PHYSICS 504

Advanced Mechanics

Instructor: Al Shapere
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office hours: 4pm – 5pm TR
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Textbook:

Lectures will be based on my notes, available on Canvas.
I recommend David Tong's Classical Mechanics (Cambridge U Press, 2025) as a supplemental textbook. An older version is available as a pdf.
Another useful text is Classical Mechanics (3rd ed.), by H. Goldstein, C. Poole, and J. Safko (Addison-Wesley 2002).

About the course:

This graduate-level course in classical mechanics will cover Lagrangian and Hamiltonian dynamics, rigid bodies, oscillations, special relativity, and selected other topics as time permits.

Exams and Grades:

Final grades will be based on homework scores (25%) and exam scores (75%). There will be two midterm exams (20% each) and one final exam (35%). Up to 5% in additional bonus points may be awarded at the instructor's discretion for class participation, supplemental work, and/or for completing the online course evaluation. A passing grade on the final is required to pass the course. Students will not be excused from taking an exam at the scheduled time unless approved by the instructor at least 24 hours in advance.

Homework:

Homework assignments will be given once a week and will be due by the beginning of class on the due date. All assignments should be uploaded to Canvas. Late homework will be accepted with a minimum 10% deduction plus an additional 10% deduction for each full 24-hour period late. For example, if an assignment was due on Friday and is turned in after 9am Sunday and before 9am Monday, the student's grade for that assignment will be reduced by 30%. Late homeworks should be turned in directly to the instructor or, if he is not available, by sliding them under his office door.

Prerequisites:

A one-semester undergraduate classical mechanics course with a grade of 'B' or higher. If you have not completed such a course you should take PHY 404G instead.

Course outline

Preliminaries
The mechanical philosophy of nature
Newton's laws
Conservation of angular momentum and energy

Coordinate systems
Inertial vs. noninertial reference frames
Galilean relativity
Galilean transformations

Lagrangian mechanics
Lagrangians and lagrange equations
Hamilton's principle
Calculus of variations, functional derivatives
Constaints and Lagrange multipliers

Symmetries and conservation laws
Noether's theorem
Time-translation invariance and energy
Non-conservative systems

Oscillations
Harmonic oscillators - universality
Normal modes
Continuum limit
Nonlinear oscillators

Central forces
The two-body problem
Keplerian orbits
The three-body problem
Scattering theory

Rotational motion
Finite and infinitesimal rotations
Group theory
Relation of body and lab frames
Rigid body dynamics

Relativity
Inertial reference frames revisited
Lorentz transformations
Relativistic kinematics and dynamics

Hamiltonian mechanics
Hamiltonian and Hamilton's equations
Poisson brackets
Noether's theorem
Correspondence principle
Hamilton-Jacobi theory and Schrodinger's equation