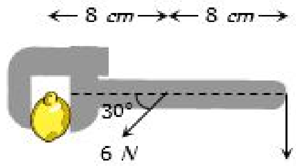
1. A force of $(2\hat{i} - 4\hat{j} + 2\hat{k})\ N$ acts at a point $(3\hat{i} + 2\hat{j} - 4\hat{k})\ metre$ from the origin. The magnitude of torque is .... $N - m$
   (A) 0 (B) 24.4
   (C) 0.244 (D) 2.444

2. When a force of $6.0\,N$ is exerted at 30^o to a wrench at a distance of $8\,cm$ from the nut, it is just able to loosen the nut. What force F would be sufficient to loosen it, if it acts perpendicularly to the wrench at $16\ cm$ from the nut .... N



   (A) 3 (B) 6
   (C) 4 (D) 1.5

3. The moment of inertia of a rod (length l, mass m) about an axis perpendicular to the length of the rod and passing through a point equidistant from its mid point and one end is
   (A) $\frac{ml^2}{12}$ (B) $\frac{7}{48}ml^2$
   (C) $\frac{13}{48}ml^2$ (D) $\frac{19}{48}ml^2$

4. The moment of inertia of a solid sphere of density ρ and radius R about its diameter is
   (A) $\frac{105}{176}R^5\rho$ (B) $\frac{105}{176}R^2\rho$
   (C) $\frac{176}{105}R^5\rho$ (D) $\frac{176}{105}R^2\rho$

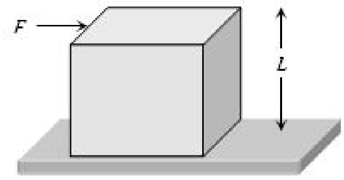
5. If I_1 is the moment of inertia of a thin rod about an axis perpendicular to its length and passing through its centre of mass, and I_2 is the moment of inertia of the ring formed by bending the rod, then
   (A) $I_1 : I_2 = 1 : 1$ (B) $I_1 : I_2 = \pi^2 : 3$
   (C) $I_1 : I_2 = \pi : 4$ (D) $I_1 : I_2 = 3 : 5$

6. From a uniform wire, two circular loops are made (i) P of radius r and (ii) Q of radius nr. If the moment of inertia of Q about an axis passing through its centre and perpendicular to its plane is 8 times that of P about a similar axis, the value of n is (diameter of the wire is very much smaller than r or nr)
   (A) 8 (B) 6
   (C) 4 (D) 2

7. The moment of inertia I of a solid sphere having fixed volume depends upon its volume V as
   (A) $I \propto V$ (B) $I \propto V^{2/3}$
   (C) $I \propto V^{5/3}$ (D) $I \propto V^{3/2}$

8. Let l be the moment of inertia of an uniform square plate about an axis AB that passes through its centre and is parallel to two of its sides. CD is a line in the plane of the plate that passes through the centre of the plate and makes an angle θ with AB. The moment of inertia of the plate about the axis CD is then equal to
   (A) l (B) $l\ \sin^2\theta$
   (C) $l\ \cos^2\theta$ (D) $l\ \cos^2\frac{\theta}{2}$

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



   (A) $Infinitesimal$ (B) $mg/4$
   (C) $mg/2$ (D) $mg(1-\mu)$

10. Let F be the force acting on a particle having position vector $\vec{r}$ and $\vec{T}$ be the torque of this force about the origin. Then ..
   (A) $\vec{r}.\vec{T} = 0$ and $\vec{F}.\vec{T} = 0$ (B) $\vec{r}.\vec{T} = 0$ and $\vec{F}.\vec{T} \neq 0$
   (C) $\vec{r}.\vec{T} \neq 0$ and $\vec{F}.\vec{T} = 0$ (D) $\vec{r}.\vec{T} \neq 0$ and $\vec{F}.\vec{T} \neq 0$

11. Two discs of the same material and thickness have radii $0.2\ m$ and $0.6\ m$. Their moments of inertia about their axes will be in the ratio
   (A) $1 :\ 81$ (B) $1 : 27$
   (C) $1 :\ 9$ (D) $1 :\ 3$

12. The planes of two rigid discs are perpendicular to each other. They are rotating about their axes. If their angular velocities are $3\,rad/sec$ and $4\,rad/sec$ respectively, then the resultant angular velocity of the system would be .... rad/sec
   (A) 1 (B) 7
   (C) 5 (D) $\sqrt{12}$

13. Let $\vec{A}$ be a unit vector along the axis of rotation of a purely rotating body and $\vec{B}$ be a unit vector along the velocity of a particle P of the body away from the axis. The value of $\vec{A}\ .\ \vec{B}$ is
   (A) 1 (B) -1
   (C) 0 (D) None of these

14. A particle B is moving in a circle of radius a with a uniform speed u. C is the centre of the circle and AB is diameter. The angular velocity of B about A and C are in the ratio
   (A) $1 : 1$ (B) $1 : 2$
   (C) $2 : 1$ (D) $4 : 1$

15. The wheel of a car is rotating at the rate of 1200 revolutions per minute. On pressing the accelerator for $10\ sec$ it starts rotating at 4500 revolutions per minute. The angular acceleration of the wheel is
   (A) $30\ radians/sec^2$ (B) $180\ degrees/sec^2$
   (C) $40\ radians/sec^2$ (D) $1980\ degrees/sec^2$

16. A strap is passing over a wheel of radius $30\,cm$. During the time the wheel moving with initial constant velocity of $2\,rev/sec.$ comes to rest the strap covers a distance of $25\,m$. The deceleration of the wheel in rad/s^2 is
   (A) 0.94 (B) 1.2
   (C) 2.0 (D) 2.5

17. For a system to be in equilibrium, the torques acting on it must balance. This is true only if the torques are taken about
(A) The centre of the system (B) The centre of mass of the system
(C) Any point on the system (D) Any point on the system or outside it

18. Two loops P and Q are made from a uniform wire. The radii of P and Q are r_1 and r_2 respectively, and their moments of inertia are I_1 and I_2 respectively. If $\frac{l_2}{l_1}$ = 4 then $\frac{r_2}{r_1}$ equals
(A) $4^{2/3}$ (B) $4^{1/3}$
(C) $4^{-2/3}$ (D) $4^{-1/3}$

19. Two men are carrying a uniform bar of length L, on their shoulders. The bar is held horizontally such that younger man gets $(1/4)^{th}$ load. Suppose the younger man is at the end of the bar, what is the distance of the other man from the end
(A) $L/3$ (B) $L/2$
(C) $2L/3$ (D) $3L/4$

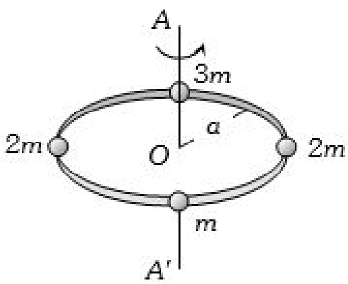
20. Three point masses m_1, m_2, m_3 are located at the vertices of an equilateral triangle of length $'a'$. The moment of inertia of the system about an axis along the altitude of the triangle passing through m_1 is
(A) $(m_2+m_3)\frac{a^2}{4}$ (B) $(m_1+m_2+m_3)a^2$
(C) $(m_1+m_2)\frac{a^2}{2}$ (D) $(m_2+m_3)a^2$

21. The angular speed of a fly-wheel making $120\,revolution/minute$ is
(A) $\pi\,rad/sec$ (B) $2\,\pi\,rad/sec$
(C) $4\,\pi\ \ rad/sec$ (D) $4\,\pi^2\,rad/sec$

22. If the position vector of a particle is $\vec{r}\ \ = (3\hat{i}+4\hat{j})\ meter$ and its angular velocity is $\vec{\omega}\ \ = (\hat{j}+2\hat{k})\ rad/sec$ then its linear velocity is (in m/s)
(A) $(8\hat{i}-6\hat{j}+3\hat{k})$ (B) $(3\hat{i}+6\hat{j}+8\hat{k})$
(C) $-(3\hat{i}+6\hat{j}+6\hat{k})$ (D) $(6\hat{i}+8\hat{j}+3\hat{k})$

23. A flywheel gains a speed of $540\ r.p.m.$ in $6\ sec$. Its angular acceleration will be
(A) $3\,\pi\,rad/sec^2$ (B) $9\,\pi\,rad/sec^2$
(C) $18\,\pi\,rad/sec^2$ (D) $54\,\pi\,rad/sec^2$

24. Four masses are joined to a light circular frame as shown in the figure. The radius of gyration of this system about an axis passing through the centre of the circular frame and perpendicular to its plane would be



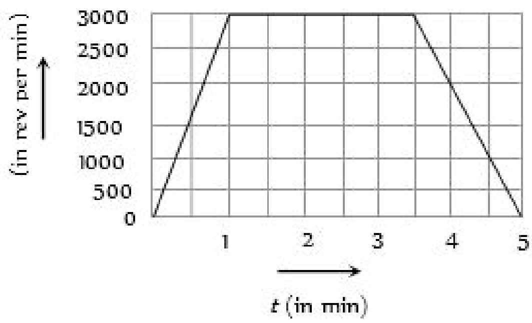
(A) $a/\sqrt{2}$ (B) $a/2$
(C) a (D) $2a$

25. On account of melting of ice at the north pole the moment of inertia of spinning earth
(A) Increases (B) Decreases
(C) Remains unchanged (D) Depends on the time

26. Two discs of same thickness but of different radii are made of two different materials such that their masses are same. The densities of the materials are in the ratio $1:3$. The moments of inertia of these discs about the respective axes passing through their centres and perpendicular to their planes will be in the ratio
(A) $1:3$ (B) $3:1$
(C) $1:9$ (D) $9:1$

27. The angular velocity of seconds hand of a watch will be
(A) $\frac{\pi}{60}\,rad/\sec$ (B) $\frac{\pi}{30}\,rad/sec$
(C) $60\,\pi\ rad/sec$ (D) $30\,\pi\ rad/sec$

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



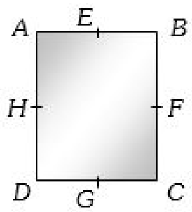
(A) 9000 (B) 16570
(C) 12750 (D) 11250

29. A car is moving at a speed of $72\,km/hr.$ the diameter of its wheels is $0.5\,m.$ If the wheels are stopped in 20 rotations by applying brakes, then angular retardation produced by the brakes is
(A) $-25.5\,\pi\,rad/sec^2$ (B) $-29.5\,\pi\,rad/sec^2$
(C) $-33.5\pi\,rad/sec^2$ (D) $-45.5\,\pi\,rad/sec^2$

30. A wheel of mass $10\,kg$ has a moment of inertia of $160\ \ kg-m^2$ about its own axis, the radius of gyration will be .... m
(A) 10 (B) 8
(C) 6 (D) 4

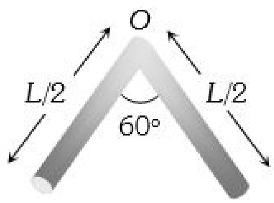
31. What is the torque of the force $\vec{F}\ \ = (2\hat{i}-3\hat{j}+4\hat{k})N$ acting at the pt. $\vec{r}\ \ = (3\hat{i}+2\hat{j}+3\hat{k})\,m$ about the origin
(A) $-17\hat{i}+6\hat{j}+13\hat{k}$ (B) $-6\hat{i}+6\hat{j}-12\hat{k}$
(C) $17\hat{i}-6\hat{j}-13\hat{k}$ (D) $6\hat{i}-6\hat{j}+12\hat{k}$

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



(A) BC (B) BD
(C) HF (D) EG

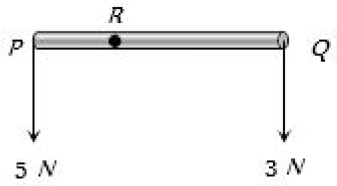
33. A thin rod of length L and mass M is bent at the middle point O at an angle of 60^o as shown in figure. The moment of inertia of the rod about an axis passing through O and perpendicular to the plane of the rod will be



(A) $\frac{ML^2}{6}$ (B) $\frac{ML^2}{12}$
(C) $\frac{ML^2}{24}$ (D) $\frac{ML^2}{3}$

34. Five particles of mass = $2\ kg$ are attached to the rim of a circular disc of radius $0.1\ m$ and negligible mass. Moment of inertia of the system about the axis passing through the centre of the disc and perpendicular to its plane is .... $kg\,m^2$
(A) 1 (B) 0.1
(C) 2 (D) 0.2

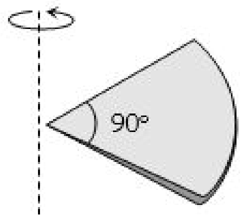
35. The resultant of the system in the figure is a force of $8N$ parallel to the given force through R. The value of PR equals to



(A) $1/4\ RQ$ (B) $3/8\ RQ$
(C) $3/5\ RQ$ (D) $2/5\ RQ$

36. Weights of $1\,g, 2\,g.....,100\,g$ are suspended from the $1\,cm, 2\,cm, ...100\ \ cm,\ marks$ respectively of a light metre scale. Where should it be supported for the system to be in equilibrium ...... cm mark.
(A) 55 (B) 60
(C) 66 (D) 72

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



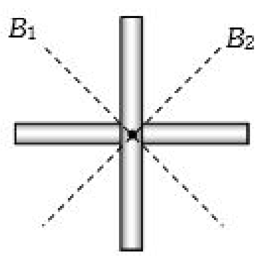
(A) $\frac{1}{2}MR^2$ (B) $\frac{1}{4}MR^2$
(C) $\frac{1}{8}MR^2$ (D) $\sqrt{2}\,MR^2$

38. When a ceiling fan is switched on, it makes $10\,rotations$ in the first $3\ \sec$. How many rotations will it make in the next $3\ \sec$ (Assume uniform angular acceleration)
(A) 10 (B) 20
(C) 30 (D) 40

39. A circular disc of radius R and thickness $\frac{R}{6}$ has moment of inertia I about an axis passing through its centre and perpendicular to its plane. It is melted and recasted into a solid sphere. The moment of inertia of the sphere about its diameter as axis of rotation is
(A) I (B) $\frac{2I}{8}$
(C) $\frac{I}{5}$ (D) $\frac{I}{10}$

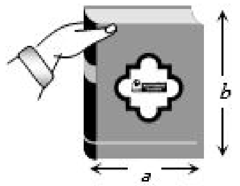
40. The moment of inertia of a meter scale of mass $0.6\ \ kg$ about an axis perpendicular to the scale and located at the $20\ \ cm$ position on the scale in $kg\,m^2$ is (Breadth of the scale is negligible
(A) 0.074 (B) 0.104
(C) 0.148 (D) 0.208

41. Two identical rods each of mass M. and length l are joined in crossed position as shown in figure. The moment of inertia of this system about a bisector would be



(A) $\frac{Ml^2}{6}$ (B) $\frac{Ml^2}{12}$
(C) $\frac{Ml^2}{3}$ (D) $\frac{Ml^2}{4}$

42. A person supports a book between his finger and thumb as shown (the point of grip is assumed to be at the corner of the book). If the book has a weight of W then the person is producing a torque on the book of



(A) $W\frac{a}{2}$ anticlockwise (B) $W\frac{b}{2}$ anticlockwise
(C) Wa anticlockwise (D) Wa clockwise

43. Three rods each of length L and mass M are placed along X, Y and Z - axes in such a way that one end of each of the rod is at the origin. The moment of inertia of this system about Z axis is
(A) $\frac{2ML^2}{3}$ (B) $\frac{4ML^2}{3}$
(C) $\frac{5ML^2}{3}$ (D) $\frac{ML^2}{3}$

44. Three identical thin rods each of length l and mass M are joined together to form a letter H. What is the moment of inertia of the system about one of the sides of H
(A) $\frac{Ml^2}{3}$ (B) $\frac{Ml^2}{4}$
(C) $\frac{2Ml^2}{3}$ (D) $\frac{4Ml^2}{3}$

45. A wheel initially at rest, is rotated with a uniform angular acceleration. The wheel rotates through an angle θ_1 in first one second and through an additional angle θ_2 in the next one second. The ratio $\frac{\theta_2}{\theta_1}$ is
(A) 4 (B) 2
(C) 3 (D) 1

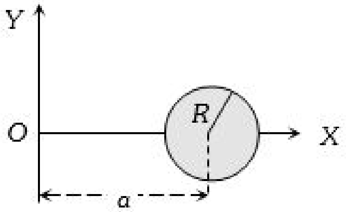
46. A circular disc A of radius r is made from an iron plate of thickness t and another circular disc B of radius $4r$ is made from an iron plate of thickness $t/4$. The relation between the moments of inertia I_A and I_B is
(A) $I_A > I_B$ (B) $I_A = I_B$
(C) $I_A < I_B$ (D) Depends on the actual values of t and r

47. In rotational motion of a rigid body, all particle move with
(A) Same linear and angular velocity
(B) Same linear and different angular velocity
(C) With different linear velocities and same angular velocities
(D) With different linear velocities and different angular velocities

48. A rigid body is rotating with variable angular velocity $(a-bt)$ at any instant of time t. The total angle subtended by it before coming to rest will be (a and b are constants)
(A) $\frac{(a-b)\,a}{2}$ (B) $\frac{a^2}{2b}$
(C) $\frac{a^2-b^2}{2b}$ (D) $\frac{a^2-b^2}{2a}$

49. A horizontal heavy uniform bar of weight W is supported at its ends by two men. At the instant, one of the men lets go off his end of the rod, the other feels the force on his hand changed to
(A) W (B) $\frac{W}{2}$
(C) $\frac{3W}{4}$ (D) $\frac{W}{4}$

50. The adjoining figure shows a disc of mass M and radius R lying in the $X-Y$ plane with its centre on $X-$ axis at a distance a from the origin. Then the moment of inertia of the disc about the $X-$ axis is



(A) $M\left(\frac{R^2}{2}\right)$ (B) $M\left(\frac{R^2}{4}\right)$

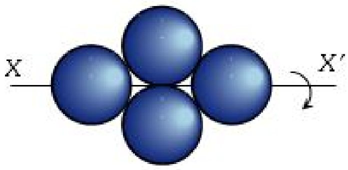
(C) $M\left(\frac{R^2}{4}+a^2\right)$ (D) $M\left(\frac{R^2}{2}+a^2\right)$

51. The moment of inertia of HCl molecule about an axis passing through its centre of mass and perpendicular to the line joining the H^+ and Cl^- ions will be, if the interatomic distance is 1

(A) $0.61\times10^{-47}\,kg.m^2$ (B) $1.61\times10^{-47}\,kg.m^2$

(C) $0.061\times10^{-47}\,kg.m^2$ (D) 0

52. The moment of inertia of a sphere (mass M and radius R) about it's diameter is I. Four such spheres are arranged as shown in the figure. The moment of inertia of the system about axis XX' will be



(A) $3\,I$ (B) $5\,I$

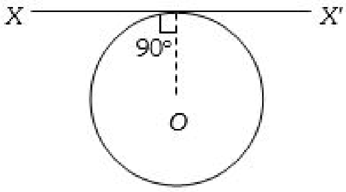
(C) $7\,I$ (D) $9\,I$

53. A particle starts rotating from rest. Its angular displacement is expressed by the following equation $\theta\ = 0.025t^2 - 0.1t$ where θ is in radian and t is in seconds. The angular acceleration of the particle is

(A) $0.5\,rad/sec^2$ at the end of $10\,sec$ (B) $0.3\,rad/sec^2$ at the end of $2\,sec$

(C) $0.05\,rad/sec^2$at the end of $1\,sec$ (D) Constant $0.05,\ rad/sec^2$

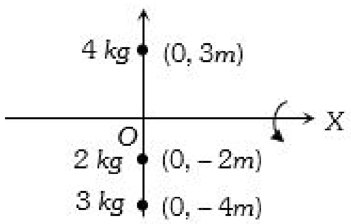
54. A thin wire of length L and uniform linear mass density r is bent into a circular loop with centre at O as shown. The moment of inertia of the loop about the axis XX' is



(A) $\frac{\rho L^3}{8\pi^2}$ (B) $\frac{\rho L^3}{16\pi^2}$

(C) $\frac{5\rho L^3}{16\pi^2}$ (D) $\frac{3\rho L^3}{8\pi^2}$

55. Three particles are situated on a light and rigid rod along Yaxis as shown in the figure. If the system is rotating with an angular velocity of $2\,rad/\,\mathrm{sec}$about Xaxis, then the total kinetic energy of the system is ...... J



(A) 92 (B) 184

(C) 276 (D) 46

56. We have two spheres, one of which is hollow and the other solid. They have identical masses and moment of inertia about their respective diameters. The ratio of their radius is given by

(A) $5:7$ (B) $3:5$

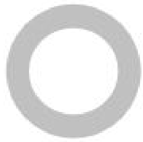
(C) $\sqrt{3}:\sqrt{5}$ (D) $\sqrt{3}:\sqrt{7}$

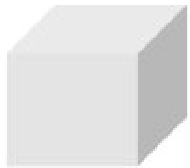
57. Two particles having mass $'M'$ and $'m'$ are moving in circular paths having radii R and r. If their time periods are same then the ratio of their angular velocities will

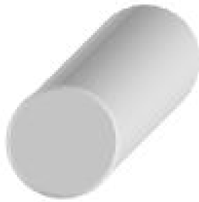
(A) $\frac{r}{R}$ (B) $\frac{R}{r}$

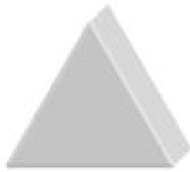
(C) 1 (D) $\sqrt{\frac{R}{r}}$

58. Four solids are shown in cross section. The sections have equal heights and equal maximum widths. They have the same mass. The one which has the largest rotational inertia about a perpendicular through the centre of mass is

(A) 

(B) 

(C) 

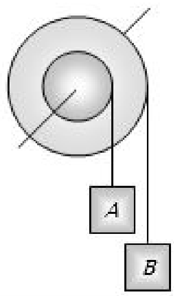
(D) 

59. A uniform cube of side a and mass m rests on a rough horizontal table. A horizontal force F is applied normal to one of the faces at a point that is directly above the centre of the face, at a height $\frac{3a}{4}$ above the base. The minimum value of F for which the cube begins to tilt about the edge is (assume that the cube does not slide)

(A) $\frac{mg}{4}$ (B) $\frac{2mg}{3}$

(C) $\frac{3mg}{4}$ (D) mg

60. Figure shows a small wheel fixed coaxially on a bigger one of double the radius. The system rotates about the common axis. The strings supporting A and B do not slip on the wheels. If x and y be the distances travelled by A and B in the same time interval, then



(A) $x=2y$ (B) $x=y$

(C) $y=2x$ (D) None of these

61. A body is in pure rotation. The linear speed v of a particle, the distance r of the particle from the axis and angular velocity ω of the body are related as $\omega\ = \frac{v}{r}$, thus

(A) $\omega\ \propto \frac{1}{r}$ (B) $\omega\ \propto r$

(C) $\omega\ = 0$ (D) ω is independent of r

62. Two point masses of $0.3\ kg$ and $0.7\ kg$ are fixed at the ends of a rod of length $1.4\ m$ and of negligible mass. The rod is set rotating about an axis perpendicular to its length with a uniform angular speed. The point on the rod through which the axis should pass in order that the work required for rotation of the rod is minimum is located at a distance of

(A) $0.4\ m$ from mass of $0.3\ kg$ (B) $0.98\ m$ from mass of $0.3\ kg$

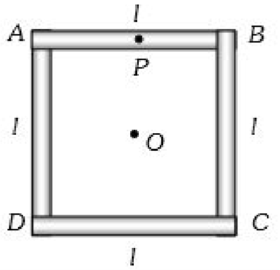
(C) $0.70\ m$ from mass of $0.7\ kg$ (D) $0.98\ m$ from mass of $0.7\ kg$

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

(A) $\frac{5}{2}I$ (B) $3\,I$

(C) $\frac{3}{2}I$ (D) $2\,I$

64. Four thin rods of same mass M and same length l, form a square as shown in figure. Moment of inertia of this system about an axis through centre O and perpendicular to its plane is



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

(C) $\frac{Ml^2}{6}$ (D) $\frac{2}{3}Ml^2$

65. A couple produces

(A) Purely linear motion (B) Purely rotational motion

(C) Linear and rotational motion (D) No motion

66. If solid sphere and solid cylinder of same radius and density rotate about their own axis, the moment of inertia will be greater for $(L = R)$

(A) Solid sphere (B) Solid cylinder

(C) Both (D) Equal both

67. A wheel completes 2000 rotations in covering a distance of $9.5\,km$. The diameter of the wheel is

(A) $1.5\,m$ (B) $1.5\,cm$

(C) $7.5\,m$ (D) $7.5\,cm$

68. The moment of inertia of semicircular ring about its centre is

(A) MR^2 (B) $\frac{MR^2}{2}$

(C) $\frac{MR^2}{4}$ (D) None of these

69. A uniform meter scale balances at the $40\,cm$ mark when weights of $10\,g$ and $20\,g$ are suspended from the $10\,cm$ and $20\,cm$ marks. The weight of the metre scale is ...... g

(A) 50 (B) 60

(C) 70 (D) 80

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

(A) Iron and aluminium layers in alternate order (B) Aluminium at interior and iron surrounding it

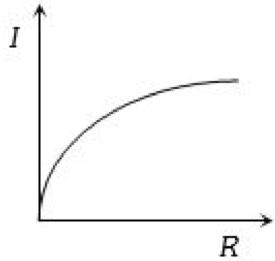
(C) Iron at interior and aluminium surrounding it (D) Either (a) or (c)

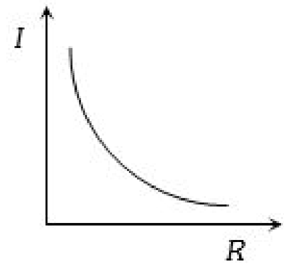
71. A circular disc X of radius R is made from an iron plate of thickness t, and another disc Y of radius $4R$ is made from an iron plate of thickness $\frac{t}{4}$. Then the relation between the moment of inertia I_x and I_y is

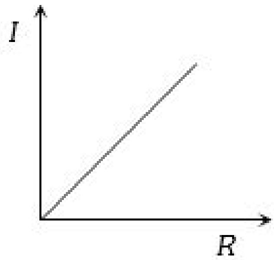
(A) $I_y = 64 I_x$ (B) $I_y = 32 I_x$

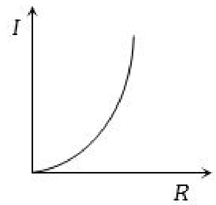
(C) $I_y = 16 I_x$ (D) $I_y = I_x$

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

(A)


(B)


(C)


(D)


73. A wheel is rotating at $900\ r.p.m.$ about its axis. When the power is cut-off, it comes to rest in $1\,minute$. The angular retardation in $radian/s^2$ is

(A) $\pi/2$ (B) $\pi/4$

(C) $\pi/6$ (D) $\pi/8$

74. What is the moment of inertia of a square sheet of side l and mass per unit area μ about an axis passing through the centre and perpendicular to its plane

(A) $\frac{\mu l^2}{12}$ (B) $\frac{\mu l^2}{6}$

(C) $\frac{\mu l^4}{12}$ (D) $\frac{\mu l^4}{6}$

75. Moment of inertia of a uniform circular disc about a diameter is I. Its moment of inertia about an axis perpendicular to its plane and passing through a point on its rim will be

(A) $5\ I$ (B) $6\ I$

(C) $3\ I$ (D) $4\ I$

ANSWER KEY

PHYSICS

1 - B	2 - D	3 - B	4 - C	5 - B	6 - D	7 - C	8 - A	9 - C	10 - A
11 - A	12 - C	13 - C	14 - B	15 - D	16 - A	17 - D	18 - B	19 - C	20 - A
21 - C	22 - A	23 - A	24 - C	25 - A	26 - B	27 - B	28 - D	29 - A	30 - D
31 - C	32 - D	33 - B	34 - B	35 - C	36 - C	37 - A	38 - C	39 - C	40 - B
41 - B	42 - B	43 - A	44 - D	45 - C	46 - C	47 - C	48 - B	49 - D	50 - B
51 - B	52 - D	53 - D	54 - D	55 - B	56 - C	57 - C	58 - A	59 - B	60 - C
61 - D	62 - B	63 - A	64 - A	65 - B	66 - A	67 - A	68 - A	69 - C	70 - B
71 - A	72 - D	73 - A	74 - D	75 - B					

SOLUTION

PHYSICS

1. A force of $(2\hat{i}-4\hat{j}+2\hat{k})\ N$ acts at a point $(3\hat{i}+2\hat{j}-4\hat{k})\ metre$ from the origin. The magnitude of torque is .... $N-m$

   (A) 0 (B) ✓24.4

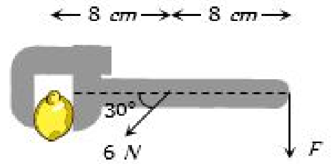
   (C) 0.244 (D) 2.444

   Sol : $\vec{F} = (2\hat{i}-4\hat{j}+2\hat{k})\,N$ and $\vec{r} = (3i+2-4\hat{k})\ meter$

   Torque $\vec{\tau} = \vec{r} \times \vec{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 2 & -4 \\ 2 & -4 & 2 \end{vmatrix}$

   $\Rightarrow \vec{\tau} = -12\hat{i} - 14\hat{j} - 16\hat{k}$ and $|\vec{\tau}| = \sqrt{(-12)^2+(-14)^2+(-16)^2} = 24.4\ N-m$

2. When a force of $6.0\,N$ is exerted at 30^o to a wrench at a distance of $8\,cm$ from the nut, it is just able to loosen the nut. What force F would be sufficient to loosen it, if it acts perpendicularly to the wrench at $16\ cm$ from the nut .... N



   (A) 3 (B) 6

   (C) 4 (D) ✓1.5

   Sol : A force 6N acting at angle of $30°$ is just able to loosen the wrench at a distance 8cm from it.

   therefore total torque acting at A about the point O.

   $\rightarrow F = \dfrac{8\times 3}{16} = 1.5N$

3. The moment of inertia of a rod (length l, mass m) about an axis perpendicular to the length of the rod and passing through a point equidistant from its mid point and one end is

   (A) $\dfrac{ml^2}{12}$ (B) ✓$\dfrac{7}{48}ml^2$

   (C) $\dfrac{13}{48}ml^2$ (D) $\dfrac{19}{48}ml^2$

   Sol : The moment of inertia of the given rod is

   $\Sigma M_i r_i^2$

   $=\int(dm)x^2$

   $=\int_{-L/4}^{3L/4}(\lambda dx)x^2$

   $=\int_{-L/4}^{3L/4}\lambda x^2 dx$

   $=\lambda\dfrac{7L^3}{48}$

   $=\dfrac{M}{L}\cdot\dfrac{7L^3}{48}$

   $=\dfrac{7}{48}ML^2$

4. The moment of inertia of a solid sphere of density ρ and radius R about its diameter is

   (A) $\dfrac{105}{176}R^5\rho$ (B) $\dfrac{105}{176}R^2\rho$

   (C) ✓$\dfrac{176}{105}R^5\rho$ (D) $\dfrac{176}{105}R^2\rho$

   Sol : Moment of inertia of sphere about it diameter

   $I=\dfrac{2}{5}MR^2 = \dfrac{2}{5}\left(\dfrac{4}{3}\pi R^3\rho\right)R^2$ [As $M = V\rho = \dfrac{4}{3}\pi R^3\rho)$]

   $I = \dfrac{8\pi}{15}R^5\rho = \dfrac{8\times 22}{15\times 7}R^5\rho = \dfrac{176}{105}R^5\rho$

5. 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, then

   (A) $I_1 : I_2 = 1:1$ (B) ✓ $I_1 : I_2 = \pi^2 : 3$

   (C) $I_1 : I_2 = \pi : 4$ (D) $I_1 : I_2 = 3:5$

   Sol : $I_1 = \dfrac{Ml^2}{12}$

   $\Rightarrow I_2 = MR^2$

   $\Rightarrow l = 2\pi R$

   $\Rightarrow R = \dfrac{l}{2\pi}$

   $\Rightarrow I = \dfrac{Ml^2}{4\pi^2}$

   $\Rightarrow \dfrac{I_1}{I_2} = \dfrac{Ml^2}{12}\times\dfrac{4\pi^2}{Ml^2} = \dfrac{\pi^2}{3}$

   $\Rightarrow I_1 : I_2 = \pi^2 : 3$

   Hence, the answer is $I_1 : I_2 = \pi^2 : 3$

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

   (A) 8 (B) 6

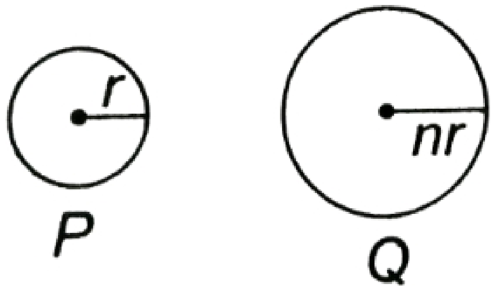
   (C) 4 (D) ✓2

   Sol : Mass $\propto$ length

   $m_p = m, m_Q = nm$

   $\dfrac{I_Q}{I_P} = \dfrac{(nm)(nr)^2}{mr^2} = 8$

   $n^3 = 8 \Rightarrow n = 2$



7. The moment of inertia I of a solid sphere having fixed volume depends upon its volume V as

   (A) $I \propto V$ (B) $I \propto V^{2/3}$

   (C) ✓$I \propto V^{5/3}$ (D) $I \propto V^{3/2}$

   Sol : Volume of solid sphere, $V = \dfrac{4}{3}\pi R^3$

   Radius of Sphere $= R$

   $V\alpha R^3$

   $v\dfrac{1}{3}\alpha R$

   Mass of sphere is, $M =$ density $\times$ Volume $= \rho V$

   Moment of inertia of sphere about its axis, $I = \dfrac{2}{3}MR^2 = \dfrac{2}{3}(\rho V)R^2$

   $I\alpha VR^2$

   $I\alpha V\left(V\dfrac{1}{3}\right)^2$

   $I\alpha V\dfrac{5}{3}$

   Moment of inertia, $I\alpha V\dfrac{5}{3}$

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

(A) ✓l (B) $l\sin^2\theta$

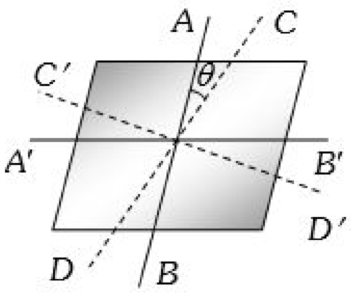
(C) $l\cos^2\theta$ (D) $l\cos^2\dfrac{\theta}{2}$

Sol : Let I_Z is the moment of inertia of square plate about the axis which is passing through the centre and perpendicular to the plane.

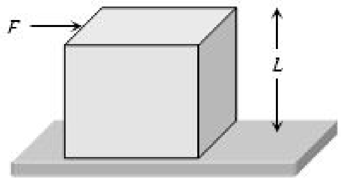
$I_Z = I_{AB} + I_{A'B'} = I_{CD} + I_{C'D'}$ [By the theorem of perpendicular axis]

$I_Z = 2I_{AB} = 2I_{A'B'} = 2I_{CD} = 2I_{C'D'}$ [As AB, $A'B'$ and CD, C' D' are symmetric axis]

Hence $I_{CD} = I_{AB} = l$



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



(A) $Infinitesimal$ (B) $mg/4$

(C) ✓$mg/2$ (D) $mg(1-\mu)$

Sol : At the critical condition, normal reaction N will pass through point P. In this

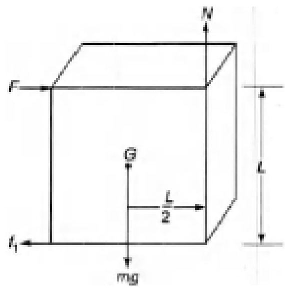
condition $\tau_N = 0 = \tau_{fr}$ (about P) the block will topple when $\tau_F > \tau_{mg}$ or

$FL > (mg)\dfrac{L}{2}$

$\therefore F > \dfrac{mg}{2}$

Therefore, the minimum force required to topple the block is

$F = \dfrac{mg}{2}$



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

(A) ✓$\vec{r}.\vec{T} = 0$ and $\vec{F}.\vec{T} = 0$ (B) $\vec{r}.\vec{T} = 0$ and $\vec{F}.\vec{T} \neq 0$

(C) $\vec{r}.\vec{T} \neq 0$ and $\vec{F}.\vec{T} = 0$ (D) $\vec{r}.\vec{T} \neq 0$ and $\vec{F}.\vec{T} \neq 0$

Sol : Torque is an axial vector i.e., its direction is always perpendicular to the plane containing vectors $\vec{r}$ and $\vec{F}$

$\vec{T} = \vec{r} \times \vec{F}$

Torque is perpendicular to both $\vec{r}$ and

$\therefore \vec{r}\cdot\vec{T} = 0$ and $\vec{F}\cdot\vec{T} = 0$

11. Two discs of the same material and thickness have radii $0.2\ m$ and $0.6\ m$. Their moments of inertia about their axes will be in the ratio

(A) ✓$1:\ 81$ (B) $1:27$

(C) $1:\ 9$ (D) $1:\ 3$

Sol : The moment of inertia of a disc about its central axis is

$I = \dfrac{1}{2}mR^2$

$\therefore \dfrac{I_1}{I_2} = \dfrac{\frac{1}{2}m_1R_1^2}{\frac{1}{2}m_2R_2^2}$

$= \dfrac{\pi R_1^2 tP \times R_1^2}{\pi R_2^2 tp \times R_2^2}$

$\therefore \quad \dfrac{I_1}{I_2} = \dfrac{R_1^4}{R_2^4}$

$= \dfrac{(0.4)^4}{(0.6)^4} = \left(\dfrac{0.1}{0.3}\right)^4 = \dfrac{1}{81}$

12. The planes of two rigid discs are perpendicular to each other. They are rotating about their axes. If their angular velocities are $3\,rad/sec$ and $4\,rad/sec$ respectively, then the resultant angular velocity of the system would be .... rad/sec

(A) 1 (B) 7

(C) ✓5 (D) $\sqrt{12}$

13. Let $\vec{A}$ be a unit vector along the axis of rotation of a purely rotating body and $\vec{B}$ be a unit vector along the velocity of a particle P of the body away from the axis. The value of $\vec{A}\,.\,\vec{B}$ is

(A) 1 (B) -1

(C) ✓0 (D) None of these

Sol : The directions of A and B will be perpendicular to each other.

Hence $A.B = |A|\cdot|B|\cdot\cos 90^\circ = 0$

14. A particle B is moving in a circle of radius a with a uniform speed u. C is the centre of the circle and AB is diameter. The angular velocity of B about A and C are in the ratio

(A) $1:1$ (B) ✓$1:2$

(C) $2:1$ (D) $4:1$

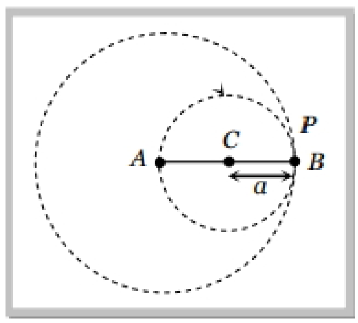
Sol : Angular velocity of P about A

$\omega_A = \dfrac{V}{2a}$

Angular velocity of P about C

$\omega_C = \dfrac{v}{a}$

$\therefore \dfrac{\omega_A}{\omega_C} = 1:2$



15. The wheel of a car is rotating at the rate of 1200 revolutions per minute. On pressing the accelerator for $10\ sec$ it starts rotating at 4500 revolutions per minute. The angular acceleration of the wheel is

(A) $30\ radians/sec^2$ (B) $180\ degrees/sec^2$

(C) $40\ radians/sec^2$ (D) ✓$1980\ degrees/sec^2$

Sol : Angular acceleration (a) = rate of change of angular speed

$= \frac{2\pi(n_2 - n_1)}{t} = \frac{2\pi\left(\frac{4500-1200}{60}\right)}{10} rad/sec^2$

$= \frac{2\pi\frac{3300}{60}}{10} \times \frac{360}{2\pi}\frac{degree}{sec^2} = 1980\ degree/sec^2$.

16. A strap is passing over a wheel of radius $30\,cm$. During the time the wheel moving with initial constant velocity of $2\,rev/sec.$ comes to rest the strap covers a distance of $25\,m$. The deceleration of the wheel in rad/s^2 is

(A) ✓0.94 (B) 1.2

(C) 2.0 (D) 2.5

Sol : $r =$ radius of the wheel $= 30\mathrm{cm} = 0.30\mathrm{m}$

$\mathrm{C}\ =$ circumference of the wheel $=$ distance traveled by wheel in one revolution $= 2\pi r$

$\mathrm{D} =$ total distance traveled by strap $= 25\mathrm{m}$

$\mathrm{N} =$ total number of revolutions by wheel

total number of revolutions by wheel is given as

$\mathrm{N} = \mathrm{D/C} = 25/(2\mathrm{Mr})$

$\theta =$ angular displacement $= 25/(2\pi r) = (25/(2\pi r))(2\pi)$ rad $= 25/\mathrm{r} = 25/0.30 = 83.33\mathrm{rad}$

$\mathrm{w_o}\ =$ initial angular velocity of wheel $=\ 2$ rev/s $=\ 2(2\pi)$ rad/s $= 12.56$ rad/s

$\mathrm{w} =$ final angular velocity after wheel stops $= 0$ rad/s

$\mathrm{a} =$ angular acceleration

Using the equation

$w^2 = w^2 o + 2a\theta$

$0^2 = 12.56^2 + 2\mathrm{a}(83.33)$

$\alpha = -0.94\mathrm{rad/s^2}$

17. For a system to be in equilibrium, the torques acting on it must balance. This is true only if the torques are taken about

(A) The centre of the system (B) The centre of mass of the system

(C) Any point on the system (D) ✓Any point on the system or outside it

18. Two loops P and Q are made from a uniform wire. The radii of P and Q are r_1 and r_2 respectively, and their moments of inertia are I_1 and I_2 respectively. If $\frac{l_2}{l_1} = 4$ then $\frac{r_2}{r_1}$ equals

(A) $4^{2/3}$ (B) ✓$4^{1/3}$

(C) $4^{-2/3}$ (D) $4^{-1/3}$

Sol : $\frac{I_1}{I_2} = \frac{1}{4} \because \frac{I_1}{I_2} = \frac{M_1R_1^2}{M_2R_2^2}$

$\frac{g(2\pi r_1)r_1^2}{g\,(2\pi r_2)\,(r_2^2)} = \frac{1}{4}$

$\frac{r_1^3}{r_2^3} = \frac{1}{4}$

$\left(\frac{r_2}{r_1}\right)^3 = 4$

$\frac{r_2}{r_1} = 4^{1/3}$

19. Two men are carrying a uniform bar of length L, on their shoulders. The bar is held horizontally such that younger man gets $(1/4)^{th}$ load. Suppose the younger man is at the end of the bar, what is the distance of the other man from the end

(A) $L/3$ (B) $L/2$

(C) ✓$2L/3$ (D) $3L/4$

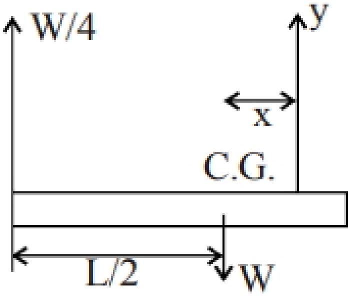
Sol : For the balance of forces, $y + w/4\ =\ w$, therefore $y = 3w/4$

Further for a balance of torque about CG we get,

$\mathrm{W/4 \times L/2 = 3W/4 \times x}$ therefore $\mathrm{x = 1/6}$

Thus distance from the left end of the rod

$= \mathrm{L/2 + L/6 = 4L/6 = 2L/3}$



20. Three point masses m_1, m_2, m_3 are located at the vertices of an equilateral triangle of length $'a'$. The moment of inertia of the system about an axis along the altitude of the triangle passing through m_1 is

(A) ✓$(m_2 + m_3)\frac{a^2}{4}$ (B) $(m_1 + m_2 + m_3)a^2$

(C) $(m_1 + m_2)\frac{a^2}{2}$ (D) $(m_2 + m_3)a^2$

Sol : moment of inertia is the product of mass and square of separation between particle and axis of rotation.

e.g. $M.I = mr^2$

here, we see, separation of mass $\mathrm{m1}$ and altitude $NN'is0.$

alteration between mass m_2 and NN' is $\left(\frac{a}{2}\right)$ also for m_3 separation is $\left(\frac{a}{2}\right)$

moment of inertia about altitude passing through $m_1\ = I_1 + I_2 + I_3$

where I_1, I_2, and I_3 are $M.I of m_1, m_2$ and m_3 respectively.

$M.I = m_1 \cdot (0) + m_2\left(\frac{a}{2}\right)^2 + m_3\left(\frac{a}{2}\right)^2$

$= \frac{a^2}{4 \times (m_2 + m_3)}$

21. The angular speed of a fly-wheel making $120\,revolution/minute$ is

(A) $\pi\,rad/sec$ (B) $2\,\pi\,rad/sec$

(C) ✓$4\,\pi\ \ rad/sec$ (D) $4\,\pi^2\,rad/sec$

Sol : $120rev\ /\min = 120 \times 2\pi/60\mathrm{rad/sec} = 4\pi\mathrm{rad/sec}$

22. If the position vector of a particle is $\vec{r}\ \ = (3\hat{i} + 4\hat{j})\ meter$ and its angular velocity is $\vec{\omega}\ \ = (\hat{j} + 2\hat{k})\ rad/sec$ then its linear velocity is (in m/s)

(A) ✓$(8\hat{i} - 6\hat{j} + 3\hat{k})$ (B) $(3\hat{i} + 6\hat{j} + 8\hat{k})$

(C) $-(3\hat{i} + 6\hat{j} + 6\hat{k})$ (D) $(6\hat{i} + 8\hat{j} + 3\hat{k})$

Sol : $\vec{v}\ = \vec{\omega}\ \times \vec{r}$

$(3\hat{i} + 4\hat{j} + 0\hat{k}) \times (0\hat{i} + \hat{j} + 2\hat{k})\ \vec{v}\ = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 4 & 0 \\ 0 & 1 & 2 \end{vmatrix} = 8\hat{i} - 6\hat{j} + 3\hat{k}$

23. A flywheel gains a speed of $540\ r.p.m.$ in $6\ sec.$ Its angular acceleration will be

(A) ✓$3\,\pi\,rad/sec^2$ (B) $9\,\pi\,rad/sec^2$

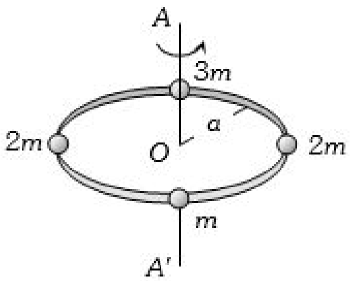
(C) $18\,\pi\,rad/sec^2$ (D) $54\,\pi\,rad/sec^2$

Sol : $\mathrm{n} = \frac{540}{60} = 9\mathrm{r.p.s.}, \omega = 2\pi\mathrm{n} = 18\pi\mathrm{rad/s}$

Angular acceleration

$= \frac{\text{Gain in angular velocity}}{\text{time}} = \frac{18\pi}{6} = 3\pi\mathrm{rads^{-2}}$

24. Four masses are joined to a light circular frame as shown in the figure. The radius of gyration of this system about an axis passing through the centre of the circular frame and perpendicular to its plane would be



(A) $a/\sqrt{2}$ (B) $a/2$
(C) ✓a (D) $2a$

Sol : Since the circular frame is massless so we will consider moment of inertia of four masses only.

$I = ma^2 + 2ma^2 + 3ma^2 + 2ma^2 = 8ma^2$ ...(i)

Now from the definition of radius of gyration $I = 8mk^2$ .....(ii) comparing (i) and (ii) radius of gyration $k = a$.

25. On account of melting of ice at the north pole the moment of inertia of spinning earth
(A) ✓Increases (B) Decreases
(C) Remains unchanged (D) Depends on the time

26. Two discs of same thickness but of different radii are made of two different materials such that their masses are same. The densities of the materials are in the ratio $1:3$. The moments of inertia of these discs about the respective axes passing through their centres and perpendicular to their planes will be in the ratio
(A) $1:3$ (B) ✓$3:1$
(C) $1:9$ (D) $9:1$

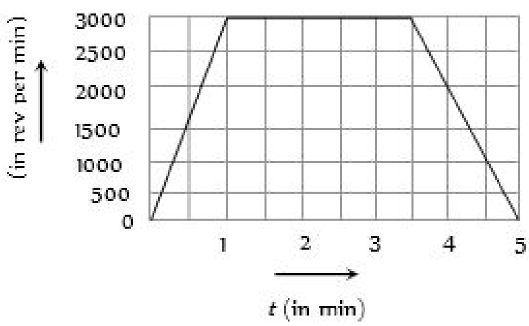
Sol : Given : thickness $= t_1 = t_2$
masses $= \mathrm{m}_1 = \mathrm{m}_2$
density $(\rho_1/\rho_2) = (1/3)$
$\mathrm{I} = \mathrm{MI}$ of disc $= \left[\left(\mathrm{MR}^2\right)/2\right]$
also $\rho = [($ mass $)/$ (volume) $]$
$= [($ mass $)/($ area $\times$ thickness) $]$
$= \left[\mathrm{m}/\left(\pi \mathrm{R}^2 \mathrm{t}\right)\right]$
$\mathrm{R}^2 = [\mathrm{m}/(\pi \mathrm{t}\rho)]$
from (1)
$\mathrm{I} = (\mathrm{M}/2)\mathrm{R}^2$
$= (M/2) \cdot [M/(\pi t\rho)]$
$= \left[M^2/(2\pi T\rho)\right]$
given: thickness $\&$ masses same.
hence $\mathrm{I} \propto (1/p)$
$(l_1/l_2) = (\rho_2/\rho_1)$ as $t_1 = t_2 m_1 = m_2$
$(l_1/l_2) = (3/1)$

27. The angular velocity of seconds hand of a watch will be
(A) $\frac{\pi}{60}\,rad/\sec$ (B) ✓$\frac{\pi}{30}\,rad/sec$
(C) $60\pi\ rad/sec$ (D) $30\pi\ rad/sec$

Sol : We know that second's hand completes its revolution $(2p)$ in $60\ sec$

$$\omega = \frac{\theta}{t} = \frac{2\pi}{60} = \frac{\pi}{30} rad/sec$$

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



(A) 9000 (B) 16570
(C) 12750 (D) ✓11250

Sol : Number of revolution = Area between the graph and time axis = Area of trapezium

$= \frac{1}{2} \times (2.5 + 5) \times 3000 = 11250$ revolution.

29. A car is moving at a speed of $72\,km/hr.$ the diameter of its wheels is $0.5\,m.$ If the wheels are stopped in 20 rotations by applying brakes, then angular retardation produced by the brakes is
(A) ✓$-25.5\,\pi\,rad/sec^2$ (B) $-29.5\,\pi\,rad/sec^2$
(C) $-33.5\pi\,rad/sec^2$ (D) $-45.5\,\pi\,rad/sec^2$

Sol : Here, $u = 72km/h = \frac{72 \times 1000}{60 \times 60} m/s = 20m/s$

$r = 0.5/2m = 0.25m$

$\omega_2 = 0, \theta = 20 \times 2\pi radian, \alpha = ?$

$\omega_1 = \frac{u}{r_e} = \frac{20}{0.25} = 80\mathrm{rad/s}$

From $\omega_2^2 - \omega_1^2 = 2\alpha\theta$

$0 - (80)^2 = 2\alpha(20 \times 2\pi)$

$\alpha = -\frac{80 \times 80}{80\pi} = -25.5\mathrm{rad/s^2}$

30. A wheel of mass $10\,kg$ has a moment of inertia of $160\ kg - m^2$ about its own axis, the radius of gyration will be .... m
(A) 10 (B) 8
(C) 6 (D) ✓4

Sol : mass $= 10\mathrm{kg}$
$Ml = 160\mathrm{kg.m^2}$ about axis
radius of gyration $=?$
$\mathrm{I} = \mathrm{MK}^2$
K is radius of gyration
$\mathrm{K}^2 = [(160)/(10)] = 16$
$\mathrm{K} = 4\mathrm{m}$

31. What is the torque of the force $\vec{F} = (2\hat{i} - 3\hat{j} + 4\hat{k})N$ acting at the pt. $\vec{r} = (3\hat{i} + 2\hat{j} + 3\hat{k})\,m$ about the origin
(A) $-17\hat{i} + 6\hat{j} + 13\hat{k}$ (B) $-6\hat{i} + 6\hat{j} - 12\hat{k}$
(C) ✓$17\hat{i} - 6\hat{j} - 13\hat{k}$ (D) $6\hat{i} - 6\hat{j} + 12\hat{k}$

Sol : Torque of a Force $\vec{F}$ acting on a point with position vector $\vec{r}$ is given by:

$\vec{\tau} = \vec{r} \times \vec{F}$

To, we can find Torque by finding the cross product of $\vec{r}$ and $\vec{F}$

We have:

$\vec{r} = 3\hat{\imath} + 2\hat{\jmath} + 3\hat{k}m$

$\vec{F} = 2\hat{\imath} - 3\hat{\jmath} + 4\hat{k}N$

So, torque will be:

$$\vec{\tau} = \begin{vmatrix} \hat{\imath} & \hat{\jmath} & \hat{k} \\ 3 & 2 & 3 \\ 2 & -3 & 4 \end{vmatrix}$$

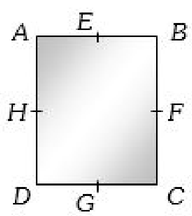
$\Longrightarrow \vec{\tau} = \hat{\imath}((2)(4) - (-3)(3)) - \hat{\jmath}((3)(4) - (2)(3)) + \hat{k}((3)(-3) - (2)(2))$

$\Longrightarrow \vec{\tau} = \hat{\imath}(8 + 9) - \hat{\jmath}(12 - 6) + \hat{k}(-9 - 4)$

$\Longrightarrow [\vec{\tau} = 17\hat{\imath} - 6\hat{\jmath} - 13\hat{k}, Nm]$

This is the torque of the force acting about Origin.

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



(A) BC (B) BD
(C) HF (D) ✓EG

Sol : The moment of inertia will be minimum about that axis, which is passing through the center of mass.

$$I_{EG}=\frac{MB^2}{12}$$

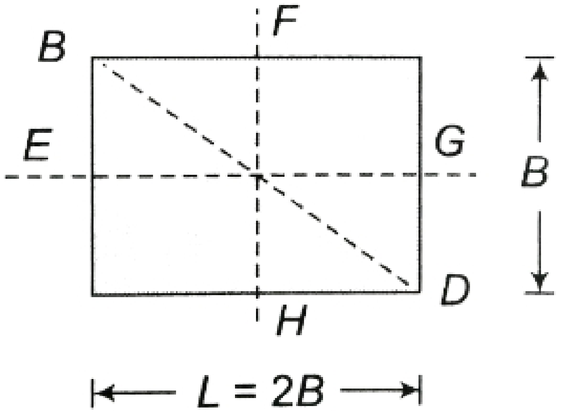
$$I_{FH}=\frac{M(2B)^2}{12}=\frac{MB^2}{6}$$

$M.I.$ of the rectangular plate about its diagonal $I_{BD}=\frac{MB^2L^2}{6\left(B^2+L^2\right)}=\frac{MB^2\times 4B^2}{6\left(B^2+4B^2\right)}=\frac{2}{15}MB^2=\frac{MB^2}{7.5}$

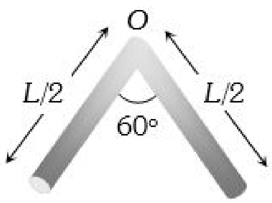
$M.I.$ about EG is minimum.

OR

By observation, distribution of mass is the nearest about axis EG.



33. A thin rod of length L and mass M is bent at the middle point O at an angle of 60^o as shown in figure. The moment of inertia of the rod about an axis passing through O and perpendicular to the plane of the rod will be



(A) $\frac{ML^2}{6}$ (B) ✓ $\frac{ML^2}{12}$

(C) $\frac{ML^2}{24}$ (D) $\frac{ML^2}{3}$

Sol : since rod is bent at the middle, so each part of it will have the same length $\left(\frac{L}{2}\right)$ and mass $\left(\frac{M}{2}\right)$ as shown

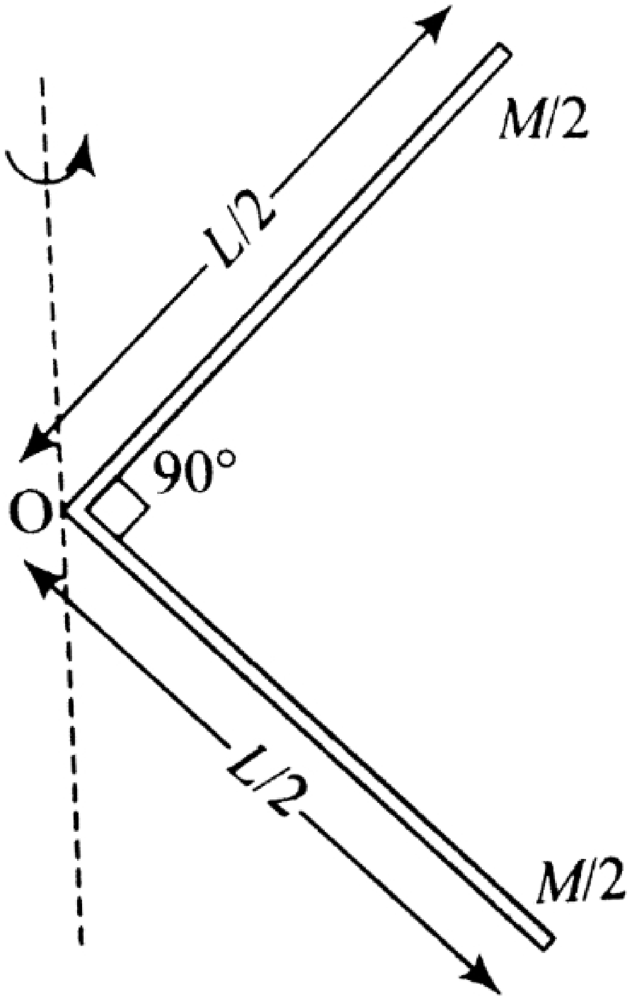
Moment of inertia of each part through its one end

$$=\frac{1}{3}\left(\frac{M}{2}\right)\left(\frac{L}{2}\right)^2$$

Hence, net moment of inertia of complete structure through its middle point O is.

$$I=\frac{1}{3}\left(\frac{M}{2}\right)\left(\frac{L}{2}\right)^2+\frac{1}{3}\left(\frac{M}{2}\right)\left(\frac{L}{2}\right)^2$$

$$=\frac{1}{3}\left[\frac{ML^2}{8}+\frac{ML^2}{8}\right]=\frac{ML^2}{12}$$



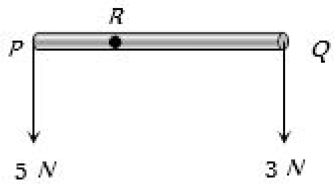
34. Five particles of mass = $2\,kg$ are attached to the rim of a circular disc of radius $0.1\,m$ and negligible mass. Moment of inertia of the system about the axis passing through the centre of the disc and perpendicular to its plane is .... $kg\,m^2$

(A) 1 (B) ✓ 0.1

(C) 2 (D) 0.2

Sol : We will not consider the moment of inertia of disc because it doesn't have any mass so moment of inertia of five particle system $I=5\,mr^2=5\times 2\times(0.1)^2=0.1\,kg{-}m^2$.

35. The resultant of the system in the figure is a force of $8N$ parallel to the given force through R. The value of PR equals to



(A) $1/4\ RQ$ (B) $3/8\ RQ$

(C) ✓$3/5\ RQ$ (D) $2/5\ RQ$

Sol : By taking moment of forces about point R, $5\times PR-3\times RQ=0$

$\Rightarrow PR=\frac{3}{5}RQ.$

36. Weights of $1\,g, 2\,g ....., 100\,g$ are suspended from the $1\,cm, 2\,cm, ...100\ cm,\ marks$ respectively of a light metre scale. Where should it be supported for the system to be in equilibrium ...... cm mark.

(A) 55 (B) 60

(C) ✓66 (D) 72

Sol : $\because$ Weights are $1g, 2g, 3g, \ldots \ldots .100g$

$\because$ Weights are suspended at a distance $=$ $1cm, 2cm, 3cm, \ldots \ldots ..100cm$

respectively to the masses.

For the system to be in equilibrium the point must lie in the center of mass.

So center of mass of the system can be calculated as

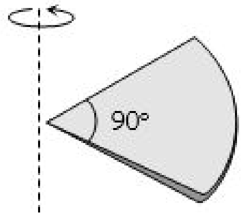
$$\text{COM} = \frac{(1^2+2^2+3^2\ldots 100^2)}{(1+2+3\ldots+100)}$$

$$COM = \left[\frac{\frac{(100)(101)(201)}{6}}{\frac{(100)(101)}{2}}\right]$$

$$\text{COM} = \frac{201}{3} = 67\text{cm}$$

Hence at 67cm from the origin or 66cm from the first particle, at that point system will be supported to get equilibrium.

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



(A) $\checkmark \frac{1}{2}MR^2$ (B) $\frac{1}{4}MR^2$

(C) $\frac{1}{8}MR^2$ (D) $\sqrt{2}\,MR^2$

Sol : For complete disc with mass $'4M'$, $M.I.$ about given axis $= (4M)\left(R^2/2\right) = 2MR^2$

Hence, by symmetry, for the given quarter of the disc

$$M.I. = 2\text{MR}^2/4 = \frac{1}{2}\text{MR}^2$$

38. When a ceiling fan is switched on, it makes $10\,rotations$ in the first 3 sec. How many rotations will it make in the next 3 sec (Assume uniform angular acceleration)

(A) 10 (B) 20

(C) $\checkmark 30$ (D) 40

Sol : In first three seconds, angle rotated $\theta = 2\pi \times 10\text{rad}$

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

$$\therefore 2\pi \times 10 = 0 + \frac{1}{2}\alpha \times 3^2 = \frac{9}{2}\alpha \ldots (i)$$

For the rotation of fan in next three second, the total time of revolutions

$=3+3=6s$

Let total number of revolutions $= N$

Then angle of revolutions, $\theta' = 2\pi$N rad

$$\therefore 2\pi N = 0 + \frac{1}{2}\alpha \times 6^2 = 18\alpha \quad ...(ii)$$

Dividing (ii) by (i), we get

$N = 40$

No. of revolutions in last three seconds

$= 40 - 10 = 30$ revolutions

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

(A) I (B) $\frac{2I}{8}$

(C) $\checkmark \frac{I}{5}$ (D) $\frac{I}{10}$

Sol : given radius of the disc $= R$

thickness of the disc $= \frac{R}{6}$

volume of the disc $V_1 = \pi R^2 t = \pi R^2 \frac{R}{6} = \pi \frac{R^3}{6}$

let the radius of the sphere be R'

volume of the sphere $V_2 = \frac{4}{3}\pi R^3$

since volume remains same

$$\pi\frac{R^3}{6} = \frac{4}{3}\pi R^3 \implies R^3 = 8\left(R'\right)^3 \implies R = 2R'$$

let I_1 be the $M.O.l$ of disc $= \frac{MR^2}{2}$

let I_2 be $M.O.l$ of the sphere $= \frac{2}{5}M\left(R'\right)^2 = \frac{2}{5}M\left(\frac{R}{2}\right)^2$

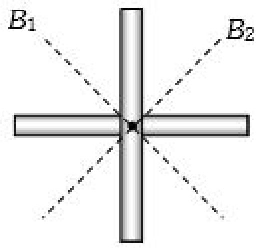
$$I_2 = I_1\left(\frac{1}{5}\right)$$

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

(A) 0.074 (B) $\checkmark 0.104$

(C) 0.148 (D) 0.208

41. Two identical rods each of mass M. and length l are joined in crossed position as shown in figure. The moment of inertia of this system about a bisector would be



(A) $\frac{Ml^2}{6}$ (B) $\checkmark \frac{Ml^2}{12}$

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

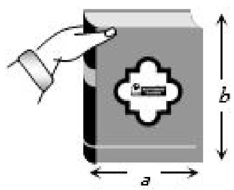
Sol : Moment of inertia of system about an axes which is perpendicular to plane of rods and passing through the common centre of rods

$$I_z = \frac{Ml^2}{12} + \frac{Ml^2}{12} = \frac{Ml^2}{6}$$

Again from perpendicular axes theorem $I_z = I_{B_1} + I_{B_2} =$ $2I_{B_1} = 2I_{B_2} = \frac{Ml^2}{6}$ [As $I_{B_1} = I_{B_2}$]

$$I_{B_1} = I_{B_2} = \frac{Ml^2}{12}.$$

42. A person supports a book between his finger and thumb as shown (the point of grip is assumed to be at the corner of the book). If the book has a weight of W then the person is producing a torque on the book of

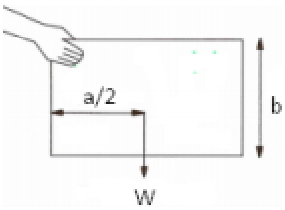


(A) $W\frac{a}{2}$ anticlockwise (B) $\checkmark W\frac{b}{2}$ anticlockwise

(C) Wa anticlockwise (D) Wa clockwise

Sol : Moment = force × perpendicular distance

Moment $= w \times \frac{a}{2}$



43. Three rods each of length L and mass M are placed along X, Y and Z - axes in such a way that one end of each of the rod is at the origin. The moment of inertia of this system about Z axis is

(A) ✓$\frac{2ML^2}{3}$ (B) $\frac{4ML^2}{3}$

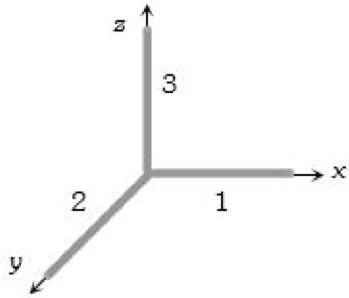
(C) $\frac{5ML^2}{3}$ (D) $\frac{ML^2}{3}$

Sol : Moment of inertia of the system about z - axis can be find out by calculating the moment of inertia of individual rod about z - axis

$I_1 = I_2 = \frac{ML^2}{3}$ because z - axis is the edge of rod 1 and 2

and $I_3 = 0$ because rod in lying on z - axis

$\therefore I_{\text{system}} = I_1 + I_2 + I_3 = \frac{ML^2}{3} + \frac{ML^2}{3} + 0 = \frac{2ML^2}{3}$.



44. Three identical thin rods each of length l and mass M are joined together to form a letter H. What is the moment of inertia of the system about one of the sides of H

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

(C) $\frac{2Ml^2}{3}$ (D) ✓$\frac{4Ml^2}{3}$

Sol : The three rods form H, So let $H = I_1(AB) + I_2(EF) + I_3(CD)$

Here we will find about left vertical axis i.e. I_1 AB

Moment of inertia of rod AB about the axis is 0

Moment of inertia of rod CD(parallel axis theorem) about the axis is ML^2

Moment of inertia of rod EF (perpendicualr axis theorem) about the axis is $\frac{1}{3}ML^2$

So, Moment of inertia of the rod about the axis is

$= 0 + ML^2 + \frac{1}{3}ML^2$

$= \frac{4}{3}ML^2$

45. A wheel initially at rest, is rotated with a uniform angular acceleration. The wheel rotates through an angle θ_1 in first one second and through an additional angle θ_2 in the next one second. The ratio $\frac{\theta_2}{\theta_1}$ is

(A) 4 (B) 2

(C) ✓3 (D) 1

Sol : Angular displacement in first one second $\theta_1 = \frac{1}{2}\alpha(1)^2 = \frac{\alpha}{2}$ ......(i) [From $\theta = \omega_1 t + \frac{1}{2}\alpha t^2$]

Now again we will consider motion from the rest and angular displacement in total two seconds

$\theta_1 + \theta_2 = \frac{1}{2}\alpha(2)^2 = 2\alpha$ ......(ii)

Solving (i) and (ii), we get $\theta_1 = \frac{\alpha}{2}$ and $\theta_2 = \frac{3\alpha}{2}$ $\therefore \frac{\theta_2}{\theta_1} = 3$.

46. A circular disc A of radius r is made from an iron plate of thickness t and another circular disc B of radius $4r$ is made from an iron plate of thickness $t/4$. The relation between the moments of inertia I_A and I_B is

(A) $I_A > I_B$ (B) $I_A = I_B$

(C) ✓$I_A < I_B$ (D) Depends on the actual values of t and r

Sol : Moment Of Inertia $= I = \frac{MR^2}{2}$

Mass = Density×Volume

Let d be the density of both the iron plate

Using the above equations,

$I_A = (d) \times \Pi r^2 t \frac{r^2}{2} = \frac{\Pi d t r^4}{2}$

$I_B = d \times \Pi(4r)^2 \frac{t}{4}\frac{(4r)^2}{2} = 64 I_A$

Therefore, $I_A < I_B$

47. In rotational motion of a rigid body, all particle move with

(A) Same linear and angular velocity

(B) Same linear and different angular velocity

(C) ✓With different linear velocities and same angular velocities

(D) With different linear velocities and different angular velocities

48. A rigid body is rotating with variable angular velocity $(a - bt)$ at any instant of time t. The total angle subtended by it before coming to rest will be (a and b are constants)

(A) $\frac{(a-b)a}{2}$ (B) ✓$\frac{a^2}{2b}$

(C) $\frac{a^2 - b^2}{2b}$ (D) $\frac{a^2 - b^2}{2a}$

Sol : $w = a - bt = 0$

$t = a/b$

$\theta = \int \omega dt = \int_0^1 (a - bt)dt$

$= \left(at - \frac{bt^2}{2}\right)_0^{a/b}$

$= a \cdot \frac{a}{b} - \frac{6}{2}\frac{a^2}{b^2}$

$= a^2/2b$

49. A horizontal heavy uniform bar of weight W is supported at its ends by two men. At the instant, one of the men lets go off his end of the rod, the other feels the force on his hand changed to

(A) W (B) $\frac{W}{2}$

(C) $\frac{3W}{4}$ (D) ✓$\frac{W}{4}$

Sol : Let the mass of the rod is M

Weight (W) = Mg

Initially for the equilibrium $F + F = Mg$

$F = Mg/2$

When one man withdraws, the torque on the rod

$\tau = I\alpha = Mg\frac{l}{2}$

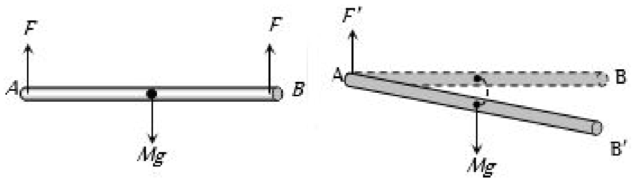
$\frac{Ml^2}{3}\alpha = Mg\frac{l}{2}$ [As $I = Ml^2/3$]

Angular acceleration $\alpha = \frac{3}{2}\frac{g}{l}$ and linear acceleration

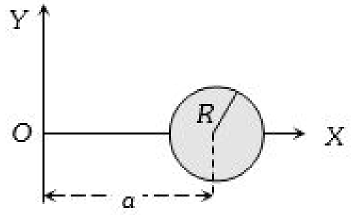
$a = \frac{l}{2}\alpha = \frac{3g}{4}$

Now if the new normal force at A is F' then $Mg - F' = Ma$

$F' = Mg - Ma = Mg - \frac{3Mg}{4} = \frac{Mg}{4} = \frac{W}{4}$.



50. The adjoining figure shows a disc of mass M and radius R lying in the $X-Y$ plane with its centre on $X-$ axis at a distance a from the origin. Then the moment of inertia of the disc about the $X-$ axis is



(A) $M\left(\frac{R^2}{2}\right)$ (B) ✓ $M\left(\frac{R^2}{4}\right)$

(C) $M\left(\frac{R^2}{4}+a^2\right)$ (D) $M\left(\frac{R^2}{2}+a^2\right)$

51. The moment of inertia of HCl molecule about an axis passing through its centre of mass and perpendicular to the line joining the H^+ and Cl^- ions will be, if the interatomic distance is 1

(A) $0.61\times10^{-47}\,kg.m^2$ (B) ✓$1.61\times10^{-47}\,kg.m^2$

(C) $0.061\times10^{-47}\,kg.m^2$ (D) 0

Sol : If r_1 and r_2 are the respective distances of particles m_1 and m_2 from the centre of mass then

$m_1r_1=m_2r_2\Rightarrow 1\times x=35.5\times(L-x)$

$x=35.5\,(1-x)$

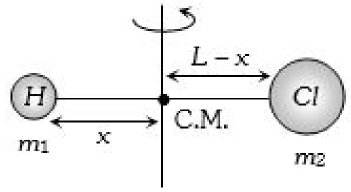
$x=0.973$ and $L-x=0.027$

Moment of inertia of the system about centre of mass

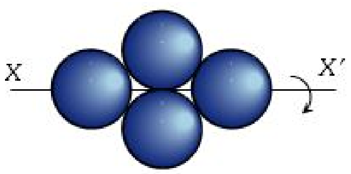
$I=m_1x^2+m_2(L-x)^2$

Substituting $1\ a.m.u.$ = $1.67\times\ 10^{-27}\ kg$ and 1 = $10^{-10}\ m$

$=1.62\times10^{-47}kg\,m^2$



52. The moment of inertia of a sphere (mass M and radius R) about it's diameter is I. Four such spheres are arranged as shown in the figure. The moment of inertia of the system about axis XX' will be



(A) $3\,I$ (B) $5\,I$

(C) $7\,I$ (D) ✓$9\,I$

Sol : Given, Moment of inertia (MOI) of sphere about its diameter $=\frac{2}{5}MR^2=I$

Using Parallel axis theorem, $I=I_{cm}+Mx^2$ where I_{cm} is MOI about centre of mass x is distance between centre of mass and axis of rotation.

$\Rightarrow MOI$ of system $=2\times\frac{2}{5}MR^2+2\times\left(\frac{2}{5}MR^2+MR^2\right)=$

$\frac{18}{5}MR^2=9I$

53. A particle starts rotating from rest. Its angular displacement is expressed by the following equation $\theta\ =0.025t^2-0.1t$ where θ is in radian and t is in seconds. The angular acceleration of the particle is

(A) $0.5\,rad/sec^2$ at the end of $10\,sec$ (B) $0.3\,rad/sec^2$ at the end of $2\,sec$

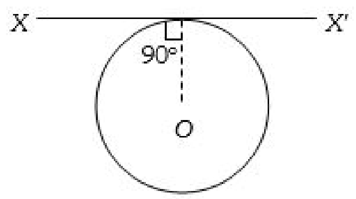
(C) $0.05\,rad/sec^2$at the end of $1\,sec$ (D) ✓ Constant $0.05,\ rad/sec^2$

Sol : $\alpha=\frac{dw}{dt}=\frac{d^20}{dt^2}$

$\frac{d\theta}{dt}=2\times0.025t-0.1$

$\frac{d^2\theta}{dt}=0.05$

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



(A) $\frac{\rho L^3}{8\pi^2}$ (B) $\frac{\rho L^3}{16\pi^2}$

(C) $\frac{5\rho L^3}{16\pi^2}$ (D) ✓ $\frac{3\rho L^3}{8\pi^2}$

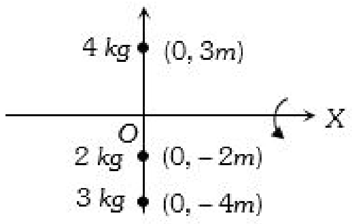
Sol : The moment of inertia of a thin loop about its diameter is $\frac{1}{2}MR^2$

about $XX'|=\frac{M\times R^2}{2}+M\times R^2=\frac{3}{2}M\times R^2$

$\mathrm{I}=\frac{3}{2}\times(l\times\rho)\left(\frac{L}{2\pi}\right)^2$

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

55. Three particles are situated on a light and rigid rod along Yaxis as shown in the figure. If the system is rotating with an angular velocity of $2\,rad/\sec$about Xaxis, then the total kinetic energy of the system is ...... J



(A) 92 (B) ✓184

(C) 276 (D) 46

Sol : Mass of first object, $m_1=4.00\mathrm{kg}$

Mass of second object, $m_2=2.00\mathrm{kg}$

Mass of third object, $m_3=3.00\mathrm{kg}$

Distance of first object from $x-axis$, $r_1=3.00\mathrm{m}$

Distance of second object from x −axis, $r_2=-2.00\mathrm{m}$

Distance of third object from x $-axis$, $r_3=-4.00\mathrm{m}$

Angular velocity, $\omega=2\mathrm{rad/s}$

$I=\sum_1^n m_ir_i^2$

$I=m_1r_1^2+m_2r_2^2+m_3r_3^2$

$I=(4.00\mathrm{kg})(3.00\mathrm{m})^2+(2.00\mathrm{kg})(-2.00\mathrm{m})^2+(3.00\mathrm{kg})(-4.00\mathrm{m})^2$

$I=92\mathrm{kg.m}^2$

$K\cdot E_{\text{rotational}}=\frac{1}{2}I\omega^2$

$K.E_{\text{rotational}}=\frac{1}{2}\left(92\mathrm{kg.m}^2\right)(2\mathrm{rad/s})^2=184\mathrm{J}$

56. We have two spheres, one of which is hollow and the other solid. They have identical masses and moment of inertia about their respective diameters. The ratio of their radius is given by

(A) $5:7$ (B) $3:5$

(C) ✓$\sqrt{3}:\sqrt{5}$ (D) $\sqrt{3}:\sqrt{7}$

Sol : Moment of Inertia of hollow sphere is $I_1 = \frac{2}{3}mr_1^2$

Moment of Inertia of solid sphere is $I_2 = \frac{2}{5}mr_2^2$

As moment of inertia is equal:

$I_1 = I_2$

$\frac{2}{3}mr_1^2 = \frac{2}{5}mr_2^2$

$\frac{r_1^2}{r_2^2} = \frac{3}{5}$

$r_1 : r_2 = \sqrt{3} : \sqrt{5}$

57. Two particles having mass $'M'$ and $'m'$ are moving in circular paths having radii R and r. If their time periods are same then the ratio of their angular velocities will

(A) $\frac{r}{R}$ (B) $\frac{R}{r}$

(C) ✓1 (D) $\sqrt{\frac{R}{r}}$

Sol : Time period of revolution $T = \frac{2\pi}{w}$

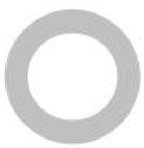
As according to question, $T_1 = T_2$

$\therefore \frac{2\pi}{w_1} = \frac{2\pi}{w_2}$

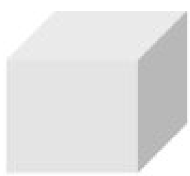
$\Longrightarrow w_1 = w_2 = 1$

58. Four solids are shown in cross section. The sections have equal heights and equal maximum widths. They have the same mass. The one which has the largest rotational inertia about a perpendicular through the centre of mass is

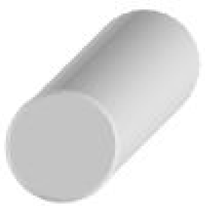
(A) ✓



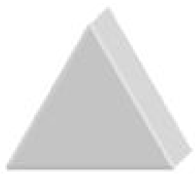
(B)



(C)



(D)



59. A uniform cube of side a and mass m rests on a rough horizontal table. A horizontal force F is applied normal to one of the faces at a point that is directly above the centre of the face, at a height $\frac{3a}{4}$ above the base. The minimum value of F for which the cube begins to tilt about the edge is (assume that the cube does not slide)

(A) $\frac{mg}{4}$ (B) ✓$\frac{2mg}{3}$

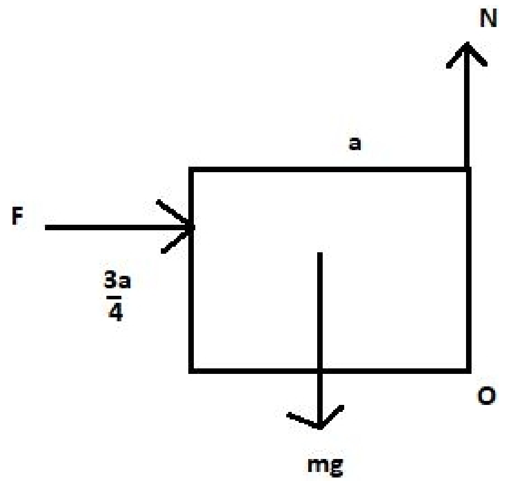
(C) $\frac{3mg}{4}$ (D) mg

Sol : The minimum force for which cube begins to tilt, the normal reaction should pass through the tilting edge point $'O'$.

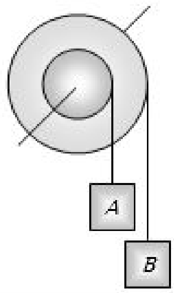
Taking moments about point O,

$F \times \frac{3a}{4} = mg \times \frac{a}{2}$

$\Rightarrow F = \frac{2}{3}mg$



60. Figure shows a small wheel fixed coaxially on a bigger one of double the radius. The system rotates about the common axis. The strings supporting A and B do not slip on the wheels. If x and y be the distances travelled by A and B in the same time interval, then



(A) $x = 2y$ (B) $x = y$

(C) ✓$y = 2x$ (D) None of these

Sol : Linear displacement (S) = Radius (r) $\times$ Angular displacement (q)

$\therefore S \propto r$ (if θ $=$ constant)

$\frac{\text{Distance travelled by mass } A\,(x)}{\text{Distance travelled by mass } B\,(y)}$

= $\frac{\text{Radius of pulley concerned with mass } A\,(r)}{\text{Radius of pulley concerned with mass } B\,(2r)} = \frac{1}{2}$

$y = 2x$.

61. A body is in pure rotation. The linear speed v of a particle, the distance r of the particle from the axis and angular velocity ω of the body are related as $\omega = \frac{v}{r}$, thus

(A) $\omega \propto \frac{1}{r}$ (B) $\omega \propto r$

(C) $\omega = 0$ (D) ✓ω is independent of r

Sol : Explanation $\Rightarrow$ In the given Relation,

$\omega = v/r$

ω is the Constant of Proportionality, v is the Velocity of the Particles which is directly proportional to the distance of the particles from the axis (r).

$\therefore v \propto r$

$\Rightarrow v = \omega \times r$

since, ω is the constant of Proportionality, its value will be remains same for the given values of v and r.

$\therefore$ Option (d). is correct.

62. Two point masses of $0.3\ kg$ and $0.7\ kg$ are fixed at the ends of a rod of length $1.4\ m$ and of negligible mass. The rod is set rotating about an axis perpendicular to its length with a uniform angular speed. The point on the rod through which the axis should pass in order that the work required for rotation of the rod is minimum is located at a distance of

(A) $0.4\ m$ from mass of $0.3\ kg$ (B) ✓$0.98\ m$ from mass of $0.3\ kg$

(C) $0.70\ m$ from mass of $0.7\ kg$ (D) $0.98\ m$ from mass of $0.7\ kg$

Sol : $Work - energy$ theorem, $W_{\text{all forces}} = \frac{1}{2}Iw^2$

Given: w is constant

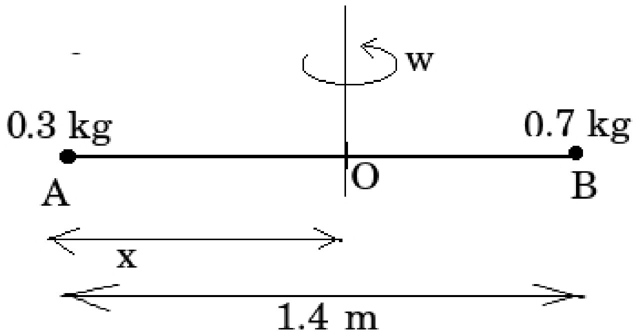
So required work done to be minimum implies that I must be minimum.

Let the rotational axis passes through O. $I = 0.3(x^2) + 0.7(1.4-x)^2$

For I to be minimum, $\frac{dI}{dx} = 0$

$\implies 0.3 \times 2(x) - 0.7 \times 2(1.4-x) = 0$

$\implies x = 0.98m$



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

(A) ✓ $\frac{5}{2}I$ (B) $3\,I$

(C) $\frac{3}{2}I$ (D) $2\,I$

Sol : M.I. of disc about an axis passing through its COM and perpendicular to the plane

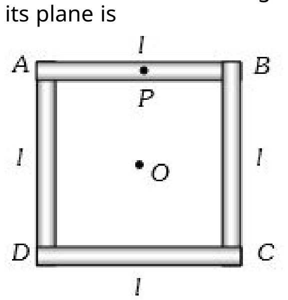
is $I = \frac{1}{2}MR^2$

$M.I.$ of disc about its diameter is $I' = \frac{MR^2}{4} = \frac{I}{2}$

$M.I.$ of disc about its tangential axis

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

64. Four thin rods of same mass M and same length l, form a square as shown in figure. Moment of inertia of this system about an axis through centre O and perpendicular to its plane is



(A) ✓ $\frac{4}{3}Ml^2$ (B) $\frac{Ml^2}{3}$

(C) $\frac{Ml^2}{6}$ (D) $\frac{2}{3}Ml^2$

Sol : Moment of inertia of rod AB about point $P = \frac{1}{12}Ml^2$

$M.I.$ of rod AB about point $O = \frac{Ml^2}{12} + M\left(\frac{l}{2}\right)^2 = \frac{1}{3}Ml^2$

[by the theorem of parallel axis] and the system consists of 4 rods of similar type so by the symmetry $I_{System} = \frac{4}{3}Ml^2$.

65. A couple produces

(A) Purely linear motion (B) ✓Purely rotational motion

(C) Linear and rotational motion (D) No motion

Sol : Couple (formed by two equal and opposite forces) produces purely rotational motion.

66. If solid sphere and solid cylinder of same radius and density rotate about their own axis, the moment of inertia will be greater for $(L = R)$

(A) ✓ Solid sphere (B) Solid cylinder

(C) Both (D) Equal both

Sol : Moment of inertia of solid cylinder about z -axis passing through its centre and parallel to its height is given by:

$I_C = \frac{1}{2}MR^2 = 0.5MR^2$

Moment of inertia of solid cylinder about an axis passing through its centre s given by:

$I_S = \frac{2}{5}MR^2 = 0.4MR^2$

So, $I_C > I_S$

Hence, The moment of inertia of the solid cylinder will be greater than that of solid sphere.

67. A wheel completes 2000 rotations in covering a distance of $9.5\,km$. The diameter of the wheel is

(A) ✓$1.5\,m$ (B) $1.5\,cm$

(C) $7.5\,m$ (D) $7.5\,cm$

Sol : Distance covered by wheel in 1 rotation = $2\pi r = \pi D$ (Where D= 2r = diameter of wheel)

$\therefore$ Distance covered in 2000 rotation = 2000 πD= $9.5 \times 10^3 m$ (given)

$\therefore D = 1.5\,meter$

68. The moment of inertia of semicircular ring about its centre is

(A) ✓MR^2 (B) $\frac{MR^2}{2}$

(C) $\frac{MR^2}{4}$ (D) None of these

Sol : $\partial m = \frac{m}{\pi R} \cdot R\partial\theta$

$\partial m = \frac{m}{\pi}\partial\theta$

$\partial I = \partial m \cdot R^2$

$I = \frac{m}{\pi}R^2 \int_0^\pi \partial\theta$

$= \frac{m}{\pi}R^2(\theta)_0^\pi$

$I = mR^2$

69. A uniform meter scale balances at the $40\,cm$ mark when weights of $10\,g$ and $20\,g$ are suspended from the $10\,cm$ and $20\,cm$ marks. The weight of the metre scale is ...... g

(A) 50 (B) 60

(C) ✓70 (D) 80

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

(A) Iron and aluminium layers in alternate order (B) ✓Aluminium at interior and iron surrounding it

(C) Iron at interior and aluminium surrounding it (D) Either (a) or (c)

Sol : A disc is composed of rings and moment of inertia of disk can be found by using integral of moment of inertia of concentric elemental rings.

Moment of inertia of continuous body is found by using $I = \int R^2 dm$

For increasing the moment of inertia of a $non-uniform$ disc, it is hence desired that the mass density is more in the exterior parts of the disc.

Thus, B is the correct option.

71. A circular disc X of radius R is made from an iron plate of thickness t, and another disc Y of radius $4R$ is made from an iron plate of thickness $\frac{t}{4}$. Then the relation between the moment of inertia I_x and I_y is

(A) ✓$I_y = 64I_x$ (B) $I_y = 32I_x$

(C) $I_y = 16I_x$ (D) $I_y = I_x$

Sol : Moment of Inertia of disc $I=\frac{1}{2}MR^2=\frac{1}{2}(\pi R^2 t\rho)R^2 = \frac{1}{2}\pi t\rho R^4$

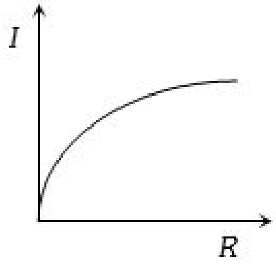
[As $M = V\times\rho = \pi R^2 t\rho$ where t = thickness, r = density]

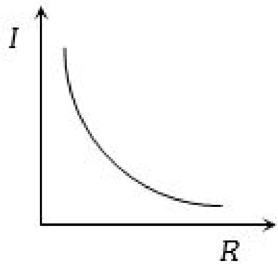
$\frac{I_y}{I_x}=\frac{t_y}{t_x}\left(\frac{R_y}{R_x}\right)^4$ [If ρ = constant]

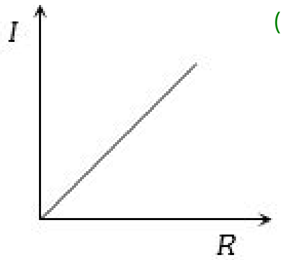
$\frac{I_y}{I_x}=\frac{1}{4}(4)^4=64$ [Given $R_y=4R_x$, $t_y=\frac{t_x}{4}$]

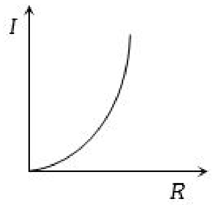
$I_y=64I_x$

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

(A)


(B)


(C)


(D) ✓


Sol : sphere: $I=(2/5)MR^2$ i.e $I\propto R^2$ as M is constant graph should be parabolic symmetrical about I axis.

73. A wheel is rotating at $900\ r.p.m.$ about its axis. When the power is cut-off, it comes to rest in $1\,minute$. The angular retardation in $radian/s^2$ is

(A) ✓$\pi/2$ (B) $\pi/4$
(C) $\pi/6$ (D) $\pi/8$

Sol : As, $\omega=\omega_0+\alpha t$

Here, $\omega_0 = 900\text{rpm} = \frac{(2\pi\times 900)}{60}\text{rads}^{-1}, \omega=0$

and $t=60s, 0=\frac{2\pi\times 900}{60}+\alpha\times 60$

$\alpha=\frac{2\pi\times 900}{60\times 60}=\frac{\pi}{2}$

74. What is the moment of inertia of a square sheet of side l and mass per unit area μ about an axis passing through the centre and perpendicular to its plane

(A) $\frac{\mu l^2}{12}$ (B) $\frac{\mu l^2}{6}$
(C) $\frac{\mu l^4}{12}$ (D) ✓$\frac{\mu l^4}{6}$

Sol : side $=l$

Mass per unit area $=\mu$

Total mass $M=\mu l^2$

Now, the moment of inertia is $I=\frac{MR^2}{12}$

By perpendicular axis theorem $I=I_x+I_y$

$I=2I_x$

$I=2\times\frac{\mu l^2\times l^2}{12}$

$I=\frac{\mu l^4}{6}$

Hence, the moment of inertia of a square sheet is $\frac{\mu l^4}{6}$

75. Moment of inertia of a uniform circular disc about a diameter is I. Its moment of inertia about an axis perpendicular to its plane and passing through a point on its rim will be

(A) $5\ I$ (B) ✓$6\ I$
(C) $3\ I$ (D) $4\ I$

Sol : Moment of inertia of disc about a diameter $=\frac{1}{4}MR^2=I$ (given)

$\therefore MR^2=4I$

Now moment of inertia of disc about an axis perpendicular to its plane and passing through a point on its rim

$=\frac{3}{2}MR^2=\frac{3}{2}(4I)=6I.$