Physics 301: Analytical Mechanics

Spring 2026
TR 10:50- 12:05 PM

Course Description

Analytical mechanics is not just an advanced treatment of motion—it is the foundation of how we formulate physics itself. Centered on Hamilton's principle of least action, this course develops the Lagrangian and Hamiltonian formalisms and explores the profound role of symmetry, culminating in Noether's theorem, which reveals conservation laws as the natural consequence of symmetry. These methods extend far beyond mechanics, providing the conceptual bridge to quantum theory, relativity, and modern physics. By the end of the course, you will not only have mastered advanced tools to tackle sophisticated physical systems but also gained an appreciation for the beauty and universality of analytical methods. This is a course that transforms the way you think about the laws of nature, preparing you for deeper study in the physical sciences.

Topics include:

- Variational principles and Hamilton's principle of least action.
- Lagrangian mechanics and generalized coordinates.
- Conservation laws and symmetries.
- Small oscillations and normal modes, Central force motion, Rigid body dynamics.
- Hamiltonian mechanics and phase space.
- Canonical transformations and Poisson brackets.
- Connections to quantum theory, relativity and chaos.

Grading

The breakdown of the total grade is as follows:

- Two mid-term exams 40%
- Final exam 30%
- Homework 30%

Course Materials

Required Textbook:

- Modern Classical Mechanics by Helliwell and Sahakian.