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Date : 28.03.2025 **TEST ID: 47**
Time : 03:00:00 **PHYSICS**
Marks : 200

1.ROTATIONAL DYNAMICS ,3.ROTATIONAL MOTION

Single Correct Answer Type

1. If a system of particles performing rotational motion about the axis of rotation then it is true that:
   a) All will describe the same circle of same radius about the axis
   b) AII will describe the same circle of different radius about the same axis
   c) All particles will be at rest
   d) All particle move with same translational velocity
2. What torque will increase angular velocity of a solid disc of mass 16 kg and diameter 1 m from zero to 2rpm in 8 s ?
   a) $\left(\frac{\pi}{4}\right)\mathrm{N-m}$ b) $\left(\frac{\pi}{2}\right)\mathrm{N-m}$
   c) $\left(\frac{\pi}{3}\right)\mathrm{N-m}$ d) $(\pi)\mathrm{N-m}$
3. A disc of mass 25 kg and radius 0.2 m is rotating at 240 r. p. m. A retarding torque bring it to rest in 20 s. If the torque is due to a force applied tangentially on the rim of the disc, then the magnitude of the force in newton is
   a) π b) 4π
   c) 3π d) 2π
4. Four spheres of diameter 2 a and mass M are placed with their centres on the four corners of a square of side b. Then, the moment of inertia of the system about an axis along one of the sides of the square is
   a) $\frac{4}{5}\mathrm{Ma^2}+2\mathrm{Mb^2}$ b) $\frac{8}{5}\mathrm{Ma^2}+2\mathrm{Mb^2}$
   c) $\frac{8}{5}\mathrm{Ma^2}$ d) $\frac{4}{5}\mathrm{Ma^2}+4\mathrm{Mb^2}$
5. A point at which -the whole mass of the body is supposed to be concentrated in order to study the motion of an external force in accordance with Newton's laws of motion is
   a) centre of gravity
   b) weight of the body
   c) centre of mass of a body
   d) acceleration due to gravity acts on a body
6. Kinetic energy of rotation E and angular momentum L are related as
   a) $\mathrm{E}=\frac{\mathrm{L}^2}{2\mathrm{I}}$ b) $\mathrm{E}=2\,\mathrm{IL}$
   c) $\mathrm{E}=\sqrt{2\,\mathrm{IL}}$ d) $E=2\sqrt{\frac{\mathrm{I}}{\mathrm{L}}}$
7. A bucket containing water is revolved in a vertical circle of radius 'r'. To prevent the water from falling down, the minimum frequency of revolution required is [g = acceleration due to gravity]
   a) $\frac{1}{2\pi}\sqrt{\frac{r}{g}}$ b) $2\pi\sqrt{\frac{g}{r}}$
   c) $\frac{1}{2\pi}\sqrt{\frac{g}{r}}$ d) $\frac{2\pi g}{r}$
8. Calculate the angular momentum of the earth due to rotation about its own axis. Assume that the earth is a sphere of mass 6×10^{24} kg and radius 6400 km
   a) $714.5\times10^{32}\ \mathrm{m^2\ s^{-1}}$ b) $71.45\times10^{30}\ \mathrm{m^2\ s^{-1}}$
   c) $71.45\times10^{31}\ \mathrm{m^2\ s^{-1}}$ d) $7.145\times10^{33}\ \mathrm{m^2\ s^{-1}}$
9. A ring of diameter 0.4 m and of mass 10 kg is rotating about its axis at the rate of 1200rpm. The angular momentum of the ring is
   a) $60.28\ \mathrm{kg-m^2\ s^{-1}}$ b) $55.26\ \mathrm{kg-m^2\ s^{-1}}$
   c) $40.28\ \mathrm{kg-m^2\ s^{-1}}$ d) $50.28\ \mathrm{kg-m^2\ s^{-1}}$
10. 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
11. Two discs having moment of inertia I_1 and I_2 are made from same material have same mass. Their thickness and radii are t_1, t_2 and R_1, R_2 respectively. The relation between moment of inertia of each disc about an axis passing through its centre and perpendicular to its plane and its thickness is
    a) $I_1t_2^2=I_2t_1^2$ b) $I_1t_1=I_2t_2$
    c) $I_1t_2=I_2t_1$ d) $I_1t_1^2=I_2t_2^2$
12. A particle moves along a circle of radius P with constant tangential acceleration. If the velocity

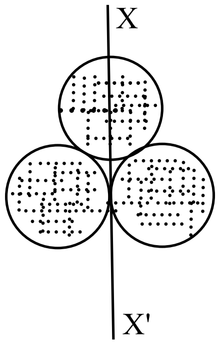
of the particle is V at the end of third revolution, after the revolution has started, then the tangential acceleration is

a) $\frac{V^2}{12\pi r}$
b) $\frac{V^2}{10\pi r}$
c) $\frac{V^2}{14\pi r}$
d) $\frac{V^2}{9\pi r}$

13. The moment of inertia of a thin uniform rod of mass 'M' and length 'L' about an axis passing through a point at a distance $\frac{L}{4}$ from one of its ends and perpendicular to the length of the rod is

a) $\frac{ML^2}{48}$
b) $\frac{7ML^2}{48}$
c) $\frac{5ML^2}{48}$
d) $\frac{9ML^2}{48}$

14. 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



a) $\frac{11}{5}mr^2$
b) $3mr^2$
c) $\frac{16}{5}mr^2$
d) $4mr^2$

15. Moment of inertia of the rod about an axis passing through the centre and perpendicular to its length is 'I_1'. The same rod is bent into a ring and its moment of inertia about the diameter is 'I_2', then $\frac{I_2}{I_1}$ is

a) $\frac{3}{2\pi^2}$
b) $\frac{3}{4\pi^2}$
c) $\frac{2\pi^2}{3}$
d) $\frac{4\pi^2}{3}$

16. The relative angular speed of hour hand and second hand of a clock is (m rad/s)

a) $\frac{311\pi}{578}$
b) $\frac{719\pi}{21600}$
c) $\frac{421\pi}{11600}$
d) $\frac{119\pi}{15600}$

17. A liquid kept in a cylindrical vessel is rotated about vertical axis through the centre of circular base. The difference in the heights of the liquid at the centre of vessel and its edge is (R = radius of vessel, ω = angular velocity of rotation, g = acceleration due to gravity)

a) $\frac{R\omega}{g}$
b) $\frac{R^2\omega^2}{g}$
c) $\frac{R\omega}{2g}$
d) $\frac{R^2\omega^2}{2g}$

18. Two particles of masses m_1 and m_2 are separated by a distance 'd' Then moment of inertia of the system about an axis passing through centre of mass and perpendicular the line joining them is

a) $\left(\frac{m_1 m_2}{m_1+m_2}\right)\frac{d^2}{2}$
b) $\left(\frac{m_1 m_2}{m_1+m_2}\right)d$
c) $\left(\frac{m_1 m_2}{m_1+m_2}\right)d^2$
d) $\left(\frac{2m_1 m_2}{m_1+m_2}\right)d^2$

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

a) MR^2 b) $\frac{1}{2}MR^2$ c) $\frac{1}{4}MR^2$ d) $\frac{2}{5}MR^2$

20. A sphere is suspended by a thread of length l. What minimum horizontal velocity has to be imparted the ball for it to reach the height of the suspension?

a) gl
b) 2gl
c) $\sqrt{gl}$
d) $\sqrt{2gl}$

21. A motor cycle racer takes a round with speed 20 m/s on a curved road of radius 40 m. The leaning angle of motor cycle with vertical for safe turn is
($g = 10\frac{m}{s^2}$, $\tan 45^0 = 1$)

a) 30^0
b) 75^0
c) 60^0
d) 45^0

22. A child starts running from rest along a circular track of radius 'r' with constant tangential acceleration 'a'. After time 't' he feels that slipping of shoes on the ground has started. The coefficient of friction between shoes and the ground is [g = acceleration due to gravity]

a) $\frac{[a^4t^4 + a^2r^2]}{rg}$
b) $\frac{[a^4t^2 + a^2r^4]}{rg}$

c) $\frac{[a^4t^4 - a^2r^2]^{1/2}}{rg}$ d) $\frac{[a^4t^4 + a^2r^2]^{1/2}}{rg}$

23. Choose the wrong statement out of the following
 a) There need not be any mass at the centre of mass
 b) A force applied at the centre of mass produces both translatory and rotatory motions
 c) The ratio of distances of two particles from their centers of mass is the inverse ratio of their masses
 d) Moment of inertia of the body is minimum about an axis passing through the centre of mass in a plane of body

24. A cosmonaut is orbiting the earth is a spacecraft at an altitude h = 630 km with a speed of 8 km s^{-1}. If the radius of the earth is 6400 km, the acceleration of the cosmonaut is
 a) $9.10\ ms^{-2}$ b) $9.80\ ms^{-2}$
 c) $10.0\ ms^{-2}$ d) $9.88\ ms^{-2}$

25. 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) $\frac{2}{5}MR^2$

26. A stone of mass 200 g attached at the end of inextensible string 1 m long is whirled in a vertical circle. If the speed of the stone is 50 cm/s and the tension in the string is 1.05 N, the angle (θ) made by the string with the vertical, measured from the lowest position is
 [Take $g = 10\ m/s^2$]
 a) $\cos^{-1}(1)$ b) $\sin^{-1}\left(\frac{1}{2}\right)$
 c) $\cos^{-1}\left(\frac{1}{2}\right)$ d) $\sin^{-1}\left(\frac{1}{\sqrt{2}}\right)$

27. A dancer is standing on a stool rotating about the vertical axis passing through its centre. She pulls her arm towards the body reducing her moment of inertia by a factor of n. The new angular speed of turn table is proportional to
 a) n^0 b) n^1 c) n^{-1} d) n^2

28. Two discs A and B of equal mass and thickness have densities $6800\frac{kg}{m^3}$ and $8500\ kg/m^3$ respectively. The ratio of their moments of inertia (A to B) is
 a) $\frac{1}{6.8 \times 8.5}$ b) $\frac{4}{5}$
 c) $\frac{5}{4}$ d) $\frac{5}{9}$

29. An uniform rod AB of mass 'm' and length 'l' is at rest on a smooth horizontal surface. An impulse 'P' is applied to the end B. The time taken by the rod to turn through a right angle is
 a) $\frac{\pi}{12}\frac{ml}{P}$ b) $2\frac{\pi P}{ml}$
 c) $2\pi\frac{ml}{P}$ d) $\frac{\pi P}{ml}$

30. A circular disc X of radius R made from iron plate of thickness 't' and another disc Y of radius 4R made from an iron plate of thickness $\frac{t}{4}$. Then the relation between the moments of inertia I_X and I_Y is
 a) $I_Y = 32\ I_X$ b) $I_Y = 16\ I_X$
 c) $I_Y = I_X$ d) $I_Y = 64\ I_X$

31. A wheel has an angular acceleration of $3.0\ rad/s^2$ and an initial angular speed of 2.00 rad/s. In a time of 2 s, it has rotated through an angle (in radian) of
 a) 6 b) 10 c) 12 d) 4

32. Unit of angular momentum is
 a) N s b) $N\ s^{-1}$ c) $J\ s^{-1}$ d) J s

33. A molecule consists of two atoms each of mass 'm' and separated by a distance 'd'. At room temperature, if the average rotational kinetic energy is 'E' then the angular frequency is
 a) $\frac{2}{d}\sqrt{\frac{E}{m}}$ b) $\frac{d}{2}\sqrt{\frac{m}{E}}$
 c) $\sqrt{\frac{Ed}{m}}$ d) $\sqrt{\frac{m}{Ed}}$

34. A particle starting from rest moves along the circumference of a circle of radius 'r' with angular acceleration 'α'. The magnitude of the average velocity, in the time it completes the small angular displacement 'θ' is
 a) $r\left(\frac{\alpha\theta}{2}\right)^{1/2}$ b) $r\left(\frac{\alpha\theta}{2}\right)^{2}$
 c) $r\left(\frac{\alpha\theta}{2}\right)$ d) $r\left(\frac{2}{\alpha\theta}\right)^{2}$

35. A particle of mass 'm' moves along a circle of radius 'r' with constant tangential acceleration. If kinetic energy 'E' of the particle becomes three times by the end of third revolution after beginning of acceleration the magnitude of tangential acceleration is

a) $\frac{E}{6\pi rm}$ b) $\frac{E}{12\pi rm}$
c) $\frac{E}{24\pi rm}$ d) $\frac{E}{3\pi rm}$

36. A disc of mass 'M' and radius 'R' is rotating about its own axis. If one quarter part of the disc is removed then new moment of inertia of the disc about the same axis is
a) $\frac{2MR^2}{15}$ b) $\frac{MR^2}{8}$
c) $\frac{2MR^2}{13}$ d) $\frac{3MR^2}{8}$

37. A particle executes uniform circular motion with angular momentum 'L'. Its rotational kinetic energy becomes half, when the angular frequency is doubled. Its new angular momentum is
a) 4L b) $\frac{L}{4}$
c) 2L d) $\frac{L}{2}$

38. The car of a wheel rotating with certain angular velocity is topped in 5 s and before it stops, it makes 20 revolutions. Then initially, it was rotating with the frequency
a) 8 Hz b) 11 Hz
c) 12 Hz d) 15 Hz

39. A disc has mass 'M' and radius 'R'. How much tangential force should be applied to the rim of the disc so as to rotate with angular velocity 'ω' in time 't'?
a) $\frac{MR\omega}{4t}$ b) $\frac{MR\omega}{2t}$
c) $\frac{MR\omega}{t}$ d) $MR\omega t$

40. A rotating body has angular momentum 'L'. If its frequency of rotation is halved and rotational kinetic energy is doubled, its angular momentum becomes
a) $\frac{L}{2}$ b) 4L
c) 2L d) $\frac{L}{4}$

41. A body rolling down an inclined plane is an example of:
a) rotational motion
b) translation motion
c) combined rot as well as translation
d) none of these

42. A car is moving with speed 30 ms^{-1} on a circular path of radius 500 m. Its speed is increasing at a rate of 2 ms^{-2}, what is the acceleration of the car?
a) 2 ms^{-2} b) 2.7 ms^{-2}
c) 1.82 ms^{-2} d) 9.82 ms^{-2}

43. The moment of inertia of a solid sphere about an axis passing through centre of gravity is $(2/5)MR^2$, then its radius of gyration about a parallel axis at a distance 2R from first axis is
a) 5R b) $\sqrt{\frac{22}{5}}R$
c) $\frac{5}{2}R$ d) $\sqrt{\frac{12}{5}}R$

44. The moment of inertia of a thin uniform rod about perpendicular axis passing through one of its ends is T. Now the rod is bent in a ring and its moment of inertia about diameter is 'I_1', then $I: I_1$ is
a) $\frac{11\pi^2}{3}$ b) $\frac{4\pi^2}{3}$
c) $\frac{\pi^2}{3}$ d) $\frac{8\pi^2}{3}$

45. From a disc of mass 'M' and radius 'R' a circular hole of diameter R is cut whose rim passes through the centre. The moment of inertia of the remaining part of the disc about perpendicular axis passing through the centre is
a) $\frac{9MR^2}{32}$ b) $\frac{7MR^2}{32}$
c) $\frac{11MR^2}{32}$ d) $\frac{13MR^2}{32}$

46. A thin wire of length 'L' and uniform linear mass density 'm' is bent into a circular loop. The moment of inertia of this loop about the tangential axis and in the plane of the coil is
a) $\frac{3mL^3}{4\pi^2}$ b) $\frac{3mL^3}{8\pi^2}$
c) $\frac{3mL^3}{16\pi^2}$ d) $\frac{3mL^3}{2\pi^2}$

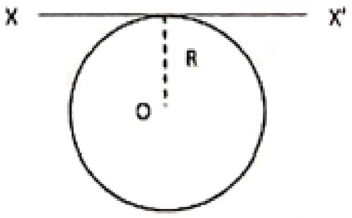
47. The moment of inertia of a disc about a tangent axis in its plane is
a) $\frac{mR^2}{4}$ b) $\frac{3MR^2}{2}$
c) $\frac{5}{4}MR^2$ d) $\frac{7MR^2}{4}$

48. Which effect becomes a boon for scatters, ballet dancers or divers:
a) Angular mass is directly proportional angular velocity about that axis
b) Angular mass is inversely proportional to angular velocity about that axis

c) Inertia is directly proportional angular acceleration

d) Torque is proportional to angular acceleration directly

49. A thin metal wire of length ‘L’ and uniform linear mass density ‘ρ’ is bent into a circular coil with ‘O’ as centre. The moment of inertia of a coil about the axis XX′ is



a) $\frac{3\rho L^3}{8\pi^2}$ b) $\frac{3\rho L^2}{4\pi^2}$

c) $\frac{\rho L^3}{8\pi^2}$ d) $\frac{\rho L^3}{4\pi^2}$

50. An inclined plane makes an angle of 30° with the horizontal. A solid sphere rolling down this inclined plane from rest without slipping has a linear acceleration equal to

a) $\frac{g}{3}$ b) $\frac{2g}{3}$ c) $\frac{5g}{7}$ d) $\frac{5g}{14}$

51. From the theorem of parallel axes,

a) $I = I_G - Md^2$ b) $I = I_G + Md^2$

c) $I + I_G = Md^2$ d) $I_G = I + Md^2$

52. The moment of inertia of a body about the given axis, rotating with angular velocity 1 rad/s is numerically equal to ‘P’ times its rotational kinetic energy. The value of ‘P’ is

a) $\frac{1}{4}$ b) $\frac{1}{2}$

c) 2 d) 1

53. A ring and a disc roll on the horizontal surface without slipping with same linear velocity. If both have same mass and total kinetic energy of the ring is 4 J, then total kinetic energy of the disc is

a) 3 J b) 4 J

c) 5 J d) 6 J

54. When a steady torque or couple acts on a body, the body

a) continues in a state of rest or of steady motion by Newton's first law

b) gets linear acceleration by Newton's second law

c) continues to rotate at a steady rate

d) gets an angular acceleration

55. The angle of banking ‘θ’ for a meter gauge railway line is given by $\theta = \tan^{-1}\left(\frac{1}{20}\right)$. What is the elevation of the outer rail above the inner rail?

a) 20 cm b) 10 cm

c) 0.2 cm d) 5 cm

56. A circular coil and a disc having same mass roll without slipping on the horizontal with same linear velocity. If the total K. E. of the coil is 12 J then total K. E. of the disc is

a) 6 J b) 15 J

c) 9 J d) 12 J

57. The centre of mass or a symmetrical and uniform continuous distribution of mass of a rigid, body is

a) at the centre of the surface

b) outside the body

c) inside the body

d) at the geometric centre of the body

58. For a uniform rectangular plate of mass m, length l and breath b, rotated about transverse axis through its centre its moment of inertia is

a) $\frac{m(l^2 + b^2)}{12}$ b) $\frac{m(l^2 + b^2)}{8}$

c) $\frac{m(l^2 + b^2)}{10}$ d) $\frac{m(l^2 + b^2)}{6}$

59. Three points masses, each of mass ‘m’ are placed at the corners of an equilateral triangle of side ‘l’. The moment of inertia of the system about an axis passing through one of the vertices and parallel to the side joining other two vertices, will be

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

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

60. If all a sudden the radius of the earth increases, then

a) the angular momentum of the earth will be greater than that of the sun

b) the orbital speed of the earth will increase

c) the periodic time of the earth will increase

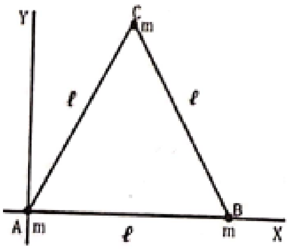
d) the energy and angular momentum will remain constant

61. Moment of inertia of a solid sphere about its diameter is ‘I’. It is then casted into 27 small spheres of same diameter. The moment of inertia of each new sphere is

a) $\frac{1}{188}$ b) $\frac{1}{243}$

c) $\frac{1}{121}$ d) $\frac{1}{156}$

62. 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 AY perpendicular to AB and in the plane of the triangle in gram cm^2 will be $(\sin 30^0 = 0.5)$



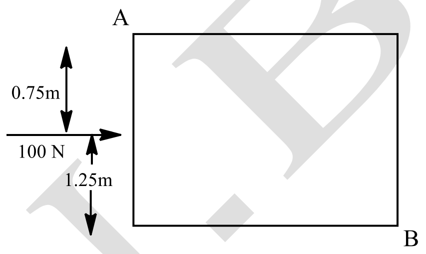
a) $\frac{3ml^2}{2}$ b) $\frac{5ml^2}{4}$

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

63. Calculate the M.I. of a thin uniform ring about an axis tangent to the ring and in a plane of the ring, if its M.I. about an axis passing through the centre and perpendicular to plane is $4\ kg\ m^2$

a) $12\ kg\ m^2$ b) $3\ kg\ m^2$ c) $6\ kg\ m^2$ d) $9\ kg\ m^2$

64. A force of 100 N is applied perpendicularly to the left edge of the rectangle as shown in the figure. The torque (magnitude and direction) produced by this force with respect to an axis perpendicular to the plane of the rectangle at corner A and with respect to a similar axis at corner B are respectively



a) 75 N − m counter-clockwise, 125 N − m counter-clockwise
b) 125 N − m counter-clockwise, 75 N-m clockwise
c) 125 N − m clockwise, 75 N − m counter-clockwise
d) 125 N − m counter-clockwise, 75 N-m clockwise

65. A same torque is applied to a disc and a ring of equal mass and radii then

a) Both will rotate with same angular acceleration
b) The ring will rotate with greater angular acceleration
c) Both will rotate with same angular velocity
d) The disc will rotate with greater angular frequency

66. If the radius of the earth contracts to half of its present value keeping mass constant, then the length of the day will be

a) 48 hr b) 24 hr c) 12 hr d) 6 hr

67. A ring, a disc and a solid sphere have same mass and radius. All of them are rolled down on an inclined plane from same height, simultaneously. The body that will reach at the bottom, last amongst is

a) Ring b) Disc
c) Ring and disc d) Solid sphere

68. The moment of inertia of a thin uniform rod of mass M about an axis passing through its centre and perpendicular to its length is given to be I_0. The moment of inertia of the same rod about an axis passing through one of its ends and perpendicular to its length is

a) $\frac{1}{2} I_0$ b) $3\ I_0$ c) $5\ I_0$ d) $4\ I_0$

69. The ratio of radii of gyration of a ring to a disc (both circular) of same radii and mass, about a tangential axis perpendicular to the plane is

a) $\frac{2}{\sqrt{5}}$ b) $\frac{\sqrt{3}}{\sqrt{2}}$

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

70. The term moment of momentum is called

a) angular momentum b) torque
c) force d) couple

71. The moment of inertia of a thin uniform rod rotating about the perpendicular axis passing through one end is 'I'. The same rod is bent into a ring and its moment of inertia about the diameter is 'I_1'. The ratio $\frac{I}{I_1}$ is

a) $\frac{4\pi}{3}$ b) $\frac{8\pi^2}{3}$ c) $\frac{5\pi}{3}$ d) $\frac{8\pi^2}{5}$

72. A heavy disc is rotating with uniform angular velocity w about its own axis. A piece of wax sticks to it. The angular velocity of the disc will

a) increase b) decrease
c) becomes zero d) remain unchanged

73. When same torque acts on two rotating rigid bodies to stop them, which have same angular momentum,

a) body with greater moment of inertia stops first
b) body with smaller moment of inertia stops first

c) both the bodies will be stopped after the same time

d) we can not predict which stops first

74. A uniform solid sphere having radius 'R' and density 'ρ' is rotating about a tangent to the surface of the sphere. The moment of inertia of the solid sphere is

a) $\frac{28}{15}\pi R^5 \rho$ b) $\frac{21}{20}\pi R^3 \rho$

c) $\frac{28}{15}\pi R^3 \rho$ d) $\frac{21}{20}\pi R^5 \rho$

75. Moment of inertia of a rod is minimum, when the axis passes through

a) Its end

b) Its centre

c) At a point midway between the end and centre

d) At a point $\frac{1}{8}$ length from centre

76. From the theorem of perpendicular axes, if the lamina is in X-Y plane, then

a) $I_x - I_y = I_z$ b) $I_x + I_z = I_y$

c) $I_x + I_y = I_z$ d) $I_y + I_z = I_x$

77. A disc of moment of inertia 'I_1' is rotating in horizontal plane about an axis passing through a centre and perpendicular to its plane with constant angular speed 'ω_1'. Another disc of moment of inertia 'I_2' having zero angular speed is placed coaxially on a rotating disc. Now both the discs are rotating with constant angular speed 'ω_2'. The energy lost by the initial rotating disc is

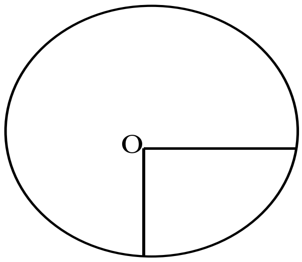
a) $\frac{1}{2}\left[\frac{I_1+I_2}{I_1 I_2}\right]\omega_1^2$ b) $\frac{1}{2}\left[\frac{I_1 I_2}{I_1-I_2}\right]\omega_1^2$

c) $\frac{1}{2}\left[\frac{I_1-I_2}{I_1 I_2}\right]\omega_1^2$ d) $\frac{1}{2}\left[\frac{I_1 I_2}{I_1+I_2}\right]\omega_1^2$

78. The speed of a homogenous solid sphere after rolling down an inclined plane of vertical height h from rest without sliding is

a) $\sqrt{\frac{10}{7}gh}$ b) $\sqrt{gh}$ c) $\sqrt{\frac{6}{5}gh}$ d) $\sqrt{\frac{4}{3}gh}$

79. The moment of inertia of a disc of mass M and radius R, about an axis passing through the centre O and perpendicular to the plane of the disc is $\frac{MR^2}{2}$. If one quarter of the disc is removed, the new moment of inertia of the disc will be



a) $\frac{MR^2}{3}$ b) $\frac{MR^2}{4}$

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

80. A stone of mass 'm' tied to a string of length 'l' is whirled in a circle of radius 'r' under the effect of gravity. If its radial acceleration is 'p' times the acceleration due to gravity (g) then its linear acceleration at a point on the circle, where the string becomes horizontal (P is +ve)

a) $g\sqrt{(p^2-1)}$ b) $g\sqrt{(p-1)}$

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

81. A rigid body is rotating with angular velocity ω about an axis of rotation. Let v be the linear velocity of particle which is at perpendicular distance r from the axis of rotation. Then the relation $v = r\omega$ implies that

a) ω does not depend on r b) $\omega \propto \frac{1}{r}$

c) $\omega \propto r$ d) $\omega = 0$

82. Match the following columns (R = radius, K = Radius of gyration)

	Column I		Column II
(a)	'K' for a solid sphere rotating about its tangent	(p)	$\sqrt{2}R$
(b)	'K' for a ring rotating about its tangent perpendicular to its plane	(q)	$\frac{R}{2}$
(c)	'K' for a uniform solid right circular cone rotating about its central	(r)	$\frac{\sqrt{7}}{\sqrt{5}}R$

	axis		
(d)	'K' for a uniform disc rotating about its diameter	(s)	$\frac{\sqrt{3}}{\sqrt{10}}R$

a) (A) → (q); (B) → (r); (C) → (p); (D) → (s)
b) (A) → (r); (B) → (q); (C) → (s); (D) → (p)
c) (A) → (p); (B) → (r); (C) → (q); (D) → (s)
d) (A) → (r); (B) → (p); (C) → (s); (D) → (q)

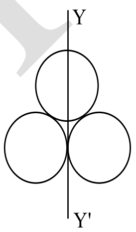
83. Three uniform thin rods, each of mass 1 kg and length $\sqrt{3}$ m, are placed along three co-ordinate axes with one end at the origin. The moment of inertia of the system about X-axis is
a) 2 kg m^2
b) 3 kg m^2
c) 0.75 kg m^2
d) 1 kg m^2

84. The moment of inertia of the body an axis is 1.2 kg-m^2. Initially the body is at rest. In order to produce a rotational kinetic energy of 1500 J, an angular acceleration of 25 rads^{-2} must be applied about the axis for the duration of
a) 2 s b) 4 s c) 8 s d) 10 s

85. In vertical circular motion, the ratio of kinetic energy of a particle at highest point to that at lowest point is
a) 5
b) 2
c) 0.5
d) 0.2

86. A solid sphere of mass 'M' and radius 'R' is rotating about its diameter. A solid cylinder of same mass and same radius is also rotating about its geometrical axis with an angular speed twice that of the sphere. The ratio of the kinetic energy of rotation of the sphere to that of the cylinder is
a) 2:3
b) 1:5
c) 1:4
d) 3:1

87. Three rings each of mass M and radius R are arranged as shown in the figure. The moment of inertia of the system about YY' will be



a) 3 MR^2 b) $\frac{3}{2}MR^2$ c) 5 MR^2 d) $\frac{7}{2}MR^2$

88. The point at which total mass of a body is suppose to be concentrated is known as
a) deep centre
b) centre of gravity
c) centre of mass
d) geometric centre

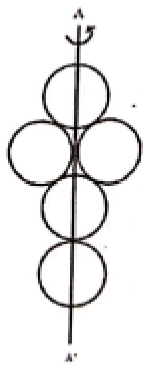
89. A constant torque of 200 N turns a flywheel, which is at rest, about an axis through its centre and perpendicular to its plane. If its moment of inertia is 50 kg $-$ m^2, then in 4 second, what will be change in its angular momentum?
a) 200 kg $-$ m^2/s
b) 800 kg $-$ m^2/s
c) 20 kg $-$ m^2/s
d) 40 kg $-$ m^2/s

90. Velocity vector and acceleration vector in a uniform circular motion are related as
a) both in the same direction
b) perpendicular to each other
c) both in opposite direction
d) not related to each other

91. The mass of the earth is increasing at the rate of 1 part in 5×10^{19} per day by the attraction of meteors falling normally on the earth's surface. Assuming that the density of earth is uniform, the rate of change of the period of rotation of the earth is
a) 2.0×10^{-20}
b) 2.66×10^{-19}
c) 4.33×10^{-18}
d) 5.66×10^{-17}

92. The bob of a simple pendulum of length 'l' is pulled through an angle 'θ' from its equilibrium position and then released. When it passes through its equilibrium position, its speed is given by
(g = acceleration due to gravity)
a) $\sqrt{2gL(1-\cos\theta)}$
b) $\sqrt{2gL(1+\cos\theta)}$
c) $\sqrt{2gL}$
d) $\sqrt{2gL(1+\sin\theta)}$

93. Five solid spheres each of mass 'm' and radius 'R' are rotting about an axis AA′ as shown in figure. Hence the moment of inertia of the system about the axis of rotation AA′ is



a) 5 mR^2
b) 6 mR^2
c) 3 mR^2
d) 4 mR^2

94. Three point masses, each of mass m are placed at the corners of an equilateral triangle of side

I . Moment of inertia of this system about an axis along one side of triangle is

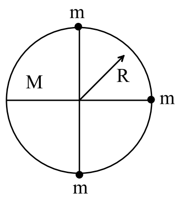
a) $3ml_2$ b) $\frac{3}{2}ml^2$

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

95. Two rings are placed with common centres such that their planes are perpendicular. Two more rings are placed concentric with the previous two rings such that their planes make 45° with the planes of the two given rings. Find the moment of inertia of the system about an axis passing through the diameter of one of the rings

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

96. A solid cylinder of mass M and radius R is pivoted at its centre and three particles of mass m are fixed at the perimeter of the cylinder. Find the angular velocity of the cylinder after the system has moved through 90°



a) $\sqrt{\frac{Mg}{R(M+6m)}}$ b) $\sqrt{\frac{4mg}{R(M+6m)}}$

c) $\sqrt{\frac{2Mg}{R(M+6m)}}$ d) $\sqrt{\frac{3mg}{R(M+6m)}}$

97. The moment of inertia of a circular ring of mass 1 kg about an axis passing through its centre and perpendicular to its plane is 4 kg-m^2. The diameter of the ring is

a) 2 m b) 4 m

c) 5 m d) 6 m

98. A car of mass 1000 kg moves on a circular track of radius 20 m. If the coefficient of friction is .64, then the maximum velocity with which the car can move is

a) 22.4 ms $^{-1}$ b) 5.6 ms $^{-1}$

c) 11.2 ms $^{-1}$ d) None of these

99. Ratio of rotational K.E. to rolling K.E. of a solid sphere is

a) 2/3 b) 2/5 c) 2/7 d) ∞

100. A railway carriage has its centre of gravity at a height of 0.75 m above the rails, which are 1 m apart. The maximum safe speed at which it could travel round on unbanked curve of radius 100 m is

a) 12 ms $^{-1}$ b) 18 ms $^{-1}$

c) 22 ms $^{-1}$ d) 27.1 ms $^{-1}$

101. The dimensions of torque are

a) $[M^0 L^3 T^{-2}]$ b) $[M^2 L^2 T^{-3}]$

c) $[M^1 L^2 T^{-2}]$ d) $[M^{-1} L^2 T^{-3}]$

102. Moment of inertia of a thin uniform rod rotating about the perpendicular axis passing through its centre is I. If the same rod is bent into a ring and its moment of inertia about its diameter is I' , then the ratio $\frac{I}{I'}$ is

a) $\frac{2}{3}\pi^2$ b) $\frac{3}{2}\pi^2$

c) $\frac{5}{3}\pi^2$ d) $\frac{8}{3}\pi^2$

103. When a 12000 J of work is done on a flywheel, its frequency of rotation increases from 10 Hz to 20 Hz. The moment of inertia of flywheel about its axis of rotation is (Take, $\pi^2 = 10$)

a) $1\ kg - m^2$ b) $2\ kg - m^2$

c) $1.688\ kg - m^2$ d) $1.5\ kg - m^2$

104. In non-uniform circular motion, the ratio of tangential to radial acceleration is (r = radius of circle, v = speed of the particle, α = angular acceleration)

a) $\frac{\alpha^2 r^2}{v}$ b) $\frac{\alpha^2 r}{v^2}$

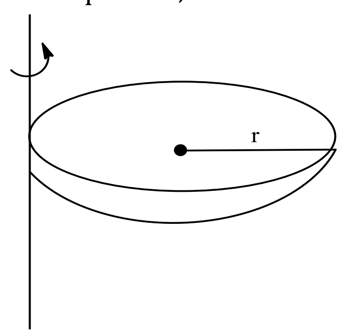
c) $\frac{\alpha r^2}{v^2}$ d) $\frac{v^2}{r^2\alpha}$

105. A solid sphere of mass 1 kg and radius 10 cm rolls without slipping on a horizontal surface, with velocity of 10 cm/s. The total kinetic energy of sphere is

a) 0.007 J b) 0.05 J

c) 0.01 J d) 0.07 J

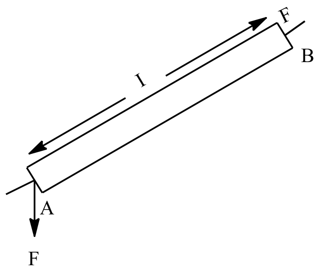
106. A solid sphere of radius R has moment of inertia I about its geometrical axis. If it is melted into a disc of radius r and thickness t. If its moment of inertia about the tangential axis (which is perpendicular to plane of the disc), is also equal to I, then the value of r is equal to



a) $\frac{2}{\sqrt{15}}R$ b) $\frac{2}{\sqrt{5}}R$
c) $\frac{3}{\sqrt{15}}R$ d) $\frac{\sqrt{3}}{\sqrt{15}}R$

107. A solid sphere and a disc of equal radii are rolling on a inclined plane without slipping. One reaches earlier than the other due to different
a) sizes b) frictional force
c) moment of inertia d) radius of gyration

108. A rod $\frac{}{\text{m}}$ long is acted upon by a couple as shown in the figure. The moment of couple is τNm. If the force at each end of the rod, then magnitude of each force is ($\sin 30° = \cos 60° = 0.5$)



a) $\frac{\tau}{l}$ b) $\frac{1}{2\tau}$
c) $\frac{2\tau}{1}$ d) $\frac{21}{\tau}$

109. In rotational motion of a rigid body, all particles move with
a) Same linear and angular velocity
b) Same linear velocity and different angular velocities
c) Different linear velocities and same angular velocity
d) Different linear and angular velocities

110. A van is moving with a speed of 108 km/hr on a level road where the coefficient of friction between the tyres and the road is 0.5. For the safe driving of the van, the minimum radius of curvature of the road shall be
a) 180 m b) 40 m
c) 80 m d) 120 m

111. A heavy mass is attached at one end of a thin wire and whirled in a vertical circle. The changes of breaking the wire are maximum when
a) The wire makes an angle of 60^0 with the horizontal
b) The mass is at the highest point of the circle
c) The mass is at the lowest point of the circle
d) The wire is horizontal

112. A thin uniform rod of length / 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
a) $\frac{1}{2}\frac{l^2\omega^2}{g}$ b) $\frac{1}{6}\frac{1\omega}{g}$
c) $\frac{1}{2}\frac{l^2\omega^2}{g}$ d) $\frac{1}{6}\frac{l^2\omega^2}{g}$

113. Select the WRONG statement
a) The amount of inertia is the torque acting per unit angular acceleration
b) The S.I. unit of moment of inertia is kg m^2
c) The dimensions of moment of inertia are $[M^1L^2T^0]$
d) The moment of inertia for a given body is a constant

114. When mass is rotating in a plane about a fixed point. Its angular momentum is directed along:
a) The radius
b) The tangent to orbit
c) Line at angle of 45° to the plane of rotation
d) The axis of rotation

115. The moment of inertia of a thin uniform rod about a perpendicular axis passing through one of its ends is 'I'. Now, the rod is bent in a ring and its moment of inertia about diameter is 'I_1'. Then I/I_1 is
a) $\frac{8\pi^2}{3}$ b) $\frac{\pi^2}{3}$
c) $\frac{11\pi^2}{3}$ d) $\frac{4\pi^2}{3}$

116. If a gymnast sitting on a rotating disc with his arms out stretched suddenly lowers his arms, then
a) angular velocity decreases
b) moment of inertia decreases
c) angular velocity remains constant
d) angular momentum decreases

117. If I_1 is 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 is the moment of inertia of the ring formed by bending the rod about an axis perpendicular to plane, then
a) $I_1 : I_2 = 1 : 1$ b) $I_1 : I_2 = \pi^2 : 3$
c) $I_1 : I_2 = \pi : 4$ d) $I_1 : I_2 = 3 : 5$

118. Rotational motion can be
a) one or two dimensional

b) one or three dimensional
c) two or three dimensional
d) one dimensional

119. Two solid spheres A and B having same mass and different radii rotate with kinetic energies E_A and E_B respectively. The M. I. about their axis of rotation are I_A and I_B respectively. If $I_A = \frac{I_B}{4}$ and $E_A = 100E_B$, then the ratio of their angular momenta L_A to L_B is
a) $\frac{5}{4}$ b) $\frac{1}{4}$
c) 25 d) 5

120. Two rings of radii R and nR made from the same wire have the ratio of moments of inertia about an axis passing through their centre and perpendicular to the plane of the rings is 1:8. The value of n is
a) $2\sqrt{2}$ b) 2
c) 4 d) $\frac{1}{2}$

121. Two particles of masses m and M are a distance d apart and constitute a system. If v is the frequency of revolution about the axis passing through the centre of mass and perpendicular to the line joining the masses, the rotational (K.E.) of the system is
a) $\frac{\pi v^2 mMd^2}{(M+m)}$ b) $\frac{2\pi^2 v^2 mMd^2}{(m+M)}$
c) $\frac{2\pi v^2 mM^2 d^2}{(m+M)^2}$ d) $\frac{2\pi v^2 d^2}{(m+M)^2}$

122. If the resultant of all external forces is zero, then velocity of centre of mass will be
a) zero b) infinite
c) constant d) either 'a' or 'c'

123. The moment of inertia of uniform circular disc about an axis passing through its centre is $6\ kgm^2$. Its M.I. about an axis perpendicular to its plane and just touching the rim will be
a) $18\ kgm^2$ b) $30\ kgm^2$ c) $15\ kgm^2$ d) $3\ kgm^2$

124. A thin circular ring of mass M and radius r is rotating about its axis with a constant angular velocity ω. If two objects of mass m are attached gently to opposite ends of a diameter of ring, ring will now rotate with an angular velocity given by
a) $\frac{2\omega M}{(M-2m)}$ b) $\frac{(M-2m)}{M}$
c) $\frac{\omega M}{(M+2m)}$ d) $\frac{2\omega M}{(M-2m)}$

125. The ratio of radius of gyration of a ring to that of a disc (Both circular) of same radius and mass, about a tangential axis perpendicular to the plane is
a) $\frac{\sqrt{2}}{1}$ b) $\frac{2}{\sqrt{3}}$
c) $\frac{\sqrt{3}}{2}$ d) $\frac{2}{\sqrt{5}}$

126. A particle suspended by a light inextensible thread of length l is projected horizontally from its lowest position with velocity $\sqrt{7gl/2}$. The string will slack after swinging through an angle equal to
a) 30° b) 90°
c) 120° d) 150°

127. Let ' M ' be the mass and L be the length of a thin uniform rod. In first case, axis of rotation is passing through centre and perpendicular to the length of the rod. In second case, axis of rotation is passing through one end and perpendicular to the length of the rod. The ratio of radius of gyration in first case to second case is
a) 1 b) $\frac{1}{2}$
c) $\frac{1}{4}$ d) $\frac{1}{8}$

128. By considering frictional force for a vehicle of mass 'm' moving along rough curved road, banked at an angle 'θ' the maximum safety speed of a vehicle is (R = radius of circular path, g = acceleration due to gravity)
a) $V_m = \sqrt{Rg\left[\frac{\mu_s + \tan\theta}{1-\mu_s \tan\theta}\right]}$ b) $V_m = \sqrt{Rg\left[\frac{\mu_s + \tan\theta}{1+\mu_s \tan\theta}\right]}$
c) $V_m = \sqrt{Rg\left[\frac{\mu_s + \tan\theta}{1+\tan\theta}\right]}$ d) $V_m = \sqrt{\frac{1}{Rg}\left[\frac{1+\mu_s \tan\theta}{\mu_s + \tan\theta}\right]}$

129. A body is said to be rigid, if the distance between any two position of the particle
a) changes with force
b) remains constant with the force
c) changes with the force initially and maximum force changes laterally
d) erratically changes with force

130. A particle is moving along a circular path with constant speed and centripetal acceleration 'a'. If the speed is doubled, the ratio of its acceleration after the before the change is
a) 2:1 b) 1:4

c) 3:1 d) 4:1

131. A body situated on earth's surface at its equator becomes weightless when the rotational kinetic energy of the earth reaches a critical value which is given by (M and R be the mass and radius of earth respectively)

a) $\frac{MgR}{2}$ b) $\frac{MgR}{3}$

c) $\frac{MgR}{4}$ d) $\frac{MgR}{5}$

132. Moment of inertia of a solid sphere of radius r and density p about its tangent is :

a) $\frac{28}{15}\pi r^5\rho$ b) $\frac{28}{15}\pi r^2\rho$

c) $\frac{15}{25}\pi r^5\rho$ d) $\frac{15}{28}\pi r^5\rho$

133. Two rigid bodies have same moment of inertia about there axes of symmetry. Then which will have more kinetic energy?

a) A Body having greater angular momentum

b) Body having smaller angular momentum

c) Both will have same kinetic energy

d) Can not decided

134. A wheel having moment of inertia $2\ \mathrm{kg-m^2}$ about its vertical axis, rotates at the rate of 60rpm 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

135. A ring, a solid sphere and a disc have same mass and radius. Which of them have the largest moment of inertia?

a) All have the same moment of inertia b) Ring only

c) Solid sphere only d) Disc only

136. $\frac{L^2}{2I}$ represents

a) Rotational kinetic energy of a particle

b) Potential energy of a particle

c) Torque on a particle

d) Power

137. Two bodies have their moments of inertia I and 2I respectively, about their axis of rotation. If their kinetic energies of rotation are equal, then the ratio of their angular momenta will be

a) 2: 1 b) 1: 2

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

138. A disc has mass 'M' and radius 'R'. How much tangential force should be applied to the rim of the disc so as to rotate with angular velocity 'ω' in time t?

a) $\frac{MR^2\omega}{t}$ b) $\frac{MR\omega}{t}$

c) $\frac{MR^2\omega}{2t}$ d) $\frac{MR\omega}{2t}$

139. A can filled with water is revolved in a vertical circle of radius 'r' and water just does not fall down. The time period of revolution is (g = acceleration due to gravity)

a) $2\pi\sqrt{rg}$ b) $2\pi\sqrt{\frac{r}{g}}$

c) $2\pi\sqrt{5rg}$ d) $2\pi\sqrt{\frac{g}{r}}$

140. The dimensional formula for the radius of gyration of a body is

a) $L^0M^0T^0$ b) $L^1M^0T^0$ c) $L^1M^1T^0$ d) $L^0M^2T^{-1}$

141. A disc of uniform thickness and radius 50 cm is made of two zones. The central zone of radius 20.0 cm is made of metal and has a mass of 4.00 kg. The outer zone is of wood and has a mass of 3.00 kg. The M.I. of the disc about a transverse axis through its centre is

a) 0.510 kg-m^2 b) 0.515 kg-m^2

c) 0.500 kg-m^2 d) 0.525 kg-m^2

142. The over-bridge of a canal is in the form of a concave circular arc of radius 'r'. The thrust at the lowest point is (m = mass of the vehicle, v = velocity of the vehicle, g = acceleration due to gravity)

a) $mg + mv^2/r$ b) $\left(mg + \frac{mv^2}{r}\right)$

c) $\left(mg - \frac{mv^2}{r}\right)$ d) $mg \times \frac{mv^2}{r}$

143. A body of mass 10 kg is attached to a wire 0.3 m long. Its breaking stress is $4.8 \times 10^7\ \mathrm{N/m^2}$. The area of cross-section of the wire is $10^{-6}\ \mathrm{m^2}$. The maximum angular velocity with which it can be rotated in a horizontal circle is

a) 6 rad/s b) 5 rad/s

c) 7 rad/s d) 4 rad/s

144. The same torque is applied to a disc and a ring of equal mass and radii then

a) Both will rotate with same angular velocity b) Both will rotate with same angular acceleration

c) The ring will rotate with greater angular d) The disc will rotate with greater angular frequency frequency

145. A fly wheel used in steam or diesel engine must have
a) large mass and moment of inertia
b) small mass and moment of inertia
c) large mass and small moment of inertia
d) large moment of inertia and small mass

146. The new dimensional formula for the moment of inertia of a body is
a) $L^0M^1T^{-2}$ b) $L^2M^1T^0$ c) $L^1M^1T^0$ d) $L^3M^2T^0$

147. A uniform rod AB of mass m and length / at rest on a smooth horizontal surface. An impulse P is applied to the end B. The time taken by the rod to turn through at right angle is
a) $2\pi\frac{ml}{P}$ b) $2\frac{\pi P}{ml}$
c) $\frac{\pi}{12}\frac{ml}{P}$ d) $\frac{\pi P}{ml}$

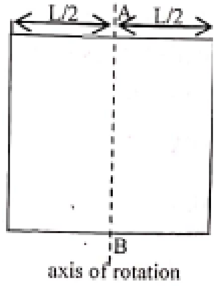
148. A constant torque is applied on a circular wheel, which changes its angular momentum from 0 to 4L in 4 seconds. The torque is
a) 3L/4 b) L c) 4L d) 12L

149. From a disc of radius R, a concentric circular portion of radius r is cut out, so as to leave an annular disc of mass M. The moment of inertia of this annular disc about the axis perpendicular to its plane and passing through its centre of gravity is
a) $\frac{1}{2}M(R^2+r^2)$ b) $\frac{1}{2}M(R^2-r^2)$
c) $\frac{1}{2}M(R^4+r^4)$ d) $\frac{1}{2}M'(R^4-r^4)$

150. The moment of momentum is called:
a) Couple b) Torque
c) Impulse d) Angular Momentum

151. In non-uniform circular motion, the ratio of tangential to radial acceleration is (r = radius of circle, v = speed of the particle, α = angular acceleration)
a) $\frac{\alpha^2r^2}{v}$ b) $\frac{\alpha^2 r}{v}$
c) $\frac{\alpha r^2}{v^2}$ d) $\frac{v^2}{r^2\alpha}$

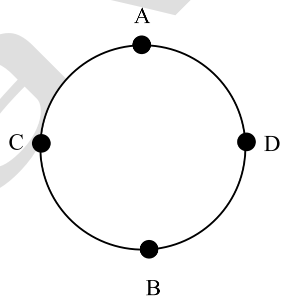
152. Four metal rods each of mass 'M' and length 'L' are welded to form a square as shown. What is M. I. of the system about axis 'AB'?



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

153. The moment of inertia of a sphere is 20 kg-m² about the diameter. The moment of inertia about any tangent is
a) 25 kg-m² b) 50 kg-m²
c) 70 kg-m² d) 80 kg-m²

154. A stone is attached to one end of a string and rotated in a vertical circle. If string breaks at the position of maximum tension, it will break at



a) A b) B
c) C d) D

155. A bucket tied at the end of 1.6 m long string is whirled in a vertical circle with a constant speed. The minimum speed at which water from the bucket does not spill when it is at the highest position is
a) 4 ms $^{-1}$ b) 6.25 ms $^{-1}$
c) 2 ms $^{-1}$ d) 16 ms $^{-1}$

156. The radius of gyration of a thin rod of mass 100 gm and length 1 m about an axis passing through its centre of gravity and perpendicular to its length is
a) $\frac{1}{2\sqrt{3}}$m b) $\frac{1}{6\sqrt{2}}$m c) $\frac{1}{3\sqrt{2}}$m d) $\frac{1}{4\sqrt{3}}$m

157. The radius of gyration of a flywheel is $\left(\frac{3}{\pi}\right)$ m and its mass is 1 kg. The speed of the flywheel is changed from 20 r.p.m. to 60 r.p.m. The work required to be done is
a) 16 J b) 20 J c) 24 J d) 32 J

158. The mass 'm' is rotating in vertical circle of radius 'R'. The difference in its kinetic energy

at the top and the bottom of the circle is (g = acceleration due to gravity)

a) 6mgR b) 4mgR
c) mgR d) 2mgR

159. A person is standing on a rotating wheel. If he sits on the wheel, then the angular momentum of the system will

a) increase b) decrease
c) remain same d) double

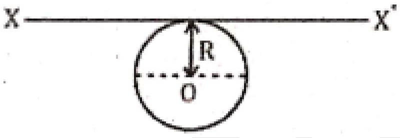
160. Radius of gyration of a disc rotating about an axis perpendicular to its plane and passing through its centre is

a) $\frac{R}{\sqrt{2}}$ b) $\frac{R}{\sqrt{3}}$ c) $\frac{R}{3}$ d) $\frac{R}{2}$

161. A ring of mass 'M' and radius 'R' is rotating about an axis passing through centre and perpendicular to its plane. Two particles of mass 'm' are placed gently on the opposite ends of a diameter of the ring. Now the angular speed of the ring is (ω = initial angular speed of ring)

a) $\frac{M\omega}{M-m}$ b) $\frac{M\omega}{M+m}$
c) $\frac{M\omega}{M+2m}$ d) $\frac{M\omega^2}{M-2m}$

162. A thin wire of length 'L' and uniform linear mass density 'ρ' is bent into a circular coil with 'O' as centre. The moment of inertia of a coil about the axis XX' is



a) $\frac{3\rho L^3}{8\pi^2}$ b) $\frac{\rho L^3}{4\pi^2}$
c) $\frac{3\rho L^2}{4\pi^2}$ d) $\frac{\rho L^3}{8\pi^2}$

163. A disc at rest is subjected to a uniform angular acceleration about its axis. Let 'θ_1' and 'θ_2' be the angles described by the disc in 1st and 2nd second of its motion. The ratio $\frac{\theta_1}{\theta_2}$ is

a) $\frac{1}{2}$ b) $\frac{1}{3}$
c) $\frac{1}{4}$ d) 1

164. Which of the following has the highest moment of inertia when each of them has the same mass and the same radius?

a) A hollow sphere about one of its diameter
b) A solid sphere about one of its diameter
c) A disc about its axis perpendicular to the plane of the disc and passing through the centre of mass
d) A ring about its axis perpendicular to the plane and passing through the centre of mass

165. A particle moves with uniform speed in a circular path, the angle between instantaneous velocity and acceleration is

a) 0^0 b) 180^0
c) 90^0 d) 45^0

166. A flywheel rotating about a fixed axis has a kinetic energy of 225 J when its angular speed is 25 rad/s. The angular momentum of the flywheel about its axis of rotation is

a) 18 kg m^2 b) 36 kg m^2/s
c) 18 J s d) 9 kg m^2/s

167. With the increase in temperature, moment of inertia of a solid sphere about the diameter:

a) Decrease b) Increases
c) Does not change d) Can not be predicted

168. A car of mass 1500 kg is moving with a speed of 12.5 ms^{-1} on a circular path of radius 20 m on a level road. What should be the coefficient of friction between the car and the road, so that the car does not slip?

a) 0.2 b) 0.4
c) 0.6 d) 0.8

169. From a disc of mass 'M' and radius 'R', a circular hole of diameter 'R' is cut whose rim passes through the centre. The moment of inertia of the remaining part of the disc about perpendicular axis passing through the centre is

a) $\frac{7MR^2}{32}$ b) $\frac{11MR^2}{32}$
c) $\frac{9MR^2}{32}$ d) $\frac{13MR^2}{32}$

170. When a polar ice caps melt, then the duration of day

a) increases
b) decreases
c) some times decreases, some times increases
d) remains constant

171. 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) MR^2 b) $\frac{2}{5}MR^2$

c) $\frac{3}{2}MR^2$ d) $\frac{1}{2}MR^2$

172. In non-uniform circular motion, the ratio of tangential acceleration to radial acceleration is (r = radius of circle, V = speed and α = angular acceleration)

a) $\frac{r\alpha}{V}$ b) $\left(\frac{r}{V}\right)^2 \alpha$

c) $\left(\frac{V}{r}\right)^2 \frac{1}{2}$ d) $\left(\frac{V}{r}\right)^2 \alpha$

173. A solid sphere, disc, and solid cylinder all of same mass and made up of same material are allowed to roll down (from rest on inclined plane) :

a) Solid sphere reaches the bottom first

b) Disc reaches the bottom first

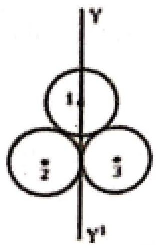
c) Solid sphere reaches the bottom last

d) All reach simultaneous

174. If the kinetic energy of rotation of a body about an axis is 9 J and the moment of inertia is 2 kg m^2, then the angular velocity of the body about the axis of rotation in rad/s is

a) 2 b) 3 c) 1 d) 9

175. Three hollow spheres each of mass 'M' and radius 'R' are arranged as shown in the figure. The moment of inertia of the system about axis YY′ will be



a) $2MR^2$ b) $5MR^2$

c) $4MR^2$ d) $3MR^2$

176. A disc of radius R and thickness $\frac{R}{6}$ has moment of inertia I, about an axis passing through its centre perpendicular to its plane. Disc is melted and reduced into a solid sphere. The moment of inertia of a sphere about its diameter is

a) $\frac{1}{5}$ b) $\frac{1}{6}$

c) $\frac{1}{32}$ d) $\frac{1}{64}$

177. 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) $6.25\ s^{-2}$

178. A particle with position vector $\vec{r}$ has a linear momentum $\vec{P}$. Which one of the following statements is true in respect of its angular momentum 'L' about the origin?

a) $\vec{L}$ acts along $\vec{P}$

b) L is maximum when $\vec{P}$ is perpendicular to $\vec{r}$

c) $\vec{L}$ acts along $\vec{r}$

d) L is maximum when $\vec{P}$ and $\vec{r}$ are parallel

179. If the earth were to suddenly contract to $1/n^{th}$ of its present radius without any change in its mass, the duration of the new day will be nearly

a) $24/n$ hours b) $24n$ hours

c) $24/n^2$ hours d) $24n^2$ hours

180. A particle is moving in a circle of radius R in such a way that at any instant the normal and tangential components of its acceleration are equal. If its speed at $t = 0$ is v_0, the time taken to complete the first revolution is

a) $\frac{R}{v_0}(1 - e^{-2\pi})$ b) $\frac{2R}{v_0}(1 - e^{-2\pi})$

c) $\frac{3R}{v_0}(1 - e^{-2\pi})$ d) None of the above

181. A person can balance easily on a moving bicycle but cannot balance on stationary bicycle. This is possible because of law of conservation of

a) mechanical energy b) mass

c) angular momentum d) A linear momentum

182. The imaginary line passing through the common centres of all particles moving in different circles of a body is:

a) Equational line b) Axils line

c) Axis of rotation d) All of these

183. A solid sphere Has mass 'M' and radius 'R'. Its moment of inertia about a parallel axis passing through a point at a distance $\frac{R}{2}$ from its centre is

a) $\frac{13}{20}MR^2$ b) $\frac{8}{11}MR^2$

c) $\frac{11}{15}MR^2$ d) $\frac{6}{10}MR^2$

184. A bob of a simple pendulum of mass 'm' is displaced through 90^0 from mean position and released. When the bob is at lowest position, the tension in the string is

a) 4mg b) 2mg

c) mg d) 3mg

185. Eight identical small solid spheres, each of moment of inertia 'I' are recast to form a big solid sphere. M.I. of the big solid sphere is
a) 8 I b) 16 I c) 24 I d) 32 I

186. A molecule consists of two atoms each of mass 'm' and separately by a distance 'd'. At room temperature, if the average rotational kinetic energy is 'E' then the angular frequency is

a) $\frac{2}{d}\sqrt{\frac{E}{m}}$ b) $\frac{d}{2}\sqrt{\frac{m}{E}}$

c) $\sqrt{\frac{Ed}{m}}$ d) $\sqrt{\frac{m}{Ed}}$

187. A man turns on a rotating table with an angular velocity ω. He is holding two equal masses at arms Without moving his arms, he just drops the masses. Then his angular velocity
a) less than ω b) more than ω
c) equal to ω d) any of these three

188. The centre of mass of particles does not depend upon:
a) mass of individual particle
b) force acting on each particle
c) position of the particle w.r.t. fixed point
d) relative position of particle from the axis

189. A ring of mass 0.3 kg and radius 0.1 m and a solid cylinder of mass 0.4 kg and of the same radius are given the same kinetic energy and released simultaneously on a flat horizontal surface. They begin to roll as soon as released towards a wall which is at the same distance from the ring and cylinder. Which will reach the wall first?
a) Ring
b) Cylinder
c) Both ring and cylinder will reach simultaneously
d) Data is insufficient

190. A particle of mass 'm' is rotating in a horizontal circle of radius 'r' with uniform velocity $\vec{V}$. The change in its momentum at two diametrically opposite points will be
a) $-m\vec{V}$ b) $-2m\vec{V}$
c) $m\vec{V}$ d) $3m\vec{V}$

191. A denser about the same axis spins faster when she folds har arms. Due to this is :
a) increase in energy & increase in angular momentum
b) decrease in friction at axle
c) retarding momentum and increase of kinetic energy
d) increase in energy and decrease in angular momentum

192. If the length of second's hand of a clock is 10 cm, the speed of its tip (in cms^{-1}) is nearly
a) 2 b) 0.5
c) 1 d) 3

193. 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
a) $\frac{1}{12}ma^2$ b) $\frac{7}{12}ma^2$ c) $\frac{2}{3}ma^2$ d) $\frac{5}{6}ma^2$

194. Three identical rods each of mass M and length L are joined to form a symbol H. The moment of inertia of the system about one of the sides of ' H ' is
a) $\frac{2ML^2}{3}$ b) $\frac{ML^2}{2}$
c) $\frac{ML^2}{6}$ d) $\frac{4ML^2}{3}$

195. A thin uniform metal rod of mass 'M' and length 'L' is swinging about a horizontal axis passing through its end. Its maximum angular velocity is 'ω'. Its centre of mass rises to a maximum height of
(g = acceleration due to gravity)
a) $\frac{L^2\omega^2}{g}$ b) $\frac{L^2\omega^2}{3g}$
c) $\frac{L^2\omega^2}{8g}$ d) $\frac{L^2\omega^2}{6g}$

196. A force $\vec{F}$ is acting on a particle of position vector $\vec{r}$, the torque will be
a) $\vec{r} \times \vec{F}$ b) $\vec{F} \times \vec{r}$ c) rF d) $\frac{\vec{F}}{\vec{r}}$

197. The moment of inertia of a thin uniform rod of length L and mass M about an axis passing through a point at a distance of 1/3 from one of its ends and perpendicular to the rod is
a) $\frac{ML^2}{12}$ b) $\frac{ML^2}{9}$
c) $\frac{7ML^2}{48}$ d) $\frac{ML^2}{48}$

198. The moments of inertia of two rotating bodies A and B are I_1 and I_2, where $I_2 > I_1$. If K_A and K_B are their rotational kinetic energies and if their angular momenta are equal, then
a) $K_A = K_B$ b) $K_A > K_B$
c) $K_A < K_B$ d) $K_A = \frac{K_B}{2}$

199. Two circular rings 'A' and 'B' of radii 'nR' and 'R' are made from the same wire. The moment of inertia of 'A' about an axis passing through the centre and perpendicular to the plane of 'A' is 64 times that of ring 'B'. The value of 'n' is

a) 3 b) 4

c) 8 d) 6

200. Which of the following statements is true in case of the principal of perpendicular axes?

a) It is applicable to only three dimensional objects

b) It is applicable to planar as well as three dimensional objects

c) It is applicable to only planar objects

d) It is applicable to only denser objects

N.B.Navale

Date : 28.03.2025
Time : 03:00:00
Marks : 200

TEST ID: 47
PHYSICS

1.ROTATIONAL DYNAMICS ,3.ROTATIONAL MOTION

: ANSWER KEY :

1)	b	2)	d	3)	a	4)	b	105)	a	106)	a	107)	d	108)	c
5)	c	6)	a	7)	c	8)	d	109)	c	110)	a	111)	c	112)	d
9)	d	10)	d	11)	b	12)	a	113)	d	114)	d	115)	a	116)	b
13)	b	14)	d	15)	a	16)	b	117)	b	118)	b	119)	d	120)	b
17)	d	18)	c	19)	b	20)	d	121)	b	122)	d	123)	a	124)	c
21)	d	22)	d	23)	b	24)	a	125)	b	126)	c	127)	b	128)	a
25)	a	26)	c	27)	b	28)	c	129)	b	130)	d	131)	d	132)	a
29)	a	30)	d	31)	b	32)	d	133)	a	134)	c	135)	b	136)	a
33)	a	34)	a	35)	d	36)	d	137)	d	138)	d	139)	b	140)	b
37)	b	38)	a	39)	b	40)	b	141)	b	142)	b	143)	d	144)	d
41)	c	42)	b	43)	b	44)	d	145)	d	146)	b	147)	c	148)	b
45)	d	46)	b	47)	c	48)	b	149)	a	150)	d	151)	c	152)	a
49)	a	50)	d	51)	b	52)	c	153)	c	154)	b	155)	a	156)	a
53)	a	54)	d	55)	d	56)	c	157)	a	158)	d	159)	c	160)	a
57)	d	58)	a	59)	d	60)	c	161)	c	162)	a	163)	b	164)	d
61)	b	62)	b	63)	c	64)	c	165)	c	166)	c	167)	b	168)	d
65)	d	66)	d	67)	a	68)	d	169)	d	170)	a	171)	c	172)	b
69)	c	70)	a	71)	b	72)	b	173)	a	174)	b	175)	c	176)	a
73)	c	74)	a	75)	b	76)	c	177)	c	178)	b	179)	c	180)	a
77)	d	78)	a	79)	c	80)	d	181)	d	182)	c	183)	a	184)	d
81)	a	82)	d	83)	a	84)	a	185)	d	186)	a	187)	b	188)	b
85)	d	86)	b	87)	d	88)	c	189)	c	190)	b	191)	a	192)	c
89)	b	90)	b	91)	a	92)	a	193)	c	194)	d	195)	d	196)	a
93)	d	94)	d	95)	c	96)	b	197)	b	198)	b	199)	b	200)	c
97)	b	98)	c	99)	c	100)	d								
101)	c	102)	a	103)	b	104)	c								

N.B.Navale

Date : 28.03.2025
Time : 03:00:00
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TEST ID: 47
PHYSICS

1.ROTATIONAL DYNAMICS ,3.ROTATIONAL MOTION

: HINTS AND SOLUTIONS :

Single Correct Answer Type

2 **(d)**

As,$I=\frac{1}{2}mr^2=\frac{1}{2}\times 16\left(\frac{1}{2}\right)^2 = 2\text{ kg}-\text{m}^2$

$\alpha=\frac{2\pi(n_2-n_1)}{t}$

$=\frac{2\pi(2-0)}{8}=\frac{\pi}{2}\text{rads}^{-2}$

Now, $\tau=l\alpha=2\cdot\frac{\pi}{2}=\pi N-m$

3 **(a)**

$M=25\text{ kg}, K=0.2\text{ m}, f=240\text{ r.p.m}=\frac{240}{60}$
$=4\text{ r.p.s}$

Moment of inertia of the disc $I=\frac{MR^2}{2}$
$=\frac{25\times(0.2)^2}{2}=0.5\text{ kg m}^2$

$\omega=2\pi f=2\pi\times 4=8\pi\frac{\text{rad}}{\text{s}}$

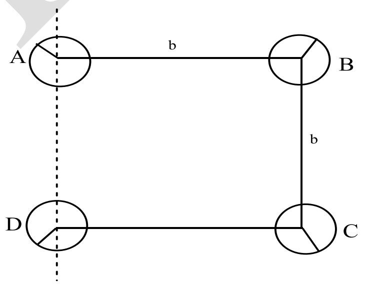
Retardation $\alpha=\frac{8\pi}{20}=\frac{2\pi}{5}\text{ rad/s}^2$

torque $\tau=I\alpha=FR$

$\therefore F=\frac{I\alpha}{R}=\frac{0.5\times 2\pi}{0.2\times 5}=\pi\text{ N}$

4 **(b)**

We calculate moment of inertia of the system about AD,



Moment of inertia of each of the spheres A and D about

$AD=\frac{2}{5}Ma^2$

Moment of inertia of each of the sphere B and C about

$AD=\left(\frac{2}{5}Ma^2+Mb^2\right)$, [using theorem of parallel axis]

$\therefore$ Total moment of inertia,

$I=\left(\frac{2}{5}Ma^2\right)\times 2+\left(\frac{2}{5}Ma^2+Mb^2\right)\times 2$

$=\frac{8}{5}Ma^2+2Mb^2$

6 **(a)**

$E=\frac{1}{2}I\omega^2=\frac{(I\omega^2)}{2I}=\frac{L^2}{2I}$

7 **(c)**

For minimum velocity at the highest point we should have

$mr=mg$

$\therefore \omega^2=\frac{g}{r}$ or $\omega=\sqrt{\frac{g}{r}}$

$2\pi f=\sqrt{\frac{g}{r}}$

$\therefore f=1/2\pi\sqrt{\frac{g}{r}}$

8 **(d)**

$R=6400\times 10^3\text{m}=6.4\times 10^6\text{m}, T=24\times 3600\text{ s}$

$L=I\omega=\frac{2}{5}MR^2\times\frac{2\pi}{T}$

$=\frac{2}{5}\times 6\times 10^{24}\times(6.4\times 10^6)^2\times\left(\frac{2\pi}{24\times 3600}\right)$

$L=7.145\times 10^{33}\text{kg m}^2\text{s}^{-1}$

9 **(d)**

Given, $r=0.2\text{ m}, M=10\text{ kg}$ and $n=1200\text{rpm}=$

20rps

Angular momentum, $L = \hbar\omega = (Mr^2)(2\pi n)$

$= 10 \times (0.2)^2 \times 2 \times \frac{22}{7} \times 20 = 50.28 \text{ kg} - \text{m}^2 \text{ s}^{-1}$

10 **(d)**

Velocity of the small object is given as,

$v = \sqrt{\frac{2gh}{1+\frac{k^2}{r^2}}}$

$\therefore v^2 = \frac{2g\,3v^2}{4g\left(1+\frac{k^2}{r^2}\right)}$

$\therefore 1 + \frac{k^2}{r^2} = \frac{3}{2} \Rightarrow k^2 = \frac{1}{2}r^2$

But $k = \sqrt{\frac{I}{M}}$

$\therefore \frac{I}{M} = \frac{1}{2}r^2 \Rightarrow I = \frac{1}{2}Mr^2 \rightarrow$ disc

11 **(b)**

$I_1 = \frac{mR_1^2}{2}$

$m_1 = \pi R_1^2 t_1$

$I_2 = \frac{mR_2^2}{2}$

$m_2 = \pi R_2^2 t_2$

$m_1 = m_2$

$\frac{I_1}{I_2} = \frac{R_1^2}{R_2^2} = \frac{t_2}{t_1}$

$\therefore R_1^2 t_1 = R_2^2 t_2$

$\therefore I_1 t_1 = I_2 t_2$

12 **(a)**

Given, initial velocity, $u = 0$

$\because$ Radius of circle $= r$

Velocity of particle, $v = v$

$\therefore$ Distance moved in 3 revolution,

$s = 3 \times 2\pi r = 6\pi r$

We know that, $v^2 = u^2 + 2a_t s$

On putting the value of all variables, we get

$v^2 = 2a_t \times 6\pi r$

$\Rightarrow a_t = \frac{v^2}{12\pi r}$

13 **(b)**

The moment of inertia of the rod about an axis passing through the centre and perpendicular to its length is given by

$I_0 = \frac{ML^2}{12}$

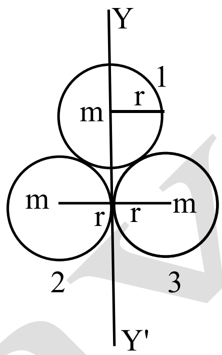
A point at a distance $\frac{L}{4}$ from its end will also be at a distance $\frac{L}{4}$ from the centre.

Hence by parallel axis theorem,

$I = I_0 + M(L/4)^2 = \frac{ML^2}{12} + \frac{ML^2}{16} = \frac{7ML^2}{48}$

14 **(d)**

The total moment of inertia of the system is



$I = I_1 + I_2 + I_3$.......(i)

Here, $I_1 = \frac{2}{3}mr^2$ and $I_2 = I_3 = \frac{2}{3}mr^2 + mr^2$

[from parallel axes theorem]

$= \frac{5}{3}mr^2$

From Eq. (i),

$I = \frac{2}{3}mr^2 + 2 \times \frac{5}{3}mr^2 = mr^2\left(\frac{2}{3} + \frac{10}{3}\right) = 4mr^2$

15 **(a)**

$I_1 = \frac{ML^2}{12}$

When the rod is bent into a ring

$L = 2\pi r$ or $r = \frac{L}{2\pi}$

Moment of inertia of a ring about a diameter is given by

$I_2 = \frac{Mr^2}{12} = \frac{M}{2} \cdot \frac{L^2}{4\pi^2} = \frac{ML^2}{8\pi^2}$

$\therefore \frac{I_2}{I_1} = \frac{ML^2}{8\pi^2} \times \frac{12}{ML^2} = \frac{3}{2\pi^2}$

16 **(b)**
Angular speed of hour hand ω_h

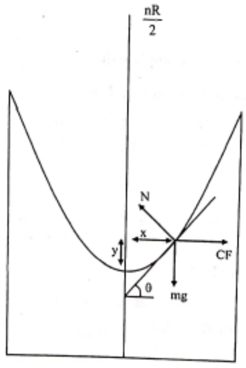
$$= \frac{2\pi}{12 \times 3600} \text{ rad/s}$$

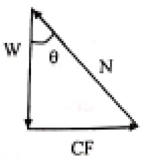
Angular speed of second hand $\omega_s = \frac{2\pi}{60}\frac{\text{rad}}{\text{s}}$

Relative speed $= \frac{2\pi}{60} - \frac{2\pi}{12 \times 3600}$

$= \frac{719\pi}{21600}$ rad/s

17 **(d)**





$\tan\theta = \frac{CF}{W}$

$\therefore \tan\theta = \frac{m\omega^2 x}{mg} = \frac{\omega^2 x}{g}$

Where $\tan\theta$ is the slope of the surface of the paraboloid at any distance x from the axis of rotation.

slope $= \frac{dy}{dx} = \tan\theta = \frac{\omega^2}{g}$

$\therefore dy = \frac{\omega^2 x}{g} dx$

$\therefore \int dy = \frac{\omega^2}{g} \int x\, dx$

$\therefore y = \frac{x^2\omega^2}{2g} = \frac{R^2\omega^2}{2g}$

19 **(b)**
M.I. of the circular disc will be

$2I = \frac{(2M)R^2}{2}$

$\therefore$ M.I. of the semicircular disc, $I = \frac{1}{2}MR^2$

20 **(d)**
KE given to a sphere at lowest point = PE at the height of suspension

$\frac{1}{2}mv^2 = mgl$

$\Rightarrow v = \sqrt{2gl}$

21 **(d)**
$\tan\theta = \frac{v^2}{rg} = \frac{(20)^2}{40 \times 10} = \frac{400}{400} = 1$

$\therefore \theta = 45^0$

22 **(d)**
After time t, velocity V = at

$\therefore$ radial acceleration $a_r = \frac{V^2}{r} = \frac{a^2t^2}{r}$

Total acceleration $= \sqrt{\frac{a^4t^4}{r^2} + a^2}$

$\therefore \mu g = \sqrt{\frac{a^4t^4 + a^2r^2}{r^2}}$

$\therefore \mu = \frac{[a^4t^4 + a^2r^2]^{1/2}}{rg}$

24 **(a)**
Given, $v = 8\text{kms}^{-1} = 8000 \text{ ms}^{-1}$,

$r = (6400 + 630)\text{km} = (6400 + 630) \times 1000 \text{ m}$

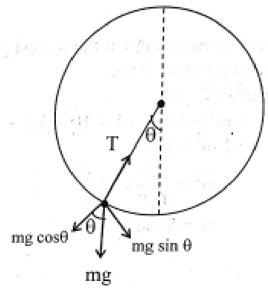
Acceleration of the cosmonaut, $a = \frac{v^2}{r}$

$= \frac{(8000)^2}{(6400 + 630) \times 1000} = 9.10 \text{ ms}^{-2}$

25 **(a)**
Moment of inertia of a uniform circular disc about an axis through its centre and perpendicular to its plane is $I_C = \frac{1}{2}MR^2$
$\therefore$ Applying theorem of parallel axes, moment of inertia of a uniform circular disc about an axis touching the disc at its diameter and normal to the disc

$$I = I_C + Mh^2 = \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$$

26 **(c)**



$$T - mg\cos\theta = \frac{mv^2}{l}$$

$$\therefore mg\cos\theta = T - \frac{mv^2}{l}$$

$$\therefore 0.2 \times 10\cos\theta = 1.05 - \frac{0.2 \times (0.5)^2}{1}$$

$$\therefore 2\cos\theta = 1.05 - 0.05 = 1$$

$$\therefore \cos\theta = \frac{1}{2}$$

$$\therefore \theta = \cos^{-1}\left(\frac{1}{2}\right)$$

28 **(c)**

Mass M and thickness t are equal

Densities are $\rho_1 = 6800\frac{kg}{m^3}$ and $\rho_2 = 8500\frac{kg}{m^3}$

$\therefore M - \pi R_1^2\rho_1 = \pi R_2^2\rho_2$

$\therefore R_1^2\rho_1 = R_2^2\rho_2$

$$\therefore \frac{R_1^2}{R_2^2} = \frac{\rho_2}{\rho_1} = \frac{8500}{6800} = \frac{5}{4}$$

Moment of inertia of disc $I = \dfrac{MR^2}{2}$

$$\therefore \frac{I_1}{I_2} = \frac{R_1^2}{R_2^2} = \frac{5}{4}$$

29 **(a)**

Impulse = Change in momentum

$$P\frac{l}{2} = I\omega = \frac{ml^2}{12}\omega$$

$$\omega = \frac{6P}{ml}$$

Now $\theta = \dfrac{\pi^c}{2}$ $\theta = \omega t + \dfrac{1}{2}\alpha t^2$

$$\frac{\pi}{2} = \frac{6P}{ml}$$

$$\therefore t = \frac{\pi}{2} \times \frac{ml}{6P} = \frac{\pi ml}{12P}$$

30 **(d)**

$M = V_\rho - \pi R^2 t\rho$

$\therefore M_X = \pi R_X{}^2 tx\rho$ and $M_Y = \pi R_Y{}^2 t\gamma\rho$

Let $I = \frac{MR^2}{2}$

$\therefore I_X = \frac{\pi R_x{}^4 t_x\rho}{2}$ and $I_Y = \frac{\pi R_y{}^4 t_y\rho}{2}$

$$\therefore \frac{I_Y}{I_X} = \frac{R_y{}^4 t_y}{R_x{}^4 t_x}$$

$$= \frac{(4R)^4(t/4)}{R^4 t} = \frac{(4)^4}{4} = 64$$

$= I_Y = 64\, I_X$

31 **(b)**

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2 = 2 \times 2 + \frac{1}{2} \times 3 \times (2)^2 = 10 \text{ rad}$$

32 **(d)**

Unit of angular momentum, $L = kg\ m^2/s$

$$= \frac{kg\ m^2}{s}\frac{s}{s}$$

$$= \frac{kg\ m^2}{s^2}s$$

$= J\text{-}s$

33 **(a)**

$$E = \frac{1}{2}I\omega^2$$

$$I = 2m\left(\frac{d}{2}\right)^2 = \frac{md^2}{2}$$

$$\therefore E = \frac{1}{2} \times \frac{md^2}{2}.\omega^2 = \frac{md^2}{4}.\omega^2$$

$$\therefore \omega^2 = \frac{4E}{md^2}$$

$$\therefore \omega = \frac{2}{d}\sqrt{\frac{E}{m}}$$

34 **(a)**

$S = r\theta$

$$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$$

$$\therefore t = \sqrt{\frac{2\theta}{\alpha}}$$

$$\text{Average velocity} = \frac{\text{displacement}}{\text{time}} = \frac{r\theta}{\sqrt{\frac{2\theta}{\alpha}}}$$

$= r\sqrt{\frac{\alpha}{2\theta}}.\theta = r\sqrt{\frac{\alpha\theta}{2}} \therefore$

35 **(d)**

$E_1 = \frac{1}{2}mv^2 = \frac{1}{2}mr^2\omega_1^2$

$E_2 = \frac{3}{2}mr^2\omega_1^2$

$\frac{E_2}{E_1} = 3$

$\therefore E_2 = 3E_1$

$\frac{1}{2}mr^2\omega^2 = 3\frac{1}{2}m\omega_0^2r^2$

$\omega^2 = 3\omega_0^2$

$\frac{1}{2}m\omega_0^2r^2 = E$

$\omega_0^2 = \frac{2E}{mr^2}$

$\omega^2 = \omega_0^2 + 2\alpha\theta$

$3\omega_0^2 = 12\alpha\pi$

$\alpha = \frac{\omega_0^2}{6\pi} = \frac{2E}{mr^2} \times \frac{1}{6\pi} = \frac{E}{3\pi mr^2}$

But $a = r\alpha = r \times \frac{E}{3\pi mr^2} = \frac{E}{3\pi rm}$

36 **(d)**

MI of the disc is $\frac{1}{2}MR^2$

$I_{total} = I_{removed} + I_{remain}$

$\frac{1}{2}MR^2 = \left(\frac{M}{4}\right)\frac{R^2}{2} + I_{remain}$

$I_{remain} = \frac{1}{2}MR^2 - \frac{1}{8}MR^2$

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

37 **(b)**

$K = \frac{1}{2}I\omega^2, L = I\omega$

$K' = \frac{1}{2}I'\omega'^2$

$\omega' = 2\omega$

$\therefore K' = \frac{1}{2}I'(2\omega)^2,$

$K' = \frac{K}{2}$

$\therefore \frac{1}{2}\left(\frac{1}{2}I\omega^2\right) = \frac{1}{2}I'(2\omega)^2$

$\therefore I' = \frac{I}{8}$

$L' = I'\omega' = \frac{1}{8} \times 2\omega = I\omega/4 = \frac{L}{4}$

38 **(a)**

Given, $t = 5$ s and $n = 20 \therefore \theta = 2\pi n$

We have $\omega = \omega_0 + \alpha t$

$\alpha = \frac{-\omega_0}{5}$ $(\therefore \omega = 0)$

$\omega^2 = \omega_0^2 + 2\alpha\theta$

$\Rightarrow \omega_0^2 = -2\alpha\theta$

$\Rightarrow \omega_0^2 = 2\frac{\omega_0}{5} \cdot 40\pi$

$\omega_0 = 16\pi$

$2\pi n = -16\pi$ $(\therefore \omega = 2\pi n)$

$\therefore n = 8$ Hz

39 **(b)**

$\alpha = \frac{\omega}{t}$

Torque $\tau = I\alpha = \frac{MR^2}{2}.\frac{\omega}{t} = \frac{MR^2\omega}{2t}$

Force $= F = \frac{\tau}{R} = \frac{MR\omega}{2t}$

40 **(b)**

Kinetic energy $k = \frac{1}{2}I\omega^2$

$\therefore \frac{k_2}{k_1} = \frac{I_2\omega_2^2}{I_1\omega_1^2}$

$\therefore 2 = \frac{I_2}{I_1}\left[\frac{1}{2}\right]^2$

$\therefore \frac{I_2}{I_1} = 8$

Angular momentum $L = I\omega$

$\frac{L_2}{L_1} = \frac{I_2\omega_2}{I_1\omega_1} = 8 \times \frac{1}{2} = 4$

$\therefore L_2 = 4L_1 = 4L$

42 **(b)**

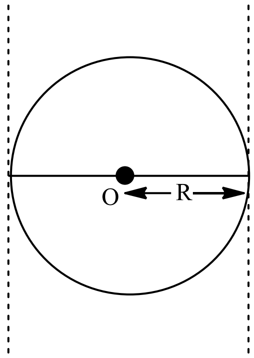
Net acceleration in non-uniform circular motion,

$$a = \sqrt{a_t^2 + a_c^2} = \sqrt{(2)^2 + [900/500]^2} = 2.7\ \text{ms}^{-2}$$

43 **(b)**

As, $I = MK^2 = \Sigma MR^2$ where, M is the total mass of the body.

This means that, $K = \sqrt{\left(\frac{1}{M}\right)}$



According to theorem of parallel axes, $I = I_{CG} + M(2R)^2$ where, I_{CG} is moment of inertia about an axis through centre of gravity.

$$\therefore I = \frac{2}{5}MR^2 + 4MR^2$$

$$= \frac{22}{5}MR^2$$

$$\Rightarrow MK^2 = \frac{22}{5}MR^2$$

$$\therefore K = \sqrt{\frac{22}{5}}R$$

44 **(d)**

$$I = \frac{ML^2}{3}$$

$$I_1 = \frac{Mr^2}{2} = \frac{M}{2}.\frac{L^2}{4\pi^2} = \frac{ML^2}{8\pi^2}$$

where $r = \frac{L}{2\pi}$

$$\therefore \frac{I}{I_1} = \frac{8\pi^2}{3}$$

45 **(d)**

$$I_{total} = \frac{MR^2}{2}$$

$$M_{removed} = \frac{M}{4}$$

$$I_{removed} = \frac{M}{4} \times \frac{\left(\frac{R}{2}\right)^2}{2} + \frac{M}{4}\left(\frac{R}{2}\right)^2$$

$$= \frac{3MR^2}{32}$$

$$\therefore I_{remaining} = I_{total} - I_{removed}$$

$$= \frac{MR^2}{2} - \frac{3MR^2}{32} = \frac{13MR^2}{32}$$

46 **(b)**

The mass of the wire= $M = mL$

The radius of the circular loop= $r = \frac{L}{2\pi}$

The moment of inertia of this loop about the tangential axis in the plane of the coil is

$$I = \frac{3}{2}mr^2 = \frac{3}{2} \times mL \times \frac{h^2}{4\pi^2}$$

$$\frac{3mL^3}{8\pi^2}$$

47 **(c)**

We know that, moment of inertia of a circular disc about its tangent axis, $I = \frac{5}{4}mR^2$

49 **(a)**

$$I = \frac{3}{2}mR^2 = \frac{3}{2}L\rho R^2$$

$$L = 2\pi R$$

$$= \frac{3}{2}L\frac{\rho L^2}{4\pi^2}$$

$$= \frac{3\rho L^3}{8\pi^2}$$

50 **(d)**

$$a = \frac{g\sin\theta}{\left(1 + \frac{K^2}{R^2}\right)} = \frac{g\sin 30°}{\left(1 + \frac{2}{5}\right)}$$

$$\therefore a = \frac{5g}{7} \times \left(\frac{1}{2}\right) = \frac{5g}{14}$$

52 **(c)**

The angular velocity

$$\omega = 1\frac{\text{rad}}{\text{s}}$$

$$I = P.\left(\frac{1}{2}I\omega^2\right)$$

$$I = P.\frac{1}{2}.1$$

$$\therefore P = 2$$

53 **(a)**

Total K. E. of the rolling disc or ring is given by

$$K.E. = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

For ring and disc, translational kinetic energy $\frac{1}{2}mv^2$ is constant.

Rolling K. E. of disc is $\frac{1}{4}mR^2\omega^2$

Rolling K. E. of ring is $\frac{1}{2}mR^2\omega^2$

As for ring,

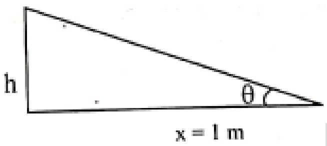
$$4J = \frac{1}{2}mv^2 + \frac{1}{2}mR^2\omega^2$$

$$\therefore mR^2\omega^2 = 4J$$

For disc,

$$\frac{1}{2}mR^2\omega^2 + \frac{1}{4}mR^2\omega^2 = \left(\frac{4}{2} + \frac{4}{2}\right)J = (2+1)J = 3J$$

55 **(d)**



$$\tan\theta = \frac{1}{20} = \frac{h}{1}$$

$$\therefore h = \frac{1}{20}m = 0.05\ m = 5\ cm$$

56 **(c)**

$$I_{coil} = mr^2$$

$$I_{disc} = \frac{1}{2}mr^2$$

$$KE_{coil} = \frac{1}{2}mr^2\omega^2 + \frac{1}{2}mr^2\omega^2 = mr^2\omega^2$$

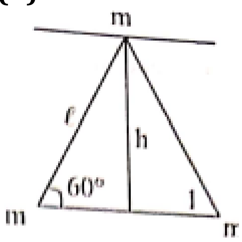
$$KE_{disc} = \frac{1}{2}m\omega^2r^2 + \frac{1}{2}.\frac{1}{2}m\omega^2r^2$$

$$= \frac{3}{4}m\omega^2r^2$$

$$\frac{KE_{coil}}{KE_{disc}} = \frac{4}{3}$$

$$\Rightarrow KE_{disc} = KE_{coil} \times \frac{3}{4} = 9\ J$$

59 **(d)**



$$I = 2mh^2$$

$$h = l\sin 60^0 = l \times \frac{\sqrt{3}}{2}$$

$$I = 2m \times \frac{3}{4}.l^2 = \frac{3}{2}ml^2$$

61 **(b)**

$$I = \frac{1}{2}MR^2$$

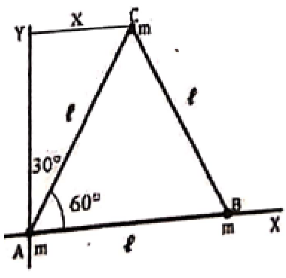
For smaller spheres mass $M' = \frac{M}{27}$

Radius of each smaller sphere $= R' = \frac{R}{3}$

$$\therefore I' = \frac{1}{2}M'^{R'^2} = \frac{1}{2}.\frac{M}{27}.\frac{R^2}{9}$$

$$= \frac{1}{243}\left(\frac{1}{2}MR^2\right) = \frac{1}{243}.I$$

62 **(b)**



$$I = ml^2 + mx^2$$

$$x = l\sin 30^0 = \frac{l}{2}$$

$$\therefore I = ml^2 + m\left(\frac{l}{2}\right)^2$$

$$= ml^2 + \frac{ml^2}{4}$$

$$= \frac{5}{4}ml^2$$

63 **(c)**

$I_c = 4 \text{ kg m}^2 = MR^2$

Using theorem of perpendicular axes,

M.I. of ring about any diameter,

$I_d = \frac{I_c}{2} = \frac{4}{2} = 2 \text{ kg m}^2$

Applying theorem of parallel axes, M.I. about tangent in its plane

$It = I_d + MR^2$

$= 2 + 4 = 6 \text{ kg m}^2$

64 **(c)**

As torque = force × perpendicular distance

∴ Torque about axis at A,

$\tau_A = 100 \times 0.75 = 75 \text{ N} - \text{m}$ counter-clockwise,

Torque about axis at B,

$\tau_B = 100 \times 1.25 = 125 \text{ N} - \text{m}$ clockwise

65 **(d)**

The angular acceleration $\alpha = \frac{\tau}{I}$

α is inversely proportional to the moment of inertia I.

The moment of inertia of the ring is MR^2 which is greater than moment of inertia of the disc $\left(\frac{MR^2}{2}\right)$

Hence angular acceleration and therefore angular velocity will be greater for the disc.

66 **(d)**

By principle of conservation of angular momentum, $I\omega = I_1\omega_1$ ...(i)

Assuming earth to be a uniform solid sphere,

$I = \frac{2}{5} = MR^2$

Then equation (i) becomes, $\frac{2}{5}MR^2$

$\therefore \omega = \frac{2}{5}M\left(\frac{R}{2}\right)^2 \omega_1 \Rightarrow \frac{\omega}{\omega_1} = \frac{1}{4}$

$\therefore \frac{T_1}{T} = \frac{1}{4}$ $\quad ...\left[\because \omega = \frac{2\pi}{T}\right]$

$\therefore T_1 = \frac{T}{4} = \frac{24}{4} = 6$ hours

67 **(a)**

$a = \frac{g \sin\theta}{1 + \frac{K^2}{R^2}}$

For ring $K = R$

For disc $K = \frac{R}{\sqrt{2}}$

For sphere $K = \sqrt{\frac{2}{5}}R$

Putting these

$a_{ring} = 0.5 \text{ g} \sin\theta$

$a_{disc} = 0.6 \text{ g} \sin\theta$

$a_{sphere} = 0.7 \text{ g} \sin\theta$

∴ ring will reach the bottom, last.

68 **(d)**

$I_0 = \frac{1}{12}ML^2$

By applying theorem of parallel axes,

$I = I_0 + M\left(\frac{L}{2}\right)^2$

$= \frac{1}{12}ML^2 + \frac{1}{4}ML^2 = 4 \times \left(\frac{1}{12}ML^2\right)$

$\therefore I = 4\, I_0$

69 **(c)**

$I_{Ring} = MR^2 + Mh^2 = MR^2 + MR^2 = 2MR^2$

$I_{Disc} = \frac{1}{2}MR^2 + Mh^2 = \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$

$\therefore K_{Ring} = \sqrt{2}R \;\&\; K_{disc} = \sqrt{\frac{3}{2}}R$

$\therefore \frac{K_{Ring}}{K_{disc}} = \frac{\sqrt{2}R}{\frac{\sqrt{3}}{\sqrt{2}}R} = \frac{2}{\sqrt{3}}$

71 **(b)**

M.I. of thin Rod about one end, $I = \frac{ML^2}{3}$

Now, $L = 2\pi R \Rightarrow R = \frac{L}{2\pi}$

M.I. of ring about diameter,

$I_1 = \frac{MR^2}{2} = \frac{M\left(\frac{L^2}{4\pi^2}\right)}{2} = \frac{ML^2}{8\pi^2}$

$\therefore \frac{I}{I_1} = \frac{ML^2}{3} \times \frac{8\pi^2}{ML^2} = \frac{8\pi^2}{3}$

74 **(a)**

The moment of inertia of a solid sphere about a tangent is given by

$I = \frac{7}{5}mR^2 = \frac{7}{5}\left(\frac{4}{3}\pi R^3\rho\right)R^2 = \frac{28}{15}\pi R^5\rho$

75 **(b)**

M.I. at end of rod $= \frac{ML^2}{3} = 0.33ML^2$

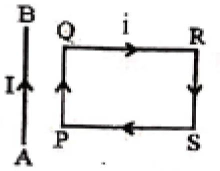
M.I. at its centre $= \frac{ML^2}{12} = 0.083\ ML^2$

M.I. at a point midway between end and centre $= \frac{7ML^2}{48} = 0.145\ ML^2$

M.I. at a point $\frac{1}{8}$ length from centre

$$= \frac{67ML^2}{768} = 0.087ML^2$$

77 **(d)**



$$I_1\omega_1 = (I_1 + I_2)\omega_2$$

$$\frac{\omega_2}{\omega_1} = \frac{I_1}{I_1 + I_2}$$

$$E_1 - E_2 = \frac{1}{2}I_1\omega_1^2 - \frac{1}{2}(I_1 + I_2)\omega_2^2$$

$$= \frac{1}{2}\omega_1^2\left[I_1 - (I_1 + I_2)\frac{\omega_2^2}{\omega_1^2}\right]$$

$$= \frac{1}{2}\omega_1^2\left[I_1 - (I_1 + I_2)\frac{I_1}{(I_1 + I_2)^2}\right]$$

$$= \frac{1}{2}\omega_1^2\left[\frac{I_1^2 + I_1I_2 - I_1^2}{I_1 + I_2}\right]$$

$$= \frac{1}{2}\left[\frac{I_1I_2}{I_1 + I_2}\right]\omega_1^2$$

79 **(c)**

Moment of inertia of the disc of mass M, $I = \frac{1}{2}MR^2$

When a quarter of the portion is removed, the new mass

$$= \frac{3}{4}M = M'$$

$\therefore$ New MI $= \frac{1}{2}M'R^2 = \frac{1}{2}\left(\frac{3}{4}M\right)R^2 = \frac{3}{8}MR^2$

80 **(d)**

$$a = a_T + a_r$$

$$a^2 = a_r^2 + a_T^2 = \frac{v^2}{r} + g^2 = p^2g^2 + g^2 = g^2(1 + p^2)$$

$$a = \sqrt{1 + p^2}.g$$

81 **(a)**

Using the given relation, $V = r\,\omega$

If the perpendicular distance r from the axis of rotation is increased or decreased, then the value of liner velocity V accordingly increases or decreases. Thus, the value of angular velocity ω does not depend on r.

82 **(d)**

1. For solid sphere about its tangent: $\frac{7}{5}MR^2 = MK^2 \therefore K = \sqrt{\frac{7}{5}}$

2. For a ring about its tangent perpendicular to plane: $2MR^2 = MK^2 \therefore K = \sqrt{2}R$

3. For a night circular cone about its axis: $\frac{3}{10}MR^2 = MK^2 \therefore K = \sqrt{\frac{3}{10}}R$

4. For uniform disc about its diameter: $\frac{MR^2}{4} = MK^2 \quad \therefore K = R/2$

83 **(a)**

M.I. of a rod about an axis passing through its edge and perpendicular to the rod

$$= \frac{ML^2}{3}$$

$$\therefore I_x = \frac{ML^2}{3} + \frac{ML^2}{3} = \frac{2 \times 1 \times (\sqrt{3})^2}{3} = 2\ \text{kg m}^2$$

84 **(a)**

$$E = \frac{1}{2}I\omega^2 = 1500$$

$$\frac{1}{2}I(\alpha t)^2 = 1500$$

$$\therefore (1.2)(25)^2t^2 = 3000$$

$$\therefore t^2 = 4 \Rightarrow t = 2\ s$$

85 **(d)**

$$K.E. = \frac{1}{2}mv^2$$

At lowest point in vertical circular motion. $V_L = \sqrt{5rg}$ and at highest point $V_h = \sqrt{rg}$

$$\therefore \frac{(K.E.)_h}{(K.E.)_L} = \frac{1}{5} = 0.2$$

86 **(b)**

Moment of inertial of the sphere

$$I_1 = \frac{2}{5}MR^2$$

Moment of inertia of the cylinder

$$I_2 = \frac{1}{2}MR^2$$

$$\therefore \frac{I_1}{I_2} = \frac{4}{5}, \frac{\omega_1}{\omega_2} = \frac{1}{2}$$

$$K.E. = \frac{1}{2}I\omega^2$$

$$\therefore \frac{k_1}{k_2} = \frac{I_1}{I_2}\left(\frac{\omega_1}{\omega_2}\right)^2 = \frac{4}{5} \times (1/2)^2 = \frac{1}{5}$$

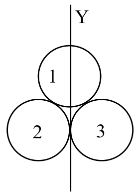
87 **(d)**

Moment of inertia of system about YY,'

$$I = I_1 + I_2 + I_3$$

$$= \frac{1}{2}MR^2 + \frac{3}{2}MR^2 + \frac{3}{2}MR^2$$

$$= \frac{7}{2}MR^2$$



89 **(b)**

Change in angular momentum= $\tau.t = 200 \times 4 = 800\ kg\ m^2/s$

90 **(b)**

Velocity vector and acceleration vector in a uniform circular motion are related as perpendicular to each other.

91 **(a)**

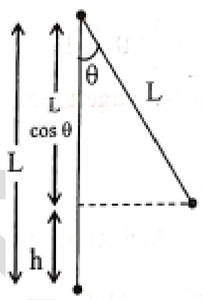
As angular momentum is conserved in the absence of a torque, therefore $I_0\omega_0 = 1\omega$

$$\left(\frac{2}{3}MR^2\right)\left(\frac{2\pi}{T_0}\right) = \left[\frac{2}{5}MR^2 + \frac{2}{5}\frac{MR^2}{5 \times 10^{19}}\right]\frac{2\pi}{T}$$

$$\frac{T}{T_0} = 1 + \frac{1}{5 \times 10^{19}} \Rightarrow \frac{T}{T_0} - 1 = \frac{1}{5 \times 10^{19}}$$

$$= 2 \times 10^{-20}$$

92 **(a)**



Height of the bob above the equilibrium position

$$h = L - L\cos\theta = L(1 - \cos\theta)$$

When it is released, it moves to equilibrium position. It loses potential energy and gains equal kinetic energy.

$$\therefore \frac{1}{2}mv^2 = mgh$$

$$\therefore v^2 = 2gh = 2gL(1 - \cos\theta)$$

$$\therefore v = \sqrt{2gL(1 - \cos\theta)}$$

93 **(d)**

Moment of inertia of a solid sphere about an axis passing through the centre is given by

$$I_0 = \frac{2}{5}mR^2$$

Moment of inertia about a tangent is given by

$$I_t = \frac{2}{5}mR^2 + mR^2 + mR^2 = \frac{7}{5}mR^2$$

In the figure three spheres are rotating about axis passing through the centre and two sphere are rotating about a tangent.

Hence the total moment of inertia of the system

$$I = 3 \times \frac{2}{5}mR^2 + 2 \times \frac{7}{5}mR^2$$

$$= \frac{6}{5}mR^2 + \frac{14}{5}mR^2$$

$$= \frac{20}{5}mR^2 = 4mR^2$$

94 **(d)**

Distance of corner mass from opposite side,

$$r = \sqrt{l^2 - (l/2)^2} = \frac{\sqrt{3}}{2}l \text{ and } I = mr^2 = \frac{3}{4}ml^2$$

97 **(b)**

Moment of inertia of circular ring about an axis passing through its centre of mass and perpendicular to its plane,

$$I = MR^2$$

Here, $I = 4\ kg - m^2, m = 1\ kg$

$$\therefore R^2 = \frac{4}{1} = 4 \Rightarrow R = 2\ m$$

Therefore, diameter of ring = 4 m.

98 **(c)**

Given $\mu = 0.64, r = 20\ m$

Maximum velocity of the car is given by

$v=\sqrt{\mu rg}=\sqrt{0.64\times 20\times 10}$

$\therefore v=\sqrt{0.64\times 200}=\sqrt{128}\approx 11.2\ ms^{-1}$

100 **(d)**

Given, $h=0.75$ m, $r=100$ m, $b=1$ m

For no skidding, $\frac{mv^2}{r}\times b=mgh$

$$v=\sqrt{\frac{grh}{b}}=\sqrt{\frac{9.8\times 100\times 0.75}{1}}$$

$=27.1\ ms^{-1}$

102 **(a)**

We know that, radius of ring, $R=\frac{L}{2\pi}$ ....(i)

Moment of inertia of thin uniform rod,

$I=\frac{ML^2}{12}$..........(ii)

and same rod is bent into a ring, then its moment of inertia,

$r'=\frac{1}{2}MR^2$[from Eq. (i)]

$r'=\frac{1}{2}\frac{ML^2}{4\pi^2}=\frac{ML^2}{8\pi^2}$..........(iii)

On dividing Eq. (ii) by Eq. (iii), we get

$$\frac{I}{r'}=\frac{ML^2}{12}\times\frac{8\pi^2}{ML^2}$$

$$=\frac{8\pi^2}{12}=\frac{2\pi^2}{3}$$

103 **(b)**

Given, work done, $W=12000$ J,

Initial frequency, $f_1=10$ Hz

and final frequency, $f_2=20$ Hz

Angular velocity for rotational motion is given by $\omega=2\pi f$

$\therefore \omega_1=2\pi f_1=2\pi\times 10=20\pi rad/s$

and $\omega_2=2\pi f_2=2\pi\times 20=40\pi rad/s$

According to work-energy theorem,

work done in rotation = change in rotational kinetic energy

$$\Rightarrow W=\frac{1}{2}/\omega_2^2-\frac{1}{2}I\omega_1^2\left[\because KE_{rotational}=\frac{1}{2}/\omega^2\right]$$

$$=\frac{1}{2}/(\omega_2^2-\omega_1^2)$$

where, I = moment of inertia of the flywheel.

Substituting given values in Eq. (i), we get

$$12000=\frac{1}{2}I(1600\pi^2-400\pi^2)$$

$$\Rightarrow=\frac{1}{2}I(1200\times 10)$$

$$\Rightarrow I=\frac{12000\times 2}{12000}=2\ kg-m^2[\because \pi^2=10]$$

104 **(c)**

$a_t=r\alpha$

$$a_r=\frac{v^2}{r}$$

$$\frac{a_t}{a_r}=\frac{r\alpha}{(\frac{v^2}{r})}=\frac{\alpha r^2}{v^2}$$

105 **(a)**

$$KE=\frac{1}{2}I\omega^2+\frac{1}{2}mv^2$$

$$=\frac{1}{2}\left(\frac{2}{5}MR^2\right)\frac{v^2}{R^2}+\frac{1}{2}Mv^2$$

$$=\frac{1}{5}Mv^2+\frac{1}{2}Mv^2$$

$$=\frac{7}{10}Mv^2=\frac{7}{10}\times 1\times 10\times 10^{-2}=7\times 10^{-2}\ J$$

$=0.007$ J

106 **(a)**

According to the question,

$$\frac{2}{5}MR^2=\frac{1}{2}Mr^2+Mr^2=\frac{3}{2}Mr^2\Rightarrow r=\frac{2}{\sqrt{15}}R$$

108 **(c)**

Length of rod = 1

Moment of couple, $\tau=F/\sin\theta$

$$\therefore F=\frac{\tau}{1\sin\theta}=\frac{\tau}{1\sin 30^\circ}=\frac{\tau}{1\times\frac{1}{2}}$$

Force, $F=\frac{2\tau}{1}$

110 **(a)**

The centripetal force is provided by the friction.

$$\therefore \frac{mv^2}{r}=\mu m$$

$$\therefore r = \frac{v^2}{\mu g}\left(v = 108\frac{km}{hr} = 30\frac{m}{s}\right)$$

$$= \frac{(30)^2}{0.5 \times 10} = 180 \text{ m}$$

111 **(c)**

The tension in the wire is maximum when the mass is at the lowest position.

$$T = \frac{mv^2}{r} + mg\cos\theta$$

At the lowest position $\theta = 0^0$ and $\cos\theta = 1$

112 **(d)**

Loss in KE = Gain in PE

$$\frac{1}{2}I\omega^2 = mgh \text{ and the MI of the rod } I = \frac{ml^2}{3}$$

$$\frac{1}{2}\left(\frac{ml^2}{3}\right)\omega^2 = mgh \Rightarrow h = \frac{1}{6}\frac{l^2\omega^2}{g}$$

113 **(d)**

Moment of Inertia of a given body is $I = MR^2$

Thus, M.I. of a body depends on position of the axis of rotation and hence is not constant

115 **(a)**

If M is the mass of the rod and L is its length, then

$$I = \frac{ML^2}{3}$$

Radius of the circular ring is given by

$$2\pi r = L$$

$$\therefore r = \frac{L}{2\pi}$$

$$I_1 = \frac{Mr^2}{2} = \frac{M}{2}\cdot\frac{L^2}{4\pi^2}$$

$$\therefore \frac{I}{I_1} = \frac{8\pi^2}{3}$$

117 **(b)**

M.I. of thin rod, $I_1 = \frac{ML^2}{12}$ ...(i)

M.I. of ring, $I_2 = MR^2$ ...(ii)

The rod is bend to form a ring $\Rightarrow L = 2\pi R$

$$\frac{I_1}{I_2} = \frac{ML^2}{12} \times \frac{1}{MR^2}$$

$$= \frac{M(2\pi R)^2}{12} \times \frac{1}{MR^2} = \frac{4M\pi^2R^2}{12\ MR^2} = \frac{\pi^2}{3}$$

119 **(d)**

$$I_A = \frac{I_B}{4}, \frac{E_A}{E_B} = 100$$

$$\text{kinetic energy } E = \frac{1}{2}I\omega^2 = \frac{1}{2}\frac{L^2}{I}$$

$$\therefore \frac{E_A}{E_B} = \left(\frac{L_A}{L_B}\right)^2\left(\frac{I_B}{I_A}\right)$$

$$\therefore \left(\frac{L_A}{L_B}\right)^2 = \frac{E_A}{E_B}\cdot\frac{I_A}{I_B} = 100 \times \frac{1}{4} = 25$$

$$\frac{L_A}{L_B} = 5$$

120 **(b)**

$$I_1 = m_1R^2$$

$$I_2 = m_2n^2R^2$$

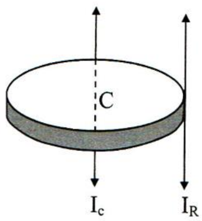
$$\frac{I_1}{I_2} = \frac{m_1}{m_2}\frac{R^2}{n^2R^2} = \frac{2\pi R}{2\pi nR} \times \frac{R^2}{n^2R^2} = \frac{1}{n^3} = \frac{1}{8}$$

$$\therefore n = 2$$

123 **(a)**

$$I_c = \frac{1}{2}MR^2$$

$$\Rightarrow MR^2 = 6 \times 2 = 12$$



Using theorem of parallel axes,

$I_r = I_c + MR^2$

$= 6 + 12 = 18\ kgm^2$

124 **(c)**

Apply the law of conservation of angular momentum,

$$I_1\omega_1 = I_2\omega_2$$

$$Mr^2\omega = (M + 2m)r^2\omega'$$

$$\text{Thus, } \omega' = \frac{\omega M}{M + 2m}$$

125 **(b)**

Moment of inertia of a ring about the given axis in

$$I_r = 2MR^2$$

$$\therefore MK_r^2 = 2MR^2$$

or $K_r = \sqrt{2}R$

Moment of inertia of a disc about the given axis is

$$I_d = \frac{3}{2}MR^2$$

$$\therefore mK_d^2 = \frac{3}{2}MR^2$$

$$\therefore K_d = \sqrt{\frac{3}{2}}R$$

$$\therefore \frac{K_r}{K_d} = \sqrt{2}R \times \sqrt{2/3} \times \frac{1}{R} = \frac{2}{\sqrt{3}}$$

126 **(c)**

$h = I + I\sin\theta = I(1+\sin\theta)$

$v^2 = u^2 - 2gh = u^2 - 2gl(1+\sin\theta)$

String will slack where, component of weight towards centre is just equal to centripetal force

or $mg\sin\theta = \frac{mv^2}{l} = \frac{m}{l}[u^2 - 2gl(1+\sin\theta)]$

On substituting $u^2 = \frac{7gl}{2}$, we get $\sin\theta = \frac{1}{2}$ or $\theta = 30°$

$\therefore$ The desired angle is $(90° + 30°)$ or $120°$.

127 **(b)**

$I = \frac{ML^2}{12}$ and $I = MK_1^2$ (where K_1 radius of gyration)

$\therefore\ MK_1^2 \Rightarrow K_1 = \frac{L}{2\sqrt{3}}$.........(i)

When axis rotation of rod is passing through one and of rod, then

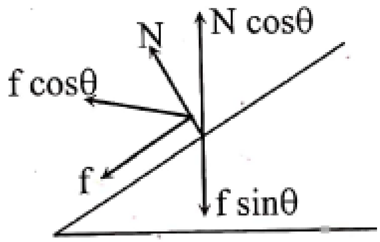
$I = MK_2^2$

$\Rightarrow K_2 = \frac{L}{\sqrt{3}}$..........(ii)

From Eqs. (i) and (ii), we get

$$\therefore \frac{K_1}{K_2} = \frac{L/2\sqrt{3}}{L/\sqrt{3}} = \frac{1}{2}$$

128 **(a)**



$N\cos\theta = mg + f\sin\theta$

$mg = N\cos\theta - f\sin\theta$

$$N\sin\theta + f\cos\theta = \frac{mv^2}{R}$$

$$\frac{mv^2}{R} = N\sin\theta + f\cos\theta$$

$$\frac{v^2}{Rg} = \frac{N\sin\theta + f\cos\theta}{N\cos\theta - f\sin\theta}$$

$$v_m = \sqrt{Rg\left[\frac{N\sin\theta + f\cos\theta}{N\cos\theta - f\sin\theta}\right]}$$

$$= \sqrt{Rg\left[\frac{\mu + \tan\theta}{1 - \mu\tan\theta}\right]}$$

130 **(d)**

Centripetal acceleration $a = \frac{V^2}{r}$

$$\frac{a_2}{a_1} = \left(\frac{V_2}{V_1}\right)^2 = (2)^2 = 4$$

$\therefore a_2 = 4a_1$

131 **(d)**

The body becomes weightless when the centripetal force on it is equal to its weight

$$\therefore mR\omega^2 = \frac{GMm}{R^2}$$

$$\therefore \omega^2 = \frac{GM}{R^3} = \frac{gR^2}{R^3} = \frac{g}{R} \quad (GM = gR^2)$$

Kinetic energy of earth

$$= \frac{1}{2}I\omega^2 = \frac{1}{2} \times \frac{2}{5}MR^2 \times \frac{g}{R} = \frac{MgR}{5}$$

134 **(c)**

Given, $I = 2\ kg - m^2, \omega_0 = \frac{60}{60} \times 2\pi rads^{-1}$,

$\omega = 0, t = 60$ s.

The torque required to stop the wheel's rotation,

$$\tau = I\alpha = I\left(\frac{\omega_0 - \omega}{t}\right) = \frac{2 \times 2\pi \times 60}{60 \times 60} = \frac{\pi}{15}\ \mathrm{N-m^{-1}}$$

135 **(b)**

$$I_{sph} = \frac{2}{5}MR^2, I_{disc} = \frac{MR^2}{2}, I_{ring} = MR^2$$

Ring has largest moment of inertia.

137 **(d)**

First Method Given, $\frac{1}{2}I_1\omega_1^2 = \frac{1}{2}(2I)\omega_2^2$

$$\therefore \frac{\omega_1}{\omega_2} = \sqrt{2}$$

$$\therefore \frac{L_1}{L_2} = \frac{I_1\omega_1}{I_2\omega_2} = \frac{1}{2} \times \sqrt{2} = \frac{1}{\sqrt{2}}$$

Second Method

The relation between L and K is $L = \sqrt{2KI}$

$\therefore \frac{L_1}{L_2} = \sqrt{\frac{2KI}{2K(2I)}} = \frac{1}{\sqrt{2}}$ ($\because$ same K for both)

138 **(d)**

$\tau = I\alpha$

$$\therefore \alpha = \frac{\tau}{I} = \frac{F \times R}{\frac{MR^2}{2}} = \frac{2F}{MR} = \text{constant}$$

$$\omega = \omega_0 + \alpha t = \frac{2F}{MR}.t$$

$$\therefore F = \frac{MR\omega}{2t}$$

139 **(b)**

At the highest point,

$$\frac{mv^2}{r} = mg \text{ or } v = \sqrt{rg}$$

Also $v = r\omega$

$$r\omega = \sqrt{rg}$$

$$\therefore \omega = \sqrt{\frac{g}{r}}$$

$$\therefore \frac{2\pi}{T} = \sqrt{\frac{g}{r}}$$

$$\therefore T = 2\pi\sqrt{\frac{r}{g}}$$

141 **(b)**

M.I. of disc of central zone,

$$I_1 = \frac{4 \times (0.2)^2}{2} = 0.08\ \mathrm{kgm^2}$$

M.I. of wooden annular disc,

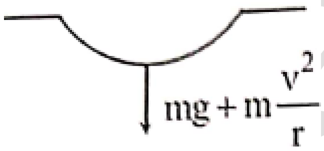
$$I_2 = \frac{3}{2}[(0.2)^2 + (0.5)^2] = \frac{3}{2}[0.04 + 0.25]$$

$= 1.5 \times 0.29 = 0.435\ \mathrm{kg\ m^2}$

$\therefore$ M.I. of whole disc $= I_1 + I_2 = 0.08 + 0.435$

$= 0.515\ \mathrm{kgm^2}$

142 **(b)**



Both centrifugal force and weight of the vehicle will be experienced downward.

143 **(d)**

$m = 10$ kg, $l = 0.3$ m

$$\text{B.S.} = 4.8 \times 10^7 \frac{N}{m^2}$$

$A = 10^{-6}\ m^2$

$\therefore F = 4.8 \times 10^7 \times 10^{-6} = 48$ N

$$\frac{mv^2}{r} = 48$$

$$v^2 = \frac{48 \times 0.3}{10} = \frac{144}{100}$$

$$v = \frac{12}{10} = 1.2\frac{m}{s}$$

$$\omega = \frac{1.2}{r} = \frac{12}{0.3} = 4\ \text{rad/sec}$$

144 **(d)**

Moment of inertia of disc

$$I_d = \frac{MR^2}{2}$$

Moment of inertia of ring,

$$I_r = MR^2$$

Angular acceleration $\alpha = \frac{\tau}{I}$

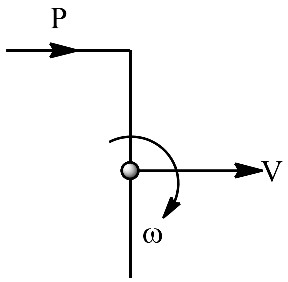
$\because \alpha_d > \alpha_r$

$\therefore$ Disc will rotate with greater angular frequency

147 **(c)**

Angular impulse $= P \times \frac{1}{2}$

= change in angular moment



$\therefore\ \frac{Pl}{2} = l\omega = \left(\frac{ml^2}{12}\right)\omega \Rightarrow \omega = \frac{6P}{ml}$

Now, $t = \frac{\theta}{\omega} = \frac{\pi/2}{6P/ml} = \frac{\pi ml}{12P}$

148 **(b)**

$\tau = \frac{dL}{dt} = \frac{4L - 0}{4} = L$

149 **(a)**

The moment of inertia of this annular disc about the axis perpendicular to its plane will be $\frac{1}{2}M(R^2 + r^2)$.

151 **(c)**

Tangential acceleration $a_t = r\alpha$

Radial acceleration $a_{tr} = \frac{v^2}{r}$

$\therefore\ \frac{a_t}{a_r} = \frac{\alpha r^2}{v^2}$

152 **(a)**

$2 \times \frac{ML^2}{12} + 2 \times \frac{ML^2}{4} = \frac{4}{6}ML^2 = \frac{2}{3}ML^2$

153 **(c)**

M.I. of sphere about the diameter $= \frac{2}{5}MR^2$

$\frac{2}{5}MR^2 = 20$ or $MR^2 = 50$

According to theorem of parallel axes, M.I. about the tangent

$= \frac{2}{5}MR^2 + MR^2 = \frac{7}{5}MR^2 = \frac{7}{5} \times 50 = 70\ \text{kg m}^2$

154 **(b)**

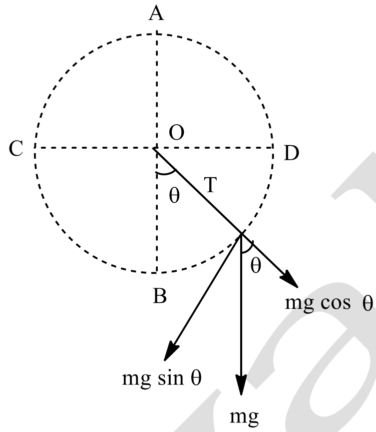
The body is describing a vertical circle,

$\therefore\ T - mg\cos\theta = \frac{mv^2}{l}$

or $T = mg\cos\theta + \frac{mv^2}{l}$

Tension is maximum when $\cos\theta = 1$ and velocity is maximum. Both conditions are satisfied at$\theta = 0^0$

(i.e. at lowest point B) .



155 **(a)**

For water not to spil, $\frac{mv^2}{r} = mg$

$\therefore$ Minimum speed at the highest point,

$v = \sqrt{rg} = \sqrt{1.6 \times 10}$

$= 4\ \text{ms}^{-1}$

156 **(a)**

M.I. of thin rod about axis passing through centre perpendicular to length is

Using, $I = MK^2 = \frac{ML^2}{12}$

$\therefore\ K = \frac{L}{\sqrt{12}} = \frac{L}{2\sqrt{3}} = \frac{1}{2\sqrt{3}}\text{m}$

157 **(a)**

$n_1 = 20\ \text{r.p.m.} = \frac{20}{60} = \frac{1}{3}\text{r.p.s.},$

$n_2 = 60\ \text{r.p.m.} = \frac{60}{60} = 1\ \text{r.p.s.},$

Work done by torque is the change in its rotational K.E.

$W = (K.E.)_f = (K.E.)_i$

$= \frac{1}{2}I\omega_f^2 - \frac{1}{2}I\omega_i^2 = \frac{1}{2}I(\omega_f^2 - \omega_i^2)$

$= \frac{1}{2}MK^2[(2\pi n_f)^2 - (2\pi n_i)^2]$

$= \frac{1}{2} \times 1 \times \frac{9}{\pi^2} \times 4\pi^2\left[(1)^2 - \left(\frac{1}{3}\right)^2\right]$

$= \frac{1}{2} \times 1 \times \frac{9}{\pi^2} \times 4\pi^2 \times \frac{8}{9}$

$\therefore\ W = 16\ \text{J}$

158 **(d)**

The difference in kinetic energy is same as difference in potential energy, which is mgh whereh = 2R

161 **(c)**

$I = I_1 + I_2$

$= MR^2 + 2(mR^2) = MR^2 + 2mR^2 = (M + 2m)R^2$

$I_1\omega_1 = I_2\omega_2$

$\omega_2 = \frac{I_1\omega_1}{I_2} = \frac{MR^2\omega}{(M+2m)R^2} = \frac{M\omega}{M+2m}$

162 **(a)**

Mass of the wire $M = \rho L$

If r is the radius of the coil then

$2\pi r = L$ or $r = \frac{L}{2\pi}$

The moment of inertia of a ring about a tangent in its plane is

$I = \frac{3}{2}Mr^2 = \frac{3}{2}\rho L \times \frac{L^2}{4\pi^2} = \frac{3\rho L^3}{8\pi^2}$

163 **(b)**

Angle described in 1st second:

$\theta_1 = \frac{1}{2}\alpha t^2 = \frac{1}{2}\alpha$ [t = 1s]

Angle described in first two seconds:

$\theta' = \frac{1}{2}\alpha(2)^2 = 2\alpha$

Angle described in 2nd second:

$\theta_2 = \theta' - \theta_1 = 2\alpha - \frac{1}{2}\alpha = \frac{3}{2}\alpha$

$\therefore \frac{\theta_1}{\theta_2} = \frac{1}{3}$

165 **(c)**

Angle between instantaneous velocity and acceleration is 90^0 in uniform circular motion.

166 **(c)**

$E = \frac{1}{2} \times L \times \omega$

$\therefore 225 = \frac{1}{2} \times L \times 25$

$\therefore L = 9 \times 2 = 18$ J s

168 **(d)**

In this case, centripetal force provides by friction

$\therefore \frac{mv^2}{r} = \mu mg$ and $\mu = \frac{v^2}{rg} = \mu = \frac{12.5 \times 12.5}{20 \times 9.8} = 0.8$

169 **(d)**

$I_{total} = \frac{MR^2}{2}$

$I_{removed} = \frac{\frac{M}{4}\left(\frac{R}{2}\right)^2}{2} + \frac{M}{4}\left(\frac{R}{2}\right)^2 = \frac{3MR^2}{32}$

$\left[\because \frac{Mr^2}{2} + mh^2\right]$

$I_{remain} = I_{total} - I_{removed}$

$= \frac{MR^2}{2} - \frac{3}{32}MR^2 = \frac{13}{32}MR^2$

171 **(c)**

The moment of inertia about an axis passing through centre of mass of disc and perpendicular to its plane is

$I_{CM} = \frac{1}{2}MR^2$

Where, M is the mass of disc and R its radius.

According to theorem of parallel axes, moment of inertia of circular disc about an axis touching the disc at its diameter and normal to the disc is

$= I_{CM} + MR^2 = \frac{1}{2}MR^2 + MR^2 = \frac{3}{2}MR^2$

172 **(b)**

Tangential acceleration= $r\alpha$

Radial acceleration $= \frac{v^2}{r}$

$\therefore \frac{\text{tangential acceleration}}{\text{radial acceleration}} = \frac{r\alpha}{v^2/r} = \frac{r^2}{v^2}\alpha = \left(\frac{r}{v}\right)^2 \alpha C$

174 **(b)**

$E = \frac{1}{2}I\omega^2$

$\therefore \omega = \sqrt{\frac{2E}{I}} = \sqrt{\frac{2 \times 9}{2}} = 3$ rad/s

175 **(c)**

Moment of inertial of sphere 1, $I_1 = \frac{2}{3}MR^2$

Moment of inertia of sphere 2, $I_2 = \frac{2}{3}MR^2 + MR^2$

$= \frac{5}{3}MR^2$

Moment of inertial of sphere 3, $I_3 = \frac{5}{3}MR^2$

Total moment of inertia of the systems

$$I = I_1 + I_2 + I_3 = \left(\frac{2}{3} + \frac{5}{3} + 5/3\right)MR^2 = \frac{12}{3}MR^2$$
$$= 4MR^2$$

176 **(a)**
According to question,
Moment of inertia of disc is given by $I = \frac{MR^2}{2}$
When the disc is remoulded into solid sphere, then volume remains same.
i.e. Volume of disc = Volume of solid sphere
i.e. $\pi R^2 \times \frac{R}{6} = \frac{4}{3}\pi r^3$

$$\Rightarrow r^3 = \frac{R^3}{8} \Rightarrow r = \frac{R}{2}$$

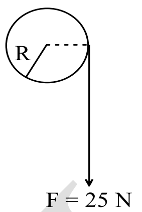
Now, moment of inertia of solid sphere,

$$I = \frac{2}{5}mr^2$$

$$= \frac{2}{5} \times m \times \frac{R^2}{4} = \frac{mR^2}{10}$$

i. e. $= \frac{I}{5}$

177 **(c)**
$R = 20\text{ cm} = \frac{1}{5}\text{m}$
Moment of inertia of flywheel about its axis,



$I = \frac{1}{2}MR^2$
$= \frac{1}{2} \times 20 \times \left(\frac{1}{5}\right)^2$
$= 0.4\text{ kg m}^2$
Using $\tau = I\alpha$,

$$\alpha = \frac{\tau}{I} = \frac{FR}{I} = \frac{25 \times \frac{1}{5}}{0.4} = \frac{5\text{ Nm}}{0.4\text{ kgm}^2}$$
$= 12.5\text{ s}^{-2}$

178 **(b)**
The angular momentum of the particle is given by

$$\vec{L} = \vec{r} \times \vec{p}$$

Its magnitude is $L = rp\sin\theta$

L will be maximum when $\theta = 90^0$

179 **(c)**
According to principle of conservation of angular momentum,
$I_1\omega_1 = I_2\omega_2$
$\therefore \frac{2}{5}MR^2 \times \frac{2\pi}{24} = \frac{2}{5}M\left(\frac{R}{n}\right)^2\frac{2\pi}{T'}$
$\therefore T' = \frac{24}{n^2}\text{hours}$

180 **(a)**
Centripetal acceleration is given by

$$a_N = \frac{dv}{dt} = \frac{v^2}{R}$$

$$\text{or}\int_0^t \frac{dt}{R} = \int_{v_0}^{v}\frac{dv}{v^2}$$

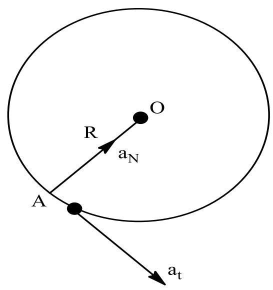
$$\text{or} t = -R\left[\frac{1}{v}\right]_{v_0}^{v}$$

$$\Rightarrow v = \frac{v_0 R}{R - v_0 t}$$

$$\text{Also, } \frac{dr}{dt} = \frac{v_0 R}{R - v_0 t}$$

$$\int_0^{2\pi R} dr = v_0 R\int_0^T \frac{dt}{R - v_0 t}$$

$$\Rightarrow T = \frac{R}{v_0}(1 - e^{-2\pi})$$



183 **(a)**
By parallel axis theorem

$$I = \frac{2}{5}MR^2 = M\left(\frac{R}{2}\right)^2$$

$$= \frac{2}{5}MR^2 + \frac{MR^2}{4} = \frac{13}{20}MR^2$$

184 **(d)**
When it is displaced through 90^0 from mean

position, it is at a height 'r' and has potential energy mgr. At the lowest position this potential energy is converted into kinetic energy.

$\therefore \frac{1}{2}mv^2 = mgr$

$\therefore mv^2 = mgr$

At the lowest position the tension in the string

$T = mg + \frac{mv^2}{r} = mg + 2mg = 3mg$

186 **(a)**

$E = \frac{1}{2}I\omega^2$

$I = 2m\left(\frac{d}{2}\right)^2 = \frac{md^2}{2}$

$\therefore E = \frac{1}{2} \times \frac{md^2}{2}.\omega^2 = \frac{md^2}{4}.\omega^2$

$\therefore \omega^2 = \frac{4E}{md^2}$

$\therefore \omega = \frac{2}{d}\sqrt{\frac{E}{m}}$

189 **(c)**

In the case of rolling, as K.E.,

$E = \frac{1}{2}Mv^2\left(1 + \frac{1}{MR^2}\right)$ ... (i)

For ring, $I = MR^2$

$\therefore E_{ring} = M_{ring}\, v_{ring}^2$

$\therefore v_{ring} = \sqrt{\frac{E_{ring}}{0.3}}$ ... (ii)

$\therefore$ For cylinder, $I = \frac{1}{2}MR^2$

$\therefore E_{cylinder} = \frac{3}{4}M_{cylinder}v_{cylinder}^2$ ...from (i)

$\therefore v_{cylinder} = \sqrt{\frac{4E_{cylinder}}{3 \times 0.4}} = \sqrt{\frac{E_{cylinder}}{0.3}}$ ... (iii)

According to problem,

$E_{ring} = E_{cylinder}$

$\therefore v_{ring} = v_{cylinder}$

As the motion is uniform, both will reach the wall simultaneously

190 **(b)**

$mv - (-mv) = 2mv$

192 **(c)**

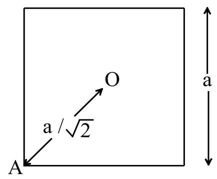
We know that, $\omega = 2\pi rad$ in 60 s $= \frac{\pi}{30}rads^{-1}$

$\therefore\ v = r\omega = 10 \times \frac{\pi}{30} = \frac{\pi}{3}rads^{-1}$ ($\because r = 10$ cm)

$= \frac{3.14}{3}rads^{-1} = 1.046 \simeq 1cms^{-1}$

193 **(c)**

M.I. of the plate about an axis perpendicular to its plane and passing through its centre



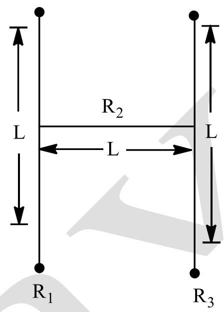
$I_0 = \frac{ma^2}{6}$

Applying parallel axes theorem,

$I_A = I_0 + m\left(\frac{a}{\sqrt{2}}\right)^2 = \frac{ma^2}{6} + \frac{ma^2}{2} = \frac{2}{3}ma^2$

194 **(d)**

The given situation can be shown as



Let us take the moment of inertia of the system about rod R_1, then total moment of inertia is

$I_T = I_1 + I_2 + I_3$

For rod R_1, $I_1 = 0$

For rod R_2, using perpendicular axes theorem,

$I_2 = \frac{ML^2}{3}$

For rod R_3, using parallel axes theorem,

$I_3 = I_{CM} + I_{(at\,L)} = 0 + ML^2 = ML^2$

Now, putting the values of I_1, I_2 and I_3 in Eq. (i), we get

$I_T = 0 + \frac{ML^2}{3} + ML^2 \Rightarrow I_T = \frac{4ML^2}{3}$

195 **(d)**

The moment of inertia of rod about one end

$I = \frac{ML^2}{3}$

Its kinetic energy KE

$= \frac{1}{2}I\omega^2 - \frac{1}{2}.\frac{ML^2}{3}\omega^2 = \frac{ML^2\omega^2}{6}$

If its centre of mass rises by h, then it will gain potential energy P. E.

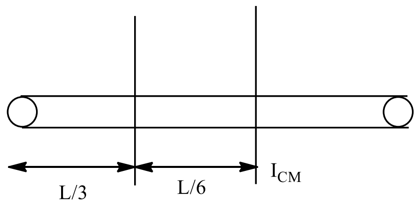
$= Mgh$

$$\therefore Mgh = \frac{ML^2\omega^2}{6}$$

$$\therefore h = \frac{L^2\omega^2}{6g}$$

197 **(b)**

$I_{CM} = \frac{ML^2}{12}$ (about middle point)



$$I = I_{CM} = Mx^2 = \frac{ML^2}{12} + M\left(\frac{L}{6}\right)^2 = \frac{ML^2}{9}$$

198 **(b)**

For body A, $K_A = \frac{1}{2}I_1\omega_1^2 = \frac{1}{2}(I_1\omega_1)\omega_1$

For body B, $K_B = \frac{1}{2}I_2\omega_2^2 = \frac{1}{2}(I_2\omega_2)\omega_2$

But it is given that, $l_1\omega_1 = l_2\omega_2$

$\therefore \ \frac{K_A}{K_B} = \frac{\omega_1}{\omega_2}$

But $\frac{l_2}{l_1} = \frac{\omega_1}{\omega_2}$

$(\because I_2 > I_1 \therefore \omega_1 > \omega_2)$

$\therefore$ From (1), $K_A > K_B$

199 **(b)**

$$\frac{I_A}{I_B} = \frac{64}{1}$$

$$64 = \frac{m_A r_A^2}{m_B r_B^2} = \frac{2\pi r_A}{2\pi r_B} = \frac{r_A^3}{r_B^3} = n^3$$