Theoretical Mechanics

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Lecture room D, Friday 10.00-12.00, Fall 2023

Theoretical mechanics is crucial for a deeper understanding of various areas within theoretical physics. This course is intended not only for PhD students specializing in theoretical physics but also for those working in other fields, such as plasma simulation and solid-state physics, among others.

Prerequisites: A strong grasp of calculus, linear algebra, and analytical geometry, typically covered in undergraduate programs in exact sciences like physics and engineering, is required.

To pass the course, each student will be assigned a randomly selected theoretical problem from a list of problems. They will then have a few days to solve the problem independently and subsequently present their solution to the lecturer.

Program of the course, 15×2 hr.

1. Coordinate systems and motion of mechanical systems with imposed constraints. Lagrangian formalism.
2. Study of motion using Lagrange's equations. Integrals of motion. Generalized momentum. Lagrangian functions for a moving particle.
3. The motion of charged particles in an electromagnetic field.
4. Study of one-dimensional motion. Harmonic oscillator. Qualitative analysis of one-dimensional motion.
5. Motion in a central field. Effective potential.
6-7. Kepler's problem and its applications. Perihelion shift of Mercury.
8. Motion of two interacting bodies. Scattering problem in a repulsive potential.
9-10. Hamiltonian function and Hamilton's equations. Transition from the Hamiltonian function to the Lagrangian function and vice versa. Integrals of motion.
11. Motion of a rigid body. Tensor of inertia. Application to a symmetric top and rolling disc motions.
12-13. Canonical transformations. Generating functions of canonical transformations. Poisson brackets.
14-15. Hamilton-Jacobi method. Solving problems using the Hamilton-Jacobi method.

Recommended literature.

1. H. C. Corben, P. Stehle, Classical Mechanics
2. J. W. Leech, Classical Mechanics
3. L. D. Landau, E. M. Lifshitz, Mechanics
4. I. I. Olchowski, Mechanika teoretyczna (in Polish)
5. Supplementary materials accompanying the lecture notes provided by the instructor

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