

MIDTERM EXAM

**Room:** ARC-207

**Time:** November 1 (Thursday), 10:20-11:40

GROUND RULES

- There are four problems based on the below-listed material.
- Closed book
- Closed 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).

• **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).