MPHC4112

Classical Mechanics I and Nonlinear Dynamics

Group A: Classical Mechanics–I

Revision of Canonical formalism: Lagrangian and Hamiltonians, P.B formalism. Rotations, Rigid bodies and Classical Scattering Theory; An overview of the Lagrangian formalism; Some specific applications of Lagarange's equation; small oscillations, normal modes and frequencies.

[6 lectures]

Hamilton's principle; Calculus of variations; Hamilton's principle; Lagrange's equation from Hamilton's principle;

Legendre transformation and Hamilton's canonical equations; Canonical equations from a variational principle; Principle of least action.

[6 lectures]

Canonical transformations; Generating functions; examples of canonical transformations; group property; Integral variants of Poincare; Lagrange and Poisson brackets; Infinitesimal canonical transformations;

Conservation theorem in Poisson bracket formalism; Jacobi's identity; Angular momentum and Poisson bracket relations.

[8 lectures]

Action angle variables, Hamilton-Jacobi theory, The Hamilton Jacobi equation for Hamilton's principle function; The harmonic oscillator problem; Hamilton's characteristic function;

[6 lectures]

Rigid bodies; Independent coordinates; orthogonal transformations and rotations (finite and infinitesimal);

Euler's theorem, Euler angles; Inertia tensor and principal axis system; Euler's equations;

Heavy symmetrical top with precession and nutation.

[10 lectures]

Group B: Non-Linear Dynamics

Theory:

Physics of nonlinear systems, dynamical equations and constants of motion, phase space, fixed points, stability analysis, bifurcations and their classifications, Poincarè section and iterative maps.

[8 lectures]

One dimensional non-invertible maps, period doubling and universality, intermittency, invariant measure, Lyapunov exponents. Two dimensional systems, Henon map, idea of attractors, Lorenz equations.

[8 lectures]

Fractal geometry and concept of dimensions.

[4 lectures]

Introduction to Hamiltonian systems and integrability. **[4 lectures]**

Computation Lab:

Discrete time problems: Time-series analysis, Iterative maps and Cobweb diagrams, The logistic map, Bifurcation, State space methods: orbits, Chaos and sensitivity to initial conditions.

Continuous systems: The damped driven pendulum: Expected features, approach to chaos through the period doubling route, other non-linear oscillators.

[12 lectures]

References:

(1) Chaos and Fractals - An Elementary Introduction, D.P. Feldman, OUP
(2) Non Linear Dynamics, S. H. Strogatz, Perseus Books
(3)Chaotic Dynamics - an introduction, G. L. Baker and J. P. Gollub, CUP
(4) Non Linear Workbook, Willi - Hans Steeb, World Scientific (3rd edition)
(5) Non Linear Physics with Mathematica for Scientists and Engineers, R. Enns and G. C. McGuire, Berkhauser publications.