The Hebrew University of Jerusalem

Syllabus

Advanced analytical mechanics - 77966

Last update 09-03-2025

HU Credits: 3

Degree/Cycle: 2nd degree (Master)

Responsible Department: Physics

Academic year: 0

Semester: 2nd Semester

Teaching Languages: English and Hebrew

Campus: E. Safra

Course/Module Coordinator: Dr. Ido Barth

Coordinator Email: ido.barth@mail.huji.ac.il

Coordinator Office Hours: By appointment

Teaching Staff:

Dr. Ido Barth

Course/Module description:
Advanced course in analytical mechanics

Course/Module aims:
1. To deepen the theoretical understanding of nonlinear multidimensional Hamiltonian systems.
2. To provide applicable knowledge in perturbation theories and in numerical methods for dynamical systems.

Learning outcomes - On successful completion of this module, students should be able to:
1. To analyze Hamilonian systems by the means of action-angle variables.
2. To identify symmetries, topology, constants of motion, and adiabatic invariants.
3. To use perturbation theories for solving stationary, dynamical, and resonant problems.
4. To write a symplectic scheme for numerical simulations of dynamical systems.

Attendance requirements(%):
0

Teaching arrangement and method of instruction: Lecture, exercise, and homework

Course/Module Content:
1. A review of the formalisms of Lagrange, Hamilton, and Hamilton-Jacobi.
2. The Symplectic condition for canonical transformations, Poisson brackets, phase space, Liouville theorem, infinitesimal canonical transformations, and Symplectic numerical schemes.
3. The variational principle, the abbreviated action, and the action integral.
4. Action-angle variables, integrability, phase space topology, degeneracy, and Poincare surface of section. Examples: the Harmonic oscillator, the anharmonic oscillator (pendulum), the Kepler problem.
5. Perturbation theories: Time independent perturbation theory, nearly integrable systems Canonical perturbation theory, secular (time dependent) perturbation theory, nonlinear resonance, Chirikov criterion for resonance overlap, Arnold diffusion, KAM theorem,
6. Adiabatic invariants.

7. Autoresonance.
8. Introduction to classical field theory.

Required Reading:
non

Additional Reading Material:
• H. Goldstein, Classical mechanics, (Pearson 2013).
• L.D. Landau and E.M. Lifshitz, Mechanics, (Addison–Wesley 1960).
• A.J. Lichtenberg and M.A. Lieberman, Regular and stochastic motion, (Springer 1983).
• R.Z. Sagdeev, D.A. Usikov, and G.M. Zaslavsky, Nonlinear physics - from the pendulum to turbulence and chaos, (Harwood 1988).

Grading Scheme:
Essay / Project / Final Assignment / Home Exam / Referat 30 %
Submission assignments during the semester: Exercises / Essays / Audits / Reports / Forum / Simulation / others 70 %

Additional information:
none