving uniformly along a straight line $XX$ with a speed of 4 m/s.




The particle crosses the shown position at $t = 0$, what would be the angular velocity of $P$ about $O$ at $t = 1$ s?
(a) $\frac{4}{3}$ rad/s (b) $\frac{12}{25}$ rad/s
(c) $\frac{3}{4}$ rad/s (d) $\frac{25}{12}$ rad/s

16. If $I_1$ be the moment of inertia of a thin rod about an axis perpendicular to its length and passing through its centre of mass and $I_2$ be the moment of inertia of the ring formed by bending the rod, then the ratio $I_1 : I_2$ is
(a) 1 : 1 (b) $\pi^2 : 3$
(c) $\pi : 4$ (d) 3 : 5

17. A thin uniform rod of mass $m$ and length $l$ is free to rotate about an horizontal axis as shown in figure. The minimum initial angular velocity imparted to rod so that it becomes horizontal is




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

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

18. The angular momentum of a projectile projected at a speed $u$ at an angle $\alpha$ with the horizontal about the point of projection when it reaches the maximum height is

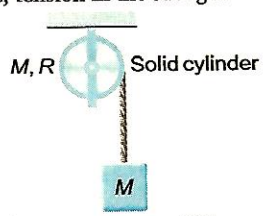
(a) $\frac{mu^2 \sin^2 \alpha}{g}$

(b) $\frac{mu^2 \cos \alpha}{g}$

(c) $\frac{mu^3 \sin^2 \alpha \cos \alpha}{2g}$

(d) $\frac{mu^3 \sin^2 \alpha}{g}$

19. For the arrangement shown in the figure, tension in the string is




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

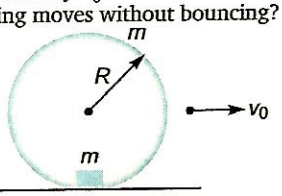
(c) $\frac{3Mg}{2}$ (d) $\frac{Mg}{3}$

20. A uniform disc of radius $R$ is rotating about its axis with angular velocity $\omega_0$ and then it is gently placed on a rough horizontal surface. After what time its rotational motion ceases instantaneously (*Take coefficient of friction as* $\mu$)

(a) $\frac{4\omega_0 R}{3\mu g}$ (b) $\frac{3\omega_0 R}{4\mu g}$

(c) $\frac{\omega_0 R}{3\mu g}$ (d) $\frac{4\omega_0 R}{\mu g}$

21. A small mass $m$ is attached to the inside of a rigid ring of the same mass $m$ and radius $R$. The ring performs pure rolling on a rough horizontal surface. At the moment the mass $m$ gets into the lowest position, the centre of the ring moves with velocity $v_0$. For what values of $v_0$, the ring moves without bouncing?

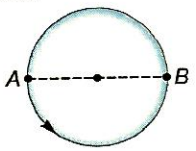



(a) $v_0 \geq \sqrt{8gR}$ (b) $v_0 \leq \sqrt{8gR}$

(c) $v_0 \leq \sqrt{3gR}$ (d) $v_0 \geq \sqrt{3gR}$

22. Mark out the incorrect statement(s).
(a) Relative velocity of point of contact of body performing pure rolling motion is zero.
(b) Acceleration of point of contact of body performing pure rolling motion is zero.
(c) Friction acting in the above case is non-zero.
(d) Friction acting in the above case is static in nature.

23. A particle performs uniform circular motion on a horizontal circular path. Two points $A$ and $B$ are marked as shown. Mark out the correct statement(s).



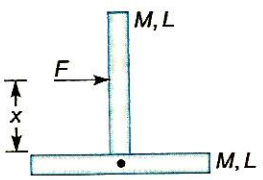

(a) $\vec{F}_A + \vec{F}_B = 0$

(b) $\vec{L}_B - \vec{L}_A = 0$

(c) $KE_B - KE_A = 0$

(d) All of the above

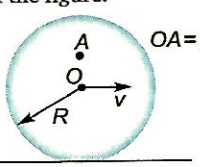
24. An inverted T-shaped object is placed on a smooth horizontal floor as shown in the figure. A force $F$ is applied on the system as shown. The value of $x$ so that system performs pure translational motion is




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

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

25. A sphere is performing pure rolling as shown in the figure.

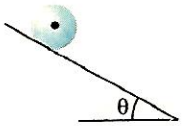



The radius of curvature of trajectory of point $A$ in the shown position is

(a) $\frac{9}{4}R$ (b) $\frac{R}{2}$

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

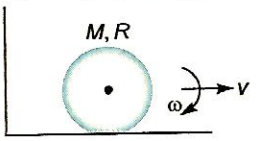
26. A sphere of mass $M$ and radius $R$ is released from rest from the top of a smooth incline of inclination $\theta$ as shown in the figure. The velocity of the sphere as it travels a distance $l$ on the incline, is




(a) $\sqrt{2gl}$ (b) $\sqrt{2gl \sin \theta}$

(c) $\sqrt{\frac{10}{7} gl \sin \theta}$ (d) $\sqrt{\frac{5}{6} gl \sin \theta}$

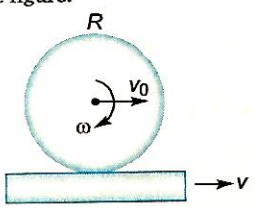
27. Find the ratio of angular momentum of the disc about origin to that about centre of mass of disk as shown in figure (*Disk is performing pure rolling*)




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

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

28. A solid cylinder is performing pure rolling on a moving platform as shown in the figure.

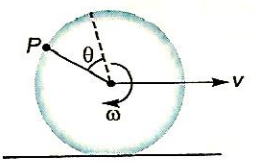



The velocity of the platform is

(a) $v = v_0 - R\omega$ (b) $v = v_0$

(c) $v = 0$ (d) $v = v_0 + R\omega$

29. A wheel of radius $R$ is performing pure rolling as shown. At any instant velocity

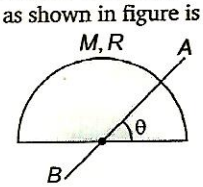



of centre of mass *wrt* surface is $v$, then at this instant velocity of any point $P$ on the rim of the wheel *wrt* surface $S$ will be (*Point P is shown in diagram*)

(a) $v$ (b) $v + v \cos \theta$

(c) $2v \cos\left(\frac{\theta}{2}\right)$ (d) $2v \sin\left(\frac{\theta}{2}\right)$

30. Moment of inertia of the semicircular ring of mass $M$ and radius $R$ about an axis $AB$ as shown in figure is




(a) dependent on angle $\theta$

(b) independent of angle $\theta$

(c) $\frac{MR^2}{2}$ if $\theta = 45°$

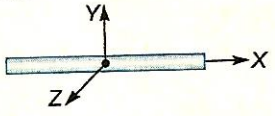
(d) $MR^2$ if $\theta = \frac{\pi}{2}$

31. A wheel is performing accelerated pure rolling motion on a flat surface, then
(a) net torque acting on the wheel may be zero or non-zero
(b) the net torque acting on wheel must be non-zero
(c) the net torque acting on wheel must be zero
(d) No information can be deduced regarding torque

32. A particle of mass $m$ is moving in a circular path under the action of radially inward acting conservative force $F = -\frac{K}{r^2}$. The total energy of the particle is ($r$ *is the radius of the circular path*)
(a) $\frac{K}{2r}$ (b) $-\frac{K}{2r}$
(c) $-\frac{K}{r}$ (d) $\frac{K}{r}$

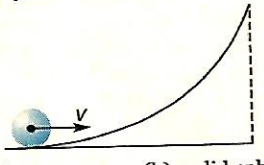
33. A body rolls down without slipping on an inclined plane. The fraction of its total energy associated with rotation will be ($K \rightarrow$ *radius of gyration,* $R \rightarrow$ *radius of body*)
(a) $\frac{R^2}{R^2 + K^2}$ (b) $\frac{K^2}{R^2 + K^2}$
(c) $K^2 + R^2$ (d) $\frac{1}{K^2 + R^2}$

34. A uniform rod of mass $m$ and length $2a$ lies on the $X$-axis with its centre of mass at the origin. The locus of the point $P$ in the $XY$ plane such that moment of inertia of the rod about an axis parallel to $Z$-axis passing through $P$ remains constant is




(a) straight line (b) circle
(c) ellipse (d) parabola

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




(a) ring (b) solid sphere
(c) hollow sphere (d) disc

36. A uniform cube of side $a$ and mass $M$ rests on a rough horizontal table. A horizontal force $F$ is applied normal to one of the faces at a point directly above the centre of the face, at a height $\frac{3a}{4}$ above the base. The minimum value of $F$ for which the cube will tip is (*Assume friction is enough to prevent sliding*)
(a) $Mg$ (b) $\frac{Mg}{2}$
(c) $\frac{2}{3}Mg$ (d) $\frac{3}{2}Mg$

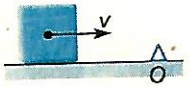
37. A solid cylinder of mass $M$ and radius $R$ is resting on a horizontal platform (*which is parallel to the x-y plane*) with its axis fixed along $Y$-axis and free to rotate about its axis. The platform is given a motion in the $X$ direction given by $x = A\cos(\omega t)$. There is no slipping between the cylinder and the platform. The maximum torque acting on the cylinder during its motion is
(a) $\frac{M\omega^2 AR}{3}$
(b) $\frac{M\omega^2 AR}{2}$
(c) $\frac{2}{3} \times M\omega^2 AR$
(d) The situation is not possible

38. A rod of weight $w$ is supported by two parallel knife edges $A$ and $B$ and is in equilibrium in horizontal position. The knives are at distance $d$ from each other. The centre of mass of the rod is at distance $x$ from $A$, the normal reaction exerted on rod by $A$ is
(a) $\frac{wx}{d}$ (b) $\frac{wd}{x}$
(c) $\frac{w(d-x)}{d}$ (d) $w$

39. A thin uniform circular disc of mass $M$ and radius $R$ is rotating in a horizontal plane about an axis passing through its centre and perpendicular to its plane with an angular velocity $\omega$. Another disc of the same dimensions but of mass $\frac{M}{4}$ is placed gently on the first disc coaxially. The new angular velocity of the system is
(a) $\frac{2\omega}{\sqrt{5}}$ (b) $\frac{\omega}{2}$
(c) $\frac{5\omega}{4}$ (d) $\frac{4\omega}{5}$

40. A mass $m$ is moving with constant velocity along a line parallel to the $X$-axis, away from the origin. Its angular momentum with respect to the origin
(a) is zero
(b) remains constant
(c) goes on increasing
(d) goes on decreasing

41. 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

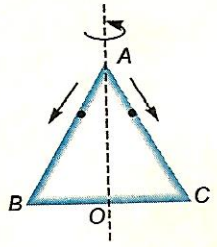



(a) $\frac{3v}{4a}$ (b) $\frac{3v}{2a}$
(c) $\sqrt{\frac{3}{2}}\,a$ (d) zero

42. A tube of length $L$ is filled completely with incompressible liquid of mass $M$ and closed at both the ends. The tube is then rotated in a horizontal plane about one of its ends with a uniform angular velocity $\omega$. The force exerted by the liquid on the tube at other end is
(a) $\frac{M\omega^2 L}{2}$ (b) $M\omega^2 L$
(c) $\frac{M\omega^2 L}{4}$ (d) $\frac{3M\omega^2 L}{4}$

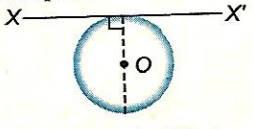
43. A smooth sphere $A$ is moving on a frictionless horizontal plane with angular velocity $\omega$ and centre of mass velocity $v$. It collides elastically and heads on with an identical sphere at rest. Neglect friction everywhere. After the collision their angular speeds are $\omega_A$ and $\omega_B$, respectively. Then
(a) $\omega_A < \omega_B$ (b) $\omega_A = \omega_B$
(c) $\omega_A = \omega$ (d) $\omega_B = \omega$

44. An equilateral triangle $ABC$ formed from a uniform wire has two 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 as shown.




Neglecting friction losses, the quantities that are conserved as beads slides 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 axis of rotation
(d) total angular momentum and moment of inertia about axis of rotation

45. A thin wire of length $L$ and uniform linear mass density $\rho$ is bent into a circular loop with centre at $O$ as shown.




The moment of inertia of the loop about the axis $XX'$ is
(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) $\frac{3\rho L^3}{8\pi^2}$