M.Sc. Physics (Semester–VI) under **Analytical/Mathematical Physics**.

Holonomic Systems

Course: M.Sc. Physics
Semester: VI
Paper: Analytical / Mathematical Physics

1. Introduction

In classical mechanics, a system is said to be **holonomic** if all the constraints acting on it can be expressed as **equations relating the coordinates and time only**, and are **integrable**. Holonomic systems play a crucial role in **Lagrangian and Hamiltonian mechanics**, as they simplify the mathematical formulation of physical problems.

2. Holonomic Constraints

A **holonomic constraint** is one that can be written in the form:

$$f(q_1, q_2, q_3, \ldots, q_n, t) = 0$$

where

- q_i are the generalized coordinates
- t is time

Characteristics

- Does **not involve velocities**
- Reduces the number of independent coordinates
- Can be used to define **generalized coordinates**

3. Degrees of Freedom

For a holonomic system:

$$\text{Degrees of Freedom} = 3N - k$$

where

- N = number of particles
- k = number of independent holonomic constraints

4. Examples of Holonomic Systems

1. **Particle moving on a sphere**

$$x^2 + y^2 + z^2 - R^2 = 0$$

2. **Simple pendulum of fixed length l**

$$x^2 + y^2 - l^2 = 0$$

3. **Rigid body**
   Distance between particles remains constant (constraint equations exist)