BACHELORS WITH PHYSICS AS MAJOR

6th SEMESTER

PHY622J2 PHYSICS _ CLASSICAL MECHANICS

CREDITS: THEORY – 4, TUTORIALS: 2

THEORY (4 CREDITS: 60 HOURS)

LEARNING OUTCOMES

The learning outcomes cover a wide range of topics in classical mechanics, including Lagrangian and Hamiltonian dynamics, variational calculus, Poisson Brackets, and oscillatory systems. Students completing this course should have a strong understanding of these subjects and their applications in classical mechanics.

1. *Explain how to handle constraints in mechanical systems and introduce generalized coordinates.*
2. *Define and apply the principles of virtual displacement, virtual work, and generalized force.*
3. *Describe d'Alembert's principle and its role in deriving generalized equations of motion.*
4. *Understand the Lagrangian and the Euler-Lagrange equation of motion.*
5. *Explain the concept of the Hamiltonian and how it relates to the Lagrangian formalism.*
6. *Explain the principle of least action and its connection to the Euler-Lagrange equation.*
7. *Handle constraints within variational dynamics and discuss their implications.*
8. *Introduce Hamiltonian dynamics, including Legendre transformations and Hamilton's equations.*
9. *Discuss conservation laws in Hamiltonian mechanics.*
10. *Explain the concept of phase space and Liouville's theorem.*
11. *Define Poisson Brackets (PB) and analyze their properties.*
12. *Discuss the invariance of Poisson Brackets under canonical transformations.*
13. *Introduce the Hamilton-Jacobi (HJ) Equation and its applications.*
14. *Discuss particle motion under central forces.*
15. *Understand the dynamics of the damped harmonic oscillator and its solutions.*
16. *Analyze the behavior of coupled simple harmonic oscillators, such as the coupled pendulum.*
17. *Apply the general method of solution to analyze oscillatory systems.*

UNIT-I (15 HOURS)

The Lagrangian Approach to Mechanics: degrees of freedom, constraints and generalized coordinates, virtual displacement, virtual work and generalized force, d'Alembert's principle and the generalized equation of motion, the Lagrangian and the Euler Lagrange equation of motion, the Hamiltonian, cyclic coordinates and canonical momenta.

UNIT-II (15 HOURS)

Variational calculus and Hamiltonian dynamics: the variational calculus and the Euler equation, the principle of least action and the Euler Lagrange equation, constraints in variational dynamics. Hamiltonian dynamics: Legendre-transformations, Hamilton's equations, conservation laws, phase space and Liouville's theorem

UNIT-III (15 HOURS)

Theoretical Mechanics: canonical transformations and generating functions, Poisson Brackets (PB); the angular momentum PB relations, invariance of PBs under canonical transformations, action-angle variables and adiabatic invariance, the Hamilton Jacobi (HJ) Equation; HJ equation for Hamilton's characteristic function, separation of variables, particle motion under central force.

UNIT IV (15 HOURS)

Oscillations: the simple harmonic oscillator; the damped harmonic oscillator, the damped simple and damped harmonic oscillator, coupled simple harmonic oscillators; couple pendulum, general method of solution.

TUTORIALS (2 CREDITS: 30 HOURS)

1. Euler-Langrage equation for double pendulum,
2. Euler-Langrage equations for spherical pendulum,
3. Euler-Langrage equation for particle in electromagnetic field.
4. Scattering cross-section: Scattering by a central force.
5. Rutherford scattering formula.
6. Relation between Center of mass frame and Lab frame cross sections.

TEXT BOOKS:

1. Classical Mechanics" by John R. Taylor, University Science Books (US).
2. Classical Mechanics: Systems of Particles and Hamiltonian Dynamics" by Walter Greiner.
3. Mechanics" by Keith R. Symon, Pearson.
4. Analytical Mechanics" by Louis N. Hand and Janet D. Finch.