PH201: CLASSICAL MECHANICS
Aug-Dec 2004

Tuesdays and Thursdays 1130-1300, Physics Dept Lecture Hall I
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- **Grades based on**:
  Midsemester exam: 35 %
  Homework Assignments 25 %
  End-semester Exam 40 %
  Note: (a) Exams are closed book, closed notes. No external material, not even your class notes, is permitted.
  (b) Homework will not be accepted *at all* after the due date.

- **Texts**:
  H. Goldstein, *Classical Mechanics* (Narosa, New Delhi 1998)
  N.C. Rana and P.S. Joag, *Classical Mechanics* Tata McGraw-Hill, New Delhi (1991).
  L.D. Landau and E.M. Lifshitz, *Mechanics*, 3rd edition, Butterworth-Heinemann, New Delhi (1998).
  J.V. José and E.J. Saletan, *Classical Dynamics: A Contemporary Approach* Cambridge University Press (1998).

Course Outline
In parentheses are the *estimated* numbers of 90-minute lectures for the topic. The total number of lectures in this outline is 26; if we have more time I won't expand the syllabus but simply cover the same material at a slower pace; if we have less time I will have to cut out some topics.

1. **From Newton to Lagrange**: Newton's Laws; conservative forces; symmetries and conservation laws; constraints; generalised coordinates; d'Alembert's principle; the calculus of variations and Lagrange's principle of least action; mechanical similarity for homogeneous potentials; Virial theorem; velocity-dependent forces and dissipation; variational problems in general; rotating frames of reference and apparent forces in such a frame. (4)

2. **The two-body central-force problem in general**: the centrifugal barrier and the effective one-dimensional radial potential; the nature of orbits; conditions for the existence of closed orbits; the Kepler problem: motion in a $-1/r$ potential; scattering in a central potential (4);

3. **Many-particle systems (A)** – Rigid bodies: number of degrees of freedom of a rigid object in d dimensions; parametrising rotations – the Euler angles; generators of rotations; some properties of the group of rotations; dynamics of a rigid body: inertia tensor; precession of rotating objects,

stable and unstable trajectories; the heavy symmetric top with one point fixed. (4)

4. **Many-particle systems (B)** – Small oscillations of non-rigid objects: Local minima of the potential energy; digression – harmonic oscillators, damped and undamped, resonance, parametric resonance, motion in rapidly oscillating fields and the effective potential; normal modes as the eigenvalues of the dynamical matrix; a variety of examples – model molecules, the harmonic chain, continuum elasticity (4)

5. **Many-particle systems (C)** – A very elementary introduction to fluid mechanics (4)

6. **Elements of special relativity**: difficulties with Galilean relativity, Lorentz transformations and the Lorentz group, the invariant spacetime interval, relativistic mechanics, time dilation and related effects, four-vectors, proper time; applications to collisions, Thomas precession etc. (4)

7. **Hamiltonian mechanics**: from Lagrangians to Hamiltonians; canonical momentum; phase space; Poisson brackets; the action; canonical transformations as preservers of Poisson brackets, i.e., of the symplectic form; time evolution as a canonical transformation; Liouville's theorem; Hamilton-Jacobi theory; action-angle variables; integrable and non-integrable systems; adiabatic invariants; canonical perturbation theory; the problem of small divisors; outline of the KAM theorem; introduction to chaos. (6)