«APPROVED»
Member of the Management Board,
Vice-Rector for Operations
NJSC «Al-Farabi KazNU»
_____ Duisenov E.E.
«__19_» __04__ 2024

The program of
the entrance exam for the group of educational programs of the Faculty of Physics and Technology for
PhD degree
for foreign citizens to study on a paid basis

1. General Provisions

1.1 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 Regulations for admission to studies in educational organization, implementing educational programs of technical and vocational education» (hereinafter – the Standard Rules).

1.2. In Al-Farabi KazNU for educational programs of postgraduate education (doctoral studies) are admitted persons who have mastered educational programs of postgraduate education. The admission to the doctoral program is allowed to applicants who have a "Master's" degree.

1.3. Entrance examinations according to Annex 2 to the Standard Rules are held **in the format of an interview** for the following groups of educational programs:

- ✓ 8D01501 – Physics
- ✓ 8D05306 – Physics
- ✓ 8D05307 – Physics and Astronomy
- ✓ 8D05303 – Technical physics
- ✓ 8D05308 – Nuclear physics
- ✓ 8D05309 – Nuclear Medicine
- ✓ 8D06201 – Radioengineering, electronics and telecommunications
- ✓ 8D07106 – Thermal power engineering
- ✓ 8D07108 – Electric Power Engineering
- ✓ 8D07110 – Materials science and technology of new materials
- ✓ 8D07112 – Nanomaterials and nanotechnology
- ✓ 8D07502 – Standardization and certification (by industry)

1.4 For the organization and conduct of entrance examinations for admission of a foreign applicant by the decision of the rector of AL-FARABI Kazakh National University is creating an examination committee for the period of examinations.

The commission of entrance examinations for admission of a foreign applicant to KazNU includes employees of the Internationalization and Recruiting Office (hereinafter referred to as the Office) and the professor-teaching staff of KazNU.

1.5 In case a foreign applicant who meets the above requirements has no possibility to come to the University for an entrance interview, he has the opportunity to take it online.

1.6 Entrance exam in the form of oral conversation (interview) for admission to a foreign applicant are evaluated on a 100-point system. When enrolling on a paid basis, 75 points are counted.

1.7 Based on the results of the entrance exam, an interview protocol is drawn up in the prescribed form according to the requirements of the Office. The interview record is signed by the chairman and all members of the commission present and submitted to the Office.

1.8 The decision on admission is made by the University Admissions Committee on the results of the interview. The results of the entrance exam are announced on the same day.

1.9 Retaking the entrance exam is not permitted.

1.10 An appeal against the results of the interview is not considered.

2. Conducting the entrance exam in 2024

2.1 The interview is conducted in Russian, Kazakh and English. The oral interview also contains questions aimed at revealing the ability to learn, creative activity and critical thinking, personal qualities of the applicant.

2.2 An indicative list of interview topics:

1. Basic principles of modern physics. Principle of relativity.
2. Galilean and Lorentz transformations. Equations of physics in covariant form.
3. Principles of symmetry, superposition, uncertainty. Principle of correspondence as an orientation when constructing of new physical theories.
4. Principle of symmetry and conservation laws. Energy conservation law and time homogeneity.
5. Impulse and momentum conservation law as a consequence of translational invariance and isotropy of space. Mirror symmetry of space and parity conservation law.
6. Principle of in distinguishability of identical particles in quantum mechanics and particles statistics. Charge independence of strong interactions.
7. Additive conservation laws as a consequence of invariance with respect to gauge transformations: electric charge, baryonic and lepton number. Symmetry and levels' degeneracy order. Operator of symmetry and unitary transformations. Application of uncertainty principle in physical problems.
8. Use of relativistic invariance (invariant mass) when describing the processes at high energies in the micro world. Connection of particles energies in laboratory system and system of mass center. Particles beams accelerators – synchrotrons and colliders. Large hadron Collider.
9. Measurement of mass of unstable elementary particles. Thresholds of nuclear processes. Short-living particles-resonances. Lifetime of fast moving elementary particles. Conception of virtual particles and processes.

10. Classical fields theory. Lagrange formalism. Fields and particles. Hamilton and Lagrange formalisms. Lagrange function and principle of stationary action. Transformational properties of field function. Tensors and spinors.

11. Scalar field. Klein-Gordon equation. Lagrange formalism of real scalar field. Impulse representation and frequency components. Discrete representation. Complex scalar field. Pion field. Notation of Klein-Gordon equation in a form of a system of first order equations.

12. Electromagnetic field. Potential of electromagnetic field. Gradients transformation and Lorentz condition. Lagrange formalism. Cross, dilatational and time components. Spin.

13. Quantization of free fields. General principles of quantization.

14. Operator nature of field functions and state amplitude. Representations of Schrodinger equations. Transformational properties of state amplitude and field operators. Postulate of wave fields quantization. Physical meaning of positive and negative frequency components and conjugated functions. Vacuum state and state amplitude in Fock' representation.

15. Permutation relations. Types of permutation relations. Fermi-Dirac and Bose-Einstein permutation relations. Connection of spin and statistics. Pauli theorem. Normal product of operators and notation of dynamical variables. Permutation relations in discrete impulse representation.

16. Quantization of scalar, vector fields. Real and complex scalar fields. Pi-meson fields. Complex vector field. Hamilton formalism and canonical quantization.

17. Quantization of electromagnetic and spinor fields. Peculiarities of electromagnetic field and quantization scheme. Indefinite metric. Notation of fundamental quantities. Quantization by Fermi-Dirac and permutation functions. Dynamical variables. Charge conjugation. Quantized neutrino's field.

18. Fundamentals of theory of interacting fields. S-matrix. S-matrix in interaction representation. Green's functions. Reduction formula. Feynman rule for S-matrix. Calculation of matrix elements. Cross section of particles scattering. Some interaction models.

19. Open the chronological products. Chronological coupling. Vick' theorem for chronological products.

20. Examples of second order processes calculation. Compton scattering. Annihilation of electron-positron pair. Braking radiation

2.3 List of recommended literature for preparation:

1. Grushevitskaya T. G., Sadokhin A. P. Concepts of modern natural science. Moscow-2003. Unity-Dana. 670 p.

2. Frauenfelder F., Henley E. Subatomic physics «Mir «, Moscow, 1979, 730 p.

3. Rader L., Elementary particles and symmetries «Nauka «, Moscow, 1983, 317 p.

4. M. A. Zhusupov, S. K. Sakhiev, R. S. Kabataeva. Quantum Scattering Theory, Astana, 2012, 206 p.

5. Zhusupov M. A., Yushkov A.V. The beginning of physics. Volume 1. Almaty, 2006. 464 p.David Tong, Quantum Field Theory, Department of Applied Mathematics and Theoretical Physics, Center for Mathematical Sciences, Wilberforce Road, Cambridge, CB3

OWA, United Kingdom http://www.damtp.cam.ac.uk/user/tong/qft.html.

6. Warren Siegel, FIELDS, K. N. Yang Institute for Theoretical Physics, State University of New York at Stony Brook, Stony Brook, New York 11794-3840, USA, http://insti.physics.sunysb.edu/~siegel/plan.html.

Additional:

7. Faustov R. N., Shelest V. P. Quantum metrology and fundamental constants. Moscow, Mir, 1981. 368 p.

8. P. A. M. Dirac, The relativistic electron equation. Successes of Physical Sciences, volume 129, issue 1, pp. 681-691; Memories of an extraordinary era of the UFN, volume 153, issue 1, pp. 105-134.

9. D. Mehra. The Golden Age of Theoretical Physics, UFN, volume 153, issue 1, pp. 135-172.

10. General information about antiparticles. L. Valentin. Subatomic physics: nuclei and particles, M., «Mir «, 1986, pp. 83-94.

11. Davydov A. S. Quantum Mechanics. Physical and mathematical literature. M., 1973, 611 p.

12. Valentin L. et al. Subatomic physics: Nuclei and particles, volume 1 and 2, «Mir «, Moscow, 1986.272 pages in 1 volume and 330 pages in 2 volumes.

13. Varshalovich L. et al. Quantum theory of angular momentum. M. Higher School. 1981.

14. Zhusupov M. A., Yushkov A.V. Physics of elementary particles. Almaty 2006, 488 p.

15. Collection of the Fundamental Structure of matter, edited by J. Mulvey, Moscow, Mir, 1984, 311 p.

16. L. V. Tarasov. Fundamentals of Quantum Mechanics, Moscow, Higher School, 1978, 287 p.

17. J. Elliot, P. Dober. Symmetries in Physics, volume 1, 368 p., volume 2, 416 p. Moscow, Mir, 1983.

18. ERNEST M. HENLEY, WALTER THIRRING, ELEMENTARY QUANTUM FIELD THEORY, McGraw-HILL BOOK COMPANY, INC.

19. Bo Tid, The theory of the electromagnetic field, http://www.plasma.uu.se/CED/Book.

20. Luis Alvarez-Gaumea and Miguel A. Vasquez-Mozo, Introductory lectures on Quantum Field Theory, Faculty of Physics, Theoretical Department, CERN, CH-1211 Geneva 23, Switzerland, arXiv:hep-th/0510040v4.

3. Scale and assessment criteria of the entrance examination for admission to the doctoral program for foreign citizens on a fee-paying basis:

Number of points	Compliance criteria
90–100 points «Excellent»	Demonstrates knowledge of the fundamental processes within the studied subject area; depth and completeness of addressing the issue; logically and sequentially expresses own opinion on the

	discussed problem; possesses conceptual-categorical framework, scientific terminology; logical coherence of the answer, adherence to the norms of contemporary scientific language.
80–89 points «Good»	Competent use of scientific terminology; mastery of conceptual-categorical framework; problem-oriented presentation of formulated questions; occasional errors in presenting factual material; incompleteness in presenting scientifically established facts within the scope of questions; logical coherence of the answer, adherence to the norms of contemporary scientific language.
75–79 points «Satisfactory»	Insufficient use of scientific terminology; inadequate mastery of conceptual-categorical framework; ability to address only one of the problems formulated in the questions; errors in presenting factual material; superficial knowledge of the subject area; violation of logical coherence in the answer, norms of contemporary scientific language.
0–74 points «Unsatisfactory»	Absence of necessary scientific terminology in the answers; descriptive presentation of discussed issues, inability to identify and present problems; gross errors in presenting factual material; lack of knowledge of historiography of the studied subject area.