Course Code	Course Name	Credits
26PH509	CLASSICAL MECHANICS	04

Course Objectives

- To introduce generalized coordinates and constraints with examples.
- To discuss mathematical formulation of rigid body dynamics
- To point out the relation between various conservation theorems and their associated symmetry properties.
- To demonstrate the use of Lagrange and Hamiltonian formulation through some applications
- To enable the students, apply the laws of classical mechanics to various physical systems

Learning Outcomes

After completion of the course, students will be able to:

- Formulate multi-particle systems using Lagrange equations, D'Alembert's principle, Hamilton's principle, apply to central force problems, orbits, Kepler's problem, and scattering in lab/CM frames.
- Analyze rigid body kinematics via Euler angles, inertia tensor, principal axes, Euler's equations, torque-free motion, symmetric top precession/nutation, and fictitious forces in rotating frames.
- Solve small oscillations through eigenvalue problems, principal axis transformation, normal modes/coordinates for systems like linear triatomic molecules, double/triple pendulums.
- Develop Hamiltonian dynamics via Legendre transformation, canonical transformations, Poisson brackets, cyclic coordinates, and conservation theorems for diverse physical applications.
- Apply Hamilton-Jacobi theory, principal function, action-angle variables to free particles, central forces, harmonic oscillators, and Kepler problems for exact solvability.

Unit 1 - Lagrangian Formulaton (12 Hrs.)

Mechanics of a system of particles - Constraints - D'Alembert's principle - Lagrange equations - velocity dependent potentials - applications - Variational principle - Hamilton's principle - non-holonomic systems - Conservation theorems and symmetry properties. Two body central force problem - equations of motion - first integrals - classification of orbits - conditions for closed orbits - Kepler's problem – Laplace Runge Lenz vector - scattering in a central force field - Lab frame - center of mass frame transformation.

Unit 2 – Rigid Body Dynamics (12 Hrs.)

Kinematics - degrees of freedom - Euler angles - Euler's theorem on the motion of a rigid body - Rotations - finite and infinitesimal. Angular momentum and kinetic energy - Inertia tensor - Principal axes - Euler's equations – Torque free motion of a rigid body - Symmetric top - Precession and nutation - applications – Motion in rotational frames – centrifugal and Coriolis forces.

Unit 3 - Small Oscillations (12 Hrs.)

The eigenvalue equation - the principal axis transformation - free vibrations - normal coordinates – Normal modes- linear triatomic molecule – double pendulum – triple pendulum – triple parallel pendulum.

Unit 4 – Hamiltonian Formulation (12 Hrs.)

Legendre transformation and Hamiltonian equations - Cyclic coordinates and conservation theorems - Hamiltonian equations from Variational principle: Application to various physical systems - Canonical transformations - Poisson brackets - equations of motion - conservation theorems in Poisson bracket formulation.

Unit 5 - Hamilton – Jacobi Formulation (12 Hrs.)

Hamilton-Jacobi theory - Hamilton - Jacobi equation - Hamilton's principal function - free particle in Cartesian coordinates - central force in spherical polar coordinates - application to harmonic oscillator problem – Action- angle variables - simple harmonic oscillator- Kepler's problem.

Reference Books:

1. Goldstein, H., Poole, C., & Safko, J. (2011). Classical mechanics (3rd ed.). Pearson.
2. Calkin, M. G. (1996). Lagrangian and Hamiltonian mechanics. World Scientific.
3. Upadyaya, J. C. (2019). Classical mechanics (3rd ed.). Himalaya Publishing House.
4. Rana, N. C., & Joag, P. S. (2017). Classical mechanics. McGraw-Hill Education.

Websites and eLearning Sources:

1. https://nptel.ac.in/courses/115105098
2. https://youtu.be/zobHbOr3n6o?si=Hf-2SDTTGfMmFrLY
3. https://youtu.be/IYMmA_-yNHs?si=Duke_Oxf1xIVALBz

COs and Bloom's Taxonomy Mapping – 26PH509		
Course Outcomes	**On successful completion of this course, students will be able to**	**BTL**
CO1	Recall Lagrangian and Hamiltonian formulations in classical mechanics.	K1, K2
CO2	Apply analytical mechanics to solve multi-particle and rigid body systems.	K3
CO3	Analyze oscillations, rotational dynamics, and canonical transformations.	K4
CO4	Evaluate conservation laws and symmetry principles in mechanics.	K5
CO5	Develop solutions using Hamilton-Jacobi theory and advanced mechanics.	K6

BTL (Bloom's Taxonomy Level) - K1 – Remembering, K2 – Understanding, K3- Applying, K4 – Analyse, K5- Evaluate and K6 - Create

Relationship Matrix – 26PH509													
Course Outcomes	**Programme Outcomes (POs)**						**Programme Specific Outcomes (PSOs)**						**Mean Score of Cos**
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	
CO1	3	2	1	1	1	1	3	2	1	1	1	1	1.58
CO2	3	3	2	2	1	1	2	3	2	2	2	1	2.00
CO3	3	3	3	2	1	1	2	3	3	2	2	2	2.25
CO4	3	3	3	3	2	1	2	3	3	3	2	2	2.42
CO5	3	3	3	3	2	2	3	3	3	3	3	2	2.75
												Total	2.20

Mean Score: 3- High, 2- Medium/Moderate, 1-Low