1. Detail of Unit Revision

Subject Name	Physics
Course Name	Physics 01 (Physics Part-1,Class XI)
Module Name/Title	Unit 5: Motion of System of Particles and Rigid Body study guide
Objectives	After going through this lesson, the learners will be able to • Plan for consolidation of the unit • Make a list of key concepts learnt in the unit
Keywords	Centre of mass, rotational motion, momentum, torque, moment of inertia, angular momentum

2. Development team

Role	Name	Affiliation
National MOOC Coordinator (NMC)	Prof. Amarendra P. Behera	Central Institute of Educational Technology, NCERT, New Delhi
Course Coordinator / PI	Anuradha Mathur	Central Institute of Educational Technology, NCERT, New Delhi
Teaching Assistants	Chinty Chhawari Shivam Dixit	Central Institute of Educational Technology, NCERT, New Delhi Central Institute of Educational Technology, NCERT, New Delhi

Study guide

Unit 5

Motion of system of particles and rigid body

Read the syllabus for the unit carefully, highlighting any concept that is not very clear to you.

Syllabus

Motion of System of Particles and Rigid body

Chapter 7: System of particles and Rotational Motion

Centre of mass of a two-particle system; momentum conservation and centre of mass motion.

Centre of mass of a rigid body; Centre of mass of a uniform rod.

Moment of a force; torque; angular momentum; law of conservation of angular momentum and its applications.

Equilibrium of rigid bodies; rigid body rotation and equations of rotational motion; comparison of linear and rotational motions.

Moment of inertia; radius of gyration; values of moments of inertia for simple geometrical objects (no derivation); Statement of parallel and perpendicular axes theorems and their applications.

Study the break up into modules carefully. Sometimes we rearrange the unit syllabus to work on a logical way to learn the concepts.

The above unit has been divided into 8 modules for better understanding.

Module 1	• Rigid body • Centre of mass • Distribution of mass • Types of motion: Translatory, circulatory and rotatory
Module 2	• Centre of mass • Application of centre of mass to describe motion • Motion of centre of mass
Module 3	• Analogy of circular motion of a point particle about a point and different points on a rigid body about an axis • Relation $v = r\omega$ • Kinematics of rotational motion
Module 4	• Moment of inertia • Difference between mass and moment of inertia • Derivation of value of moment of inertia for a lamina about a vertical axis perpendicular to the plane of the lamina • S I Unit • Radius of gyration • Perpendicular and Parallel axis theorems
Module 5	• Torque • Types of torque • Dynamics of rotational motion • $\tau = I\alpha$
Module 6	• Equilibrium of rigid bodies • Condition of net force and net torque • Applications
Module 7	• Law of conservation of angular momentum and its applications. • Applications
Module 8	• Rolling on plane surface • Horizontal • Inclined surface • Applications

Next write the syllabus spread and make your check list

1. **Centre of mass of a two-particle system;**

2. **Momentum conservation and**
3. **Centre of mass motion.**
4. **Centre of mass of a rigid body;**
5. **Centre of mass of a uniform rod.**
6. **Moment of a force;**
7. **Torque;**
8. **Angular momentum;**
9. **Law of conservation of angular momentum and its applications.**
10. **Equilibrium of rigid bodies;**
11. **Rigid body rotation and equations of rotational motion;**
12. **Comparison of linear and rotational motions.**
13. **Moment of inertia;**
14. **Radius of gyration;**
15. **Values of moments of inertia for simple geometrical objects (no derivation);**
16. **Statement of parallel and perpendicular axes theorems and their applications.**

Our suggestion is to first realize and look for objects moving around us, which we term as translatory or in a straight path, moving in a circle or rotating. In our earlier studies, we have taken a point that represents the rigid body and take it as the entire mass is located at that point. This is an ok idea for uniformly distributed mass in a body, but in real life the rigid system may be made of many particles, may be of dissimilar masses and any distribution, this is the reason why you need to learn about the center of mass before considering rotation about any axis.

In circular motion, the body was a point mass and it moved in a circular track. It was accelerated motion as the direction was continuously changing even if the speed remained the same. We have learnt the relation between angular velocity, and linear speed $v = \omega r$ also that the centripetal acceleration is $a = \omega^2 r = v^2/r$

In case the speed changed, we would deal with angular acceleration which would not be in the direction of the centripetal acceleration take time to understand the direction of angular velocity, and angular acceleration.

Now understand the relevance of circular motion in a rigid body rotation.

Study a cycle wheel rotation, put a cycle on a stand and rotate the wheel. The rim moves faster than the inner portion of the wheel. The entire system remains together. Slowly appreciate the motion of the wheel allowing yourself time to think about, linear speeds of particles at different locations, Centre of mass, axis of rotation, angular velocity of the particles at different locations, direction of angular velocity, clockwise and anticlockwise motion of the wheel. Why can we not rotate the wheel in the opposite direction?

Next understand the equations of motion and angular acceleration, direction of angular acceleration, do simple numerical problems to get a better understanding.

Dynamics of rotation means what causes a body to rotate, why should there be an axis of rotation, turning effect of a force, condition when a force will cause linear motion and parabolic motion, motion in a circle, and rotation. Moment of a force and calculation of its value, why cross product of vectors is used, significance and relevance of

Choice of axis of rotation

Magnitude of force

Line of action of the force

Mass distribution about the axis of rotation

Distance of point of application of the force from the axis of rotation

Analyze each situation

A force causing linear motion

A force causing projectile motion

A force causing circular motion

A force causing rotation

How is motion in a circle different from rotation?

Does the axis of rotation always pass through the rotating object?

Now understand the significance of moment of inertia, how is it different from inertia. Do the derivation for moment of inertia of a ring about an axis passing through the center of the ring. Why would the value change if we considered another axis of rotation, may be parallel or perpendicular to the initial axis of rotation?

The derivation may not be required for different shapes of objects as we see around us; we must still understand how it is calculated.

Why do we need to consider radius of gyration?

Use all the equations of motion in translator motion and write them for rotatory motion

Watch the videos and study the e-content. Answer the assignment questions.

Do as many practice problems from NCERT text book and NCERT Exemplar.