

**MOSCOW AVIATION INSTITUTE  
(NATIONAL RESEARCH UNIVERSITY)**

**The program of the entrance exam in Physics**

The program is based on the federal state educational standard of secondary education and the federal state educational standard of general education.

## Elements of Mechanics

### **1. Kinematics of a particle**

Motion. A reference frame. A particle. Path. The distance along path and displacement. Velocity and acceleration. Uniform motion. Rectilinear motion with a constant acceleration.

Relative motion. The law of summation of velocities.

Graphical representation of motion. Graphs of the kinematic quantities time dependence in uniform motion and linear motion with constant acceleration.

Freely falling bodies. Acceleration of free fall.

Uniform circular motion. Linear and angular velocities. The acceleration of the body in uniform motion along a circle (centripetal acceleration). Motion with a constant acceleration along a circle (tangential acceleration). Curvilinear motion, centripetal and tangential acceleration.

The principle of the independence of motions.

The motion of a body thrown at an angle to the horizon (the projectile motion).

The motion of a rigid body. Translational and rotational motion. The motion description of points of rolling wheel.

### **2. Fundamentals of dynamics**

Newton's first law. Inertial frame of reference. Galilean relativity principle.

Newton's second law. The force acting on a body. The mass of a body. Summation of forces. Moment of force (the torque). The equilibrium conditions of a particle and the bodies. The center of mass. Movement of the center of mass for an isolated system of bodies.

Newton's third law.

The elastic forces. Hooke's law. The frictional force. The static frictional force. The kinetic frictional force. The coefficient of friction. The motion of the body under the force of friction.

Gravitational forces. Newton's law of gravitation. Body weight. The movement of the body under the action of gravity. The movement of the planets and satellites. Weightlessness. The planet satellite speed and escape speed.

### **3. The conservation laws of mechanics**

The momentum of a body. The law of conservation of momentum. Jet propulsion.

Work. Power. The kinetic and potential energies. The law of conservation of energy in mechanics. The efficiency of the machines in mechanics.

## **4. Liquids and gases**

Pressure. Pascal's law for liquids and gases. Barometers and manometers. Communicating vessels. The principle of the hydraulic press.

Atmospheric pressure. Changing of atmospheric pressure with altitude.

Buoyancy forces for liquids and gases. Terms of floatation for bodies on the surface and inside the liquid.

The motion of an incompressible fluid through pipes. Dependence of a pressure on the speed of a fluid flow.

## **Molecular Physics. Thermal phenomena**

### **1. Elements of the kinetic theory**

The mass and size of a molecule. Avogadro's number. Brownian motion. The interaction of molecules. An ideal gas. Random motion of molecules.

The basic equation of the kinetic theory of an ideal gas. Temperature and its kinetic meaning. The absolute temperature scale and the Celsius scale. The rms velocity of the molecules of a gas.

### **2. Thermal effects**

The equation of state of an ideal gas (Mendeleev-Clapeyron equation). Molar gas constant. Isothermal, isobaric and isochoric processes.

The internal energy of an ideal gas. The amount of heat. The heat capacity of a body, specific and molar heat capacity, the connection between them. Work in thermodynamics. The law of conservation of energy in thermal processes (the first law of thermodynamics). Application of the first law of thermodynamics to various processes. Adiabatic process.

The principle of operation of heat engines. An ideal heat engine. Carnot cycle. Efficiency of a heat engine. Efficiency of an ideal heat engine.

Evaporation and condensation. Saturated and unsaturated vapor. Humidity. Absolute and relative humidity. The dew point.

Crystalline and amorphous bodies. Properties of solids. Elastic deformation. Hooke's law.

## **Elements of electrodynamics**

### **1. Electrostatics**

Electric charge. Interaction of charged bodies. Coulomb's law. The law of conservation of electric charge.

Electric field. The electric field strength. The electrostatic field of a point charge. The principle of superposition of electric fields. Conductors in an electric field. The electrostatic field created by an infinite uniformly charged plane and charged sphere.

Dielectrics in an electric field. The dielectric constant of the material.

The work done by the electrostatic field during the move of charge. Potential and potential difference. The potential field of a point charge. The link between the electrostatic field and potential difference.

Electrical capacitance. Capacitors. Electrical capacitance of the parallel plate capacitor. The energy of a charged capacitor.

## **2. Laws for DC**

Electric current. Current (amperage). Ohm's law for the wire with current. Calculation current in a single-loop circuit. The resistance of the conductor. Resistances in series and in parallel,. Electromotive force. Work and power in electrical circuits.

Electric current in various materials and in vacuum. Dependence of the resistance of metals on the temperature. Electric current in liquids. The laws of electrolysis. Electric current in gases. The concept of plasma. Electron emission. Cathode-ray tube.

Semiconductors. Electric conductivity of intrinsic and extrinsic semiconductors. Semiconductor diode.

## **3. The magnetic field. Electromagnetic induction**

The magnetic interaction of currents. Magnetic field. The magnetic field  $\vec{B}$  (magnetic flux density). The force acting on a current-carrying conductor in a magnetic field (Ampere's law).

The action of a magnetic field on a moving charge. Lorentz force.

The magnetic properties of a substance. The magnetic permeability of a material.

Electromagnetic induction. Magnetic flux. The law of electromagnetic induction. Lenz law. The phenomenon of self-induction. Inductance. The energy of a magnetic field.

## **Oscillations and Waves**

### **1. Mechanical vibrations and Waves**

Simple harmonic motion (SHM). The amplitude, period, frequency and phase of SHM. Undamped free harmonic oscillations. The simple pendulum. The period of a simple pendulum. SHM of the block on the spring and the period of this SHM.

The conversions of energy in harmonic oscillations.

Forced oscillations. Resonance.

Propagation of mechanical waves in elastic media. The speed of waves. Wavelength. Transverse and longitudinal waves. Standing waves.

Sound waves.

The speed of sound.

### **2. Electromagnetic oscillations and Waves**

The oscillatory circuit. Free electromagnetic oscillations in the circuit. The conversions of energy in the oscillatory circuit. The natural frequency of this circuit.

Forced electrical oscillations. Alternating electrical current. The RMS values of current and voltage. Resistance, capacitive and inductive reactance.

Transformer. Transmission of electricity.

Electromagnetic waves. The speed of their propagation. Emission and reception of electromagnetic waves. Principles of wireless communication. Properties of electromagnetic waves.

### **Elements of optics**

Rectilinear propagation of light. Laws of reflection and refraction of light. The index of refraction. Total internal reflection. The critical angle. The paths of rays in a prism.

Drawing of an image formed by a plane mirror.

Converging and diverging lenses. Thin lens formula. Drawing of an images formed by lenses. Camera. Eyes. Spectacles.

Interference of light and its application in technology.

Diffraction of light. The diffraction grating. The diffraction pattern and its main diffraction peaks.

### **Elements of the special theory of relativity**

The invariance of the speed of light. The principle of relativity. The speed light in a vacuum as the limit rate of a signal. Relationship between mass and energy.

### **Elements of quantum physics**

#### **1. Light quanta (photons)**

Photoeffect and its laws. Planck's constant. Photon as a quantum of light. Einstein's equation for the photoelectric effect.

Light pressure. P.N. Lebedev's experiments.

#### **2. The atom and atomic nucleus**

Rutherford's experiments on the scattering of alpha particles. The nuclear model of an atom. Bohr's postulates. Emission and absorption of light by an atom. Lasers (their construction and properties of laser radiation).

Experimental methods for the detection of charged particles. Radioactivity. The law of radioactive decay. Protons and neutrons. Isotopes. Alpha-, beta- and gamma-radiation.

The binding energy of an atomic nuclei. Specific binding energy. The mass defect of nucleus. Nuclear reactions. The fission of uranium nuclei. Nuclear fusion, thermonuclear fusion.