

200A Classical Mechanics

Course description

Graduate level introductory classical mechanics course. Variational principle, Euler-Lagrange equations, central force problem, rigid bodies, oscillations, Hamiltonian formulation, canonical transformations, Noether's theorem etc. In addition, the following topics should be included in the material: Hamilton-Jacobi theory, special relativity, and classical chaos (especially the KAM theorem). This roughly corresponds to Chapters 1-11 and 13 of Goldstein (3rd ed).

Detailed syllabus

Particle mechanics: general discussion of Newtonian dynamics, canonical coordinates, Lagrangians (2 lectures)

Variational principle: general variational calculus, Euler-Lagrange equations, constrained systems, conservation laws. Noether's theorem. (3-4 lectures)

Hamiltonian dynamics: Legendre transformation to phase space, Hamilton's equations (2 lectures)
Canonical transformations, Poisson brackets, Liouville's theorem (2 lectures) optional: symplectic structures and symmetries (1 lecture)

Central force problem: two-body problem: solution by quadratures, angular momentum conservation, Kepler orbits, Laplace-Runge Lenz vector. Comments on the 3-body problem in Newtonian gravity (2 lectures)

Classical Chaos: periodic orbits, KAM theorem, chaotic trajectories, Lyapunov exponents, and attractors (2 lectures)

optional: Rigid bodies: Kinematics, conserved quantities, rotations and Euler angles, moment of inertia, precession (2-3 lectures)

Equilibrium and stability: small oscillations about stationary points. damping and dissipation, unstable modes (2 lectures)

Special relativity & classical field theory: review of special relativity, introduction to Lorentz symmetries and Poincare algebra. Lagrangian densities, conservation laws (Noether construction). Klein-Gordon and Maxwell theories. optional: Continuum dynamics of fluids (Navier-Stokes for Galilean invariant systems and generalizations to relativistic fluids). (4 lectures)

Resources:

Goldstein, Poole, Safko: Classical mechanics (3rd edition)

Landau, Lifshitz: Mechanics