B.SC. (HONOURS) PHYSICS

DISCIPLINE SPECIFIC CORE COURSE – DSC 19: CLASSICAL MECHANICS

Course Title and Code	Credits	Credit distribution of the course			Pre-requisite of the course
		Lecture	Tutorial	Practical	
Classical Mechanics DSC 19	4	3	1	0	DSC – 2 (Mechanics)

Course Objectives

- To introduce variational principles and their application to derive equations of motion for complex systems with constraints.
- To deepen the understanding of foundational principles of Classical Mechanics including Lagrangian and Hamiltonian formalisms
- To Develop an understanding of symmetries and conservation laws through Noether's Theorem
- To develop analytical skills to solve problems in dynamics, including those involving rigid bodies.
- To analyze the motion of particles in central force fields, and understand orbital mechanics, including scattering phenomena.
- To introduce theory of small oscillations, enabling students to analyze stability and coupled oscillatory systems.

Learning Outcomes

By the end of this course, students will be able to:

- Apply the calculus of variations to derive the Euler-Lagrange equations and use them to analyze constrained mechanical systems.
- Formulate and analyze mechanical systems using Lagrangian and Hamiltonian formalisms.
- Apply the principles of symmetry and conservation laws through Noether's theorem.
- Analyze motion in phase space and construct phase portraits
- Understand the dynamics of rigid bodies.
- Analyze the motion of particles under central forces and solve scattering problems.
- Understand and compute normal modes and normal frequencies in small oscillation problems.
- Develop critical thinking and problem-solving skills

<u>SYLLABUS OF DSC 19</u>
<u>THEORY COMPONENT</u>
(Credits: 3; Hours: 45)

Unit I **(10 Hours)**

Variational Principle and Lagrangian Formulation
Calculus of Variation with applications. Generalized coordinates. Lagrangian, Hamilton's Principle, Euler-Lagrange equations of motion. Constrained systems. Cyclic coordinates and conserved quantities. Applications to physical systems.

Unit II **(10 Hours)**

Hamiltonian Formulation and Phase Space
Legendre transformation, Hamilton's equations of motion. Phase space, phase trajectories, Phase portraits. Canonical transformations, Poisson brackets, Liouville's theorem and conservation of phase space volume. Applications to Physical Systems.

Unit III **(11 Hours)**

Rigid Body Dynamics
Rotation Matrices, Euler Angles. Angular momentum and kinetic energy of rigid bodies, The Inertia Tensor, Principal Axis Transformation. Euler's equations of motion for rigid body. Torque-free motion. The symmetrical top with one point fixed.

Unit IV **(14 Hours)**

Central Force and Orbital Mechanics
Equation of motion under central force, Classification and Stability of orbits. Virial Theorem. Conditions for Closed Orbits (Bertrand's Theorem). The Kepler Problem. Scattering in central force field. Rutherford scattering as an application.
Theory of small oscillations: Linearization of equations of motion. The Eigenvalue Equation and the Principal Axis Transformation, Normal coordinates and normal frequencies of oscillations. Damped and forced oscillations, Coupled oscillators.

<u>References</u>

Essential Readings

1. Classical Mechanics, H. Goldstein, C. P. Poole, J. L. Safko, 3/e, Pearson Education (2014).
2. Classical Mechanics, John R. Taylor, University Science Books (2005).
3. Classical Mechanics, R. Douglas Gregory, Cambridge University Press (2015).
4. Mechanics, L. D. Landau and E. M. Lifshitz, Pergamon (2010).
5. Classical Mechanics, P. S. Joag, N. C. Rana, McGraw Hall Education (2017).
6. Classical Dynamics of particles and system, S. T. Thornton, J. B. Marion, Cengage Learning (2012).
7. Theory and Problems of Theoretical Mechanics, Murray R. Spiegel, McGraw Hill Education (1997).

Additional Readings

1. Classical Mechanics, Tai L. Chow, CRC Press (2013).
2. Analytical Mechanics: Solutions to Problems in Classical Physics, I. Merches, D. Radu, CRC Press (2015).
3. Solved Problems in Classical Mechanics, O. L. Delange and J. Pierrus, Oxford University Press (2010).
4. Mathematical Methods of Classical Mechanics, V.I. Arnold, Springer Nature (1989).
5. Classical Mechanics: A course of lectures, A K Raychoudhuri, Oxford University Press (1984).