APPROVED
at a meeting of the
Scientific Council
NJSC «Al-Farabi KazNU».
Minutes No.10 dated
May 23, 2022.

The program of the entrance exam for applicants to the PhD
for the group of educational programs
D090 – «Physics»

1. General provisions.

1. The program was drawn up in accordance with the Order of the Minister of Education and Science of the Republic of Kazakhstan dated October 31, 2018 No. 600 "On Approval of the Model Rules for Admission to Education in Educational Organizations Implementing Educational Programs of Higher and Postgraduate Education" (hereinafter referred to as the Model Rules).
2. The entrance exam for doctoral studies consists of writing an essay, passing a test for readiness for doctoral studies (hereinafter referred to as TRDS), an exam in the profile of a group of educational programs and an interview.

Block	Points
1. Essay	10
2. Test for readiness for doctoral studies	30
3. Exam according to the profile of the group of the educational program	40
4. Interview	20
Total admission score	100/75

3. The duration of the entrance exam is 4 hours, during which the applicant writes an essay, passes a test for readiness for doctoral studies, and answers an electronic examination. The interview is conducted on the basis of the university separately.

2. Procedure for the entrance examination.

1. Applicants for doctoral studies in the group of educational programs D090 - «Physics» write a problematic / thematic essay. The volume of the essay is at least 250-300 words.

2. The electronic examination card consists of 3 questions.

Topics for exam preparation according to the profile of the group of the educational program.

Discipline **"Basic principles of modern physics"**

Laws of conservation of momentum and energy. Particle motion in a centrally symmetric field. Limit motion of material points. Equation of motion. Reference system. Coriolis force. Hamilton's method. Lagrange and Hamilton functions. Lagrange equations of I, II kind. Canonical transformations. The smallest operating principle of Hamilton. Hamilton-Jacobi equations. Poisson brackets. Jacobi's theorem. Elastic collision of particles. Regularities of oscillatory systems. Forced hesitation. Regularities of movement in the central field. Kepler's problem. Basic properties of an electric charge. Point charge. The principle of superposition of electric fields. Gauss's electrostatic theorem. Electric field potential. The relationship between potential and electric field strength. Equipotential surfaces. Dipole. Poisson and Laplace equations. Conditions at the boundary of the environment of the electromagnetic field. Bio-Savart-Laplace law. Vector potential properties and relationship with magnetic induction. The movement of a charge in constant electric and magnetic fields. The physical nature of the phenomenon of magnetic induction. Magnetic and dielectric sensitivity of a substance. Maxwell's system of equations. The phenomenon of interference of electromagnetic waves. Principle of action and principles of least action in mechanics. Forced oscillations of the oscillatory circuit. Skin effect. Principles of the special theory of relativity. Nonlinear electrodynamics. Exposure of dielectrics to an external electric field. Lienar-Wiechert potentials. Field vectors in the wave region. Features of the propagation of electromagnetic waves in an anotropic medium.

Discipline **"Quantum statistical physics and the equation of state of matter"**

The first and second laws of thermodynamics for reversible and irreversible processes. Systems with a high degree of freedom. Phase space of the macrosystem. Gibbs Ensemble. Liouville's theorem. Relative deviation of the additive value for the macrosystem. The canonical Gibbs distribution. Canonical distribution for ideal gas. Boltzmann-Maxwell distribution. Basic thermodynamic characteristics of an ideal gas. Reversible and irreversible processes. Fermi-Dirac and Bose-Einstein statistics. Equation of state for an ideal Bose gas. Equation of state for an ideal Fermi gas. Internal energy and heat capacity of a Fermi gas. Pauli phenomenon of paramagnetism for the ideal Fermi gas. The sum of a system of independent quantum oscillators. Heat capacity. Thermodynamics of surface tension. Phase transition of the second kind. Entropy of classical systems. Microcanonical, canonical distribution. Gibbs' canonical distribution theorem. Entropy of the problem of irreversibility. Features of Van der Waals gas. Features of Bose condensate. Fluctuations of basic thermodynamic quantities.

Discipline **"Quantum scattering theory"**

Wave function and its physical meaning. Operators for physical quantities in quantum mechanics. Properties of eigenfunctions and eigenvalues of Hermitian operators. Classification of the wave function by an orthonormal basis in a series. Complete quantum mechanical characteristics of microsystems. Schrödinger's equation of stationarity and nonstationarity. Changes in physical quantities over time in quantum mechanics. Principles and postulates of quantum mechanics. Conservation laws in quantum mechanics. The physical meaning of the equation of continuity in quantum mechanics. Schrödinger equation for a particle in a one-dimensional infinite potential well. Pauli's principle and its consequences. Matrix concept of quantum mechanics. Linear harmonic oscillator. Particle motion in a central symmetric field. Method of variation in quantum mechanics. Experiments to test the principles of quantum theory. The two-body problem in quantum mechanics. Components of the angular momentum operator in spherical coordinates. The

connection between the rotation operator and the angular momentum of the system in quantum mechanics. Coulomb (random) degeneration of the energy level of the hydrogen atom and its multiplicity. Distribution of variables in the Schrödinger equation for the case when the Hamiltonian is independent of time. Differences between the ideas of Schrödinger and Heisenberg.

3. List of references.

Main:

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2. Л.Д. Ландау, Е.М. Лившиц. Теория поля. М., Наука, 1988.
3. Л.Г. Гречко, В.И. Сугаков, О.Ф. Томасевич, А.М. Федорченко «Сборник задач по теоретической физике».
4. Тамм И.Е. Основы теории электричества.
5. Джексон Д. Классическая электродинамика.
6. Ансельм А.И. Основы статистической физики и термодинамики. 2-е изд., СПб. Лань, 2007, 423 с.
7. Варикаш В.М., Болсун А.И., Аксенов В.В. Сборник задач по статистической физике. Изд.3, 2011.
8. Давыдов А.С. Квантовая механика. Санкт-Петербург., 2011. 703.
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10. Ландау Л.Д., Лифшиц Е.М. Квантовая механика. Нерелятивистская теория. Физматлит, 2008. 800.

Additional:

1. 1. Бухгольц Н.Н. «Основной курс теоретической механики».
2. Ольховский И.И. «Курс теоретической механики для физиков.
3. Квасников И.А. Термодинамика и статистическая физика (теория равновесных систем). Изд. МГУ, 1991.
4. Румер Ю.Б., Рывкин М.Ш. Термодинамика, статистическая физика и кинетика. М., 2001.