PHYSICS 507 Fall 2015

MIDTERM EXAM

Room: ARC-203
Time: October 29 (Thursday), 12:00-1:20pm

GROUND RULES

- There are four problems based on the below-listed material.
- Open book
- Open notes
- Partial credit will be given. Do as many parts of a problem as possible.

PROGRAM

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. Bertrand's theorem
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).