Classical Mechanics - Video course

COURSE OUTLINE

This is a basic course in classical mechanics at the senior undergraduate/ master's level. It covers the standard topics in this subject, including the Lagrangian and Hamiltonian formalisms. It also places the subject in the broader context of classical dynamical systems.

The phase space description of such systems is highlighted, and the distinction between integrable and chaotic Hamiltonian systems is brought out. The role of symmetries is elucidated, and the connection between symmetry, invariance and conservation principles is explained. Special relativity is also covered, with an emphasis on the invariance and symmetry aspects as applied to classical mechanics.

COURSE DETAIL

Topics	No. of. lectures (1 hr each)
Mechanics of a system of particles in vector form. Conservation of linear momentum, energy and angular momentum.	3
Degrees of freedom, generalized coordinates and velocities. Lagrangian, action, and the principle of extremal action. Euler-Lagrange equations. Constraints. Applications of the Lagrangian formalism.	6
Legendre transform, generalized momenta. Hamiltonian and Hamilton's equations of motion. Phase space, phase trajectories. Applications to systems with a small number of degrees of freedom.	6
Scattering in a central potential, Rutherford formula, scattering cross section.	1
Charged particle in an electromagnetic field.	2
Non-inertial frames of reference and pseudo-forces: centrifugal, Coriolis and Euler forces.	2
Rotations in three dimensions, Euler angles. Angular momentum. Elements of rigid-body dynamics. The symmetric top.	3
Small oscillations. Normal mode analysis. Normal modes of simple molecules and harmonic chains.	3
Elementary ideas on general dynamical systems:	5

NP-TEL

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Physics

Pre-requisites:

Basic calculus, basic mechanics (at the undergraduate level).

Coordinators:

Prof. V. Balakrishnan
Department of PhysicsIIT Madras

conservative versus dissipative systems. Hamiltonian systems and Liouville's theorem. Constants of the motion and symmetries in classical mechanics. Noether's Theorem and the connection between symmetry, invariance and conservation principles.	
Canonical transformations, Poisson brackets. Action-angle variables. Integrable Hamiltonians. Non-integrable systems and elements of chaotic motion.	4
Special relativity: Inertial frames. Principle and postulate of Relativity. Lorentz transformations. Length contraction, time dilation and the Doppler effect. Velocity addition formula. Rapidity.	2
Four-vectors and tensors. Energy-momentum of a free particle. Relativistic invariance of physical laws. The wave equation. Transformation properties of electric and magnetic fields. The homogeneous and inhomogeneous Lorentz groups.	5

References:

1. H. Goldstein, C. P. Poole and J. L. Safko, Classical Mechanics, 3rd edition.
2. L. N. Hand and J. Finch, Analytical Mechanics.
3. J. V. Jose and E. J. Saletan, Classical Dynamics: A Contemporary Approach.
4. I. Percival and D. Richards, Introduction to Dynamics.
5. L. D. Landau and E. M. Lifshitz, Mechanics.
6. W. Rindler, Introduction to Special Relativity.
7. E. F. Taylor and J. A. Wheeler, Spacetime Physics.