1. A shell fired from a gun at an angle to the horizontal explodes in mid–air. Then the centre of mass of the shell fragments will move
   (a) vertically down
   (b) horizontally
   (c) along the same parabolic path along which the 'intact' shell, was moving
   (d) along tangent to the parabolic path of the 'intact' shell, at the point of explosion.
2. A child is standing at one end of a long trolley moving with a speed $v$ on a smooth horizontal track. If the child starts running towards the other end of the trolley with a speed $u$, the centre of mass of the system (trolley + child) will move with a speed
   (a) zero (b) $(v + u)$
   (c) $(v - u)$ (d) $v$
3. Choose the only incorrect statement from the following:
   (a) The position of the centre of mass of a system of particles does not depend upon the internal forces between particles.
   (b) The centre of mass of a solid may lie outside the body of the solid.
   (c) A body tied to a string is whirled in a circle with a uniform speed. If the string is suddenly cut, the angular momentum of the body will change from its initial value.
   (d) The angular momentum of a comet revolving around a massive star, remains constant over the entire orbit.
4. A loaded spring gun of mass $M$ fires a 'shot' of mass $m$ with a velocity $v$ at an angle of elevation $\theta$. The gun is initially at rest on a horizontal frictionless surface. After firing, the centre of mass of the gun–shot system
   (a) moves with a velocity $v\, m/M$
   (b) moves with velocity $\frac{vm}{M}\cos\theta$ in the horizontal direction
   (c) remains at rest
   (d) moves with a velocity $\frac{v(M-m)}{(M+m)}$ in the horizontal direction.
5. If a man of mass $M$ jumps to the ground from a height $h$ and his centre of mass moves a distance $x$ in the time taken by him to 'hit' the ground, the average force acting on him (assuming his retardation to be constant during his impact with the ground) is

(a) $M g h/x$ (b) $M g x/h$

(c) $M g (h/x)^2$ (d) $M g (x/h)^2$

**6.** Four particles of masses $m$, $m$, $2m$ and $2m$ are placed at the four corners of a square of side $a$ as shown in Fig. 5.39. The $(x, y)$ co-ordinates of the centre of mass are

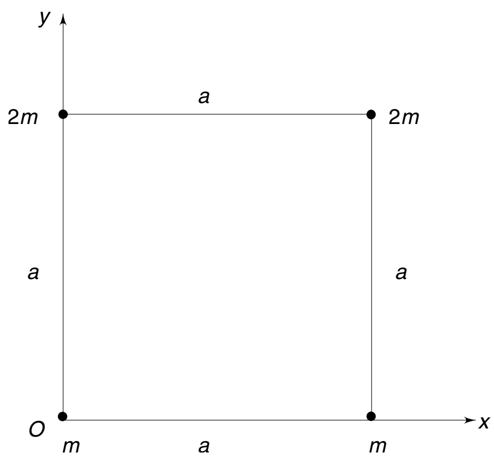


**Fig. 5.39**

(a) $\left(\frac{a}{2}, 2a\right)$ (b) $\left(\frac{a}{2}, a\right)$

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

7. A carpet of mass $M$, made of an inextensible material, is rolled along its length in the form of a cylinder of radius $R$ and kept on a rough floor. If the carpet is unrolled, without sliding, to a radius $R/2$, the decrease in potential energy is

(a) $\frac{1}{2}\ MgR$ (b) $\frac{5}{8}\ MgR$

(c) $\frac{3}{4}\ MgR$ (d) $\frac{7}{8}\ MgR$

8. Three point masses $m_1$, $m_2$ and $m_3$ are located at the vertices of an equilateral triangle of side $a$. What is the moment of inertia of the system about an axis along the altitude of the triangle passing through $m_1$?

(a) $(m_1 + m_2)\frac{a^2}{4}$ (b) $(m_2 + m_3)\frac{a^2}{4}$

(c) $(m_1 + m_3)\frac{a^2}{4}$ (d) $(m_1 + m_2 + m_3)\frac{a^2}{4}$

9. A molecule consists of two atoms, each of mass $m$, separated by a distance $a$. The moment of inertia of the molecule about its centre of mass is

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

(c) $\frac{1}{2}\ ma^2$ (d) $\frac{1}{4}\ ma^2$

10. In Q. 9, if $k$ is the average rotational kinetic energy of the molecule at room temperature, its frequency of rotation is

(a) $\frac{1}{\pi a}\sqrt{\frac{k}{m}}$ (b) $\frac{1}{2\pi a}\sqrt{\frac{k}{m}}$

(c) $\frac{1}{\pi a}\sqrt{\frac{2k}{m}}$ (d) $\frac{1}{2\pi a}\sqrt{\frac{2k}{m}}$

11. The moment of inertia of a solid sphere of mass $M$ and radius $R$, about an axis through its centre, is $\frac{2}{5}\ MR^2$. The moment of inertia about an axis tangential to the surface of the sphere will be

(a) $\frac{4}{5}\ MR^2$ (b) $MR^2$

(c) $\frac{6}{5}\ MR^2$ (d) $\frac{7}{5}\ MR^2$

12. The moment of inertia of a uniform circular disc of mass $M$ and radius $R$ about any of its diameters is $\frac{1}{4}\ MR^2$. What is the moment of inertia of the disc about an axis passing through its centre and normal to the disc?

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

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

13. In Q.18, what is the moment of inertia of the disc about an axis passing through a point on its edge and normal to the disc?

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

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

14. When $W$ joule of work is done on a flywheel, its frequency of rotation increases from $\nu_1$ Hz to $\nu_2$ Hz. The moment of inertia of the flywheel about its axis of rotation is given by

(a) $\frac{W}{2\pi^2\left(\nu_2^2 - \nu_1^2\right)}$ (b) $\frac{W}{2\pi^2\left(\nu_2^2 + \nu_1^2\right)}$

(c) $\frac{W}{4\pi^2\left(\nu_2^2 - \nu_1^2\right)}$ (d) $\frac{W}{4\pi^2\left(\nu_2^2 + \nu_1^2\right)}$

15. Two discs of moments of inertia $I_1$ and $I_2$ about their respective axes, rotating with angular frequencies $\omega_1$ and $\omega_2$ respectively, are brought into contact face to face with their axes of rotation coincident. The angular frequency of the composite disc will be

(a) $\frac{I_1\omega_1 - I_2\omega_2}{I_1 - I_2}$ (b) $\frac{I_1\omega_1 + I_2\omega_2}{I_1 + I_2}$

(c) $\frac{I_2\omega_1 + I_1\omega_2}{I_1 + I_2}$ (d) $\frac{I_2\omega_1 - I_1\omega_2}{I_1 - I_2}$

16. A solid cylinder of mass $M$ and radius $R$ rolls down an inclined plane of height $h$. The angular velocity of the cylinder when it reaches the bottom of the plane will be

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

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

17. In Q.22, the rotational kinetic energy of the cylinder when it reaches the bottom of the plane will be

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

(c) $\frac{Mgh}{3}$ (d) $\frac{Mgh}{4}$

18. A light-weight boy holds two heavy dumb-bells of equal mass with outstretched arms while standing on a turn-table which is rotating at an angular frequency $\omega_1$ when the dumb-bells are at a distance $r_1$ from the axis of rotation. The boy suddenly pulls the dumb-bells towards his chest until they are at a distance $r_2$ from the axis of rotation. The new angular frequency of rotation $\omega_2$ of the turn-table will be equal to

(a) $\omega_1 \frac{r_2}{r_1}$ (b) $\omega_1 \frac{r_1^2}{r_2^2}$

(c) $\omega_1 \frac{r_1}{r_2}$ (d) $\omega_1 \frac{r_2^2}{r_1^2}$

19. A cord is wound around the circumference of a bicycle wheel (without tyre) of diameter 1 m. A mass of 2 kg is tied to the end of the cord and it is allowed to fall from rest. The weight falls 2 m in 4 s. The axle of the wheel is horizontal and the wheel rotates with its plane vertical. The angular acceleration produced is (Take $g = 10\ \text{ms}^{-2}$)

(a) 0.5 rad $s^{-2}$ (b) 1.0 rad $s^{-2}$

(c) 2.0 rad $s^{-2}$ (d) 4.0 rad $s^{-2}$

20. In Q. 19, the moment of inertia of the wheel about the horizontal axis is

(a) 10 kg $m^2$ (b) 20 kg $m^2$

(c) 30 kg $m^2$ (d) 40 kg $m^2$

21. If the earth were to suddenly contract to half its present size, without any change in its mass, the duration of the new day will be

(a) 6 hours (b) 12 hours

(c) 18 hours (d) 30 hours

22. Two circular discs have masses in the ratio of 1 : 2 and radii in the ratio of 2 : 1. The ratio of their moments of inertia about their diameter is

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

(c) 4 : 1 (d) 8 : 1

23. A circular ring of mass $M$ and radius $R$ is rotating about its axis at an angular frequency $\omega$. Two blocks, each of mass $m$, are gently placed on the opposite ends of a diameter of the ring. The angular frequency of the ring becomes $\omega'$. The ratio $\omega'/\omega$ is

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

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

24. A solid sphere rolls down from the top of an inclined plane. Its velocity on reaching the bottom of the plane is $v$. When the same sphere slides down from the top of the plane, its velocity on reaching the bottom is $v'$. The ratio $v'/v$ is

(a) $\sqrt{\frac{3}{5}}$ (b) 1

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

25. A circular disc rolls down an inclined plane without slipping. What fraction of its total energy is translational?

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

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

26. A sphere rolls down an inclined plane without slipping. What fraction of its total energy is rotational?

(a) $\frac{2}{7}$ (b) $\frac{3}{7}$

(c) $\frac{4}{7}$ (d) $\frac{5}{7}$

27. A circular disc is rolling down an inclined plane without slipping. If the angle of inclination is 30°, the acceleration of the disc down the inclined plane is

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

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

28. A block of mass $M$ is released from the top of an inclined plane. Its velocity on reaching the bottom of the plane is $v$. A circular disc of the same mass $M$ rolls down the incline plane from the top. Its velocity on reaching the bottom is $v'$. The ratio $v'/v$ will be

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

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

29. Two circular loops $A$ and $B$ of radii $R$ and $2R$ respectively are made of the same wire. Their moments of inertia about the axis passing through the centre and perpendicular to their plane are $I_A$ and $I_B$ respectively. The ratio $I_A/I_B$ is

(a) 1 (b) $\frac{1}{2}$

(c) $\frac{1}{4}$ (d) $\frac{1}{8}$

30. Two circular loops $A$ and $B$ are made of the same wire and their radii are in the ratio $1:n$. Their moments of inertia about the axis passing through the centre and perpendicular to their plane are in the ratio $1:m$. The relation between $m$ and $n$ is

(a) $m = n$ (b) $m = n^2$

(c) $m = n^3$ (d) $m = n^4$

31. A small coin is placed at a distance $r$ from the centre of a gramophone record. The rotational speed of the record is gradually increased. If the coefficient of friction between the coin and the record is $\mu$, the minimum angular frequency of the record for which the coin will fly off is given by

(a) $\sqrt{\frac{2\mu g}{r}}$ (b) $\sqrt{\frac{\mu g}{2r}}$

(c) $\sqrt{\frac{\mu g}{r}}$ (d) $2\sqrt{\frac{\mu g}{r}}$

32. In Q. 31, what would be the minimum angular frequency at which two identical coins, placed one on top of the other, at the same location on the record, will fly off?

(a) $\sqrt{\frac{\mu g}{r}}$ (b) $\sqrt{\frac{2\mu g}{r}}$

(c) $2\sqrt{\frac{\mu g}{r}}$ (d) $2\sqrt{\frac{2\mu g}{r}}$

33. Three particles, each of mass $m$, are placed at the corners of a right angled triangle as shown in Fig. 5.40. If $OA = a$ and $OB = b$, the position vector of the centre of mass is (here **i** and **j** are unit vectors along $x$ and $y$ axes respectively).

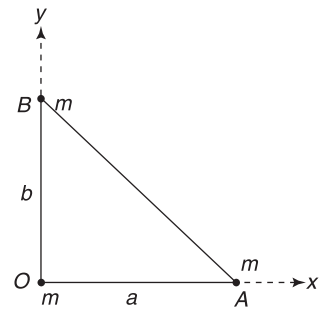


**Fig. 5.40**

(a) $\frac{1}{3}\ (a\mathbf{i} + b\mathbf{j})$ (b) $\frac{1}{3}\ (a\mathbf{i} - b\mathbf{j})$

(c) $\frac{2}{3}\ (a\mathbf{i} + b\mathbf{j})$ (d) $\frac{2}{3}\ (a\mathbf{i} - b\mathbf{j})$

34. Three particles each of mass $m$, are placed at the corners of an equilateral triangle of side $a$, as shown in Fig. 5.41. The position vector of the centre of mass is

(a) $\frac{a}{2}(\mathbf{i} + \mathbf{j}/\sqrt{3})$ (b) $\frac{a}{2}(3\,\mathbf{i} + \mathbf{j})$

(c) $\frac{a}{2}(3\,\mathbf{i} + \sqrt{3}\,\mathbf{j})$ (d) $\frac{a}{2}(3\,\mathbf{i} + \mathbf{j}/\sqrt{3})$

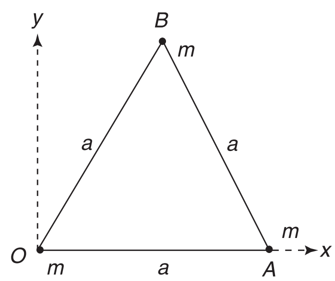


**Fig. 5.41**

35. A cylinder of mass $m$ and radius $r$ is rotating about its axis with a constant speed $v$. Its kinetic energy is

(a) $2\ mv^2$ (b) $mv^2$

(c) $\frac{1}{2}\ mv^2$ (d) $\frac{1}{4}\ mv^2$

36. A circular disc of mass $m$ and radius $r$ is rolling on a horizontal surface with a constant speed $v$. Its kinetic energy is

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

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

37. Two solid spheres $A$ and $B$, each of radius $R$, are made of materials of densities $\rho_A$ and $\rho_B$ respectively. Their moments of inertia about a diameter are $I_A$ and $I_B$ respectively. The ratio $I_A/I_B$ is

(a) $\sqrt{\frac{\rho_A}{\rho_B}}$ (b) $\sqrt{\frac{\rho_B}{\rho_A}}$

(c) $\frac{\rho_A}{\rho_B}$ (d) $\frac{\rho_B}{\rho_A}$

38. A cylinder, released from the top of an inclined plane, rolls without sliding and reaches the bottom with speed $v_r$. Another identical cylinder, released from the top of the same inclined plane, slides without rolling and reaches the bottom with speed $v_s$. Then

(a) $v_r > v_s$ (b) $v_r < v_s$
(c) $v_r = v_s$ (d) $v_r = v_s = 0$

39. A sphere of mass $M$ and radius $R$ is released from the top of an inclined plane of inclination $\theta$. The minimum coefficient of friction between the plane and the sphere so that it rolls down the plane without sliding is given by

(a) $\mu = \tan\theta$ (b) $\mu = \frac{2}{3}\tan\theta$

(c) $\mu = \frac{2}{5}\tan\theta$ (d) $\mu = \frac{2}{7}\tan\theta$

40. Three thin metal rods, each of mass $M$ and length $L$, are welded to form an equilateral triangle. The moment of inertia of the composite structure about an axis passing through the centre of mass of the structure and perpendicular to its plane is

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

(c) $\frac{ML^2}{8}$ (d) $\frac{ML^2}{12}$

41. Four thin metal rods, each of mass $M$ and length $L$, are welded to form a square $ABCD$ as shown in Fig. 5.42. What is the moment of inertia of the composite structure about a line which bisects rods $AB$ and $CD$ and perpendicular to the plane of the structure?

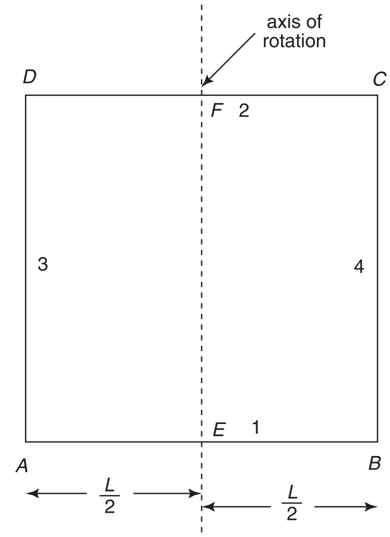


**Fig. 5.42**

(a) $\frac{ML^2}{6}$ (b) $\frac{ML^2}{3}$

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

42. A thin uniform metallic triangular sheet of mass $M$ has sides $AB = BC = L$. What is its moment of inertia about axis $AC$ lying in the plane of the sheet? (See Fig. 5.43)

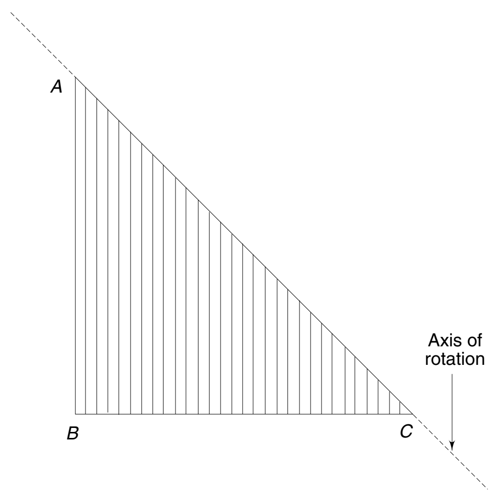


**Fig. 5.43**

(a) $\frac{ML^2}{12}$ (b) $\frac{ML^2}{6}$

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

43. In the rectangular lamina $ABCD$ shown in Fig. 5.44, $a = AB = BC/2$. The moment of inertia of the lamina is the minimum along the axis passing through

(a) $BC$ (b) $AB$

(c) $HF$ (d) $EG$

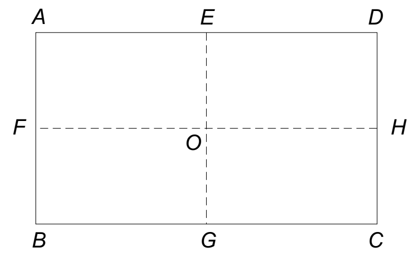


**Fig. 5.44**

44. The track shown in Fig. 5.45 ends in a circular track of radius $r$ with centre at $O$. A small solid sphere of mass $m$ rolls from rest without slipping from a point $A$ at a height $h = 6r$ from the level ground. What is the speed of the sphere when it reaches a point $B$ at height $r$ above the level ground?

(a) $\sqrt{10gr}$ (b) $\sqrt{\frac{50}{7}gr}$

(c) $\sqrt{\frac{22}{7}gr}$ (d) zero

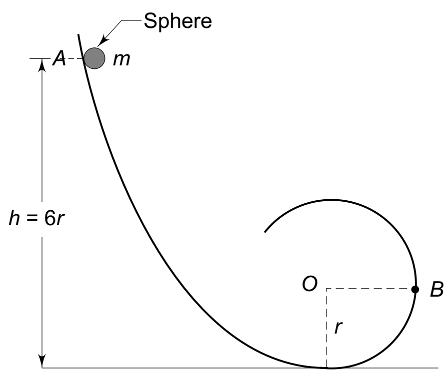


**Fig. 5.45**

45. In Q. 44 above, the horizontal force acting on the sphere when it reaches $B$ is

(a) 10 $mg$ (b) $mg$

(c) $\frac{50}{7}\ mg$ (d) $\frac{22}{7}\ mg$

46. A solid sphere is rotating about a diameter at an angular velocity $\omega$. If it cools so that its radius reduces to $\frac{1}{n}$ of its original value, its angular velocity becomes

(a) $\frac{\omega}{n}$ (b) $\frac{\omega}{n^2}$

(c) $n\omega$ (d) $n^2\omega$

47. In Q. 46 above, if the original rotational kinetic energy of the sphere is $K$, its new value will be

(a) $\frac{K}{n^2}$ (b) $\frac{K}{n^4}$

(c) $n^2K$ (d) $n^4K$

48. A solid sphere is rotating about its diameter. Due to increase in room temperature, its volume increases by 0.5%. If no external torque acts, the angular speed of the sphere will

(a) increase by nearly $\frac{1}{3}$ %

(b) decrease by nearly $\frac{1}{3}$ %

(c) increase by nearly $\frac{1}{2}$ %

(d) decrease by nearly $\frac{2}{3}$ %

49. A cylinder of mass $M$ has a length $L$ that is $\sqrt{3}$ times its radius $R$. What is the ratio of its moment of inertia about its own axis and that about an axis passing through its centre and perpendicular to its axis?

(a) 1 (b) $\frac{1}{\sqrt{3}}$

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

50. A uniform rod of length $L$ is suspended from one end such that it is free to rotate about an axis passing through that end and perpendicular to the length. What minimum speed must be imparted to the lower end so that the rod completes one full revolution?

(a) $\sqrt{2gL}$ (b) $2\sqrt{gL}$

(c) $\sqrt{6gL}$ (d) $2\sqrt{2gL}$

51. The height of a solid cylinder is four times its radius. It is kept vertically at time $t = 0$ on a belt which is moving in the horizontal direction with a velocity $v = 2.45\ t^2$ where $v$ is in $ms^{-1}$ and $t$ is in second. If the cylinder does not slip, it will topple over at time $t$ equal to

(a) 1 s (b) 2 s

(c) 3 s (d) 4 s

52. A thin uniform rod $AB$ of mass $M$ and length $L$ is hinged at one end $A$ to the horizontal floor. Initially it stands vertically. It is allowed to fall freely on the floor in the vertical plane. The angular velocity of the rod when its end $B$ strikes the floor is

(a) $\sqrt{\frac{g}{L}}$ (b) $\sqrt{\frac{2g}{L}}$

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

53. The moment of inertia of a thin rod of mass $M$ and length $L$ about an axis passing through the point at a distance $L/4$ from one of its ends and perpendicular to the rod is

(a) $\frac{7ML^2}{48}$ (b) $\frac{ML^2}{12}$

(c) $\frac{ML^2}{9}$ (d) $\frac{ML^2}{3}$

54. A circular disc of radius $R$ is free to oscillate about an axis passing through a point on its rim and perpendicular to its plane. The disc is turned through an angle of 60° and released. Its angular velocity when it reaches the equilibrium position will be

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

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

55. A massless and inextensible cord is wound round the circumference of a circular ring of mass $M$ and radius $R$. The ring is free to rotate about an axis passing through its centre and perpendicular to its plane. A mass $m$ is attached at the free end of the cord and is at rest. The angular speed of the ring when mass $m$ has fallen through at height $h$ is

(a) $\sqrt{\frac{2gh}{R^2}}$ (b) $\sqrt{\frac{2mgh}{MR^2}}$

(c) $\sqrt{\frac{2mgh}{(M+m)R^2}}$ (d) $\sqrt{\frac{2mgh}{(M+2m)R^2}}$

56. A circular portion of diameter $R$ is cut out from a uniform circular disc of mass $M$ and radius $R$ as shown in Fig. 5.46. The moment of inertia of the remaining (shaded) portion of the disc about an axis passing through the centre $O$ of the disc and perpendicular to its plane is

(a) $\frac{15}{32}MR^2$ (b) $\frac{7}{16}MR^2$

(c) $\frac{13}{32}MR^2$ (d) $\frac{3}{8}MR^2$

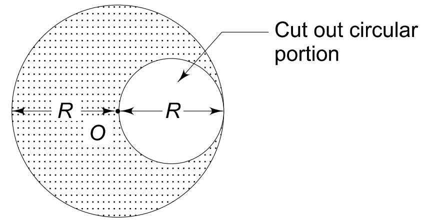


**Fig. 5.46**

57. The moment of inertia of a hollow sphere of mass $M$ and internal and external radii $R$ and $2R$ about an axis passing through its centre and perpendicular to its plane is

(a) $\frac{3}{2}MR^2$ (b) $\frac{13}{32}MR^2$

(c) $\frac{31}{35}MR^2$ (d) $\frac{62}{35}MR^2$

58. A man, standing on a turn-table, is rotating at a certain angular frequency with his arms outstretched. He suddenly folds his arms. If his moment of inertia with folded arms is 75% of that with outstretched arms, his rotational kinetic energy will

(a) increase by 33.3% (b) decrease by 33.3%

(c) increase by 25% (d) decrease by 25%

59. Two blocks of masses 1 kg and 2 kg are suspended at the end of a light string passing over a frictionless pulley of mass 4 kg and radius 10 cm. When the masses are released, the acceleration of the system is

(a) $\frac{g}{9}$ (b) $\frac{g}{7}$

(c) $\frac{g}{5}$ (d) $\frac{g}{3}$

60. A pulley of radius 2 m is rotated about its axis by a force $F = (20t - 5t^2)$ newton (where $t$ is measured in second) applied tangentially. The force is then withdrawn. 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 is reversed, is very nearly equal to

(a) $5\frac{1}{2}$ (b) $8\frac{1}{2}$

(c) $11\frac{1}{2}$ (d) $14\frac{1}{2}$

61. Four forces are applied to a wheel of radius 20 cm as shown in Fig. 5.47. The net torque produced by the forces is

(a) 5.4 Nm anticlockwise
(b) 1.8 Nm clockwise
(c) 2.0 Nm clockwise
(d) 5.4 Nm clockwise

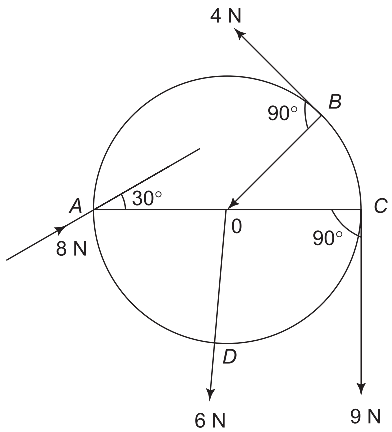


**Fig. 5.47**

62. A smooth uniform rod of length $L$ and mass $M$ has two identical beads of negligible size, each of mass $m$, which can slide freely along the rod. Initially the two beads are at the centre of the rod and the system is rotating with angular velocity $\omega_0$ about its axis perpendicular to the rod and passing through its mid point (see Fig. 5.48). There are no external forces. When the beads reach the ends of the rod, the angular velocity of the system is

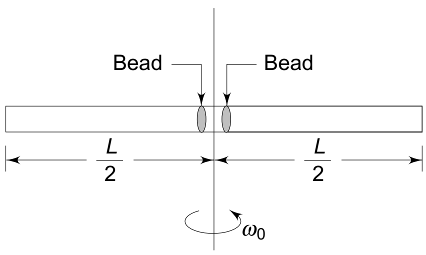


**Fig. 5.48**

(a) $\dfrac{M\omega_0}{M+3m}$ (b) $\dfrac{M\omega_0}{M+6m}$

(c) $\dfrac{(M+6m)\omega_0}{M}$ (d) $\omega_0$

63. $I_1, I_2, I_3$ and $I_4$ are respectively the moments of inertia of a thin square plate $ABCD$ of uniform thickness about axes 1, 2, 3 and 4 which are in the plane of the plate. The moment of inertia of the plate about an axis passing through the centre O and perpendicular to the plane of the plate is (Fig. 5.49)

(a) $2(I_1 + I_2)$ (b) $2(I_3 + I_4)$
(c) $I_1 + I_3$ (d) $I_1 + I_2 + I_3 + I_4$

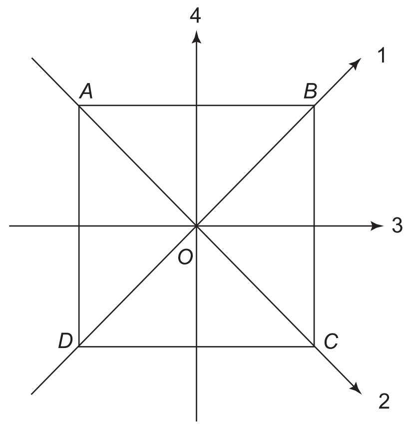


**Fig. 5.49**

64. A mass $m$ is moving with a 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

65. A smooth sphere $A$ is moving on a frictionless horizontal surface with angular speed $\omega$ 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 $\omega_A$ and $\omega_B$ respectively. Then
(a) $\omega_A < \omega_B$ (b) $\omega_A = \omega_B$
(c) $\omega_A = \omega$ (d) $\omega_B = \omega$

66. A disc of mass $M$ and radius $R$ is rolling with angular speed $\omega$ on a horizontal plane as shown in Fig. 5.50. The magnitude of angular momentum of the disc about the origin $O$ is

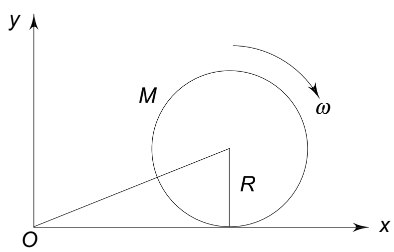


**Fig. 5.50**

(a) $\dfrac{1}{2} MR^2 \omega$ (b) $MR^2 \omega$

(c) $\dfrac{3}{2} MR^2 \omega$ (d) $2 MR^2 \omega$

67. A thin wire of length $L$ and uniform linear mass density $\rho$ is bent into a circular loop with centre at $O$ as shown in Fig. 5.51. The moment of inertia of the loop about the axis $XX'$ is

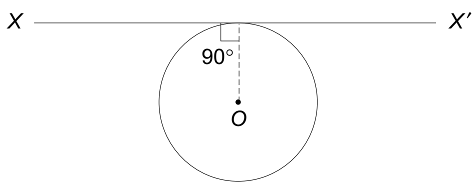


**Fig. 5.51**

(a) $\dfrac{\rho L^3}{8\pi^2}$ (b) $\dfrac{\rho L^3}{16\pi^2}$

(c) $\dfrac{5\rho L^3}{16\pi^2}$ (d) $\dfrac{3\rho L^3}{8\pi^2}$

68. A tube of length $L$ is filled completely with an incompressible liquid of mass $M$ and closed at both the ends. The tube is then rotated in a horizontal plane about one of its ends with a uniform angular velocity $\omega$. The force exerted by the liquid at the other end is

(a) $\dfrac{M\omega^2 L}{2}$ (b) $M\omega^2 L$

(c) $\dfrac{M\omega^2 L}{4}$ (d) $\dfrac{M\omega^2 L^2}{2}$

69. A cubical block of side $L$ rests on a rough horizontal surface with coefficient of friction $\mu$. A horizontal force $F$ is applied on the block as shown in Fig. 5.52. If the coefficient of friction is sufficiently high so that the block does not slide before toppling, the minimum force required to topple the block is

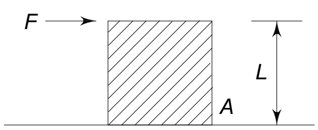


**Fig. 5.52**

(a) infinitesimal (b) $mg/4$

(c) $mg/2$ (d) $mg(1 - \mu)$

70. 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 $V$ and that *of B* is $2V$, the speed of the centre of mass of the system is

(a) 0 (b) $V$

(c) $1.5V$ (d) $3V$

71. Two blocks of masses 10 kg and 4 kg are connected by a spring of negligible mass and placed on a frictionless horizontal surface. An impulse gives a velocity of 14 m/s to the heavier block in the direction of the lighter block. The velocity of the center of mass is

(a) 30 m/s (b) 20 m/s

(c) 10 m/s (d) 5 m/s

72. 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:

(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.

73. The angular momentum of a particle moving in a circular orbit with a constant speed remains conserved about

(a) any point on the circumference of the circle

(b) any point inside the circle

(c) any point outside the circle

(d) the centre of the circle

74. The angular velocity of a body changes from $\omega_1$ to $\omega_2$ without applying a torque but by changing the moment of inertia about its axis of rotation. The ratio of the corresponding radii of gyration is

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

(c) $\sqrt{\omega_2} : \sqrt{\omega_1}$ (d) $\omega_2 : \omega_1$

75. Moment of inertia of uniform horizontal solid cylinder of mass $M$ about an axis passing through its edge and perpendicular to the axis of the cylinder if its length is 6 times its radius $R$ is:

(a) $\dfrac{39MR^2}{4}$ (b) $\dfrac{39MR^2}{8}$

(c) $\dfrac{49MR^2}{8}$ (d) $\dfrac{49MR^2}{4}$

76. If $A$ is the areal velocity of a planet of mass $M$, its angular momentum is

(a) $M$ (b) $2MA$

(c) $A^2M$ (d) $AM^2$

77. One end of a thin uniform rod of length $L$ and mass $M_1$ is rivetted to the centre of a uniform circular disc of radius '$r$' and mass $M_2$ so that both are coplanar. The centre of mass of the combination from the centre of the disc is:

(Assume that the point of attachment is at the origin)

(a) $\frac{L(M_1+M_2)}{2M_1}$ (b) $\frac{LM_1}{2(M_1+M_2)}$

(c) $\frac{2L(M_1+M_2)}{M_1}$ (d) $\frac{2LM_1}{(M_1+M_2)}$

78. A body of mass '*m*' is tied to one end of a spring and whirled round in a horizontal plane with a constant angular velocity. The elongation in the spring is one centimeter. If the angular velocity is doubled, the elongation in the spring is 5 cm. The original length of the spring is:

(a) 16 cm (b) 15 cm

(c) 14 cm (d) 13 cm

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

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

(c) $\frac{L}{2}$ (d) $\frac{L}{4}$

80. A uniform rod of length 1 metre is bent at its mid-point to make 90° angle. The distance of the centre of mass from the centre of the rod is

(a) 36.1 cm (b) 25.2 cm

(c) 17.7 cm (d) zero

81. A mass is whirled in a circular path with constant angular velocity and its angular momentum is *L*. If the string is now halved keeping the angular velocity the same, the angular momentum is

(a) $\frac{L}{4}$ (b) $\frac{L}{2}$

(c) $L$ (d) $2L$

82. A solid metallic sphere of radius *R* having moment of inertia equal to *I* about its diameter is melted and recast into a solid disc of radius *r* of a uniform thickness. The moment of inertia of the disc about an axis passing through its edge and perpendicular to its plane is also equal to *I*. The ratio *r*/*R* is

(a) $\frac{2}{\sqrt{15}}$ (b) $\frac{2}{\sqrt{10}}$

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

83. The mass per unit length of a non-uniform rod *OP* of length *L* varies as

$$m = k\frac{x}{L}$$

where *k* is a constant and *x* is the distance of any point on the rod from end *O*. The distance of the centre of mass of the rod from end *O* is

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

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

84. A uniform thin rod of mass *M* and length *L* is hinged by a frictionless pivot at its end *O*, as shown Fig. 5.53. A bullet of mass *m* moving horizontally with a velocity *v* strikes the free end of the rod and gets embedded in it. The angular velocity of the system about *O* just after the collision is

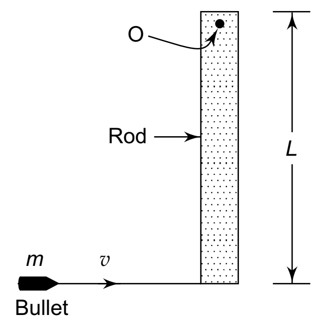


**Fig. 5.53**

(a) $\frac{mv}{L(M+m)}$ (b) $\frac{2mv}{L(M+2m)}$

(c) $\frac{3mv}{L(M+3m)}$ (d) $\frac{mv}{LM}$

85. A gramophone record of mass *M* and radius *R* is rotating at an angular velocity $\omega$. A coin of mass *m* is gently placed on the record at a distance $r = R/2$ from its centre. The new angular velocity of the system is

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

(c) $\omega$ (d) $\frac{\omega M}{M}$

86. Two blocks of masses *M* and 2*M* are hanging from the ends *AB* of a uniform rod of mass 3*M* and length 3*L* as shown in Fig. 5.54. Assuming that the centre of the rod is at the origin (0, 0) and the strings have negligible mass, the *x* and *y* coordinates of the centre of mass of the system are

(a) $\frac{L}{2}, -\frac{3L}{4}$ (b) $\frac{L}{3}, -\frac{4L}{5}$

(c) $\frac{L}{4}, -\frac{5L}{6}$ (d) $\frac{L}{4}, -\frac{3L}{5}$

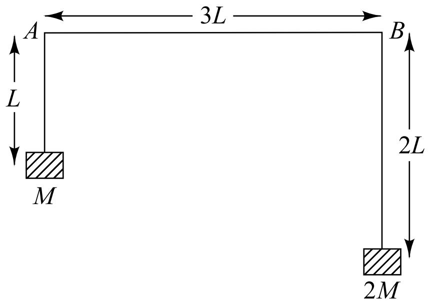


**Fig. 5.54**

87. A man of mass $m$ is standing at end $A$ of a stationary plank $AB$ of wood of mass $M$ and length $L$ floating on a pond of water. If the man walks to the other end $B$, the plank will.
   (a) remain stationary
   (b) move through a distance $\frac{mL}{M}$ opposite to the direction of motion of the man
   (c) move through a distance $\frac{mL}{2(M+m)}$ in the direction of motion of the man
   (d) move through a distance $\frac{mL}{(M+m)}$ opposite to the direction of motion of the man.

88. In Q. 87 above, if the man walks with an average velocity $v$, the average velocity of the plank will be
   (a) zero
   (b) $\frac{vm}{M}$ to the left
   (c) $\frac{vm}{m+M}$ to the left
   (d) $v$ to the right

89. A non-uniform bar $AB$ of length $L$ = 50.0 cm has a linear density $\lambda = 4x + 5$ where $\lambda$ is in kg m$^{-1}$ and $x$ is in metre. The distance of the centre of mass of the bar from its midpoint is
   (a) 1.4 cm (b) 2.6 cm
   (c) 3.0 cm (d) 3.8 cm

90. A block of mass $m$ is hung from a pulley of mass $M$ and radius $R$ as shown in Fig. 5.55. If $M = 4m$, the acceleration of the block when the system is released is
   (a) $\frac{g}{4}$ (b) $\frac{g}{3}$
   (c) $\frac{g}{2}$ (d) $\frac{2g}{3}$

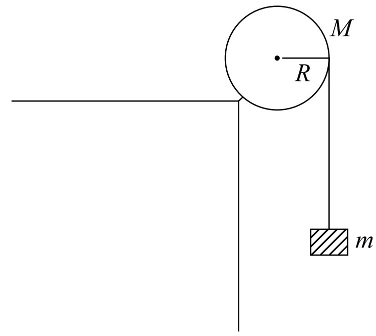


**Fig. 5.55**

# ANSWER KEY

| | | | |
|---|---|---|---|
| 1. (c) | 2. (d) | 3. (c) | 4. (c) |
| 5. (a) | 6. (c) | 7. (d) | 8. (b) |
| 9. (c) | 10. (a) | 11. (d) | 12. (b) |
| 13. (c) | 14. (a) | 15. (b) | |
| 16. (c) | 17. (c) | 18. (b) | 19. (a) |
| 20. (b) | 21. (a) | 22. (b) | 23. (a) |
| 24. (c) | 25. (d) | 26. (a) | 27. (c) |
| 28. (b) | 29. (d) | 30. (c) | 31. (c) |
| 32. (a) | 33. (a) | 34. (a) | 35. (d) |
| 36. (c) | 37. (c) | 38. (b) | 39. (d) |
| 40. (a) | 41. (d) | 42. (a) | 43. (c) |
| 44. (b) | 45. (c) | 46. (d) | 47. (c) |
| 48. (b) | 49. (a) | 50. (c) | 51. (a) |
| 52. (c) | 53. (a) | 54. (b) | 55. (c) |
| 56. (c) | 57. (d) | 58. (a) | 59. (c) |
| 60. (a) | 61. (b) | 62. (b) | 63. (c) |
| 64. (b) | 65. (c) | 66. (c) | 67. (d) |
| 68. (a) | 69. (c) | 70. (a) | 71. (c) |
| 72. (b) | 73. (d) | 74. (c) | 75. (d) |
| 76. (b) | 77. (b) | 78. (b) | 79. (d) |
| 80. (c) | 81. (a) | 82. (a) | 83. (b) |
| 84. (c) | 85. (a) | 86. (c) | 87. (d) |
| 88. (c) | 89. (a) | 90. (b) | |

**SOURCE - MC GRAW HILL**