

01. A particle of mass 'm' is projected with a velocity v making an angle of 30° with the horizontal. The magnitude of angular momentum of the projectile about the point of projection when the particle is at its maximum height 'h' is

- (a) $\frac{\sqrt{3} mv^2}{2g}$ (b) zero
 (c) $\frac{mv^3}{\sqrt{2g}}$ (d) $\frac{\sqrt{3} mv^3}{16g}$

02. 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

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

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

- (a) continuously decreases
 (b) continuously increases
 (c) first increases and then decreases
 (d) remains unchanged

04. Two cars of masses m_1 and m_2 are moving in circles of radii r_1 and r_2 , respectively. Their speeds are such that they make complete circles in the same time t . The ratio of their centripetal acceleration is

- (a) $m_1 r_1 : m_2 r_2$ (b) $m_1 : m_2$
 (c) $r_1 : r_2$ (d) $1 : 1$

05. A diatomic molecule is made of two masses m_1 and m_2 which are separated by a distance r . If we calculate its rotational energy by applying Bohr's rule of angular momentum quantization, its energy will be given by (n is an integer)

- (a) $\frac{(m_1 + m_2)^2 n^2 h^2}{2m_1^2 m_2^2 r^2}$ (b) $\frac{n^2 h^2}{2(m_1 + m_2)r^2}$
 (c) $\frac{2n^2 h^2}{(m_1 + m_2)r^2}$ (d) $\frac{(m_1 + m_2)n^2 h^2}{2m_1 m_2 r^2}$

06. A hoop of radius r and mass m rotating with an angular velocity ω_0 is placed on a rough horizontal surface.

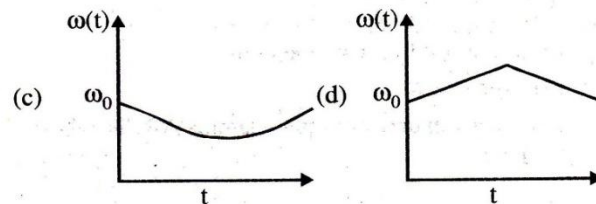
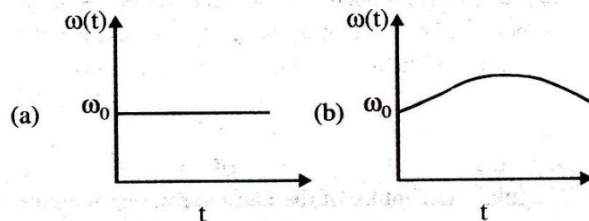
07. The initial velocity of the centre of the hoop is zero. What will be the velocity of the centre of the hoop when it ceases to slip?

- (a) $\frac{r\omega_0}{4}$ (b) $\frac{r\omega_0}{3}$ (c) $\frac{r\omega_0}{2}$ (d) $r\omega_0$

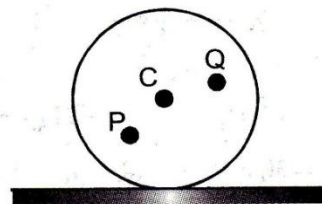
08. One quarter sector is cut from a uniform circular disc of radius R . This sector has mass M . It is made to rotate about a line perpendicular to its plane and passing through the centre of the original disc. Its moment of inertia about the axis of rotation is

- (a) $\frac{1}{2}mR^2$ (b) $\frac{1}{4}mR^2$
 (c) $\frac{1}{8}mR^2$ (d) $\sqrt{2}mR^2$

09. 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

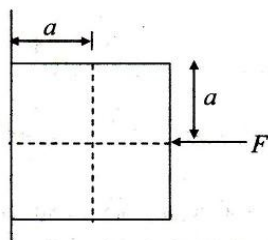


10. A disc is rolling (without slipping) on a horizontal surface, C is its centre and Q and P are two points equidistant from C. Let V_P , V_Q and V_C be the magnitude of velocities of points P, Q, and C respectively, then



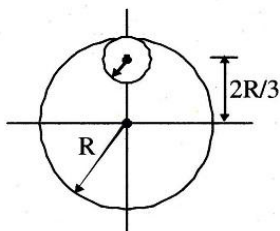
- (a) $V_Q > V_C > V_P$
- (b) $V_Q < V_C < V_P$
- (c) $V_Q = V_P, V_C = \frac{1}{2} V_P$
- (d) $V_Q < V_C < V_P$

11. A block of mass m is at rest under the action of force F against a wall as shown in figure. Which of the following statement is incorrect?



- (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

12. From a circular disc of radius R and mass $9M$, a small disc of radius $R/3$ is removed from the disc. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through O is

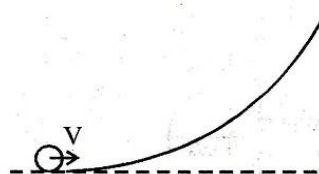


- (a) $4MR^2$
- (b) $\frac{40}{9}MR^2$
- (c) $10MR^2$
- (d) $\frac{37}{9}MR^2$

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

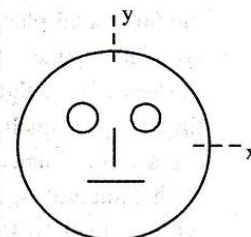
- (a) $r = \sqrt{\frac{2}{15}}R$
- (b) $r = \frac{2}{\sqrt{15}}R$
- (c) $r = \frac{2}{15}R$
- (d) $r = \frac{\sqrt{2}}{15}R$

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



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

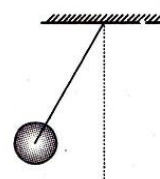
15. Look at the drawing given in the figure which has been drawn with ink of uniform line-thickness. The mass of ink used to draw each of the two inner circles, and each of the two line segments is m . The mass of the ink used to draw the outer circle is $6m$.



16. 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

- (a) $\frac{a}{10}$
- (b) $\frac{a}{8}$
- (c) $\frac{a}{12}$
- (d) $\frac{a}{3}$

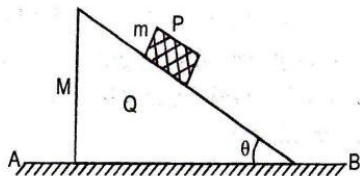
17. A metal rod of length ' L ' and mass ' m ' is pivoted at one end. A thin disc of mass ' M ' and radius ' R ' ($<L$) is attached at its center to the free end of the rod. Consider two ways the disc is attached: (case A).



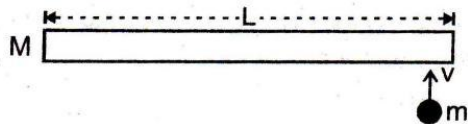
The disc is not free to rotate about its centre and (case B) the disc is free to rotate about its centre. The rod disc system performs SHM in vertical plane after being released from the same displaced position. Which of the following statement (s) is (are) true?

- (a) Restoring torque in case A = Restoring torque in case B
- (b) Restoring torque in case A < Restoring torque in case B
- (c) Angular frequency for case A > angular frequency for case B.
- (d) Angular frequency for case A < Angular frequency for case B.

18. A block Q of mass M is placed on a horizontal frictionless surface AB and a body P of mass m is released on its frictionless slope. As P slides by a length L on this slope of inclination θ , the block Q would slide by a distance



- (a) $(m/M)L \cos \theta$ (b) $mL/(M+m)$
 (c) $(M+m)/(mL \cos \theta)$ (d) $(mL \cos \theta)/(m+M)$
19. A stick of length L and mass M lies on a frictionless horizontal surface on which it is free to move in any way. A ball of mass m moving with speed v collides elastically with the stick as shown in fig.



If after the collision ball comes to rest, then what should be the mass of the ball?

- (a) $m = 2M$ (b) $m = M$
 (c) $m = M/2$ (d) $m = M/4$
20. A flywheel rotates about an axis. Due to friction at the axis, it experiences an angular retardation proportional to its angular velocity. If its angular velocity falls to half while it makes n rotations, how many more rotations will it make before coming to rest?

- (a) $2n$ (b) n
 (c) $n/2$ (d) $n/3$
21. A circular disc X of radius R is made from an iron plate of thickness t , and another disc Y of radius $4R$ is made from an iron plate of thickness $\frac{t}{4}$. Then the relation between the moment of inertia I_X and I_Y is

- (a) $I_Y = 32I_X$ (b) $I_Y = 16I_X$
 (c) $I_Y = I_X$ (d) $I_Y = 64I_X$

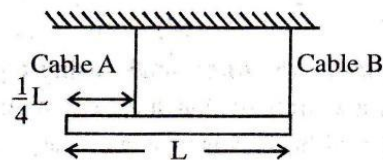
22. A smooth sphere A is moving on a frictionless horizontal plane with angular speed ω and centre of mass velocity v . It collides elastically and head on with an identical sphere B at rest. Neglect friction everywhere. After the collision, their angular speeds are ω_A and ω_B , respectively. Then

- (a) $\omega_A < \omega_B$ (b) $\omega_A = \omega_B$
 (c) $\omega_A = \omega$ (d) $\omega_B = \omega$

23. A cylinder rolls down an inclined plane of inclination 30° , the acceleration of cylinder is

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

24. A uniform bar of mass M and length L is horizontally suspended from the ceiling by two vertical light cables as shown. Cable A is connected $1/4$ th distance from the left end of the bar. Cable B is attached at the far right end of the bar. What is the tension in cable A?



- (a) $1/4 Mg$ (b) $1/3 Mg$
 (c) $2/3 Mg$ (d) $3/4 Mg$

25. A weightless ladder 20 ft long rests against a frictionless wall at an angle of 60° from the horizontal. A 150 pound man is 4 ft from the top of the ladder. A horizontal force is needed to keep it from slipping. Choose the correct magnitude from the following.

- (a) 175 lb (b) 100 lb
 (c) 120 lb (d) 17.3 lb

26. A tube one metre long is filled with liquid of mass 1 kg. The tube is closed at both the ends and is revolved about one end in a horizontal plane at 2 rev/s. The force experienced by the lid at the other end is

- (a) $4\pi^2 N$ (b) $8\pi^2 N$
 (c) $16\pi^2 N$ (d) 9.8 N

27. If the linear density (mass per unit length) of a rod of length 3m is proportional to x , where x is the distance from one end of the rod, the distance of the centre of gravity of the rod from this end is

- (a) 2.5 m (b) 1 m
 (c) 1.5 m (d) 2 m

28. A coin placed on a gramophone record rotating at 33 rpm flies off the record, if it is placed at a distance of more than 16 cm from the axis of rotation. If the record is revolving at 66 rpm, the coin will fly off if it is placed at a distance not less than

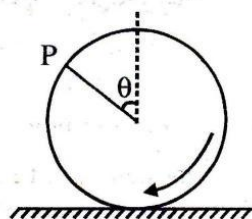
- (a) 1 cm (b) 2 cm
(c) 3 cm (d) 4 cm

29. Two fly wheels A and B are mounted side by side with frictionless bearings on a common shaft. Their moments of inertia about the shaft are 5.0 kg m^2 and 20.0 kg m^2 respectively. Wheel A is made to rotate at 10 revolution per second. Wheel B, initially stationary, is now coupled to A with the help of a clutch. The rotation speed of the wheels will become

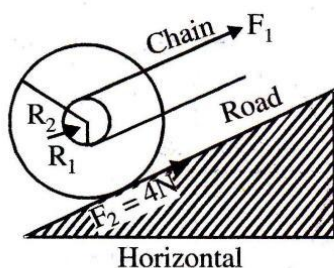
- (a) $2\sqrt{5}$ rps (b) 0.5 rps
(c) 2 rps (d) None of these

30. A wheel is rolling straight on ground without slipping. If the axis of the wheel has speed v , the instantaneous velocity of a point P on the rim, defined by angle θ , relative to the ground will be

- (a) $v \cos\left(\frac{1}{2}\theta\right)$
(b) $2v \cos\left(\frac{1}{2}\theta\right)$
(c) $v(1 + \sin \theta)$
(d) $v(1 + \cos \theta)$

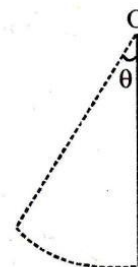


31. A certain bicycle can go up a gentle incline with constant speed when the frictional force of ground pushing the rear wheel is $F_2 = 4 \text{ N}$. With what force F_1 must the chain pull on the sprocket wheel if $R_1 = 5 \text{ cm}$ and $R_2 = 30 \text{ cm}$?



- (a) 4 N (b) 24 N
(c) 140 N (d) $\frac{35}{4}$ N

32. A uniform rod of length l is free to rotate in a vertical plane about a fixed horizontal axis through O. The rod begins rotating from rest from its unstable equilibrium position. When it has turned through an angle θ , its angular velocity ω is given as

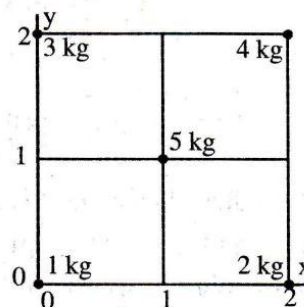


- (a) $\sqrt{\frac{6g}{l}} \sin \theta$ (b) $\sqrt{\frac{6g}{l}} \sin \frac{\theta}{2}$
(c) $\sqrt{\frac{6g}{l}} \cos \frac{\theta}{2}$ (d) $\sqrt{\frac{6g}{l}} \cos \theta$

33. A sphere of mass 2000 g and radius 5 cm is rotating at the rate of 300 rpm. Then the torque required to stop it in 2π revolutions, is

- (a) 1.6×10^2 dyne cm (b) 1.6×10^3 dyne cm
(c) 2.5×10^4 dyne cm (d) 2.5×10^5 dyne cm

34. Five masses are placed in a plane as shown in figure. The coordinates of the centre of mass are nearest to

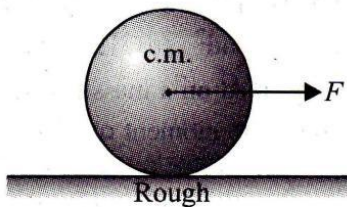


- (a) 1.2, 1.4 (b) 1.3, 1.1
(c) 1.1, 1.3 (d) 1.0, 1.0

35. A boy and a man carry a uniform rod of length L , horizontally in such a way that the boy gets $1/4^{\text{th}}$ load. If the boy is at one end of the rod, the distance of the man from the other end is

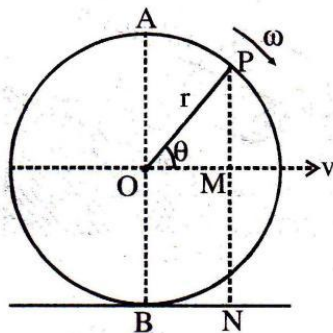
- (a) $L/3$ (b) $L/4$
(c) $2L/3$ (d) $3L/4$

36. A solid sphere of mass M and radius R is pulled horizontally on a sufficiently rough surface as shown in the figure.



Choose the correct alternative.

- (a) The acceleration of the centre of mass is F/M
 (b) The acceleration of the centre of mass is $\frac{2}{3} \frac{F}{M}$
 (c) The friction force on the sphere acts forward
 (d) The magnitude of the friction force is $F/3$
37. Fig. shows a disc rolling on a horizontal plane with linear velocity v . Its linear velocity is v and angular velocity is ω . Which of the following gives the velocity of the particle P on the rim of the disc



- (a) $v(1 + \cos \theta)$ (b) $v(1 - \cos \theta)$
 (c) $v(1 + \sin \theta)$ (d) $v(1 - \sin \theta)$

38. In a bicycle, the radius of rear wheel is twice the radius of front wheel. If r_F and r_r are the radii, v_r and v_F are the speed of top most points of wheel. Then

- (a) $v_r = 2v_F$ (b) $v_F = 2v_r$
 (c) $v_F = v_r$ (d) $v_F > v_r$

- (a) Statement -1 is false, Statement-2 is true
 (b) Statement -1 is true, Statement-2 is true; Statement -2 is a correct explanation for Statement-1
 (c) Statement -1 is true, Statement-2 is true; Statement -2 is not a correct explanation for Statement-1
 (d) Statement -1 is true, Statement-2 is false

39. **Statement 1** : When you lean behind over the hind legs of the chair, the chair falls back after a certain angle.

Statement 2 : Centre of mass lying outside the system makes the system unstable.

40. **Statement 1** : A rigid disc rolls without slipping on a fixed rough horizontal surface with uniform angular velocity. Then the acceleration of lowest point on the disc is zero.

Statement 2 : For a rigid disc rolling without slipping on a fixed rough horizontal surface, the velocity of the lowest point on the disc is always zero.

41. **Statement 1** : If no external force acts on a system of particles, then the centre of mass will not move in any direction.

Statement 2 : If net external force is zero, then the linear momentum of the system remains constant.

42. **Statement 1** : A wheel moving down a frictionless inclined plane will slip and not roll on the plane.

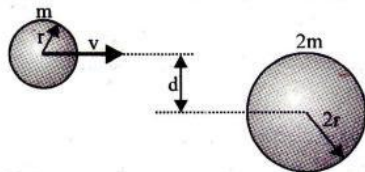
Statement 2 : It is the frictional force which provides a torque necessary for a body to roll on a surface.

43. **Statement I** : When a sphere is rolls on a horizontal table it slows down and eventually stops.

Statement II : When the sphere rolls on the table, both the sphere and the surface deform near the contact. As a result, the normal force does not pass through the centre and provide an angular declaration.

PASSAGE 1

A uniform sphere with mass $2m$ and radius $2r$ is at rest in a place where no external forces are applied.



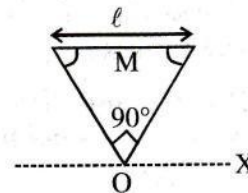
A second sphere of mass m and radius r moves towards it with a velocity v (without rotating). The two spheres stick together and then continue their motion as one body.

[Given that $d = 2r$]

44. The distance of the centre of mass of system from the centre of bigger sphere at the moment of collision is
- (a) r (b) $2r$
 (c) $3r$ (d) $4r$
45. The velocity of centre of mass immediately after the collision is
- (a) $v/3$ (b) $2v/3$
 (c) $3v/2$ (d) $2v/5$
46. The moment of inertia about the center of mass of the unified body after the collision is
- (a) $\frac{48}{5}mr^2$ (b) $\frac{48}{3}mr^2$
 (c) $\frac{24}{5}mr^2$ (d) $\frac{24}{3}mr^2$
47. The angular momentum about the center of mass shortly before and after the collision
- (a) increases (b) decreases
 (c) remains same (d) None of these
48. The kinetic energy of the body after the collision is
- (a) $\frac{11mv^2}{54}$ (b) $\frac{mv^2}{108}$
 (c) $\frac{17mv^2}{54}$ (d) $\frac{17mv^2}{108}$

PASSAGE 2

The figure shows an isosceles triangular plate of mass M and base L . The angle at the apex is 90° .



The apex lies at the origin and the base is parallel to y-axis.

49. The moment of inertia of the plate about the z-axis is-
- (a) $\frac{ML^2}{12}$ (b) $\frac{ML^2}{24}$
 (c) $\frac{ML^2}{6}$ (d) None of these
50. The moment of inertia of the plate about the x-axis is
- (a) $\frac{ML^2}{8}$ (b) $\frac{ML^2}{32}$
 (c) $\frac{ML^2}{24}$ (d) $\frac{ML^2}{6}$
51. The moment of inertia of the plate about its base parallel to the x-axis is
- (a) $\frac{ML^2}{18}$ (b) $\frac{ML^2}{36}$
 (c) $\frac{ML^2}{24}$ (d) None of these