QB365 Question Bank Software Study Materials

Motion of System of Particles and Rigid Bodies Important 2 Marks Questions With Answers (Book Back and Creative)

11th Standard

Physics

Total Marks : 60

2 Marks

30 x 2 = 60

1) Define centre of mass.

Answer : The center of mass of a body is defined as a point where the entire mass of the body appears to be concentrated.

2) Define torque and mention its unit.

Answer : Torque is defined as the moment of the external applied force about a point or axis of rotation.
Torque $\vec{\tau} = \vec{r} \times \vec{F}$ its unit is Nm.

3) Define couple.

Answer : A pair of forces which are equal in magnitude but opposite in direction and separated by a perpendicular distance so that their lines of action do not coincide that causes a turning effect is called a couple.

4) Define centre of gravity.

Answer : The center of gravity of a body is the point at which the entire weight of the body acts irrespective of the position and orientation of the body.

5) What is radius of gyration?

Answer : Radius of gyration of an object is the perpendicular distance from the axis of rotation to an equivalent point mass, which would have the same mass as well as the same moment of inertia of the object.

6) State conservation of angular momentum.

Answer : Law of conservation of angular momentum states that, when no external torque acts on the body, the net angular momentum of a rotating body remains constant.

7) What are the rotational equivalents for the physical quantities
(i) mass and
(ii) force?

Answer : The rotational equivalents of
(i) Mais is moment of inertia, I = $\sum$mr^2
(ii) Force is Torque τ = Iα

8) What is the condition for pure rolling?

Answer : The conditions for pure rolling we
1. The total kinetic energy is the sum of kinetic energies of translational and rotational motions.
2. There is no relative motion of the point of contact urith the surface.
3. When the rolling object speeds up or slower down, it must accelerate or decelerate respectively. If this suddenly happens the rolling object to ship or slide.

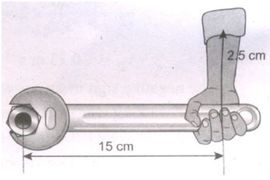
9) What is the difference between sliding and slipping?

Answer :

S.No	Sliding	Slipping
1.	In sliding the transitional motion is more than rotational	In slipping the rotation is more than ffanslational motion

	motion.	translational motion.
2.	It happens when sudden brake is applied in a moving vehicles or when the vehicle enters into a slippery road.	It happens when we suddenly start the vehicle from rest or the vehicle isstuck in mud.

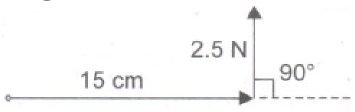
10) If the force applied is perpendicular to the handle of the spanner as shown in the diagram find the (i) torque exerted by the force about the center of the nut (ii) direction of torque and (iii) type of rotation caused by the torque about the nut.



Answer : Arm length of the spanner, r = 15 cm = 15×10^{-2}m

Force, F = 2.5 N

Angle between rand F, $\theta = 90^0$



(i) Torque, $\tau = rFsin\theta$

$\tau = 15 \times 10^{-2} \times 2.5 \times sin(90^0)$

[here, sin 90° = 1]

$\tau = 37.5 \times 10^{-2} Nm$

(ii) As per the right hand rule, the direction of torque is out of the page.

(iii) The type of rotation caused by the torque is anticlockwise.

11) A force of $(4\hat{i} - 3\hat{j} + 5\hat{k})$ N is applied at a point whose position vector is $(7\hat{i} + 4\hat{j} - 2\hat{k})$ m. Find the torque of force about the origin.

Answer : $\vec{r} = 7\hat{i} + 4\hat{j} - 2\hat{k}$

$\vec{F} = 4\hat{i} - 3\hat{j} + 5\hat{k}$

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

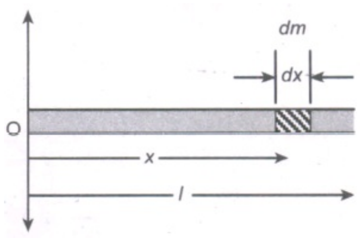
$$\vec{\tau} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 7 & 4 & -2 \\ 4 & -3 & 5 \end{vmatrix}$$

$\vec{\tau} = \hat{i}(20 - 6) - \hat{j}(35 + 8) + \hat{k}(-21 - 16)$

$\vec{\tau} = (14\hat{i} - 43\hat{j} - 37\hat{k})Nm$

12) Find the moment of inertia of a uniform rod about an axis which is perpendicular to the rod and touches anyone end of the rod.

Answer : The concepts to form the integrand to find the moment of inertia could be borrowed from the earlier derivation. Now, the origin is fixed to the left end of the rod and the limits are to be taken from 0 to l.



$I = \frac{M}{l}\int_0^1 x^2 dx = \frac{M}{l}[\frac{x^3}{3}]_0^1 = \frac{M}{l}[\frac{l^3}{3}]$

$I = \frac{1}{3}Ml^2$

13) Find the radius of gyration of a disc of mass M and radius R rotating about an axis passing through the center of mass and perpendicular to the plane of the disc.

Answer : The moment of inertia of a disc about an axis passing through the center of mass and perpendicular to the disc is,

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

In terms of radius of gyration, I = MK^2

Hence, $Mk^2 = \frac{1}{2}MR^2; K^2 = \frac{1}{2}R^2$

$K = \frac{1}{\sqrt{2}}R \; or \; K = \frac{1}{1.414}R \; or \; K = (0.707)R$

From the case of a rod and also a disc, we can conclude that the radius of gyration of the rigid body is always a geometrical feature like length, breadth, radius or their combinations with a positive numerical value multiplied to it.

14) Four round objects namely a ring, a disc, a hollow sphere and a solid sphere with same radius R start to roll down an incline at the same time. Find out which object will reach the bottom first.

Answer : For all the four objects namely the ring, disc, hollow sphere and solid sphere, the radii of gyration K are R, $\sqrt{\frac{1}{2}R}$, $\sqrt{\frac{2}{3}R}$, $\sqrt{\frac{2}{5}R}$. With numerical values the radius of gyration K are 1R, 0.707R, 0.816R, 0.632R respectively. The expression for time taken for rolling has the radius of gyration K in the numerator as per equation.

$t = \sqrt{\frac{2h(1+\frac{K^2}{R^2})}{8sin^2\theta}}$ $\quad V = \sqrt{\frac{2gh}{[1+\frac{K^2}{R^2}]}}$

The one with least value of radius of gyration K will take the shortest time to reach the bottom of the inclined plane. The order of objects reaching the bottom is first, solid sphere second, disc third, hollow sphere and last, ring.

15) A particle of mass (m) is moving with constant velocity (v). Show that its angular momentum about any point remains constant throughout the motion.

Answer : Let the particle of mass m move with constant velocity $\vec{v}$. As it is moving with constant velocity, its path is a straight line. Its momentum $(\vec{p} = m\vec{v})$ is also directed along the same path. Let us fix an origin (O) at a perpendicular distance (d) from the path. At a particular instant, we can connect the particle which is at positon Q with a position vector $(\vec{\mathrm{r}} = \overrightarrow{\mathrm{OQ}})$Take, the angle between the $\vec{\mathrm{r}}$ *and* $\vec{\mathrm{p}}$ *as* θ. The magnitude of angular momentum of that particle at that instant is,

$\mathrm{L} = \mathrm{OQp}\sin\theta = \mathrm{OQ}mv\sin\theta = mv(\mathrm{OQ}\sin\theta)$

The term $(\mathrm{OQ}\sin\theta)$ is the perpendicular distance (d) between the origin and line along which the mass is moving. Hence, the angular momentum of the particle about the origin is,

L = mvd

The above expression for angular momentum L, does not have the angle θ. As the momentum (p = mv) and the perpendicular distance (d) are constants, the angular momentum of the particle is also constant. Hence, the angular momentum is associated with bodies with linear motion also. If the straight path of the particle passes through the origin, then the angular momentum is zero, which is also a constant.

16) State principle of moments.

Answer : The principle of moments states that, "when an object is in equilibrium, the sum of the anti clockwise moments about a turning point must be equal to the sum of the clockwise moments.

17) A uniform disc of mass 100g has a diameter of 10 cm. Calculate the total energy of the disc when rolling along a horizontal table with a velocity of 20 cms^{-1}. (take the surface of table as reference)

Answer : Mass of a uniform disc M = 100g = 100 x 10^{-3} kg

Diameter d = 10cm

Radius r = 5cm =5 x 10^{-2} m

v = 20 ms^{-1}

Velocity v = 20 x 10^{-2} ms^{-1}

When rolling, the total energy of the disc = Translational K.E. + Rolling K.E

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

But I =$\frac{1}{2}mr^2$

$\therefore E = \frac{1}{2}mv^2 + \frac{1}{2}(\frac{1}{2}mr^2)\frac{v^2}{r^2}[\omega = \frac{v}{r}]$

$= \frac{1}{2}mv^2 + \frac{1}{4}mv^2 = \frac{3}{4}mv^2$

$= \frac{3}{4}$ x 100 x 10^{-3} x (20 x 10^{-2})^2

$= \frac{3}{4}$ x 100 x 10^{-3} x 400 x 10^{-4}

Total energy = 30000 x 10^{-7} = 0.003 J

18) A particle of mass 5 units is moving with a uniform speed of v = $3\sqrt{2}$ units in the XOY plane along the line y = x + 4. Find the magnitude of angular momentum.

Answer : Mass of a particular = 5 units

Uniform speed v = $3\sqrt{2}$ units

y = x + 4

Angular momentum, L = Iω

L = mr$^2\omega$

$\omega = \frac{v}{r}$

$\therefore L = m\frac{r^2 av}{r}$

L = mvr 5 x $3\sqrt{2}$ x $2\sqrt{2}$

= 60 units

19) A fly wheel rotates with a uniform angular acceleration. If its angular velocity increases from $20\pi\mathrm{rad/s}\ to\ 40\pi\mathrm{rad/s}$ in 10 seconds. Find the number of rotations in that period.

Answer : Initial angular velocity $\omega_0 = 20\pi\mathrm{rad/s}$

Final angular velocity $\omega = 40\pi\mathrm{rad/s}$

Time = 10s

Angular acceleration $\alpha = \frac{\omega - \omega_v}{t}$

$= \frac{40\pi - 20\pi}{10} = \frac{20\pi}{10} = 2\pi$

$= 2 \times 3.14 = 6.28\mathrm{rad/s}^2$

The angular displacement in time t

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

$= 20\pi \times 10 + \frac{1}{2} \times 2\pi \times (10)^2$

$= 200\pi + 100\pi$

$= 300\pi\mathrm{rad}$

Number of rotations in that period $\mathrm{n} = \frac{\theta}{2\pi} = \frac{300\pi}{2\pi} = 150$

Number of rotations in that period =150 rotations

20) Find the moment of inertia of a hydrogen molecule about an axis passing through its center of mass and perpendicular to the inter-atomic axis. Given: mass of hydrogen atom 1.7 x 10^{-27} kg and inter atomic distance is equal to 4 x 10^{-10}m.

Answer : Mass of each H-atom $= 1.7 \times 10^{-27}$ kg

Distance of each H-atom from the axis of rotation = 2 x 10^{-10} m.

Moment of inertia of a hydrogen molecule

$\mathrm{I} = mr^2 + mr^2$

$\mathrm{I} = 2mr^2$

$= 2 \times 1.7 \times 10^{-27} \times \left(2 \times 10^{-10}\right)^2$

$= 2 \times 1.7 \times 4 \times 10^{-27-20} = 13.6 \times 10^{-47}$

$\mathrm{I} = 1.36 \times 10^{-46}\mathrm{kgm}^2$

21) A torque of 2.0 x 10^{-4} Nm is applied to produce an angular acceleration of 4 rad S^{-2} in a rotating body. What is the moment of inertia of the body?

Answer : Here τ = 2.0 × 10^{-4}Nm,

α = 4 rad s^{-2}, I = ?

Formula: τ = Iα

I = $\frac{\tau}{\alpha} = \frac{2.0 \times 10^{-4}}{4}$ = 0.5 × 10^{-4} kgm^2

22) The distance between the centres of carbon and oxygen atoms in the carbon monoxide gas molecule is 1.13 $\mathring{A}$. Locate the centre of mass of the gas molecule relative to the carbon atom.

Answer : $x_{CM} = \frac{m_1 + m_2 + m_2 x_2}{m_1 + m_2} = \frac{12 \times 0 + 16 \times 1.13}{12 + 16} = 0.6457\ \mathring{A}$

23) A labourer standing near the top of an old wooden step ladder feels unstable. Why?

Answer : The ladder can rotate about the point of contact of the ladder with the ground. When the labourer is at the top of the ladder, the lener arm of the force is large. Hence the turning effect on the ladder will be large.

24) The bottom of a ship is made heavy. Why?

Answer : The bottom of a ship is made heavy so that its centre of gravity remains low. This ensures the stability of its equilibrium.

25) Which component of a force does not contribute towards torque?

Answer : The radial component of a force does not contribute towards torque.

26) What happens to the centre of mass if an explosion is caused by external forces?

Answer : The kinematic quantities of the centre of mass as well as the fragments get affected.

27) The distance between the centres of carbon and oxygen atoms in the carbon monoxide gas molecule is 1.13Å. Locate the center of mass of carbon monoxide relative to the carbon atom.

Answer : Centre of mass $x_{\mathrm{cm}}=\frac{m_1x_1+m_2x_2}{m_1+m_2}$

$x_{\mathrm{cm}}=\frac{12\times0+16\times1.13}{12+16}=\frac{18.08}{28}=0.064457\theta$

28) What is the amount of power needed to maintains uniform circular motion?

Answer : No power is needed to maintain uniform circular motion.

29) Define expression for power delivered by torque?

Answer : $\tau=\frac{dw\theta}{d\theta}$ $\therefore \mathrm{dw}=\tau \mathrm{d}\theta$

Power P = $\frac{dw}{dt}=\frac{\tau d\theta}{dt}$

$\mathrm{P}=\tau\omega$

30) What is the effect of a couple on a rigid body?

Answer : A couple have a turning effect on a rigid body.