

Taras Shevchenko National University of Kyiv

Physics Department

Course description

**Classical Mechanics**

**Level: Language: Duration: Occurrence:**

Bachelor Ukrainian 1 semester 3rd – 4th semesters

**Credits: Total Hours: Contact Hours: Self-study Hours:**

8 240 120 120

**Description of Course Work and Examinations**

Module-rating system, results are evaluated on a 100-point scale. The first semester contains 2 midterms 20 pts/90 min each, an oral colloquium 15 pts/90 min and a final problem set for 45 pts that should be completed in 3 days. The second semester contains contains 2 midterms 20 pts/90 min each, a written colloquium 15 pts/90 min and a final exam 40 pts/240 min. The rest 5 pts are given for activity during seminars.

**Prerequisites**

Mathematical Analysis (1st – 2nd semesters), Mechanics (1st semester)

**Corequisites**

Differential Equations (3rd semester)

**Syllabus**

***General Concepts:*** subject and problems of classical mechanics, point mass, operational and formal logical quantities, definitions of SI mechanical units (kg, m, s).

***Mechanics of Systems of Point Masses:*** trajectory of a particle, force, superposition principle, Newton’s laws and corollaries, mechanical state of a point mass, Galilean invariance principle, laws of conservation and integrals of motion (energy, momentum, angular momentum, Laplace-Runge-Lenz vector), potential, classification of forces (constant, potential, dissipative, gyroscopic), virial theorem.

***One-Dimensional Motion:*** solution, finite and infinite motion, periodic motion (period, turning points, probability density), small oscillations, mathematical pendulum (period-amplitude dependence, damped and driven damped pendulum) , non-harmonic oscillations, parametric resonance, motion in an oscillating outer field, motion of linear infinite chains (allowed modes and frequencies, dispersional relation).

***Oscillations with Many Degrees of Freedom:*** Lagrangian of a system with many degrees of freedom, motion around the equilibrium, normal coordinates, non-harmonic oscillations and combinational frequencies.

***Motion in a Central Field:*** center-of-mass frame, conservation laws (energy and angular momentum), reduced mass, effective potential, solutions for , and , finite and infinite motion, periodic motion (radial and angular periods, turning points, closed and unclosed path), falling to the center, capturing cross-section, scattering (angle of deflection, differential and integral scattering cross-section, Rutherford’s formula), Coulomb field, Kepler’s laws, eccentricity, types of orbits (circle, ellipse, parabola, hyperbola).

***Lagrangian Mechanics:*** motion with constraints, real and virtual displacements, reaction forces, generalized coordinates, Lagrange equations of the 1st and 2nd kind, Lagrangian, generalized forces, gauge invariance, coordinate substitution, kinetic energy in curvilinear coordinates, particle in electromagnetic field, Lagrangian of interaction, cyclic coordinates, Routh’s method, energy integral, variational principle in the space, action and the least action principle, symmetry of space-time, asynchronous variations, Noether’s theorem.

***Hamiltonian Mechanics:*** Hamiltonian as the Legendre transformation of Lagrangian, Hamilton’s equations, variational principle in the space, canonical transformations and generating functions, Poisson brackets, Hamilton-Jacobi equations, separation of variables in the Hamilton-Jacobi equation in spherical and cylindrical coordinates, Liouville’s theorem, Liouville’s equations.

***Mechanics of Rigid Bodies:*** degrees of freedom, Euler angles, angular velocity, tensor of inertia, energy, momentum and angular momentum of a rigid body, instantaneous axis of rotation, principal axes and principal moments of inertia, Lagrangian of a rigid body, motion of a body with fixed support, equations of motion, dynamics of a whirligig, free rotation, precession and nutation.

***Mechanics of Continuous Media:*** infinitesimal particle, deformations, tensor of deformations, internal and external forces, stress tensor, laws of conservation (mass, momentum, angular momentum, energy), full system of equations of motion, models of the continuous medium, elastic media, Hooke’s law, symmetry and Lame parameters, Lame equations and boundary conditions, sound in elastic media: longitudinal and transverse waves, viscous media, Navier laws, Navier-Stokes equations, motion of an ideal fluid (Pascal, Bernoulli and Thomson laws), laminar flow, Rheynolds number, Poiseuille's law, Stoke’s formula, sound in fluids.

**Literature**

1. S. Ezhov, M. Makarets, O. Romanenko. *Classical Mechanics*. Kyiv 2007, ISBN 978-966-439-029-0.

2. L. Landau, E. Lifshitz. *Theoretical Physics, Vol. 1: Mechanics; Vol. 6: Hydrodynamics; Vol. 7: Theory of Elasticity.* Moscow 1988.

3. L. Sedov. *Mechanics of Continuous Media, Vol. 1 and 2*. Moscow 1994, ISBN 5-02-007052-1 and 5-02-007052-2.

4. A. Fedorchenko. *Theoretical Physics, Vol. 1: Classical Mechanics and Electrodynamics*. Kyiv 1992.

5. L. Grechko, V. Sugakov, O. Tomasevich, A. Fedorchenko. Set of Problems in Theoretical Physics. Moscow 1984.

6. G. Kotkin, V. Serbo. Set of Problems in Classical Mechanics. Moscow 1969.

7. Yu. Pavlenko. Set of Problems in Theoretical Mechanics. Moscow 1988.

**Instructors**

Professor Mykola V. Makarets/Associate Professor Oleksandr V. Romanenko.