

MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE  
RUSSIAN FEDERATION

V.I. Vernadsky Crimean Federal University

Approved by

Vice-Rector for Academic and  
Methodological Activities



I.A. Tsvirinko

**THE PROGRAM  
OF ENTRY TEST IN  
PHYSICS**

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## 1. Explanatory note

The entry test in Physics for admission to study in the educational program of higher education - the bachelor's program, is compiled based on the Procedure for admission to study in educational programs of higher education - bachelor's programs, specialist's programs, master's programs, approved by .....

The form of the entrance examination - a test.

The results of entry test in Physics are evaluated based on a 100-point scale.

The purpose of entry test in Physics is to identify the basic knowledge and skills of the applicant, formed during the study of the main sections of the "Physics" subject in educational organizations, and their evaluation.

Tasks of electronic test:

- reveal the applicant's knowledge of the main chapters of physics (mechanics, molecular physics, electrodynamics and the foundations of the special relativity theory, quantum physics and elements of astrophysics);
- evaluate the ability to understand the physical processes occurring in the tasks of electronic test;
- reveal the ability to apply the acquired knowledge to solve physical problems;
- check the mastery of the basic physical quantities dimensions and the ability to perform numerical calculations according to the obtained physical formulas.

Skills tested on the entrance test:

- describe and explain physical phenomena and processes;
- determine the nature of the physical process according to the schedule, table, formula, products of nuclear reactions based on the laws of conservation of electric charge and mass number;
- apply the acquired knowledge to solve physical problems.

## 2. The program of entry test

### MECHANICS

**Kinematics.** Mechanical movement. Relativity of motion. Reference system. Material point. Radius vector. Trajectory. Path and movement. Velocity. Addition of velocities. Acceleration of a material point. Uniform rectilinear motion. Uniformly accelerated rectilinear motion. Free fall. Acceleration of gravity. The motion of a body thrown at an angle  $\alpha$  to the horizontal. The movement of a point in a circle. Angular and linear velocity of a point. Centripetal acceleration of a point. Rigid body. Translational and rotational motion of a rigid body.

**Dynamics.** Inertial reference systems. Newton's first law. Galileo's principle of inertia. Interaction of bodies. Body mass. Force. The principle of superposition of forces. Newton's second law for a material point in an inertial reference system. Newton's third law for material points. Law of gravity: forces of attraction between point masses. Gravity. The dependence of gravity on the height above the surface of the planet of a given radius. Movement of celestial bodies and their artificial satellites. First cosmic speed. Forces of elasticity. Hooke's law. Forces of friction. Friction coefficient. Pressure.

**Statics.** Moment of force about an axis of rotation. Equilibrium conditions for rigid body in an inertial reference system. Pascal's law. Pressure in a fluid at rest in an inertial reference system. Law of Archimedes. Conditions required for the body to float.

**Conservation laws in mechanics.** Impulse of a material point. Impulse of the system of bodies. The law of change and conservation of impulse. Mechanical work and power of force. Kinetic energy of a material point. The law of change of the material points system's kinetic energy. Potential energy of a body in a uniform gravitational field. Potential energy of an elastically deformed body. The law of change and conservation of mechanical energy.

**Mechanical vibrations and waves.** Harmonic vibrations. Amplitude and phase of vibrations. Kinematic description. Dynamic description. Energy description (law of conservation of mechanical energy). Connection of the vibrations amplitude

of the initial value with the vibrations amplitudes of its velocity and acceleration. Period and frequency of vibrations. The period of small free vibrations of the mathematical pendulum. The period of free vibrations of a spring pendulum. Forced mechanical vibrations. Resonance phenomenon. Resonance curve. Transverse and longitudinal waves. Propagation speed and wavelength. Interference and diffraction of waves. Sound waves. Sound velocity.

### **MOLECULAR PHYSICS.**

**Molecular physics.** Models of the gases, liquids and solids structure. Thermal motion of atoms and molecules of matter. Interaction of matter particles. Diffusion. Brownian motion. Ideal gas model in kinetic theory of gases: gas particles move randomly and do not interact with each other. Relationship between pressure and average kinetic energy of the translational thermal motion of ideal gas molecules. Absolute temperature. Connection of gas temperature with the average kinetic energy of the translational thermal motion of its particles. Mendeleev–Clapeyron equation. Expression for the internal energy of a monatomic ideal gas. Dalton's law for the pressure of a rarefied gases mixture. Isoprocesses in a rarefied gas with a constant number of particles  $N$  (with a constant amount of matter  $\nu$ ). Graphical representation of isoprocesses. Saturated and unsaturated steams. Qualitative dependence of the density and pressure of saturated steam on temperature, their independence from the volume of saturated steam. Air humidity. Relative humidity. Changes in the aggregate states of a substance: evaporation and condensation, boiling of a liquid. Changes in the aggregate states of matter: melting and crystallization. Energy conversion in phase transitions.

**Thermodynamics.** Thermal equilibrium and temperature. Internal energy. Heat transfer as a way of changing internal energy without doing work. Convection, conduction, radiation. Quantity of heat. Specific heat capacity of a substance. Specific heat of vaporization. Specific heat of fusion. Specific heat of fuel combustion. Elementary work in thermodynamics. The first law of thermodynamics. The second law of thermodynamics, irreversibility. Thermal machines operation

principles. Efficiency. The maximum efficiency value. Carnot cycle. Heat balance equation.

### **ELECTRODYNAMICS**

**Electric field.** Electrification of bodies and its manifestations. Electric charge. Two types of charge. Elementary electric charge. The law of electric charge conservation. Interaction of charges. Point charges. Coulomb's law. Electric field. Its action on electric charges. Electric field strength. The field of a point charge. Potentiality of the electrostatic field. Potential difference and voltage. Potential charge energy in an electrostatic field. The potential of the electrostatic field. Relationship between field strength and potential difference for a uniform electrostatic field. The principle of electric fields superposition. Conductors in an electrostatic field. Dielectrics in an electrostatic field. The dielectric constant of a substance. Capacitor. The capacitance of a capacitor. Capacitance of a flat capacitor. Parallel connection of capacitors. Series connection of capacitors. The energy of a charged capacitor.

**Direct current laws.** Current strength. Conditions for the existence of an electric current. Voltage and EMF. Ohm's law for a circuit section. Electrical resistance. The dependence of the resistance of a homogeneous conductor on its length and cross section. Specific resistance of a substance. Current sources. EMF and internal resistance of the current source. Ohm's law for a complete (closed) electrical circuit. Parallel connection of conductors. Serial connection of conductors. The work of electric current. Joule-Lenz law. Electric current power. Thermal power dissipated in the resistor. Current source power. Free carriers of electric charges in conductors. Mechanisms of conductivity of solid metals, solutions and melts of electrolytes, gases. Semiconductors. Semiconductor diode.

**Magnetic field.** Mechanical interaction of magnets. A magnetic field. Magnetic induction vector. The superposition principle of magnetic fields. Magnetic field lines. Field line pattern of strip and horseshoe permanent magnets. Oersted's experiment. The magnetic field of a current-carrying conductor. Field line pattern of

a long straight conductor and a closed ring conductor, a coil with current. Ampere force, its direction and magnitude. Lorentz force, its direction and magnitude.

**Electromagnetic induction.** Flux of the magnetic induction vector. The phenomenon of electromagnetic induction. EMF of induction. Faraday's law of electromagnetic induction. EMF of induction in a straight conductor moving at speed in a uniform magnetic field. Lenz's rule. Inductance. Self-induction. EMF of self-induction. The energy of the magnetic field of a coil with current.

**Electromagnetic oscillations and waves.** Oscillatory circuit. Free electromagnetic oscillations in an ideal oscillatory circuit. Thomson formula. Relationship between the amplitude of the capacitor charge and the amplitude of the current in the oscillatory circuit. The law of energy conservation in an oscillatory circuit. Forced electromagnetic oscillations. Resonance. Alternating current. Production, transmission and consumption of electrical energy. Properties of electromagnetic waves. Mutual orientation of vectors in an electromagnetic wave in vacuum. Scale of electromagnetic waves. The use of electromagnetic waves in technology and everyday life.

**Optics.** Rectilinear propagation of light in a homogeneous medium. A ray of light. Laws of reflection of light. Construction of images in a flat mirror. Laws of refraction of light. Absolute refractive index. Relative index of refraction. The path of rays in a prism. The ratio of frequencies and wavelengths during the transition of monochromatic light through the interface between two optical media. Total internal reflection. Limiting angle of total internal reflection. Converging and diverging lenses. Thin lens. Focal length and optical power of a thin lens. Thin lens formula. The magnification given by a lens. The path of a beam passing through a lens at an arbitrary angle to its main optical axis. Construction of images of a point and a line segment in converging and divergent lenses and their systems. The camera as an optical device. The eye as an optical system. Light interference. Coherent sources. Conditions for observing maxima and minima in the interference pattern from two in-phase coherent sources. Diffraction of light. Diffraction grating. The condition

for observing the main maxima under normal incidence of monochromatic light.  
Dispersion of light.

**Fundamentals of the special relativity theory.** Invariance of the modulus of the light speed in vacuum. Einstein's relativity principle. Energy of a free particle. Particle momentum. Relationship between mass and energy of a free particle. Rest energy of a free particle.

## THE QUANTUM PHYSICS

**Corpuscular-wave dualism.** M. Planck's hypothesis about quanta. Planck formula. Photons. Photon energy. Photon momentum. Photoelectric effect. A.G. Stoletov's experiments. Laws of the photoelectric effect. Einstein's equation for the photoelectric effect. Wave properties of particles. De Broglie waves. The de Broglie wavelength of a moving particle. Corpuscular-wave dualism. Diffraction of electrons on crystals. Light pressure. The light pressure on a fully reflective surface and on a fully absorbing surface.

**Physics of the atom.** Planetary model of the atom. Bohr's postulates. Emission and absorption of photons during the transition of an atom from one energy level to another. Line spectra. The spectrum of energy levels of the hydrogen atom. Laser.

**Physics of the atomic nucleus.** Nucleon model of the Heisenberg-Ivanenko nucleus. Nucleus charge. Mass number of the nucleus. Isotopes. Binding energy of nucleons in the nucleus. Nuclear forces. Nucleus mass defect. Radioactivity. Alpha decay. Electronic  $\beta$ -decay. Positron  $\beta$ -decay. Gamma radiation. Law of radioactive decay. Nuclear reactions. Fission and fusion of nuclei.

**Elements of astrophysics.** Solar system: terrestrial planets and giant planets, small bodies of the solar system. Stars: a variety of stellar characteristics and their patterns. Sources of stellar energy. Modern ideas about the origin and evolution of the Sun and stars. Our galaxy. Other galaxies. Spatial scales of the observable Universe. Modern views on the structure and evolution of the Universe.

### Examples of tests for entrance exam

1. Choose the correct coordinate systems:
  - a) Affine coordinate system;
  - b) Cartesian coordinate system;
  - c) Polar coordinate system;
  - d) Spherical coordinate system;
  - e) Cylindrical coordinate system;
  - f) All mentioned above.
  
2. What is rigid body?
  - a) A body the velocity of which is equal to zero;
  - b) A body the material constituents of which are always the same distances from each other;
  - c) A body the mass of which is tends to zero;
  - d) A body the mass of which is tends to infinitive.



### Entry test evaluation criteria

Entry test is conducted on the digital of V.I. Vernadsky Crimean Federal University.

Applicants are invited to perform single choice test tasks. There are 10 tasks, each correct answer is worth 10 points.

Time for test tasks – 60 minutes.

The entry test is evaluated based on the 100 point system as the sum of the points received in all tasks.

The program is compiled by

Assistant professor, PhD

Vice-Rector for Academic and  
Methodological Activities



M.M. Asanov



I.A. Tsvirinko