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C.U.Q

## CENTRE OF MASS

**1. When a force is applied on a body, Newton's second law is applicable to**

1) centre of mass 2) any part of the body
3) upper most part of body
4) lower most part of body

**2. Centre of mass of the earth–moon system lies**

1) on the surface of the earth
2) on the surface of the moon
3) with in the earth
4) at the midpoint of the line joining their centres

**3. A square plate and a circular plate made up of same material are placed touching each other on a horizontal table. If the side length of square plate is equal to diameter of the circular plate then the centre of mass of the combination will be**

1) at their point of contact
2) inside the circular plate
3) inside the square plate
4) outside the combination

**4. A uniform straight rod is placed in vertical position on a smooth horizontal surface and released. As the rod is in motion, the centre of mass moves**

1) horizontally 2) vertically down
3) in a parabolic path 4) does not move.

**5. A disc and a square sheet of same mass are cut from same metallic sheet. They are kept side by side with contact at a single point. Then the centre of mass of combination is**

1) at point of contact 2) inside the disc
3) inside the square 4) outside the system

## LINEAR MOMENTUM OF CENTRE OF MASS

**6. Two balls are thrown at the same time in air, while they are in air, the acceleration of their centre of mass**

1) depends on masses of the balls
2) depends on the direction of motion of the balls
3) depends on speeds of the balls
4) is equal to acceleration due to gravity

**7. Consider a two particle system with the particles having masses $m_1$ and $m_2$. If the first particle is pushed towards the centre of mass through a distance d, by what distance should the second particle be moved, so as to keep the centre of mass at the same position? [MAINS 2006]**

1) d 2) $\frac{m_2 d}{m_1}$ 3) $\frac{m_1 d}{m_1+m_2}$ 4) $\frac{m_1 d}{m_2}$

## VECTOR PRODUCT (OR) CROSS PRODUCT

**8. If $\vec{P} \times \vec{Q} = \vec{R};\ \vec{Q} \times \vec{R} = \vec{P}\ and\ \vec{R} \times \vec{P} = \vec{Q}$ then**

1) $\vec{P}, \vec{Q}\ and\ \vec{R}$ are coplanar

2) angle between $\vec{P}$ and $\vec{Q}$ may be less than $90^0$

3) $\vec{P} + \vec{Q} + \vec{R}$ cannot be equal to zero.

4) $\vec{P}, \vec{Q}$ and $\vec{R}$ are mutually perpendicular

## ROTATIONAL VARIABLES, RELATION BETWEEN LINEAR AND ANGULAR VARIABLES,ROTATIONAL KINEMATICS,TORQUE AND MECHANICAL EQUILIBRIUM

**9. Which of the following equation is wrong**

1) $\vec{\tau} = \vec{r} \times \vec{F}$  2) $\overrightarrow{a_r} = \vec{\ } \times \vec{V}$

3) $\overrightarrow{a_t} = \vec{\ } \times \vec{r}$  4) $\vec{V} = \vec{r} \times \vec{\omega}$

**10. The following pair of physical quantities are analogous to one another in translatory motion and rotatory motion.**

1) Mass , moment of inertia  2) Force,Torque

3) Linear momentum , Angular momentum

4) All

**11. The correct relation of the following is**

1) $\vec{t} = \vec{r}.\vec{F}$  2) $\vec{t} = \vec{r} \times \vec{F}$

3) $\vec{t} = \frac{\vec{F}}{\vec{r}}$  4) $\vec{t} = \vec{r} + \vec{F}$

**12. Two particles p and q located at distances $r_p$ and '$r_q$' respectively from the centre of a rotating disc such that $r_p > r_q$ .**

1. both p and q have the same acceleration
2. both p and q do not have any acceleration
3. 'p' has greater acceleration than 'q'
4. 'q' has greater acceleration than 'p'

**13. When a constant torque is applied on a rigid body, then**

1) the body moves with linear acceleration

2) the body rotates with constant angular velocity

3) the body rotates with constant angular acceleration

4) the body undergoes equal angular displacement in equal intervals of time

**14. Identify the increasing order of the angular velocities of the following (E-2005)**

a) earth rotating about its own axis

b) hours hand of a clock

c) seconds hand of a clock

d) fly wheel of radius 2m making 300 rps

1)a,b,c,d  2)b,c,d,a  3)c,d,a,b  4)d,a,b,c

**15. The direction of following vectors is along the line of axis of rotation**

1) angular velocity, angular acceleration only

2) angular velocity, angular momentum only

3) angular velocity, angular acceleration, angular momentum only

4) angular velocity, angular acceleration, angular momentum and torque

**16. A particle is moving along a fixed circular orbit with uniform speed. Then true statement from the following is**

1) angular momentum of particle is constant only in magnitude but its direction changes from point to point

2) angular momentum of particle is constant only in direction but its magnitude changes from point to point

3) angular momentum of particle is constant both in magnitude and direction

4) angular momentum of particle is not constant both in magnitude and direction

**17. Class I lever is that in which**

1) fulcrum is between the load and effort

2) load is between the fulcrum and effort

3) effort is between the load and fulcrum

4) fulcrum, load and effort at one point

**18. If force vector is along X-axis and radius vector is along Y-axis then the direction of torque is**

1) along +ve Z-axis  2) along -ve Z-axis

3) in X-Y plane making an angle 45° with X-axis

4) in X-Y plane making an angle 135° with X-axis

**19. During rotation of a body, the position vector is along X–axis and force vector is along Y–axis, The direction of torque vector is**

1) in the X-Y plane  2) along –ve Z-axis

3) along +ve Z-axis  4) in the X-Z plane

**20. If the direction of position vector $\vec{r}$ is towards south and direction of force vector $\vec{F}$ is towards east, then the direction of torque vector $\vec{t}$ is**

1) towards north  2) towards west

3) vertically upward  4) vertically downward

**21. Which of the following is wrong?**

1) Direction of torque is parallel to axis of rotation

2) Direction of moment of couple is perpendicular to the plane of rotation of body

3) Torque vector is perpendicular to both position vector and force vector

4) The direction of force vector is always perpendicular to both the directions of position vector and torque vector

**22. A circular disc is rotated along clockwise direction in horizontal plane. The direction of torque is**

1) horizontally right side 2) horizontally left side
3) vertically upwards 4)vertically downwards

**23. Magnitude of torque is maximum in the following case**

1) radius vector is perpendicular to force vector
2) radius vector is parallel to force vector
3) Angle between radius vector and force vector is 45°
4) Angle between radius vector and force vector is 60°

**24. A constant resultant torque rotates a wheel about its own axis. Then true statement of the following is**

1) angular velocity of wheel is constant
2) angular acceleration of wheel is constant
3)angular acceleration of wheel gradually increases
4) angular momentum of wheel is constant

**25. A wheel is free to rotate about its own axis without friction. A rope is wound around the wheel. If other end of rope is pulled with a constant force, then true statement from the following is**

1) constant torque is produced and the wheel is rotated with constant angular velocity
2) constant torque is produced and the wheel is rotated with constant angular acceleration
3) variable torque is produced and the wheel is rotated with variable angular velocity
4) variable torque is produced and the wheel is rotated with variable angular acceleration

**26. The following pairs of physical quantities are not analogous to each other in translatory motion and rotational motion**

1) force, torque 2) mass, moment of inertia
3) couple, torque
4) linear momentum, angular momentum

## ROTATIONAL INERTIA OF SOLID BODIES, ROTATIONAL DYNAMICS

**27. The moment of inertia of a rigid body depends on**

A) mass of body
B) position of axis of rotation
C) time period of its rotation
D) angular velocity of the body

1) A and B are true 2) B and C ar true
3) C and D are true 4) A and D are true

**28. $I_1, I_2$ are moments of inertia of two solid spheres of same mass about axes passing through their centres If first is made of wood and the second is made of steel, then**

1) $I_1 = I_2$ 2) $I_1 < I_2$ 3) $I_1 > I_2$ 4) $I_1 \le I_2$

**29. A Uniform metal rod is rotated in horizontal plane about a vertical axis passing through its end at uniform rate. The tension in the rod is**

1) same at all points
2) different at different points and maximum at centre of rod
3) different at different points and minimum at axis of rotation.
4) different at different points and maximum at axis of rotation

**30. A boiled egg and a raw egg of same mass and size are made to rotate about their own axis. If $I_1$ and $I_2$ are moments of inertia of boiled egg and raw egg, then**

1) $I_1 = I_2$ 2) $I_1 > I_2$ 3) $I_1 < I_2$ 4) $I_1 = \sqrt{2}\, I_2$

**31. Raw and boiled eggs are made to spin on a smooth table by applying the same torque. The egg that spin faster is**

1) Raw egg 2) Boiled egg
3) Both will have same spin rate
4) Difficult to predict

**32. Moment of Inertia of a body depends upon**

1) distribution of mass of the body
2) position of axis of rotation
3) temperature of the body 4) all the above

**33. Of the two eggs which have identical sizes , shapes and weights, one is raw and other is half boiled. The ratio between the moment of inertia of the raw to the half boiled egg about central axis is :**

1) $=1$ 2) $>1$ 3) $<1$ 4) not comparable

**34. The radius of gyration of a rotating metallic disc is independent of the following physical quantity.**

1) Position of axis of rotation 2) Mass of disc
3) Radius of disc 4) temperature of disc

**35. A brass disc is rotating about its axis. If temperature of disc is increased then its**

1) radius of gyration increases, but moment of inertia remains the same
2) moment of inertia increases but radius of gyration remains the same
3) radius of gyration, moment of inertia both remain the same
4) radius of gyration, moment of inertia both increase

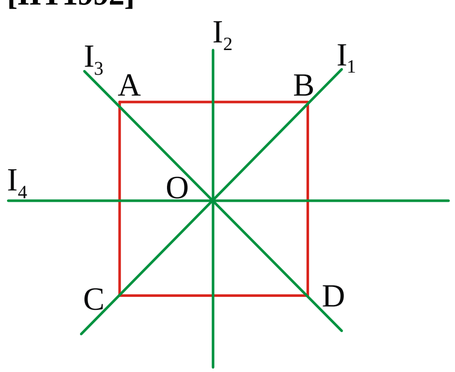
36. **The radius of gyration of a rotating circular ring is maximum about following axis of rotation**
1) natural axis
2) axis passing through diameter of ring
3) axis passing through tangent of ring in its plane
4)axis passing through tangent of ring perpendicular to plane of ring.

37. **Moment of inertia of a thin circular plate is minimum about the following axis**
1) axis perpendicular to plane of plate passing through its centre
2) axis passing through any diameter of plate
3) axis passing through any tangent of plate in its plane
4) axis passing through any tangent perpendicular to its plane

38. **A ring of mass 'm' and radius 'r' is melted and then moulded into a sphere . The moment of inertia of the sphere will be**
1) more than that of the ring
2) less than that of the ring
3) equal to that of the ring
4) none of the above

39. **Two copper circular discs are of the same thickness. The diameter of A is twice that of B. The moment of inertia of A as compared to that of B is**
1) twice as large 2) four times as large
3) 8 times as large 4) 16 times as large

40. **The moment of inertia of a thin square plate ABCD of uniform thickness about an axis passing through the centre O and perpendicular to the plane of the plate is [IIT1992]**




a) $I_1 + I_3$ b) $I_2 + I_4$
c) $2\,I_1 + I_3$ d) $I_1 + 2\,I_3$
1) a,b are true 2) b,c are true
3) c,d are true 4) b,d are true

41. **Identify the correct order in which the ratio of radius of gyration to radius increases for the following bodies.**
I) Rolling solid sphere II) Rolling solid cylinder
III) Rolling hollow cylinder
IV) Rolling hollow sphere
1) I, II, IV, III 2) I, III, II, IV
3) II, I, IV, III 4) II, I, III, IV

42. **Identify the increasing order of radius of gyration of following bodies of same radius**
I) About natural axis of circular ring
II) About diameter of circular ring
III) About diameter of circular plate
IV) About diameter of solid sphere
1) II, III, IV, I 2) III, II, IV, I
3) III, IV, II, I 4) II, IV, III, I

43. **Identify the decreasing order of moments of inertia of the following bodies of same mass and same radius.**
I) About diameter of circular ring
II) About diameter of circular plate
III) About tangent of circular ring $\perp^r$ to its plane
IV) About tangent of circular plate in its plane
1) III, IV, II, I 2) IV, III, I, II
3) IV, III, II, I 4) III, IV, I, II

44. **Three dense point size bodies of same mass are attached at three vertices of a light equilateral triangular frame. Identify the increasing order of their moment of inertia about following axis.**
I) About an axis $\perp^r$ to plane and passing through a corner
II) About an axis $\perp^r$ to plane and passing through centre
III) About an axis passing through any side
IV) About $\perp^r$ bisector of any side
1) IV,III, II, I 2) III, II, IV, I
3) II, IV, III, I 4) II, III, IV, I

45. **Four point size dense bodies of same mass are attached at four corners of a light square frame. Identify the decreasing order of their moments of inertia about following axes.**
I) Passing through any side
II) Passing through opposite corners
III) $\perp^r$ bisector of any side
IV) $\perp^r$ to the plane and passing through any corner
1) III, IV, I, II 2) IV, III, I, II
3) III, II, IV, I 4) IV, III, II, I

**46. A motor car is moving in a circular path with uniform speed v. Suddenly the car rotates through an angle $q$. Then, the magnitude of change in its velocity is**

1) $2v\cos\frac{\theta}{2}$ 2) $2v\sin\frac{\theta}{2}$

3) $2v\tan\frac{\theta}{2}$ 4) $2v\sec\frac{\theta}{2}$

**47. An electric motor rotates a wheel at a constant angular velocity $(w)$ while opposing torque is $\tau$. The power of that electric motor is**

1) $\frac{\tau\omega}{2}$ 2) $\tau\omega$ 3) $2\tau\omega$ 4) $\frac{\tau}{\omega}$

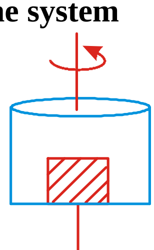
**48. A constant power is supplied to a rotating disc. The relationship between the angular velocity $(w)$ of the disc and number of rotations (n) made by the disc is governed by**

1) $w \propto n^{\frac{1}{3}}$ 2) $w \propto n^{\frac{2}{3}}$

3) $w \propto n^{\frac{3}{2}}$ 4) $w \propto n^{2}$

## ANGULAR MOMENTUM & CONSERVATION OF ANGULAR MOMENTUM

**49. An ice block is in a trough which is rotating about vertical axis passing through its centre. When ice melts completely, the angular velocity of the system**



1) increases 2) decreases

3) remains same 4)becomes double

**50. A circular disc is rotating about its own axis, the direction of its angular momentum is**

1) radial 2) along axis of rotation

3) along tangent

4) perpendicular to the direction of angular velocity

**51. A ballet dancer is rotating about his own vertical axis on smooth horizontal floor. $I$, $w$, L, E are moment of inertia, angular velocity, angular momentum, rotational kinetic energy of ballet dancer respectively. If ballet dancer stretches himself away from his axis of rotation, then**

1) $I$ increases and $w$, E decrease but L is constant

2) $I$ decreases, $w$ and E increase but L is constant

3) $I$ increases, $w$ decreases, L and E are constant

4) $I$ increases, $w$ increases but L and E are constant

**52. If polar ice caps melt, then the time duration of one day**

1) increases 2) decreases

3) does not change 4) zero

**53. A hollow sphere partly filled with water has moment of inertia $I$ when it is rotating about its own axis at an angular velocity . If its angular velocity is doubled then its moment of inertia becomes**

1) Less than $I$ 2) More than $I$

3) $I$ 4) zero

**54. If most of the population on earth is migrated to poles of the earth then the duration of a day**

1) increases 2) decreases

3) remains same

4) first increases then decreases

**55. The law of conservation of angular momentum is obtained from Newton's II law in rotational motion when**

1) external torque is maximum

2) external torque is minimum

3) external torque is zero

4) external torque is constant

**56. If earth shrinks then the duration of day**

1) increases 2) decreases

3) remains same

4) first increases then decreases to initial value

**57. A circular disc is rotating in horizontal plane about vertical axis passing through its centre without friction with a person standing on the disc at its edge. If the person gently walks to centre of disc then its angular velocity**

1) increases 2) decreases

3) does not change 4 )becomes zero

**58. A ballet dancer is rotating about his own vertical axis.Without external torque if his angular velocity is doubled then his rotational kinetic energy is**

1) halved 2) doubled

3) quadrupled 4) unchanged

**59. The following motion is based on the law of conservation of angular momentum**

A) rotation of top B) diving of diver

C) rotation of ballet dancer on smooth horizontal surface

D) a solid sphere that rolls down on an inclined plane

1) A, B and C are true 2) A, B and D are true

3) B, C and D are true 4) A, C and D are true

**60. Two bodies with moment of inertia $I_1$ and $I_2$ $(I_2 > I_1)$ are rotating with same angular momentum. If $K_1$ and $K_2$ are their K.E.s, then**

1) $K_2 > K_1$ 2) $K_2 < K_1$ 3) $K_1 = K_2$ 4) $K_2 \geq K_1$

**61. A solid sphere is rotating in free space . If the radius of the sphere is increased keeping mass same which one of the following will not be affected?**

1) Moment of inertia 2) Angular momentum
3) Angular velocity 4) Rotational kinetic energy

**62. A circular wheel is rotating in horizontal plane without friction about its axis. If a body is gently attached to the rim of the wheel then following is false.**

1) Moment of inertia increases but angular momentum remains same
2) Angular velocity decreases but angular momentum remains same
3) Rotational kinetic energy decreases but angular momentum remains same
4) Angular momentum increases but angular velocity remains same

**63. A uniform metal rod of length 'L' and mass 'M' is rotating about an axis passing through one of the ends perpendicular to the rod with angular speed 'ω'. If the temperature increases by "t $^0$C" then the change in its angular velocity is proportional to which of the following ? (Coefficient of linear expansion of rod = α )**

1) $\sqrt{\omega}$ 2) $\omega$ 3) $\omega^2$ 4) $1/\omega$

**64. A gymnast standing on a rotating stool with his arms outstretched, suddenly lowers his arms**

1) his angular velocity decreases
2) his angular velocity increases
3) his moment of inertia remains same
4) his moment of inertia increases

**65. Angular momentum of the particle rotating with a central force is constant due to [AIEEE-2007]**

1) constant force
2) constant linear momentum
3) zero torque 4) constant torque

## ROLLING MOTION &ROTATIONAL KINETIC ENERGY

**66. Solid sphere, hollow sphere, solid cylinder and hollow cylinder of same mass and same radii are simultaneously start rolling down from the top of an inclined plane. The body that takes longest time to reach the bottom is**

1) solid sphere 2) hollow sphere
3) solid cylinder 4) hollow cylinder

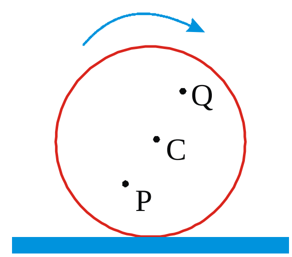
**67. Solid sphere, solid cylinder, hollow sphere, hollow cylinder of same mass and same radii are rolling down freely on an inclined plane. The body with maximum acceleration is**

1) solid sphere 2) solid cylinder
3) hollow sphere 4) hollow cylinder

**68. In the case of following rolling body translatory and rotational kinetic energies are equal for**

1) circular ring 2) circular plate
3) solid sphere 4) solid cylinder

**69. A disc is rolling (without slipping) on a frictionless surface . C is its centre and Q and P are two points equidistant from C. Let $V_p, V_Q$ and $V_c$ be the magnitudes of velocities of points P,Q and C respectively, then [IIT-2004]**




1) $V_Q > V_C > V_P$ 2) $V_Q < V_C < V_P$

3) $V_Q = V_P, V_C = \frac{1}{2}V_P$ 4) $V_Q < V_C > V_P$

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

1) 4L 2) 2 L 3) $\frac{L}{2}$ 4) $\frac{L}{4}$

**71. If V is velocity of centre of mass of a rolling body then velocity of lowest point of that body is**

1) $\sqrt{2}$V 2) V 3) 2V 4) Zero

**72. If the velocity of centre of mass of a rolling body is V then velocity of highest point of that body is**

1) $\sqrt{2}$V 2) V 3) 2V 4) $\frac{V}{\sqrt{2}}$

**73. If $x$ is ratio of rotational kinetic energy and translational kinetic energy of rolling body then the following is true**

1) $x = 1$ 2) $x \leq 1$ 3) $x \geq 1$ 4) $x = \frac{1}{2}$

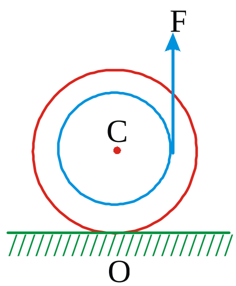
74. **A body is freely rolling down on an inclined plane whose angle of inclination is $\theta$. If 'a' is acceleration of its centre of mass then following is correct**

1) $a = g\sin\theta$ 2) $a < g\sin\theta$
3) $a > g\sin\theta$ 4) $a = 0$

75. **A Child is standing with folded hands at the centre of a platform rotating about its central axes. The K.E of the system is '$K$'. The child now stretches his hands so that the moment of inertia of the system doubles. The K.E of the system now is**

1) $2K$ 2) $\frac{K}{2}$ 3) $\frac{K}{4}$ 4) $4K$

76. **A yo-yo is placed on a rough horizontal surface and a constant force $F$, which is less than its weight, pulls it vertically. Due to this**




1) frictional force acts towards left, so it will move towards left
2) frictional force acts towards right, so it will move towards right
3) it will move towards left, so frictional force acts towards left
4) it will move towards right so friction force acts towards right

77. **When the following bodies of same radius starts rolling down on same inclined plane, identify the decreasing order of their times of descent**

I) solid cylinder II) hollow cylinder
III) hollow sphere IV) solid sphere
1) IV, I, III, II 2) II, III, I, IV
3) I, IV, III, II 4) II, III, IV, I

78. **When the following bodies having same radius starts rolling down on same inclined plane, identify the increasing order of their accelerations**

I) hollow cylinder II) solid cylinder
III) solid sphere IV) hollow sphere
1) I, IV, III, II 2) IV, I, II, III
3) I, IV, II, III 4) I, IV, III, II

79. **When a ring is rolling $V_1$, $V_2$, $V_3$ and $V_4$ are velocities of top most point, lowest point, end point of horizontal diameter, centre of ring respectively, the decreasing order of these velocities is**

1) $V_2, V_1, V_4, V_3$ 2) $V_2, V_1, V_3, V_4$
3) $V_1, V_2, V_3, V_4$ 4) $V_1, V_3, V_4, V_2$

80. **The increasing order of fraction of total kinetic energy associated with translatory motion of the following rolling bodies is**

I) circular ring II) circular plate
III) solid sphere IV) hollow sphere
1) I, II, IV, III 2) IV, I, II, III
3) I, IV, II, III 4) IV, I, III, II

81. **A and B are two solid spheres of equal masses. A rolls down an inclined plane without slipping from a height H. B falls vertically from the same height. Then on reaching the ground.**

1) both cannot do work
2) A can do more work than B
3) B can do more work than A
4) both A and B will have different linear speeds

82. **A solid sphere, a hollow sphere and a ring are released from top of an inclined plane (frictionless) so that they slide down the plane. Then maximum acceleration down the plane is (no rolling):**

1) solid sphere 2) hollow sphere
3) ring 4) same for all

83. **A sphere cannot roll on**

1) a smooth horizontal surface
2) a smooth inclined surface
3) a rough horizontal surface
4) a rough inclined surface.

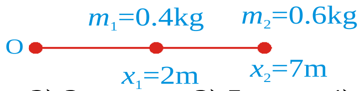
## C.U.Q - KEY

| | | | | | |
|---|---|---|---|---|---|
| 01) 1 | 02) 3 | 03) 3 | 04) 2 | 05) 2 | 06) 4 |
| 07) 4 | 08) 1 | 09) 4 | 10) 4 | 11) 2 | 12) 3 |
| 13) 3 | 14) 1 | 15) 4 | 16) 3 | 17) 1 | 18) 2 |
| 19) 3 | 20) 3 | 21) 4 | 22) 4 | 23) 1 | 24) 2 |
| 25) 2 | 26) 3 | 27) 1 | 28) 3 | 29) 4 | 30) 3 |
| 31) 2 | 32) 4 | 33) 2 | 34) 2 | 35) 4 | 36) 4 |
| 37) 2 | 38) 2 | 39) 4 | 40) 1 | 41) 1 | 42) 3 |
| 43) 4 | 44) 1 | 45) 2 | 46) 2 | 47) 2 | 48) 1 |
| 49) 2 | 50) 2 | 51) 1 | 52) 1 | 53) 2 | 54) 2 |
| 55) 3 | 56) 2 | 57) 1 | 58) 2 | 59) 1 | 60) 2 |
| 61) 2 | 62) 4 | 63) 2 | 64) 2 | 65) 3 | 66) 4 |
| 67) 1 | 68) 1 | 69) 1 | 70) 4 | 71) 4 | 72) 3 |
| 73) 2 | 74) 2 | 75) 2 | 76) 1 | 77) 2 | 78) 3 |
| 79) 4 | 80) 3 | 81) 4 | 82) 4 | 83) 2 | |

# LEVEL - I (C.W)

## CENTRE OF MASS

1. A system consists of two masses connected by a massless rod lies along x–axis. The distance of centre of mass from O is




1) 2m  2) 3m  3) 5m  4) 7m

2. Four particles, each of mass 1 kg are placed at the corners of a square OABC of side 1 m. 'O' is at the origin of the coordinate system. OA and OC are aligned along positive X-axis and positive Y-axis respectively. The position vector of the centre of mass is (in 'm')

1) $\hat{i}+\hat{j}$  2) $\frac{1}{2}\left(\hat{i}+\hat{j}\right)$  3) $\left(\hat{i}-\hat{j}\right)$  4) $\frac{1}{2}\left(\hat{i}-\hat{j}\right)$

3. A thick straight wire of length $\pi\,m$ is fixed at its midpoint and then bent in the form of a circle. The shift in its centre of mass is

1) $\pi\,m$  2) 0.5 m  3) 2 m  4) $\frac{\pi}{2}m$

4. A rigid body consists of a 3kg mass located at $\vec{r}_1=\left(2\hat{i}+5\hat{j}\right)m$ and a 2kg mass located at $\vec{r}_2=(4\hat{i}+2\hat{j})$ m. The position of centre of mass is

1) $\left(\frac{14}{5}\hat{j}+\frac{19}{5}\hat{i}\right)m$  2) $\left(\frac{14}{5}\hat{i}+\frac{19}{5}\hat{j}\right)m$

3) $\left(\frac{19}{5}\hat{i}+\frac{14}{5}\hat{j}\right)m$  4) 0

5. A boat of mass 40kg is at rest. A dog of mass 4kg moves in the boat with a velocity of 10m/s. What is the velocity of boat(nearly)?

1) 4m/s  2) 2m/s  3) 8m/s  4) 1 m/s

6. Two blocks of masses 10kg and 30 kg are placed along a vertical line if the first block is raised through a height of 7cm then the distance through the second mass should be moved to raise the centre of mass of the system by 1cm is

1)1cm up 2)1cm down 3)2 cm down 4)2 cm up

## MOTION OF CENTRE OF MASS, LINEAR MOMENTUM OF CENTRE OF MASS

7. Two bodies of different masses 2kg and 4kg are moving with velocities 2m/s and 10m/s towards each other due to mutual gravitational attraction. Then the velocity of the centre of mass is

1) $5ms^{-1}$  2) $6ms^{-1}$  3) $8ms^{-1}$  4) Zero

8. If two particles of masses 3kg and 6kg which are at rest are separated by a distance of 15m. The two particles are moving towards each other under a mutual force of attraction. Then the ratio of distances travelled by the particles before collision is

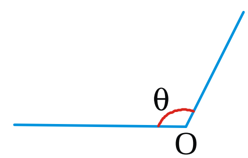
1) 2 : 1  2) 1: 2  3) 1 : 3  4) 3 :1

9. Two bodies of 6 kg and 4 kg masses have their velocity $5\hat{i}-2\hat{j}+10\hat{k}$ and $10\hat{i}-2\hat{j}+5\hat{k}$ respectively.Then the velocity of their centre of mass is

1) $5\hat{i}+2\hat{j}-8\hat{k}$  2) $7\hat{i}+2\hat{j}-8\hat{k}$

3) $7\hat{i}-2\hat{j}+8\hat{k}$  4) $5\hat{i}-2\hat{j}+8\hat{k}$

10. A thin uniform rod of length "L" is bent at its mid point as shown in the figure. The distance of the centre of mass from the point "O" is




1) $\frac{L}{2}\sin\frac{\theta}{2}$  2) $\frac{L}{2}\cos\frac{\theta}{2}$

3) $\frac{L}{4}\sin\frac{\theta}{2}$  4) $\frac{L}{4}\cos\frac{\theta}{2}$

11. Three identical spheres each of mass 'm' and radius 'R' are placed touching each other so that their centres A, B and C lie on a straight line. The position of their centre of mass from centre of A is

1) $\frac{2R}{3}$  2) 2R  3) $\frac{5R}{3}$  4) $\frac{4R}{3}$

12. A boy of mass 50kg is standing at one end of a boat of length 9m and mass 400kg. He runs to the other end. The distance through which the centre of mass of the boat boy system moves is

1) 0  2) 1m  3) 2m  4) 3m

13. A dog weighing 5kg is standing on a flat boat so that it is 10 metres from the shore. It walks 4m on the boat towards the shore and then halts. The boat weighs 20kg and one can assume that there is no friction between it and water. The dog from the shore at the end of this time is

1) 3.4 m  2) 6.8m  3) 12.6 m  4) 10 m

## VECTOR PRODUCT (or) CROSS PRODUCT

14. The angular velocity of a rotating body is $\vec{w} = 4\hat{i} + \hat{j} - 2\hat{k}$. The linear velocity of the body whose position vector $2\hat{i} + 3\hat{j} - 3\hat{k}$ is

1) $5\hat{i} + 8\hat{j} + 14\hat{k}$  2) $3\hat{i} + 8\hat{j} + 10\hat{k}$

3) $8\hat{i} - 3\hat{j} + 2\hat{k}$  4) $-8\hat{i} + 3\hat{j} + 2\hat{k}$

15. The area of the triangle whose adjacent sides are represented by the vector $\left(4\hat{i} + 3\hat{j} + 4\hat{k}\right)$ and $5\hat{i}$ in sq. units is

1) 25  2) 12.5  3) 50  4) 45

16. The angle between the vectors $\left(\hat{i} + \hat{j} + \hat{k}\right)$ and $\left(\hat{i} - \hat{j} - \hat{k}\right)$ is

1) $\sin^{-1}\frac{\sqrt{8}}{3}$  2) $\sin^{-1}\left(\frac{1}{3}\right) + \frac{p}{3}$

3) $\cos^{-1}\frac{\sqrt{8}}{3}$  4) $\cos^{-1}\sqrt{\frac{8}{3}}$

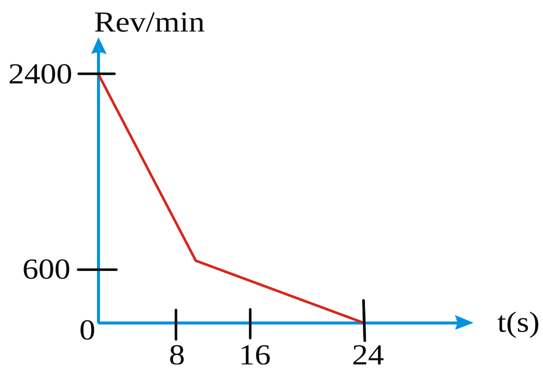
## ROTATIONAL VARIABLES, RELATION BETWEEN LINEAR & ANGULAR VARIABLES

17. The linear velocity of a point on the surface of earth at a latitude of 60° is

1) $\frac{800}{3}$ m/sec  2) $\frac{800p}{3}$ m/sec

3) $800 \times \frac{5}{18}$ m/sec  4) $\frac{2000p}{27}$ m/sec

18. A table fan, rotating at a speed of 2400 rpm is switched off and the resulting variation of the rpm with time is shown in the figure. The total number of revolutions of the fan before it comes to rest is




1) 420  2) 280  3) 240  4) 380

19. The average angular velocity of the seconds hand of a watch if the seconds hand of the watch completes one revolution in 1 minute is

1) $\frac{\pi}{15}$ rads$^{-1}$  2) $\frac{\pi}{30}$ rads$^{-1}$

3) $\frac{\pi}{45}$ rads$^{-1}$  4) $\frac{p}{7}$ rads$^{-1}$

20. The angular displacement of a particle is given by $\theta = t^3 + t^2 + t + 1$ then, its angular velocity at t = 2 sec is ......... rads$^{-1}$

1) 27  2) 17  3) 15  4) 16

21. In the above problem, the angular acceleration of the particle at t = 2 sec is ......... rads$^{-2}$

1) 14  2) 16  3) 18  4) 24

## ROTATIONAL KINEMATICS, TORQUE, MECHANICAL EQUILIBRIUM

22. A stationary wheel starts rotating about its own axis at uniform angular acceleration $8 rad/s^2$. The time taken by it to complete 77 rotations is

1) 5.5 sec  2) 7 sec  3) 11 sec  4) 14 sec

23. A stationary wheel starts rotating about its own axis at constant angular acceleration. If the wheel completes 50 rotations in first 2 seconds, then the number of rotations made by it in next two seconds is

1) 75  2) 100  3) 125  4) 150

24. If $\vec{F} = 2\hat{i} - 3\hat{j}$ N and $\vec{r} = 3\hat{i} + 2\hat{j}$ m then torque $\vec{\tau}$ is

1) $12\hat{k}$  2) $13\hat{k}$  3) $-12\hat{k}$  4) $-13\hat{k}$

25. A crowbar of length 120 cm has its fulcrum situated at a distance of 20cm from the load. The mechanical advantage of the crow bar is

1) 1  2) 3  3) 5  4) 7

## ROTATIONAL INERTIA OF SOLID BODIES

26. Three particles of masses 1gm, 2gm & 3gm are at 1cm, 2cm, & 3cm from the axis of rotation respectively then the moment of inertia of the system & radius of gyration of the system respectively are .......gm cm$^2$ and .. cm

1) 63, 2.449  2) 60, 4.5

3) 36, 4.449  4) 36, 2.449

**27. A hoop of mass 500gm & radius 10cm is placed on a nail. then the moment of inertia of the hoop, when it is rotated about the nail will be-- $kgm^2$**

1) 0.05 2) 0.02 3) 0.01 4) 0.03

**28. The ratio of moments of inertia of two solid spheres of same mass but densities in the ratio 1:8 is**

1) $1:4$ 2) $4:1$ 3) $2:1$ 4) $8:1$

**29. The radius of a solid sphere is R and its density D. When it is made to rotate about an axis passing through any diameter of sphere, expression for its moment of inertia is**

1) $\frac{8}{7}\pi DR^5$ 2) $\frac{8}{15}\pi DR^5$

3) $\frac{28}{15}\pi DR^5$ 4) $\frac{28}{5}\pi DR^5$

**30. Four point size bodies each of mass M are fixed at four corners of a light squre frame of side length L. The moment of inertia of the four bodies about an axis perpendicular to the plane of frame and passing through its centre is**

1) $4ML^2$ 2) $2\sqrt{2}ML^2$ 3) $2ML^2$ 4) $\sqrt{2}ML^2$

**31. Four particles each of mass 'm' are placed at the corners of a square of side length '$\ell$'. The radius of gyration of the system about an axis perpendicular to the plane of square and passing through its centre is**

1) $\frac{\ell}{\sqrt{2}}$ 2) $\frac{\ell}{2}$ 3) $\ell$ 4) $\sqrt{2}\ell$

**32. In the above problem the moment of inertia of four bodies about an axis perpendicular to the plane of frame and passing through a corner is**

1) $ML^2$ 2) $2ML^2$ 3) $2\sqrt{2}ML^2$ 4) $4ML^2$

**33. In above problem the moment of inertia of four bodies about an axis passing through opposite corners of frame is**

1) $\sqrt{2}ML^2$ 2) $2ML^2$ 3) $ML^2$ 4) $2\sqrt{2}ML^2$

**34. In the above problem the moment of inertia of four bodies about an axis passing through any side of frame is**

1) $4ML^2$ 2) $2\sqrt{2}ML^2$ 3) $2ML^2$ 4) $\sqrt{2}ML^2$

**35. The diameter of a fly wheel is R. Its coefficient of linear expansion is $\alpha$. If its temperature is increased by $\Delta T$ the percentage increase in its moment of inertia is**

1) $200\times a\times\Delta T$ 2) $100\times a\times\Delta T$
3) $50\times a\times\Delta T$ 4) $150\times a\times\Delta T$

**36. Three point sized bodies each of mass M are fixed at three corners of light triangular frame of side length L. About an axis perpendicular to the plane of frame and passing through centre of frame the moment of inertia of three bodies is**

1) $ML^2$ 2) $\frac{3ML^2}{2}$ 3) $\sqrt{3}ML^2$ 4) $3ML^2$

**37. In above problem, about an axis perpendicular to the plane of frame and passing through a corner of frame the moment of inertia of three bodies is**

1) $ML^2$ 2) $2ML^2$ 3) $\sqrt{3}ML^2$ 4) $\frac{3ML^2}{2}$

**38. In above problem about an axis passing through any side of frame the moment of inertia of three bodies is**

1) $ML^2$ 2) $\frac{3ML^2}{2}$ 3) $\frac{3ML^2}{4}$ 4) $\frac{2ML^2}{3}$

**39. The radius of gyration of a body is 18 cm when it is rotating about an axis passing through centre of mass of body. If radius of gyration of same body is 30 cm about a parallel axis to first axis then, perpendicular distance between two parallel axes is**

1) 12 cm 2) 16 cm 3) 24 cm 4) 36 cm

**40. The position of axis of rotation of a body is changed so that its moment of inertia decreases by 36%. The % change in its radius of gyration is**

1) decreases by 18% 2) increases by 18%
3) decreases by 20% 4) increases by 20%

**41. A diatomic molecule is formed by two atoms which may be treated as mass points $m_1$ and $m_2$ joined by a massless rod of length r. Then the moment of inertia of molecule about an axis passing through centre of mass and perpendicular to the rod is :**

1)zero 2) $(m_1+m_2)r^2$

3) $\left(\frac{m_1m_2}{m_1+m_2}\right)r^2$ 4) $\left(\frac{m_1+m_2}{m_1m_2}\right)r^2$

**42. I is moment of inertia of a thin square plate about an axis passing through opposite corners of plate. The moment of inertia of same plate about an axis perpendicular to the plane of plate and passing through its centre is**

1) I/2 2) $I/\sqrt{2}$ 3) $\sqrt{2}I$ 4) 2I

43. **Mass of thin long metal rod is 2 kg and its moment of inertia about an axis perpendicular to the length of rod and passing through its one end is $0.5 kg\,m^2$. Its radius of gyration is**
1) 20 cm 2) 40 cm 3) 50 cm 4) 1m

## ANGULAR MOMENTUM AND CONSERVATION OF ANGULAR MOMENTUM

44. **The diameter of a disc is 1m. It has a mass of 20kg. It is rotating about its axis with a speed of 120rotations in one minute. Its angular momentum in kg m²/s is**
1)13.4 2) 31.4 3) 41.4 4) 43.4

45. **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**
1) 24/n hours 2) 24n hours
3) $24/n^2$ hours 4) $24n^2$ hours

46. **A particle performs uniform circular motion with an angular momentum L. If the angular frequency f of the particle is doubled, and kinetic energy is halved, its angular momentum becomes**
1) 4L 2) 2L 3) L/2 4) L/4

47. **A ballet dancer is rotating about his own vertical axis at an angular velocity 100 rpm on smooth horizontal floor. The ballet dancer folds himself close to his axis of rotation by which is moment of inertia decreases to half of initial moment of inertia then his final angular velocity is**
1) 50rpm 2) 100rpm
3) 150rpm 4) 200rpm

48. **A circular ring of mass M is rotating about its own axis in horizontal plane at an angular velocity $w$. If two point size bodies each of mass m, are gently attached to the rim of ring at two ends of its diameter, then the angular velocity of ring is**
1) $\frac{Mw}{M+2m}$ 2) $\frac{2mw}{M+2m}$ 3) $\frac{mw}{M+2m}$ 4) $\frac{2Mw}{M+2m}$

49. **A ballet dancer is rotating at angular velocity $w$ on smooth horizontal floor. The ballet dancer folds his body close to his axis of rotation by which his radius of gyration decreases by $1/4^{th}$ of his initial radius of gyration, his final angular velocity is**
1) $\frac{3w}{4}$ 2) $\frac{9w}{4}$ 3) $\frac{9w}{16}$ 4) $\frac{16w}{9}$

50. **A particle of mass m is moving along a circle of radius r with a time period T. Its angular momentum is**
1) $\frac{2p\,mr}{T}$ 2) $\frac{4p\,mr}{T}$ 3) $\frac{2p\,mr^2}{T}$ 4) $\frac{4p\,mr^2}{T}$

51. **If the radius of earth shrinks by 0.2% without change in its mass, the % change in its angular velocity is**
1) increase by 0.4% 2) increase by 0.1%
3) decrease by 0.4% 4) decrease by 0.1%

52. **A metallic circular plate is rotating about its axis without friction. If the radius of plate expands by 0.1% then the % change in its moment of inertia is**
1) increase by 0.1% 2) decrease by 0.1%
3) increase by 0.2% 4) decrease by 0.2%

53. **A constant torque acting on a uniform circular wheel changes its angular momentum from A to 4A in 4sec. The torque acted on it is**
1) $\frac{3A}{4}$ 2) $\frac{A}{4}$ 3) $\frac{2A}{4}$ 4) $\frac{3A}{2}$

54. **Density remaining constant, if earth contracts to half of its present radius, duration of the day would be (in minutes)**
1) 45 2) 80 3) 100 4) 120

55. **A mass is whirled in a circular path with an angular momentum L. If the length of string and angular velocity, both are doubled, the new angular momentum is**
1) L 2) 4L 3) 8L 4) 16L

## ROTATIONAL DYNAMICS

56. **An automobile engine develops 100 KW when rotating at a speed of 1800 rev/min. The torque it delivers ( in N-m )**
1) 350 2) 440 3) 531 4) 628

57. **An electric motor exerts a constant torque 5Nm on a fly wheel by which it is rotated at the rate of 420rpm The power of motor is**
1)110watt 2)150watt
3)220watt 4)300watt

## ROLLING MOTION

58. **A shaft rotating at 3000rpm is transmitting a power of 3.14KW. The magnitude of the driving torque is**
1) 6Nm 2) 10Nm 3) 15Nm 4) 22Nm

59. **A solid sphere rolls down without slipping from rest on a $30^0$ incline. Its linear acceleration is**
1) 5g/7 2) 5g/14 3) 2g/3 4) g/3

60. **A hollow sphere rolls down a $30^o$ incline of length 6m without slipping. The speed of cen tre of mass at the bottom of plane is**
1) $6ms^{-1}$ 2) $3ms^{-1}$ 3) $6\sqrt{2}ms^{-1}$ 4) $3\sqrt{2}ms^{-1}$

**61. For a body rolling along a level surface, the translational and rotational K.E. are equal.The body is**

1) Solid cylinder 2) disc
3) ring 4) hollow sphere

**62. A ring and a disc of same mass roll without slipping along a horizontal surface with same velocity. If the K.E. of ring is 8J, then that of disc is**

1) 2J 2) 4J 3) 6J 4) 16J

**63. When a hollow sphere is rolling without slipping on a rough horizontal surface then the percentage of its total K.E. which is translational is**

1) 72% 2) 28% 3) 60% 4) 40%

**64. If a sphere of mass 2kg and diameter 10cm is rolling at speed of $5ms^{-1}$. Its rotational kinetic energy is**

1)10J 2) 30J 3)50J 4) 70J

## LEVEL-I - (C.W) - KEY

| | | | | | |
|---|---|---|---|---|---|
| 01) 3 | 02) 2 | 03) 2 | 04) 2 | 05) 4 | 06) 2 |
| 07) 4 | 08) 1 | 09) 3 | 10) 4 | 11) 2 | 12) 1 |
| 13) 2 | 14) 2 | 15) 2 | 16) 1 | 17) 4 | 18) 2 |
| 19) 2 | 20) 2 | 21) 1 | 22) 3 | 23) 4 | 24) 4 |
| 25) 3 | 26) 4 | 27) 3 | 28) 2 | 29) 2 | 30) 3 |
| 31) 1 | 32) 4 | 33) 3 | 34) 3 | 35) 1 | 36) 1 |
| 37) 2 | 38) 3 | 39) 3 | 40) 3 | 41) 3 | 42) 4 |
| 43) 3 | 44) 2 | 45) 3 | 46) 4 | 47) 4 | 48) 1 |
| 49) 4 | 50) 3 | 51) 1 | 52) 3 | 53) 1 | 54) 1 |
| 55) 3 | 56) 3 | 57) 3 | 58) 2 | 59) 2 | 60) 1 |
| 61) 3 | 62) 3 | 63) 3 | 64) 1 | | |

## LEVEL-I - (C.W) - HINTS

1. $x_{cm} = \dfrac{m_1x_1 + m_2x_2}{m_1 + m_2}$ 2. $\hat{r}_{cm} = x_{cm}\hat{i} + y_{cm}\hat{j}$

3. $2p\,r = l;\ r = \dfrac{l}{2p}$ 4. $\vec{r}_{cm} = \dfrac{m_1\vec{r_1} + m_2\vec{r_2}}{m_1 + m_2}$

5. $v_b = \dfrac{m \times v}{m + M}$ 6. $\Delta y_{cm} = \dfrac{m_1\Delta y_1 + m_2\Delta y_2}{m_1 + m_2}$

7. $v_{cm} = \dfrac{m_1v_1 + m_2v_2}{m_1 + m_2}$; Internal force does not change the position of centre of mass

8. $m_1r_1 = m_2r_2$ 9. $\vec{v}_{cm} = \dfrac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1 + m_2}$

10. $x_{cm} = \dfrac{-\frac{m}{2}(L/4) - \frac{m}{2}(\cos q)L/4}{m}$

$y_{cm} = \dfrac{\frac{m}{2}\sin q\,(L/4)}{m}$; $r_{cm} = \sqrt{x^2{}_{cm} + y^2{}_{cm}}$

11. $x_{cm} = \dfrac{m_1x_1 + m_2x_2 + m_3x_3}{m_1 + m_2 + m_3}$

12. Center of mass does not change

13. Distance from shore$=(10 - l + d)$ 14. $\vec{v} = \vec{w} \times \vec{r}$

15. Area of triangle $= \dfrac{1}{2}\left|\vec{A} \times \vec{B}\right|$ 16. $\sin q = \dfrac{\left|\vec{A} \times \vec{B}\right|}{AB}$

17. $v = rw;\ r = R\cos q;\ w = \dfrac{2p}{T}$

18. Number of revolutions = area under the curve

19. $w = \dfrac{2p}{60} = \dfrac{p}{30} rads^{-1}$

20. $q = t^3 + t^2 + t + 1$ ;$w = \dfrac{dq}{dt} = 3t^2 + 2t + 1$

21. $a = \dfrac{dw}{dt} = 6t + 2 = 12 + 2 = 14 rads^{-2}$

22. Given $w_i = 0$ and $\theta = \dfrac{1}{2}\alpha t^2$

23. $w_i = 0$; $t = 2s$;

$q = 50(2p) = 100p\ rad$

$\therefore a = \dfrac{2q}{t^2} = \dfrac{200p}{4} = 50p\ rad\ s^{-2}$

'$q$' in 4 sec ; $q = \dfrac{1}{2}a\,t^2 = \dfrac{1}{2}(50p)(16)$

$= 400\,p$ rad

in the last 2 sec, $q = 400p - 100p = 300p\ rad$

$\therefore$ no.of rotations $= \dfrac{q}{2p} = \dfrac{300p}{2p} = 150$

24. $\vec{t} = \vec{r} \times \vec{F}$

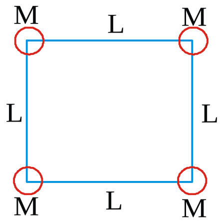
25. $MA = \dfrac{\text{effort arm}}{\text{load arm}}$

26. $I = \Sigma mr^2 = 1(1)^2 + 2(2)^2 + 3(3)^2$

and $K = \sqrt{\dfrac{I}{\Sigma m}}$ Ans: 36, 2.449

27. $I = mr^2 + mr^2 = 2mr^2$ 28. $I_{sphere} = \dfrac{2}{5}MR^2$

29. $I = \dfrac{2}{5}MR^2 = \dfrac{2}{5}\left[\dfrac{4}{3}p\,R^3\right]DR^2 = \dfrac{8}{15}p\,DR^5$

30. 


$I = \sum mr^2$

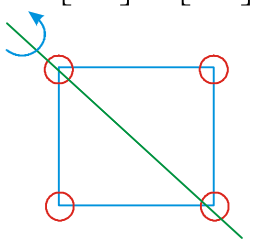
$Here\ r = \frac{L}{\sqrt{2}}$

$\therefore I = 4\left[M\left(\frac{L}{\sqrt{2}}\right)\right] = 2ML^2$

31. $I = \sum mr^2 = 4m\left[\frac{l}{\sqrt{2}}\right]^2 = \frac{4ml^2}{2} = 2ml^2$

Radius of gyration $k = \sqrt{\frac{I}{M}} = \sqrt{\frac{2ml^2}{4m}} = \frac{l}{\sqrt{2}}$

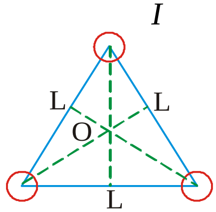
32. $I = 2\left[ML^2\right] + M\left[L\sqrt{2}\right]^2; = 2ML^2 + 2ML^2 = 4ML^2$

33. 

$I = 2\left[M\left(\frac{L}{\sqrt{2}}\right)^2\right] = ML^2$

34. $I = ML^2 + ML^2 = 2ML^2$

35. $I \propto l^2\ and\ \frac{\Delta I}{I} = \frac{2\Delta l}{l} = 2a\Delta T$

36. 


$I = 3\left[M\left(\frac{L}{\sqrt{3}}\right)^2\right]$

$= ML^2$

37. $I = 2\left[ML^2\right]$

38. $I = M\left[\frac{\sqrt{3}L}{2}\right]^2 = \frac{3ML^2}{4}$

39. $K = \sqrt{k_{cm}^2 + d^2}$

40. $I = MK^2 \Rightarrow I\ a\ K^2; \left(\frac{K_2}{K_1} - 1\right) \times 100 = \left(\sqrt{\frac{I_2}{I_1}} - 1\right)$

41. With respect to centre of mass, effective mass

$= \frac{m_1 m_2}{m_1 + m_2}; \therefore I = \left[\frac{m_1 m_2}{m_1 + m_2}\right] r^2$

42. $I = \frac{ML^2}{12}, I_z = I_x + I_y\ ; \therefore I^1 = \frac{ML^2}{6} = 2I$

43. $I = \frac{mL^2}{3}\qquad ; \therefore K = \frac{L}{\sqrt{3}}$

44. $L = Iw$ ;where $I = \frac{mr^2}{2};\ w = 2p\,n$

45. $I_1 w_1 = I_2 w_2;\ \frac{I_1}{T_1} = \frac{I_2}{T_2},\ R_2 = \frac{R_1}{n}$

46. $KE = \frac{1}{2} Lw$

47. $I_1 w_1 = I_2 w_2;\ I_1 n_1 = I_2 n_2 \Rightarrow n_2 = 200rpm$

48. $I_1 w_1 = I_2 w_2$

49. $I_1 w_1 = I_2 w_2;\ mk_1^2 w_1 = mk_2^2 w_2\ ;\ k_1^2 w_1 = \left(\frac{3}{4}k_1\right)^2 w_2$

50. $L = mvr$ and $V = \frac{2\pi r}{T}$

51. $Iw = \frac{2}{5}MR^2 w = \text{constant}\ ; \Rightarrow R^2 w = \text{constant}$

52. $I \propto R^2\ and\ \frac{\Delta I}{I} = 2\frac{\Delta R}{R}$ 53. $t = \frac{L_2 - L_1}{t}$

54. $I_1 w_1 = I_2 w_2$ and $R_1{}^5 T_1 = R_2{}^5 T_2$

55. $L = mrw^2;\ L \propto rw^2; \frac{L_1}{L_2} = \frac{r_1}{r_2} \times \left(\frac{w_1}{w_2}\right)^2$

56. $p = tw$ 57. $p = tw$ 58. $p = tw$

59. $a = \frac{g\sin q}{1 + \frac{k^2}{R^2}}$ 60. $v = \sqrt{\frac{2gl\sin q}{1 + \frac{k^2}{R^2}}}$

61. $\frac{1}{2}mv^2 = \frac{1}{2}Iw^2$ 62. $KE = \frac{1}{2}mv^2\left(1 + \frac{k^2}{R^2}\right)$

63. $\frac{KE_T}{KE_{TOTAL}} \times 100 = \left(\frac{1}{1 + \frac{K^2}{R^2}}\right) \times 100$ 64. $KE_{rot} = \frac{1}{2}Iw^2$

## LEVEL - I (H.W)

## CENTRE OF MASS

**1. The distance of centre of mass from 'O' is**


1)0.21m 2) 0.35m 3) 0.42m 4) 0.48m

2. **Four bodies of masses 1,2,3,4 kg respectively are placed at the comers of a square of side 'a'. Coordinates of centre of mass are (take 1kg at the origion, 2kg on X-axis and 4kg on Y-axis)**

1) $\left(\frac{7a}{10}, \frac{a}{2}\right)$ 2) $\left(\frac{a}{2}, \frac{7a}{10}\right)$ 3) $\left(\frac{a}{2}, \frac{3a}{10}\right)$ 4) $\left(\frac{7a}{10}, \frac{3a}{2}\right)$

3. A uniform rod of length one meter is bent at its midpoint to make $90^0$. The distance of centre of mass from the centre of rod is (in cm)
1) 20.2 2) 13.4 3) 15 4) 35.36

4. Particles of masses 1kg and 3kg are at $(2i+5j+13k)m$ and $(-6i+4j-2k)m$ then instantaneous position of their centre of mass is
1) $\frac{1}{4}(-16i+17j+7k)m$
2) $\frac{1}{4}(-8i+17j+7k)m$
3) $\frac{1}{4}(-6i+17j+7k)m$
4) $\frac{1}{4}(-6i+17j+5k)m$

5. A boat of mass 50kg is at rest. A dog of mass 5kg moves in the boat with a velocity of 20m/s. What is the velocity of boat?
1) 4m/s 2) 2m/s 3) 8m/s 4) 1 m/s

## MOTION OF CENTRE OF MASS, LINEAR MOMENTUM OF CENTRE OF MASS

6. Two bodies of masses 5kg and 3kg are moving towards each other with $2ms^{-1}$ and $4ms^{-1}$ respectively. Then velocity of centre of mass is
1) $0.25ms^{-1}$ towards 3kg 2) $0.5ms^{-1}$ towards 5kg
3) $0.25ms^{-1}$ towards 5kg 4) $0.5ms^{-1}$ towards 3kg

7. A circular disc of radius 20cm is cut from one edge of a larger circular disc of radius 50cm. The shift of centre of mass is
1) 5.7cm 2) -5.7cm 3) 3.2cm 4) -3.2cm

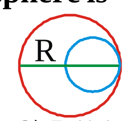
8. Two particles of masses 4kg and 6kg are separated by a distance of 20m and are moving towards each other under mutual force of attraction, the position of the point where they meet is
1) 12m from 4kg body 2) 12m from 6kg body
3) 8m from 4kg body 4) 10m from 4kg body

9. A uniform metre rod is bent into L shape with the bent arms at $90^0$ to each other. The distance of the center of mass from the bent point is
1) $\frac{L}{4\sqrt{2}}m$ 2) $\frac{L}{2\sqrt{2}}m$ 3) $\frac{L}{\sqrt{2}}m$ 4) $\frac{L}{8\sqrt{2}}m$

10. Two objects of masses 200g and 500g have velocities of $10i$ m/s and $(3i+5j)m/s$ respectively. The velocity of their centre of mass is
1) $5i-25j$ 2) $\frac{5}{7}i-25j$
3) $5i+\frac{25}{7}j$ 4) $25i-\frac{5}{7}j$

## VECTOR PRODUCT OR CROSS PRODUCT

11. The position of a particle is given by $\vec{r}=\hat{i}+2\hat{j}-\hat{k}$ and its momentum is $\vec{p}=3\hat{i}+4\hat{j}-2\hat{k}$. The angular momentum is perpendicular to
1) x-axis 2) y-axis 3) z-axis
4) line at equal angles to all the axes

12. A uniform sphere has radius R. A sphere of diameter R is cut from its edge as shown. Then the distance of centre of mass of remaining portion from the centre of mass of the original sphere is


1)R/7 2) R/14 3)2R/7 4) R/18

13. The area of the parallelogram whose adjacent sides are $P=3\hat{i}+4\hat{j};\ Q=-5\hat{i}+7\hat{j}$ is (in sq.units)
1)20.5 2) 82 3) 41 4) 46

14. If $\vec{A}=3i+j+2k$ and $\vec{B}=2i-2j+4k$ and $q$ is the angle between the two vectors, then $\sin q$ is equal to
1) $\frac{2}{3}$ 2) $\frac{2}{\sqrt{3}}$ 3) $\frac{2}{\sqrt{7}}$ 4) $\frac{2}{\sqrt{13}}$

## ROTATIONAL VARIABLES, RELATION BETWEEN LINEAR AND ANGULAR VARIABLES

15. A particle is moving with uniform speed 0.5m/s along a circle of radius 1m then the angular velocity of particle is (in $rads^{-1}$)
1)2 2)1.5 3)1 4) 0.5

16. The angular velocity of the seconds hand in a watch is
1) 0.053 rad/s 2) 0.210 rad/s
3) 0.105 rad/s 4) 0.42 rad/s

**17.** **The angular displacement of a particle is given by $q = t^3 + 2t + 1$, where t is time in seconds. Its angular acceleration at t = 2s is**

1) $14\,rad\,s^{-2}$  2) $17\,rad\,s^{-2}$

3) $12\,rad\,s^{-2}$  4) $9\,rad\,s^{-2}$

## ROTATIONAL KINEMATICS, TORQUE, MECHANICAL EQUILIBRIUM

**18.** **A circular disc is rotating about its own axis at a uniform angular velocity $w$. The disc is subjected to uniform angular retardation by which its angular velocity is decreased to $\frac{w}{2}$ during 120 rotations. The number of rotations further made by it before coming to rest is**

1)120  2) 60  3) 40  4) 20

**19.** **The handle of a door is at a distance 40cm from axis of rotation. If a force 5N is applied on the handle in a direction $30^0$ with plane of door, then the torque is**

1) 0.8 Nm  2) 1 Nm  3) 1.6 Nm  4) 2 Nm

**20.** **A door can just be opened with 10N force on the handle of the door. The handle is at a distance of 50cm from the hinges. Then, the torque applied on the door (in Nm) is**

1) 5  2) 10  3) 15  4) 20

**21.** **A particle of mass m is projected with an initial velocity u at an angle $q$ to horizontal.The torque of gravity on projectile at maximum height about the point of projection is**

1) $\frac{mgu^2 \sin 2q}{2}$  2) $mgu^2 \sin 2q$

3) $\frac{mgu^2 \sin q}{2}$  4) $\frac{1}{2} mu^2 \sin 2q$

**22.** **A uniform rod is 4m long and weights 10kg. If it is supported on a knife edge at one meter from the end, what weight placed at that end keeps the rod horizontal.**

1) 8kg  2) 10kg  3) 12kg  4) 15kg

## ROTATIONAL INERTIA OF SOLID BODIES

**23.** **The ratio of moments of inertia of a solid sphere about axes passing through its centre and tangent respectively is**

1) 2:5  2) 2:7  3) 5:2  4) 7:2

**24.** **If I is moment of inertia of a thin circular plate about an axis passing through tangent of plate in its plane. The moment of inertia of same circular plate about an axis perpendicular to its plane and passing through its centre is**

1) $\frac{4I}{5}$  2) $\frac{2I}{5}$  3) $\frac{4I}{3}$  4) $\frac{2I}{3}$

**25.** **The moment of inertia of a solid sphere about an axis passing through its centre is $0.8 kgm^2$. The moment of inertia of another solid sphere whose mass is same as mass of first sphere, but the density is 8 times density of first sphere, about an axis passing through its centre is**

1) $0.1 kgm^2$  2) $0.2 kgm^2$

3) $0.4 kgm^2$  4) $0.5 kgm^2$

**26.** **Moment of inertia of a hoop suspended from a peg about the peg is**

1) $MR^2$  2) $\frac{MR^2}{2}$  3) $2MR^2$  4) $\frac{3MR^2}{2}$

**27.** **Four particles each of mass 1kg are at the four corners of square of side 1m. The M.I.of the system about a normal axis through centre of square is**

1) $6\,kgm^2$  2) $2\,kgm^2$  3) $1.25\,kgm^2$  4) $2.5\,kgm^2$

**28.** **Three identical masses, each of mass 1kg, are placed at the corners of an equilateral triangle of side *l*. Then the moment of inertia of this system about an axis along one side of the triangle is**

1) $3l^2$  2) $l^2$  3) $\frac{3}{4}l^2$  4) $\frac{3}{2}l^2$

**29.** **A wire of mass m and length *l* is bent in the form of circular ring. The moment of inertia of the ring about its axis is**

1) $ml^2$  2) $\frac{ml^2}{4p^2}$  3) $\frac{ml^2}{2p^2}$  4) $\frac{ml^2}{8p^2}$

**30.** **The moment of inertia of a thin uniform rod of mass M and length L about an axis perpendicular to the rod, through its centre is I.The moment of inertia of the rod about an axis perpendicular to rod through its end point is**

1) $\frac{I}{4}$  2) $\frac{I}{2}$  3) $2I$  4) $4I$

**31. Four point size bodies each of mass m are fixed at four corners of light square frame of side length 1m. The radius of gyration of these four bodies about an axis perpendicular to the plane of frame passing through its centre is**

1) $\sqrt{2}$ 2) 2 3) $\frac{1}{\sqrt{2}}$ 4) $\frac{1}{2}$

**32. Uniform square plate of mass 240 gram is made to rotate about an axis passing through any diagonal of plate. If its moment of inertia is $2\times10^{-4}kgm^2$ then its side length is**

1) 10cm 2) 12cm 3) 15cm 4) 20cm

**33. Two objects of masses 1kg and 2kg separated by a distance of 1.2m are rotating about their centre of mass. Find the moment of inertia of the system**

1) $0.96kgm^2$ 2) $0.48kgm^2$

3) $0.83kgm^2$ 4) $0.72kgm^2$

**34 The radius of gyration of a body about an axis at a distance of 4cm from its centre of mass is 5cm. The radius of gyration about a parallel axis through centre of mass is**

1) 2cm 2) 5cm 3) 4cm 4) 3cm

**35. The M.I. of a thin rod about a normal axis through its centre is I. It is bent at the centre such that the two parts are perpendicular to each other and perpendicular to the axis. The M.I. of the system about the same axis will be**

1) 2I 2) I 3) I/2 4) 4I

**36. The moment of inertia of two spheres of equal masses about their diameters are the same. One is hollow, then ratio of their diameters**

1) 1:5 2) $1:\sqrt{5}$ 3) $p:1$ 4) $\sqrt{5}:\sqrt{3}$

## ANGULAR MOMENTUM AND CONSERVATION OF ANGULAR MOMENTUM

**37. A circular disc of mass 4kg and of radius 10cm is rotating about its natural axis at the rate of 5 rad/sec. its angular momentum is**

1) $0.25kgm^2s^{-1}$ 2) $0.1kgm^2s^{-1}$

3) $2.5kgm^2s^{-1}$ 4) $0.2kgm^2s^{-1}$

**38. If the mass of earth and radius suddenly become 2 times and 1/4th of the present value, the length of the day becomes**

1) 24h 2) 6h 3) 3/2h 4) 3h

**39. A child is standing with folded hands at the centre of a platform rotating about its central axis. The K.E. of the system is K. The child now stretches his arms so that the M.I. of the system doubles. The K.E. of the system now is**

1) 2K 2) K/2 3) 4K 4) K/4

**40. If radius of earth shrinks by 0.1% without change in its mass, the percentage change in the duration of one day**

1) decrease by 0.1% 2) increase by 0.1%

3) decrease by 0.2% 4) increase by 0.2%

**41. A ballet dancer spins about a vertical axis at 60rpm with his arms closed. Now he stretches his arms such that M.I. increases by 50%. The new speed of revolution is**

1) 80rpm 2) 40rpm 3) 90rpm 4) 30rpm

**42. A metallic circular wheel is rotating about its own axis without friction. If the radius of wheel expands by 0.2%, percentage change in its angular velocity**

1) increase by 0.1% 2) decrease by 0.1%

3) increase by 0.4% 4) decrease by 0.4%

**43. A uniform circular disc of radius R is rotating about its own axis with moment of inertia I at an angular velocity $w$ If a denser particle of mass m is gently attached to the rim of disc than its angular velocity is**

1) $w$ 2) $Iw(I+mR)$ 3) $\frac{I+mR^2}{Iw}$ 4) $\frac{Iw}{I+mR^2}$

**44. A particle of mass m is rotating along a circular path of radius r. Its angular momentum is L. The centripetal force acting on the particle is**

1) $\frac{L^2}{mr}$ 2) $\frac{L^2m}{r}$ 3) $\frac{L^2}{mr^2}$ 4) $\frac{L^2}{mr^3}$

**45. $\vec{F}=a\hat{i}+3\hat{j}+6\hat{k}$ and $\vec{r}=2\hat{i}-6\hat{j}-12\hat{k}$. The value of 'a' for which the angular momentum is conserved is**

1) -1 2) 0 3) 1 4) 2

**46. If earth shrinks to 1/64 of its volume with mass remaining same, duration of the day will be**

1) 1.5h 2) 3h 3) 4.5h 4) 6h

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

1) L/4 2) L/2 3) L 4) 2L

**48. A disc rotates with angular velocity $w$ and kinetic energy E. Then its angular momentum**

1) $Iw$ 2) $L=\frac{E}{w}$ 3) $L=\frac{2E}{w}$ 4) $L=\frac{w}{E}$

## ROTATIONAL DYNAMICS

49. A wheel at rest has M.I. $\frac{2}{p^2}kgm^2$. It is rotated by a 60W motor for one minute. The number of rotations made by the wheel in one minute is
1) 90 2) 450 3) 1800 4) 1200

50. The shaft of a motor is making 1260rpm. The torque supplied by the motor is 100Nm. the power of motor is (in KW)
1) 100 2) 21 3) 13.2 4) 4.8

51. An electric motor rotates a wheel at a constant angular velocity $10rps$ while opposing torque is $10Nm$. The power of that electric motor is
1) 120W 2) 628W 3) 314W 4) 3.14W

52. The work done in increasing the angular frequency of a circular ring of mass 2kg and radius 25cm from 10 rpm to 20rpm about is axis
1)0.2058J 2)0.2040J 3)0.2085J 4)0.2004J

## ROLLING MOTION

53. A ring is allowed to roll down on an incline of 1 in 10 without slipping. The acceleration of its center of mass is
1) $9.8ms^{-2}$ 2) $4.9ms^{-2}$ 3) $0.98ms^{-2}$ 4) $0.49ms^{-2}$

54. A cylinder is released from rest from the top of an incline of inclination $q$ and length '$l$'. If the cylinder roles without slipping, its speed at the bottom
1) $\sqrt{\frac{4gl\sin q}{3}}$ 2) $\sqrt{\frac{3gl\sin q}{2}}$
3) $\sqrt{\frac{4gl}{3\sin q}}$ 4) $\sqrt{\frac{4g\sin q}{3l}}$

55. For a body rolling along a level surface, without slipping the translational and rotational kinetic energies are in the ratio 2:1.The body is
1) Hollow sphere 2) solid cylinder
3) Ring 4) Solid sphere

56. A solid sphere and a spherical shell roll down an incline from rest from same height. The ratio of times taken by them is
1) $\sqrt{\frac{21}{25}}$ 2) $\frac{21}{25}$ 3) $\sqrt{\frac{25}{21}}$ 4) $\frac{25}{21}$

57. When a solid sphere is rolling along level surface the percentage of its total kinetic energy that is translational is
1) 29% 2) 71% 3) 60% 4) 40%

58. A thin ring of mass 1kg and radius 1m is rolling at a speed of $1ms^{-1}$. Its kinetic energy is
1) 2J 2) 1J 3) 0.5J 4) zero

## LEVEL-I (H.W) - KEY

| | | | | | |
|---|---|---|---|---|---|
| 01) 4 | 02) 2 | 03) 4 | 04) 1 | 05) 2 | 06) 3 |
| 07) 2 | 08) 1 | 09) 1 | 10) 3 | 11) 1 | 12) 2 |
| 13) 3 | 14) 3 | 15) 4 | 16) 3 | 17) 3 | 18) 3 |
| 19) 2 | 20) 1 | 21) 4 | 22) 2 | 23) 2 | 24) 2 |
| 25) 2 | 26) 3 | 27) 2 | 28) 3 | 29) 2 | 30) 4 |
| 31) 3 | 32) 1 | 33) 1 | 34) 4 | 35) 2 | 36) 4 |
| 37) 2 | 38) 4 | 39) 2 | 40) 3 | 41) 2 | 42) 4 |
| 43) 4 | 44) 4 | 45) 1 | 46) 1 | 47) 1 | 48) 3 |
| 49) 3 | 50) 3 | 51) 2 | 52) 1 | 53) 4 | 54) 1 |
| 55) 2 | 56) 1 | 57) 2 | 58) 2 | | |

## LEVEL-I (H.W) - HINTS

1. $x_{cm} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$

2. $x_{cm} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$; $y_{cm} = \frac{m_1y_1 + m_2y_2}{m_1 + m_2}$

3. $d = \frac{L}{4}Sin\left(\frac{\theta}{2}\right)$

4. $\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1 + m_2}$

5. $v_b = \frac{m \times v}{m + M}$

6. $v_{cm} = \frac{m_1v_1 + m_2v_2}{m_1 + m_2}$

7. $shift = -\frac{r^2d}{R^2 - r^2}$

8. $m_1r_1 = m_2r_2$

9. $r_{cm} = \sqrt{x_{cm}^2 + y_{cm}^2}$ (or) $r_{cm} = \frac{L}{4}\cos\frac{q}{2}$

10. $\vec{v}_{cm} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1 + m_2}$

11. $\vec{r} \times \vec{F} = \vec{t}$; $\vec{t} \perp x - axis$

12. $shift = \frac{r^3d}{R^3 - r^3}$

13. Area of parallelogram $= \left|\vec{P} \times \vec{Q}\right|$

14. $\sin q = \frac{\left|\vec{A} \times \vec{B}\right|}{AB}$

15. $w = \frac{v}{r}$

16. $w = \frac{2p}{60}$

17. $a = \frac{dw}{dt}$

18. $a$ is constant, $a = \dfrac{w_1^2 - w_2^2}{2q}; \ q_2 = \dfrac{q_1}{3}$

19. $t = rF \sin q$

20. $t = rF$

21. $\vec{\tau} = \left[\dfrac{R}{2}\hat{i} + H\hat{j}\right] \times mg\,\hat{j}$

22. clockwise torque = anticlockwise torque

23. $\dfrac{I_{centre}}{I_{\tan get}} = \dfrac{\frac{2}{5}MR^2}{\frac{7}{5}MR^2} = \dfrac{2}{7}$

24. $I = \dfrac{5MR^2}{4} \ \& \ I^{|} = \dfrac{MR^2}{2}$

25. Mass is same and $D \propto \dfrac{1}{R^3}; \dfrac{I_1}{I_2} = \left(\dfrac{R_1}{R_2}\right)^2 = \left(\dfrac{D_2}{D_1}\right)^{\frac{2}{3}}$

26. It is equivalent to ring rotating about an axis passing through tangent.

27. $I = \sum mr^2; \ r = \dfrac{l}{\sqrt{2}}$

28. $I = M\left[\dfrac{\sqrt{3}l}{2}\right]^2$

29. $I = mr^2; \ r = \dfrac{l}{2p}$

30. $I = \dfrac{ML^2}{12}; I = I_{CM} + M\left(\dfrac{L}{2}\right)^2$

31. $I = 2ml^2; \ k = \sqrt{\dfrac{I}{4m}}$

32. $I_z = I_x + I_y; \dfrac{Ml^2}{12} = I + I$

33. $I = \left(\dfrac{m_1 m_2}{m_1 + m_2}\right) r^2$

34. $I = mk^2; \ I = I_0 + mr^2$

35. $I = \dfrac{ml^2}{12}; \ I^{|} = \dfrac{m}{2}\dfrac{\left(\frac{l}{2}\right)^2}{3} + \dfrac{m}{2}\dfrac{\left(\frac{l}{2}\right)^2}{3} = I$

36. M.I. of solid sphere about diameter $= \dfrac{2}{5}mr^2$

M.I. of hollow sphere about diameter $= \dfrac{2}{3}mr^2$

37. $L = Iw = \dfrac{mr^2}{2}w$

38. $I_1 w_1 = I_2 w_2$

39. $KE = \dfrac{L^2}{2I}$

40. $Iw = \dfrac{2}{5}MR^2 \times \left(\dfrac{2p}{T}\right) = \text{constant}$

$T \propto R^2 \ \ and \ \ \dfrac{\Delta T}{T} = 2\dfrac{\Delta R}{R}$

41. $I_1 w_1 = I_2 w_2; \ I_1 n_1 = I_2 n_2$

42. $Iw = mr^2 w = \text{constant}$

$w \propto r^{-2} \ \ and \ \ \dfrac{\Delta w}{w} = -2\dfrac{\Delta r}{r}$

43. $I_1 w_1 = I_2 w_2; \ I_1 = I; \ I_2 = I + mR^2$

44. $L = mvr \Rightarrow v = \dfrac{L}{mr}$

centripetal force $F = \dfrac{mv^2}{r} = \dfrac{L^2}{mr^3}$

45. $\vec{t} = \vec{r} \times \vec{F} \ \ and \ \ t = \dfrac{dL}{dt} = 0$

46. $Iw = \dfrac{2}{5}MR^2 w = \text{constant} \ \ and \ V \propto R^3$

47. $L = mr^2 w; \ L \propto r^2; \ \dfrac{L_1}{L_2} = \left(\dfrac{r_1}{r_2}\right)^2 \Rightarrow L_2 = \dfrac{L}{4}$

48. $KE = \dfrac{1}{2}Lw$

49. $p = \dfrac{tq}{t}; \ q = 2pN$

50. $p = tw$

51. $p = tw$

52. $W = \dfrac{1}{2}I\left(w_2^2 - w_1^2\right)$

53. $a = \dfrac{g \sin q}{1 + \frac{k^2}{R^2}}$

54. $v = \sqrt{\dfrac{2gl \sin q}{1 + \frac{k^2}{R^2}}}$

55. $\dfrac{\frac{1}{2}mV^2}{\frac{1}{2}Iw^2} = \dfrac{2}{1}$

56. $t = \dfrac{\sqrt{2l\left(1 + \frac{k^2}{R^2}\right)}}{g \sin q}$

57. $\dfrac{KE_T}{KE_{trans}} \times 100 = \left(\dfrac{1}{1 + \frac{k^2}{R^2}}\right) \times 100$

58. $KE_{rot} = \dfrac{1}{2}Iw^2$