Syllabus

02MECH - Mechanics

This winter semester course for first-year bachelor students covers the basics of mechanics and some advanced methods, such as solving equations of motion for mechanical systems like a particle under constant force, a harmonic oscillator, the central force problem, and rigid bodies. Students take two tests during the term to qualify for the *Zápočet*, which is required to take the final exam under course code 02MECHZ. During weekly problem-solving hours, the topics are reinforced by solving problems. Below is an overview of the topics covered in the course:

- **1st week**: (Mathematical preliminaries) Scalars, scalar functions, cartesian and polar coordinates, derivatives, integrals, introduction to first- and second-order homogenous differential equations, vectors, vector operations.
- **2nd week**: (Kinematics) Reference frames, position, displacement, velocity, acceleration, speed, average speed, momentum, basic types of motion and their superposition.
- **3rd week:** (Dynamics) Inertial and non-inertial reference frames, Newton's laws of motion, equation of motion for a particle under a constant force, inclined plane, tension, drag force, friction, freefall and terminal speed, projectile motion.
- **4th week:** (Rotation) Angular velocity, torque, angular momentum, rotational inertia of a system of particles, Newton's 2nd law in rotational form, uniform circular motion.
- **5th week:** (Conservation theorems) Conservation of linear and angular momentum, work and kinetic energy, conservative forces and potential energy.
- **6th week:** (Conservation theorems) Conservation of total energy, total energy as an equation of motion, equilibrium, impulse, power.
- **7th week:** (Small oscillations) Simple harmonic oscillator, simple pendulum, phase diagrams for the oscillative behavior.
- **8th week:** (Small oscillations) Damped oscillations, driven oscillations, resonance.
- **9th week:** (Central force motion) Definition of central force, equations of motion for central force problem, orbits, centrifugal energy, effective potential.
- **10th week:** (Central force motion) Two-body problem, planetary motion (cyclic, elliptic, parabolic, and hyperbolic orbits, eccentricity, and total energy), Kepler's laws of planetary motion.
- **11th week:** (Dynamics of system of particles) Center of mass, reconsideration of basic mechanical quantities, dynamics and conservation laws for system of particles, elastic and inelastic collisions.
- **12th week:** (Motion in a non-inertial reference frame) Centrifugal and coriolis forces, motion relative to the Earth, oblateness of Earth, cyclonic motion in atmosphere.
- **13th week:** (Dynamics of rigid bodies) Yo-yo problem, physical pendulum, inertia tensor, Euler's equations, force-free motion of a symmetric top.