**PGP/PSP 4431** **CLASSICAL AND NON-LINEAR DYNAMICS** **5 hrs / 4Cr**

This course is designed to introduce to the students, the basic concepts and application of Lagrangian dynamics, Hamiltonian dynamics, small oscillations, rigid body systems and nonlinear dynamics

At the end of thecourse, students will be able to

i. construct Lagrangian for holonomic systems and analyze its behaviour using Lagrangian dynamics
ii. analyze central force problems and find the normal modes of vibration of oscillating bodies
iii. form inertia matrix and solve rigid body problems using Euler's equation of motion
iv. analyze the system using Hamiltonian dynamics and Poisson brackets
v. find the equilibrium points and classify the non-linear systems in to major bifurcations

**Unit I: Lagrangian Dynamics**

Constraints - D' Alembert's Principle and Lagrange's Equations - Velocity-Dependent Potentials and the Dissipation Function - Hamilton's Principle - Some Techniques of the Calculus of Variations - Derivation of Lagrange's Equations from Hamilton's Principle - Conservation Theorems and Symmetry Properties - Energy Function and the Conservation of Energy.

**Unit II: Central Force Problem and Small Oscillations**

Reduction to the Equivalent One-Body Problem - The Equations of Motion and First Integrals - Scattering in a Central Force Field - Transformation of the Scattering Problem to Laboratory Coordinates-Small Oscillations- The Eigenvalue Equation and the Principal Axis Transformation- Frequencies of Free Vibration, and Normal Coordinates, Linear Tri atomic Molecule.

**Unit III: Rigid body Dynamics**

The Independent coordinates of a Rigid Body - Orthogonal Transformations - The Euler Angles - Angular Momentum and Kinetic Energy of Motion about a Point – Tensors - the Inertia Tensor and the Moment ofInertia - The Eigenvalues of the Inertia Tensor and the Principal Axis Transformation - Solving Rigid Body Problems and the Euler Equations of Motion.

**Unit IV: Hamiltonian dynamics and Canonical Transformations**

Legendre Transformations and the Hamilton Equations of Motion - Cyclic Coordinates and Conservation Theorems - Equations of Canonical Transformation - Examples of Canonical Transformations - The Harmonic Oscillator - The Symplectic Approach to Canonical Transformations - Poisson Brackets and Other Canonical Invariants - The Angular Momentum Poisson Bracket Relations.

**Unit V: Nonlinear dynamics**

Autonomous and non - autonomous systems – Differential equation: equilibrium points- Phase space and Phase trajectories - Stability, Attractors and Repellers - General criteria forstability– Classification of Equilibrium Points - Periodic Attractor - Some simple bifurcations - Saddle-Node, Pitchfork, Transcritical and Hopf.

**Text Books:**


1. Goldstein, Poole and Safko, *Classical Mechanics*, 3 edition, Pearson Publication (2001)

2. M. Lakshmanan and S. Rajasekar, *Nonlinear Dynamics*, Springer (India) Pvt. Ltd. (2003)