Important Questions for Class 11 Physics Chapter 6: Chapter 6 of Class 11 Physics, titled Systems of Particles and Rotational Motion, covers the principles of motion in systems consisting of multiple particles and the rotational motion of rigid bodies.

Key topics include the center of mass, linear, and angular momentum. The chapter also discusses torque, moment of inertia, and rotational kinematics, drawing analogies between linear and rotational motion. Important concepts like the conservation of angular momentum and the dynamics of rotating bodies, along with the work-energy theorem for rotational motion, are explored. The chapter aims to build a foundational understanding of translational and rotational mechanics.

Important Questions for Class 11 Physics Chapter 6 Overview

Class 11 Physics Chapter 6, Systems of Particles and Rotational Motion, is crucial for building a strong foundation in mechanics. Key questions focus on the concepts of center of mass, torque, angular momentum, moment of inertia, and rotational dynamics.

These topics are fundamental not only for Class 11 exams but also for competitive exams. Understanding these principles is essential for analyzing real-world systems such as rotating wheels, pendulums, and planetary motion. Mastery of this chapter helps in solving complex problems in both linear and rotational motion, contributing to a deeper comprehension of physics.

Important Questions for Class 11 Physics Chapter 6 Systems of Particles and Rotational Motion

Below is the Important Questions for Class 11 Physics Chapter 6 Systems of Particles and Rotational Motion -

1. A wheel $0.5m$ in radius is moving with a speed of $12m/s$. Find its angular speed.

Ans: Angular speed can be given as $v = r\omega$

$$\Rightarrow \omega = \frac{v}{r} = \frac{12}{0.5}$$

$$\Rightarrow \omega = 24rad/s$$

2. State the condition for translational equilibrium of a body.

Ans: For a body to be in a translational equilibrium, the vector sum of all the forces acting on the body must be equal to zero.

3. How is angular momentum related to linear momentum?

Ans: Angular momentum can be related as $\vec{L} = \vec{r} \times \vec{p}$

Or $L = rp\sin\theta$

Where θ is the angle between $\vec{r}$ and $\vec{p}$.

4. What is the position of the centre of mass of a uniform triangular lamina?

Ans: The centre of mass of a uniform triangular lamina is at the centroid of the triangular lamina.

5. What is the moment of inertia of a sphere of mass $20kg$ and radius $\frac{1}{4}m$ about its diameter?

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

$$I = \frac{2}{5} \times 20 \times \left(\frac{1}{4}\right)^2$$

$$I = 0.5kgm^2$$

6. What are the factors on which moment of inertia of a body depends?

Ans: Moment of inertia of a body depends on:

- Mass of the body
- Shape and size of the body
- Position of the axis of rotation

7. Two particles in an isolated system undergo head on collision. What is the acceleration of the centre of mass of the system?

Ans: Acceleration of the centre of mass of the system is zero.

8. Which component of a force does not contribute towards torque?

Ans: The component of a force that does not contribute towards torque is the radial component.

9. What is the position of centre of mass of a rectangular lamina?

Ans: The point of intersection of diagonal is the position of the centre of mass of a rectangular lamina.

10. Give the location of the centre of mass of a

1. sphere,
2. cylinder,
3. ring, and
4. cube, each of uniform mass density.

Does the centre of mass of a body necessarily lie inside the body?

Ans: The centre of mass (C.M.) can be defined as a point where the mass of a body is supposed to be concentrated.

For the above listed geometric shapes having a uniform mass density, the centre of mass lies at their respective geometric centres.

The centre of mass of a specific body need not necessarily lie inside of the body. For example, the centre of mass of bodies such as a ring, a hollow sphere, etc., lies outside the respective body.

11. A child sits stationary at one end of a long trolley moving uniformly with a speed vv on a smooth horizontal floor. If the child gets up and runs about on the trolley in any manner, what is the speed of the CM of the (trolley + child) system?

Ans:

The system's centre of mass will continue to move at the same speed. On a tram that is travelling ahead with velocity v, the child is running erratically. The child's running, however, will not change the trolley's centre of mass's velocity. This occurs because the force resulting from the child's motion is entirely internal.

The motion of the bodies they work on is unaffected by internal forces in the body. The child's motion will not alter the trolley's centre of mass's speed because the (child + trolley) system does not involve any external forces.

12. To maintain a rotor at a uniform angular speed of $200 rad\ s^{-1}$ an engine needs to transmit a torque of $180 Nm$. What is the power required by the engine? (Note: uniform angular velocity in the absence of friction implies zero torque. In practice, applied torque is needed to counter frictional torque). Assume that the engine is 100 efficient.

Ans: Angular speed of the rotor is given as, $200 rad/s$.

Torque required by the rotor of the engine is given as $180 Nm$.

The power of the rotor (P) can be expressed in the relation of torque and angular speed by the formula

$P = \tau\omega$

$\Rightarrow P = 180 \times 200 = 30 \times 10^3$

$\Rightarrow P = 36 kW$

Therefore, the power required by the engine is $36 kW$.

Short Answer Questions (2 Marks)

1. A planet revolves around on massive star in a highly elliptical orbit is its angular momentum constant over the entire orbit. Give reason?

Ans: When a planet revolves around the star, it takes place under the effect of gravitational force. The force is radial and does not contribute towards torque. Hence, in the absence of an external torque angular momentum of the planet remains constant.

2. Obtain the equation $\omega = \omega_0 + \alpha t$.

Ans: We know the relation,

$$\alpha = \frac{d\omega}{dt}$$

$$d\omega = \alpha dt$$

Integrating within the limits

$$\int_{\omega_0}^{\omega} d\omega = \int_0^t \alpha dt$$

$$\Rightarrow \omega - \omega_0 = \alpha t$$

$$\Rightarrow \omega = \omega_0 + \alpha t$$

Hence, proved.

3. What is the torque of the force $\vec{F} = 2\hat{i} - 5\hat{j} + 4\hat{k}$ acting at the point $\vec{r} = \left(3\hat{i} + 3\hat{j} + 3\hat{k}\right) m$ about the origin?

Ans: Torque is given by

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

$$\Rightarrow \vec{\tau} = \begin{bmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & -3 & 4 \\ 3 & 2 & 3 \end{bmatrix}$$

$$\Rightarrow \vec{\tau} = \left(17\hat{i} - 6\hat{j} - 13\hat{k}\right) Nm$$

4. What is the value of linear velocity if $\vec{\omega}=\left(3\hat{i}-4\hat{j}+\hat{k}\right)$ and $\vec{r}=\left(5\hat{i}-6\hat{j}+6\hat{k}\right)$.

Ans: Linear velocity is given by

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

$$\Rightarrow\vec{v}=\left(3\hat{i}-4\hat{j}+\hat{k}\right)\times\left(5\hat{i}-6\hat{j}+6\hat{k}\right)$$

$$\Rightarrow\vec{v}=-18\hat{i}-13\hat{j}+2\hat{k}$$

5. Establish the third equation of rotational motion $\omega^2-{\omega_0}^2=2\alpha\theta$.

Ans: We have the relation, $\alpha=\dfrac{d\omega}{dt}$

Multiply and divide by $d\theta$

$$\alpha=\frac{d\omega}{dt}\times\frac{d\theta}{d\theta}$$

$$\Rightarrow\alpha=\frac{d\omega}{d\theta}\times\frac{d\theta}{dt}$$

$$\Rightarrow\alpha d\theta=\omega d\omega$$

Integrating we get

$$\int_0^\theta\alpha d\theta=\int_{\omega_0}^{\omega}\omega d\omega$$

$$\Rightarrow\alpha[\theta]_0^\theta=\left[\frac{\omega^2}{2}\right]_{\omega_0}^{\omega}$$

$$\Rightarrow\alpha\theta=\frac{\omega^2}{2}-\frac{{\omega_0}^2}{2}$$

$$\Rightarrow\omega^2-{\omega_0}^2=2\alpha\theta$$

Hence, proved.

6. Find the expression for radius of gyration of a solid sphere about one of its diameters.

Ans: Moment of inertia of a solid sphere about its diameter can be given as,

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

$K=$ Radius of Gyration

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

$$\Rightarrow K^2=\frac{2}{5}R^2$$

$$\Rightarrow K=\sqrt{\frac{2}{5}}R$$

7. Prove that the centre of mass of two particles divides the line joining the particles in the inverse ratio of their masses?

Ans: We can express the relation as $\vec{r}_{cm}=\dfrac{m_1\vec{r}_1+m_2\vec{r}_2}{m_1+m_2}$

If centre of mass is at the origin,

$$\Rightarrow \vec{r}_{cm}=0$$

$$\Rightarrow m_1\vec{r}_1+m_2\vec{r}_2=0$$

$$m_1\vec{r}_1=-m_2\vec{r}_2$$

In terms of magnitude, it can be expressed as,

$$m_1\left|\vec{r}_1\right|=m_2\left|\vec{r}_2\right|$$

$$\Rightarrow \frac{m_1}{m_2}=\frac{r_2}{r_1}$$

8. Show that cross product of two parallel vectors is zero.

Ans: $\vec{A} \times \vec{B} = AB\sin\theta\hat{x}$

If $\vec{A}$ and $\vec{B}$ are parallel to each other,

Then, $\theta = 0^\circ$

$\Rightarrow \vec{A} \times \vec{B} = 0$

9. Prove the relation $\overrightarrow{\tau} = \frac{d\overrightarrow{L}}{dt}$.

Ans: We are aware of the relation, $\overrightarrow{L} = I\overrightarrow{\omega}$

Differentiating on both sides with respect to time

$\frac{d\vec{L}}{dt} = \frac{d}{dt}(I\vec{\omega}) = I\frac{d\vec{\omega}}{dt} = I\vec{\alpha}$ ...... (1)

Where, $\vec{L} =$ Angular Momentum

$\vec{\tau} =$ Torque

And $\frac{d\vec{\omega}}{dt} = \vec{\alpha}$

$\Rightarrow \vec{\tau} = I\vec{\alpha}$ ...... (2)

From (1) and (2)

$\vec{\tau} = \frac{d\vec{L}}{dt}$

Hence, proved.

10. Show that for an isolated system the centre of mass moves with uniform velocity along a straight line path.

Ans: For the given conditions let $\vec{M}$ be the total mass concentrated at centre of mass whose position vector is $\overrightarrow{r}$.

$$\vec{F} = \frac{Md^2\vec{r}}{dt^2}$$

$$\Rightarrow \vec{F} = \frac{Md}{dt}\left(\frac{d\vec{r}}{dt}\right) = \frac{Md}{dt}\left(\vec{V}_{cm}\right)$$

For an isolated system it can be given as, $\overrightarrow{F} = 0$

$$\Rightarrow \frac{Md}{dt}\left(\vec{V}_{cm}\right) = 0$$

Or $\frac{d}{dt}\left(\vec{V}_{cm}\right) = 0$ since $M \neq 0$

$$\Rightarrow \left(\vec{V}_{cm}\right) = constant$$

11. The angle θ covered by a body in rotational motion is given by the equation $\theta = 6t + 5t^2 + 2t^3$. Determine the value of instantaneous angular velocity and angular acceleration. at time $t = 2s$.

Ans: In the question it is given that $\theta = 6t + 5t^2 + 2t^3$.

Now, Angular velocity $\omega = \frac{d\theta}{dt} = 6 + 10t + 6t^2$

At $t = 2s$

$$\omega = 6 + 10(2) + 6(2)^2$$

$$\Rightarrow \omega = 50 rad/\sec$$

Again, angular acceleration can be given as,

$$\alpha = \frac{d\omega}{dt} = \frac{d^2\theta}{dt^2} = 10 + 12t$$

At $t = 2s$

$\alpha = 10 + 12(2)$

$\alpha = 34 rad/s^2$

12. A solid cylinder of mass $20kg$ rotates about its axis with angular speed $100 rad/\sec$. The radius of the cylinder is $0.25m$. What is the kinetic energy associated with the rotation of the cylinder? What is the magnitude of angular momentum of the cylinder about its axis?

Ans: Mass of the cylinder is given as, $m = 20kg$

Angular speed is given as, $\omega = 100 rad/s$

Radius of the cylinder, $r = 0.25m$

The moment of inertia of the solid cylinder can be given as:

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

Now,

$$\Rightarrow I = \frac{1}{2} \times 20 \times (0.25)^2$$

$$\Rightarrow I = 0.625 kgm^2$$

Kinetic energy can be given as: $K.E. = \frac{1}{2} I\omega^2$

$$\Rightarrow K.E. = \frac{1}{2} \times 6.25 \times (100)^2 = 3125J$$

Angular momentum can be given as,

$L = I\omega$

$\Rightarrow L = 6.25 \times 100$

$\Rightarrow L = 62.5 Js$

13. A rope of negligible mass is wound round a hollow cylinder of mass $3kg$ and radius $40cm$. What is the angular acceleration of the cylinder if the rope is pulled with a force of $30N$? What is the linear acceleration of the rope? Assume that there is no slipping.

Ans: Given that,

Mass of the hollow cylinder is given as, $m = 3kg$

Radius of the hollow cylinder is given as, $r = 40cm = 0.4m$

Applied force on the given rope is given as, $F = 30N$

The moment of inertia of the hollow cylinder about its geometric axis can be given as:

$I = mr^2$

$\Rightarrow I = 3 \times (0.4)^2$

$\Rightarrow I = 0.48kgm^2$

Torque acting on the rope,

$\tau = F \times r$

$\Rightarrow \tau = 30 \times 0.4$

$\Rightarrow \tau = 12Nm$

For angular acceleration α , torque can also be given by the expression:

$\tau = I\alpha$

$\Rightarrow \alpha = \frac{\tau}{I} = \frac{12}{0.48}$

$\Rightarrow \alpha = 25rad\,s^{-2}$

Linear acceleration of the rope can be stated as $= ra = 0.4 \times 25 = 10ms^{-2}$.

14. A bullet of mass $10g$ and speed $500m/s$ is fired into a door and gets embedded exactly at the centre of the door. The door is $1.0m$ wide and weighs $12kg$. It is hinged at one end and rotates about a vertical axis practically without friction. Find the angular speed of the door just after the bullet embeds into it. (Hint: The moment of inertia of the door about the vertical axis at one end is $\frac{ML^2}{3}$.)

Ans: Given that,

Mass of the bullet is given as, $m = 10g = 10 \times 10^{-3}kg$

Velocity of the bullet is given as, $v = 500m/s$

Width of the door, $L = 1.0m$

Radius of the door, $r = \frac{1}{2}m$

Mass of the door is given, $M = 12kg$

Angular momentum transmitted by the bullet on the door:

$\alpha = mvr$

$\Rightarrow \alpha = \left(100 \times 10^{-3}\right) \times (500) \times \frac{1}{2} = 2.5kgm^2s^{-1}$

Moment of inertia of the door can be given as:

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

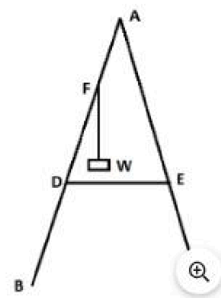
$\Rightarrow I = \frac{1}{3} \times 12 \times (1)^2 = 4kgm^2$

But we have the relation,

$\alpha = I\omega$

$\Rightarrow \omega = \frac{\alpha}{I} = \frac{2.5}{4} = 0.625rads^{-1}$, which is the required angular speed.

15. Explain why friction is necessary to make the disc in Fig. 7.41 roll in the direction indicated.



(a). Give the direction of frictional force at B, and the sense of frictional torque, before perfect rolling begins.

Ans: To roll the given disc, some torque is necessary. As per the definition of torque, the rotating force must be tangential to the disc. Since the frictional force at point B is along the tangential force at point A , a frictional force is necessary for making the disc roll.

Force of friction will act in the opposite direction to the direction of velocity at point B . The direction of linear velocity at point B can be pointed tangentially leftward. Therefore, frictional force will act tangentially rightward. The frictional torque before the start of perfect rolling is perpendicular to the plane of the disc in the outward direction.

(b). What is the force of friction after perfect rolling begins?

Ans: Since frictional force will act opposite to the direction of velocity at point B , perfect rolling will start when the velocity at that point becomes equal to zero. This will make the frictional force that acts on the disc as zero.

Long Answer Questions (3 Marks)

1. The moment of inertia of a solid sphere about a tangent is $\frac{7}{5}MR^2$. Find the moment of inertia about a diameter.

Ans: From the diagram we can infer that a tangent KCL is drawn at point C of a solid sphere of mass M and radius R . Now, draw a diameter $AOB \parallel KCL$.

Then according to Theorem of parallel axis, $I_1 = I + M(OC)^2$

M.I about the tangent can be given as $I_1 = \frac{7}{5}MR^2$

$I = I_1 - M(OC)^2$

$\Rightarrow I = \frac{7}{5}MR^2 - MR^2$

$\Rightarrow I = \frac{2}{5}MR^2$, which is the moment of inertia about a diameter.

2. Four particles of mass $1kg$, $2kg$, $3kg$ and $4kg$ are placed at the four vertices A, B, C and D of square of side $1m$. Find the position of centre of mass of the particle.

Ans: From the given data we can infer,

$m_1 = 1kg$ at $(x_1, y_1) = (0,0)$

$m_2 = 2kg$ at $(x_2, y_2) = (1,0)$

$m_3 = 3kg$ at $(x_3, y_3) = (1,1)$

$m_4 = 4kg$ at $(x_4, y_4) = (0,1)$

Now,

$$X_{cm} = \frac{m_1x_1 + m_2x_2 + m_3x_3 + m_4x_4}{m_1 + m_2 + m_3 + m_4}$$

$$\Rightarrow X_{cm} = 0.5m$$

$$Y_{cm} = \frac{m_1y_1 + m_2y_2 + m_3y_3 + m_4y_4}{m_1 + m_2 + m_3 + m_4}$$

$$\Rightarrow Y_{cm} = 0.7m$$

Therefore, the centre of mass is located at $(0.5m, 0.7m)$.

3. A circular ring of diameter $40cm$ and mass $1kg$ is rotating about an axis normal to its plane and passing through the centre with a frequency of 10 rotations per second. Calculate the angular momentum about its axis of rotation.

Ans: From the question we can write,

$$R = \frac{40}{2}cm = 20cm = 0.2m$$

$$M = 1kg$$

$$v = 10rotations/\sec$$

Now, Moment of inertia can be calculated as,

$$M.I. = MR^2 = 1 \times (0.2)^2 = 0.04kgm^2$$

$$\omega = 2\pi v = 2\pi \times 10 = 20\pi rad/s$$

Angular momentum can be calculated as,

$$\Rightarrow L = 0.04 \times 20\pi$$

$$\Rightarrow L = 2.51kgm^2/s$$

4.

(a). Which physical quantities are represented by the

(i) Rate of change of angular momentum?

Ans: Torque i.e., $\tau = \frac{d\vec{L}}{dt}$

(ii) Product of I and $\vec{\omega}$?

Ans: Angular momentum i.e., $L = I\omega$

(b). Show that angular momentum of a satellite of mass M_s revolving around the earth having mass M_e in an orbit of radius r is equal to

Ans: Given that

Mass of satellite is given as $= M_s$

Mass of earth is given as $= M_e$

Radius of satellite is given as $= r$

Required centripetal force can be given as $= \frac{M_s v^2}{r}$ ...... (1)

Where v is the orbital velocity with which the satellite revolves around the earth.

Now, Gravitational force between the satellite and the earth can be given as:

$= \frac{GM_e M_s}{r^2}$ ...... (2)

Equating equations (1) and (2)

$$\frac{M_s v^2}{r} = \frac{GM_e M_s}{r^2}$$

$$\Rightarrow v = \sqrt{\frac{GM_e}{r}}$$

Now angular momentum of the satellite can be given as,

$$L = M_s v r$$

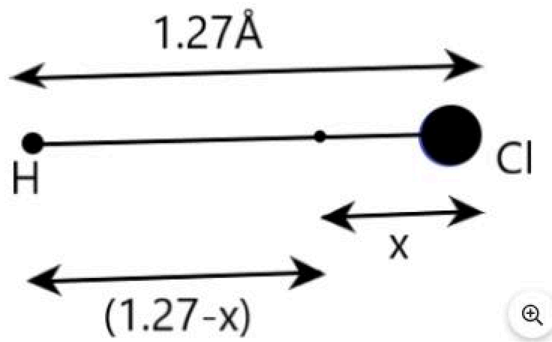
$$\Rightarrow L = M_s \times \sqrt{\frac{GM_e}{r}} \times r$$

$$\Rightarrow L = \sqrt{GM_e {M_s}^2 r}$$

Hence, proved

5. In the HCl molecule, the separation between the nuclei of the two atoms is about $1.27\overset{o}{A}\ 20kg$. Find the approximate location of the CM of the molecule, given that a chlorine atom is about 35.5 times as massive as a hydrogen atom and nearly all the mass of an atom is concentrated in its nucleus.

Ans: The provided situation can be expressed as:



Distance between H and Cl atoms $= 1.27\overset{o}{A}$

Mass of H atom $= m$

Mass of Cl atom $= 35.5m$

Let the centre of mass of the given system be at a distance x from the Cl atom.

Distance between the centre of mass and the H atom $= (1.27 - x)$

Let us suppose that the centre of mass of the given molecule lies at the origin. Therefore, it can be written as:

$$\frac{m(1.27 - x) + 35.5mx}{m + 35.5m} = 0$$

$$\Rightarrow m(1.27 - x) + 35.5mx = 0$$

$$\Rightarrow 1.27 - x = -35.5x$$

$$\Rightarrow x = \frac{-1.27}{(35.5 - 1)} = -0.037\overset{o}{A}$$

Here, the negative sign gives an indication that the centre of mass lies at the left side of the molecule.

Therefore, the centre of mass of the HCl molecule lies $0.037\overset{o}{A}$ from the Cl atom.

Benefits of Using Important Questions for Class 11 Physics Chapter 6

Using important questions for Class 11 Physics Chapter 6 (Systems of Particles and Rotational Motion) offers several benefits for students:

1. Concept Reinforcement:

Important questions are typically derived from key concepts and formulas in the chapter. By practicing these questions, students can reinforce their understanding of the core topics such as torque, angular momentum, rotational kinetic energy, and the dynamics of rigid bodies.

2. Improved Problem-Solving Skills:

These questions challenge students to apply their knowledge in a practical manner. Regular practice helps improve their problem-solving techniques, which is essential for tackling both theoretical and numerical problems in exams.

3. Time Management:

By solving important questions, students can learn how to approach problems efficiently, which is crucial for managing time effectively during exams. This enables them to solve questions quickly while maintaining accuracy.

4. Understanding of Exam Pattern:

Important questions often reflect the pattern and difficulty level of questions that frequently appear in exams. By practicing these, students gain insights into what to expect and how to prepare accordingly.

5. Boost in Confidence:

As students become more familiar with the important questions and their solutions, they feel more confident in their ability to perform well in the exam. This confidence is especially important for complex chapters like Systems of Particles and Rotational Motion, where concepts can initially seem overwhelming.

6. Focused Revision:

Important questions help students focus on the most critical aspects of the chapter. This focused revision ensures that they are not overwhelmed by the breadth of topics but instead concentrate on high-yield areas that are likely to appear in exams.