

Fall 2023

PHYS 611 - 101: Advanced Classical Mechanics

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Physics 611 Course Outline

Instructor: Prof. Tao Zhou, taozhou@njit.edu, Tel: 973-642-4931, Room: T478

Textbook: *Classical Mechanics*, by Herbert Goldstein, 2nd Edition, Addison Wesley.
Classical Mechanics, by John M. Finn, Infinity Science (2008).

Grade Decomposition

Class participation & Homework: 30%

Midterm Exam: 35%

Final Exam: 35%

Office hour: Monday 2:30 to 4 pm, Wednesday 11:30 am to 1 pm

Learning Objective: Students are expected to learn the general formalism of Lagrangian and Hamiltonian mechanics, using the differential Lagrangian equation to solve classical mechanics problem, using the variational Hamilton's principle to solve very diverse problems outside of classical mechanics. Detailed knowledge of canonical transformation and Hamilton-Jacobi equation will help students greatly in their future study of graduate level quantum mechanics. Students are also expected to become familiar with the specific topics of central force, rigid body and small oscillations.

Learning Outcome Evaluation Metrics: Through in-class quiz and discussion, instructor can evaluate students' understanding of basic physical concepts. Through homework, instructor can evaluate students' problem solving capability. Mid-term and final exams offer instructor the opportunity to comprehensively test students' understanding of course material and problem solving capability.

At the end of the semester, students should be able to

- Using D'Alembert's principle to solve virtual work problems.
- Using Euler-Lagrangian equation to solve various mechanics problems, including constrain force problems, by taking advantage of the Lagrangian Multiplier method in combination with the Lagrangian Equations.
- Solving various central force problem, particularly related to the Kepler problem.
- Solve the rigid body rotation problems using Euler's equation.
- Solve small oscillation and related eigen value and eigen function problems.
- Understand the variational principle and its equivalence to the Lagrangian Equation, and use it to solve various problems, particularly non-mechanics related problems.
- Identify the criteria for canonical transformations using Poisson bracket methods
- Using Hamilton-Jacobi equation to solve various mechanic problems, in particular using the action-angle variables methods derived from H-J equation to solve periodic problems.

Topics: (Schedule can change depending on course progress)

Date and Lecture Topic	Text Assignment	Homework Assignment
Week 1: Survey of Newtonian mechanics of particles	Chap. 1	See detailed homework assignment after each lecture
Week 2: Lagrangian Equation	Chap 3.1 – 3.4	
Week 3: Lagrangian multiplier method	Chap 3	
Week 4: Hamilton's Principle and variational approach	Chap 4	
Week 5: Central force and gravity	Chap 5	
Week 6: Rigid body kinematics and dynamics	Chap 7 & 8	
Week 7: Midterm Exam	Covers weeks 1 - 5	
Week 8: Small Oscillation	Chap 6	
Week 9: Hamilton's equations	Chap 3.4 - 3.6	
Week 10: Canonical transformation	Chap 9	
Week 11: Hamilton-Jacobi Theory	Chap 10	
Week 12: Lagrangian formulation of fields	Chap 12	
Week 13: Review		
Final Exam Period	Final exam date to be announced	Comprehensive final exam