PHYSICS 507 Fall 2015

CLASSICAL MECHANICS. TENTATIVE SYLLABUS

This is a tentative schedule of what we will cover in the course. It is subject to change, often without notice. These will occur in response to the speed with which we cover material, individual class interests, and possible changes in the topics covered. Use this plan to read ahead from the text books, so you are better equipped to ask questions in class.

I. NEWTONIAN MECHANICS

• **Space (Survey of undergraduate level vector algebra) :** Euclidean space. Vectors. Orthogonal transformation. Kronecker and Levi-Civita symbols. Euler theorem. Cross product.
Literature: 1) R.A. Sharipov, Quick Introduction to Tensor Analysis (Chapters I-III);
2) H. Goldstein: Classical Mechanics (Chapters 4.1-3, 4.5-4.7)
3) P. Lampert. Course Notes (Chapters 7.1-7.3)

• **Newton's laws (Survey of undergraduate level mechanics):** Time. Reference frame. Material point (particle). Velocity. Galilean transformations and principle of relativity. Newton's laws. Mass and force. Examples of forces.
Literature: 1) P. Lammert, Course Notes (Chapters 1.1, 1.2, 7.1)

• **Systems of particles (Survey of undergraduate level mechanics):** Internal and external forces. Linear and angular momentum. Energy. Conservative and nonconservative forces. Virial theorem.
Literature: 1). Lammert, Course Notes (Chapters 1.3-1.8)
2). H. Goldstein: Classical Mechanics (Chapters 1.1, 1.2, 3.4);
3). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 8, 10).

• **Motion in one dimension:** Local solution of the Newton equation. Phase curves.
Literature: 1). L.D. Landau and E.M. Lifshitz: Mechanics (Chapter 11).
2). Lammert, Course Notes (Chapters 4.1-1.2)

• **Two-body problem:** Reduced mass. Motion in a central field. Second Kepler law. Binet's equation.

Literature: 1). H. Goldstein: Classical Mechanics (Chapters 3.1-3.5);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 13, 14).
3). Lammert, Course Notes (Chapter 4.3)

• **Kepler problem:** Closed orbits. The Laplace-Runge-Lenz vector.

Literature: 1). H. Goldstein: Classical Mechanics (Chapters 3.7-3.9);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 15).
3). Lammert, Course Notes (Chapter 4.4)

• **Scattering:** Differential scattering cross section. Rutherford's formula.

Literature: 1). H. Goldstein: Classical Mechanics (Chapters 3.10, 3.11);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 18, 19).

II. LAGRANGIAN MECHANICS

• **Configuration space:** Generalized coordinates. Examples (cylindrical, spherical, ellipsoidal coordinates). Generalized velocities. Kinetic energy. Holonomic constraints. Degrees of freedom.

Literature: 1). Lammert, Course Notes (Chapters 2.1-2.2);
2). H. Goldstein: Classical Mechanics (Chapters 1.3);
3). L.D. Landau and E.M. Lifshitz: Mechanics (Chapter 1).

• **Lagrange's equation:** D'Alembert's principle. Lagrange's equation.

Literature: 1). H. Goldstein: Classical Mechanics (Chapters 1.4, 1.6);
2). Lammert, Course Notes (Chapters 2.3-2.4);
3). Lammert, Course Notes (Supplemental, Chapter 1)

• **Hamilton's principle:** Calculus of Variations. Hamilton's principle. Properties of the Lagrange function (Lagrangian). Lagrange's equations for systems with constraints. Lagrange multipliers.

Literature: 1). H. Goldstein: Classical Mechanics (Chapters 2.1-2.3);
2). Lammert, Course Notes (Chapters 2.5-2.8);

3). Lammert, Course Notes (Supplemental, Chapters 2, 3)
4). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 2-5).

• **Symmetries and conservation laws:** Cyclic coordinates. Routh function (Routhian). Integrals of motion. Symmetries. Noether's theorem. Energy. Momentum. Angular momentum.

Literature: 1). H. Goldstein: Classical Mechanics (Chapters 2.6-2.7, 8.3);
2). Lammert, Course Notes (Chapters 2.9);
3). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 6-10, 41).

III. RIGID BODY MOTION

• **Kinematics of rigid body motion:** Configurational space of a rigid body . Euler angles. Angular velocity.
Literature: 1). H. Goldstein: Classical Mechanics (Chapters 4.1-4.8);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 31).

• **The Lagrangian for a rigid body:** Inertia tensor. Principal axis. Angular momentum and kinetic energy of a rigid body. Heavy symmetrical top. Rigid body in contact. Non-holonomic constraints.
Literature: 1). H. Goldstein: Classical Mechanics (Chapters 5.1-5.4, 5.7);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 32-34, 38).

• **The equation of motion of a rigid body:** Euler's equations. Free assymetrical top.
Literature: 1). H. Goldstein: Classical Mechanics (Chapters 5.5, 5.6);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 34, 36, 37).

• **Motion in a non-inertial frame of reference (self-study):** Motion in a non-inertial frame of reference. Coriolis force.
Literature: 1). H. Goldstein: Classical Mechanics (Chapter 4.10);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapter 39).
3) P. Lampert. Course Notes (Chapters 7.4-7.6)

IV. SMALL OSCILLATIONS

• **Oscillations of systems with more than one degree of freedom:** Formulation of the problem. Pair of forms. Characteristic frequencies. Normal coordinates (modes).
Literature: 1). H. Goldstein: Classical Mechanics (Chapters 6.1-6.4);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 21, 23, 24).
3) P. Lampert. course Notes (Chapters 3.1-3.3, 5.1-5.7)

V. HAMILTONIAN MECHANICS

• **Canonical equations:** Legendre transformation. Phase space. Hamiltonian. Canonical equations of motion. Modified Hamilton's principle. Hamiltonian and energy.
Literature: 1). H. Goldstein: Classical Mechanics (Chapters 8.1, 8.3);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 40, 41)

• **Variational principle and Liouville's theorem:** Modified Hamilton's principle. Liouville's theorem.
Literature: 1). H. Goldstein: Classical Mechanics (Chapters 8.6, 9.9);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapter 46)

• **Poisson bracket:** Poisson bracket. Integrals of motions. Liouville-Arnold theorem (week form).
Literature: 1). H. Goldstein: Classical Mechanics (Chapters 9.5-9.7);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapter 42)

• **Canonical transformations:** Canonical transformations. Generating functions.
Literature: 1). H. Goldstein: Classical Mechanics (Chapters 9.1-9.3);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapter 45)

VI. HAMILTON-JACOBI THEORY

• **Hamilton-Jacobi equation:** Hamilton-Jacobi equation. Separation of the variables.

Literature: 1). H. Goldstein: Classical Mechanics (Chapters 10.1-10.5);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 47, 48)

• **Angle-action variables:** Angle-action variables. Adiabatic invariants. Canonical perturbation theory.

Literature: 1). H. Goldstein: Classical Mechanics (Chapters 10.6-10.8, 12.5);
2). L.D. Landau and E.M. Lifshitz: Mechanics (Chapters 49, 50, 52)