AL FARABI KAZAKH NATIONAL UNIVERSITY

Approved by
at a meeting of the academic committee (NMS)
Al-Farabi KazNU
Vice Rector for academic affairs

_____ _____ A.K. Khikmetov
Protocol No. 6 dated 22 June, 2020

PROGRAM
ENTRANCE EXAM FOR APPLICANTS IN PHD DOCTORAL ON DOUBLE DEGREE EDUCATIONAL PROGRAM "8D05304 - TECHNICAL PHYSICS"

ALMATY 2020

The program is written in accordance with the curriculum of the Double degree educational program «8D05304 - Technical Physics». The program was compiled by doctor of physical and mathematical sciences, professor A.S. Askarova, doctor of physical and mathematical sciences, professor S.A. Bolegenova.

The program was considered at a meeting of the Department of Thermal physics and Technical Physics.
Protocol No. 38 dated of 19th May, 2020

Head of the Department _____ Bolegenova S.A.

Approved at the meeting methodical bureau of Faculty of Physics and Technology
Protocol № _____ 2020

Chairman of the methodical bureau _____ Gabdullina A.T.

Approved at the meeting of the Scientific Council
Minutes No. 9 dated of 29th May, 2020

Chairman of the Scientific Council

Dean of the faculty _____ Davletov A.E.

Scientific Secretary _____ Masheeva R.U.

CONTENT

1. Goals and tasks of the entrance exam for the Double degree educational program «8D05304 - Technical Physics».

The entrance exam is designed to determine the practical and theoretical readiness of the undergraduate and is carried out to determine whether the knowledge, skills and abilities of students meet the requirements of doctoral studies in the direction of training.

To achieve this goal, it is necessary to carry out the following tasks:

- Integrated and systematic studying of natural sciences;
- Formatting of skills of independent scientific and theoretical analysis;
- Mastering the methods of studying physics;
- Development of pedagogical and research skills;

The exam form is written exam. Examiners must record their answers to questions on the exam ticket on the answer sheets. In the event of an appeal, the basis for consideration is the written entries in the answer sheet.

2. Requirements for the level of training of people who enter in PhD program.

Requirements for people who wish to master the educational programs of doctoral studies in the Double degree educational program 8D05304 - Technical Physics»:

Applicant *must*:

- *be able to* freely navigate in the fundamental and applied issues of the field of physics, for which profile, specialization was carried out within the framework of the master degree's educational program;
- *have some knowledge* of the latest achievements of science and technology;
- *know* modern experimental, theoretical and numerical methods for studying physical phenomena and processes; actual problems of physics.

3. Prerequisites of the educational program

1. Thermal physics of rheological fluids - 3 cr.
2. Thermal physics conducting media - 3 cr.
3. The basic principles of modern physics - 3 cr.

4. The list of exam topics

Discipline "Thermal physics of rheological liquids"

Classification of non-Newtonian fluids

Non-Newtonian fluids with rheological characteristics that are not time-dependent. Nonlinearly viscous fluids. Rheological fluids with characteristics that are independent of the time and background of the flow. Shvedov-Bingham plastics. Plastic viscosity. Pseudoplastics. Dilantant liquids. Non-Newtonian liquids with rheological characteristics, time-dependent. Thixotropic fluids. Rheopectic fluids. Viscoelastic materials. Feicht and Maxwell models characteristics. "Power" fluids.

Experimental determination of non-Newtonian fluids

Methods for studying stationary rheological fluids. Coaxial cylindrical viscometers. Newtonian fluid. Fake plastic and dilatant fluids. Rotational viscometers. The cone-plate type viscometer. Stationary rheological fluids in capillary tube viscometers. Methods of experimental study of the characteristics of rheological unsteady fluids. Experimental characterization of rheostable rheological fluids. Experimental characterization of non-rheostable rheological fluids. Liquid slip of a solid surface.

The flow of rheological fluids in the tubes

Secondary fluid flow in a round pipe. Speed profile and second fluid flow rate. Newtonian fluid flow. The flow of plastics “Shvedov-Bingham”. The course of "power" fluids. Axial flow in the annular channel (main relation). The flow in the annular channel of the “Shvedov-Bingham” plastics. The flow in the annular channel of "power" liquids. Heat transfer during laminar flow in a pipe.

Boundary layer in non-Newtonian fluids

The equation of the boundary layer of "power" liquids. Boundary conditions. Initial conditions. Self-similar boundary layer problems. Heat transfer during laminar flow in a pipe for a power-law fluid. The flow and low-intensity heat transfer of incompressible nonlinearly viscous fluids.

Exact solutions to problems of the theory of a stationary boundary layer.

The boundary layer of rheological fluids. Equations and boundary conditions. The boundary layer with a power-law distribution, the velocity at the outer boundary. Flow around a wedge at $U = Ax^{1/3}$. The flow around a flat permeable plate with a uniform fluid flow. Flow around a wedge under the condition of a power-law distribution of velocity at the outer boundary. Swelling of a flat permeable plate with a uniform fluid flow. Temperature boundary layer. Flat (fan) flooded stream. A jet of liquid with a free surface. Temperature distribution and heat transfer on the wedge under different boundary conditions

Discipline "Thermal physics of conductive medium"

Introduction to the mechanics of continuous media. A brief historical outline of the development of the theory of heat and mass transfer. The role and significance of convective transport theory for practice: thermal power engineering, mechanical engineering, electronics and instrument engineering, aircraft manufacturing, rocketry and astronautics, shipbuilding, chemical technology, metallurgy, medicine, and ecology. Basic concepts. Basic concepts of viscous fluid mechanics. Liquid. Fluid viscosity. Fluid movement. Continuity of the medium. Compressibility of the medium.

Basic equations of continuum media

Liquids. The law of conservation of substance. The Navier-Stokes equations. The equation of continuity. Equations of motion. Incompressible fluid flow with constant properties. Energy equation. Stationary fluid motion. Divergent form of the energy equation. Layered currents. Dynamic task. Thermal challenge. The flat course of Poiseuille. Dynamic and thermal task. Couette Current. Dynamic and thermal task. Basic concepts of the theory and equations of continuum mechanics. Obtaining basic equations of continuum mechanics.

Boundary layer

Properties of a dynamic boundary layer. The thickness of the dynamic boundary layer. Dynamic boundary layer equations. Properties of the thermal boundary layer. Obtaining an equation for the temperature boundary layer. Self-similar transformations of boundary layer equations. Methods for obtaining equations in the approximation of a boundary layer for a dynamic and thermal problem. Divergent form of the energy equation. Self-similar transformations of boundary layer equations in a general form. The problem of longitudinal flow around a plate with a uniform flow of an incompressible viscous fluid. Blasius problem. Exact solution of the equations of momentum and energy. Resistance, friction stress, heat transfer, boundary layer thickness. Iteration method for solving the Blasius problem. The analogy of the processes of momentum and heat transfer. The momentum equation for the boundary layer. Energy equation. Energy theorem for a boundary layer. The method of integral relations. Application of the method of integral relations to the calculation of the temperature boundary layer on the plate.

Jet currents

The task is about a flat flooded stream of liquid. Dynamic and thermal formulation of the problem. The main laws. Comparison of theoretical and experimental data. Flat wall spray.

Solving the equations of dynamic and thermal boundary layers for isothermal and nonisothermal problems. The main laws.

Flat free jet (flooded)

Non-isothermal free flat stream. Thermally symmetric boundary layer. Asymmetric thermal boundary layer. Semi-limited jet. Compressible gas flow. Transformations of A.A. Dorodnitsin. Transformations of R. Mises.

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

A survey of the main principles of contemporary physics

The method of evaluation of physical quantities

Scientific notation of physical value. Estimation of the mass of Earth atmosphere. What mass per second Sun loses due to radiation?

Dimensional analysis.

Physical notions. Physical quantities. System International (SI). Base and derived physical values.

Π-theorem.

Scaling. Non-dimensional quantities. Π-theorem. Dimensional analysis for problem solving.

The physical models.

The phases of the research activities. Physical phenomena and its models. The basic parameters of a model and analysis of the extreme cases.

The basic properties of Space and Time.

Inertial frames of reference. The basic properties of Space and Time and the conservation's laws. The principle of relativity.

Lorentz transformations.

Clock synchronization and the relativity of simultaneous events. Lorentz transformations.

Relativistic kinematics.

The formulas for transformation of events, velocities. Interval between two events and it's independents on the reference frame.

Relativistic dynamics.

Momentum and energy of the relativistic particle. The second Newton's law for relativistic particle. The connection between energy and momentum for relativistic particle. Einstein's formula rest energy.

For-vectors.

For-vectors of event, velocity, momentum. Relativistic invariance of the physical equations.

The basic principles of thermodynamics.

The formulations of the zeros, first, second and third laws of thermodynamics.

Thermal apparatus.

Thermal engine and heat pumps. Heat pump as a refrigerator. Heat pump as a heator. Entropy and Ecology.

Standard Model.

Big Bang and the Standard Model. Dark matter and dark energy. The consistence of the types of matter inside the Universe.

The Universal Genetic Code.

Life – as a very specific Structure of meso-scales in the Universe. The structure and mane features of the Universal Genetic Code.

5 . References

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6. Scale for assessing the results of the entrance exam for PhD Double degree education program «8D05304 - Technical Physics»

Letter Grade	The digital equivalent of points	% content	Traditional system assessment	Competency scale
A	4,0	95-100	Excellent	This assessment is given if the applicant: 1) has an idea: about the main stages of development and paradigm shift in the evolution of science; about scientific schools of the corresponding branch of knowledge, their theoretical and practical developments; on scientific concepts of world and Kazakhstani science in the relevant field; on the mechanism for introducing scientific research into practical activities. 2) knows and understands: current trends, directions and patterns of development of domestic science in the context of globalization and internationalization; perfectly knows a foreign language for the implementation of scientific communication and international cooperation. 3) can: organize, plan and implement the process of scientific research; analyze, evaluate and compare various theoretical concepts in the field of research and draw conclusions; analyze and process information from various sources; plan and predict your further professional development. 4) has the skills of: critical analysis, evaluation and comparison of various scientific theories and ideas; analytical and experimental scientific activity; planning and

				forecasting research results; oratory and public speaking at international scientific forums, conferences and seminars.
A-	3,67	90-94		This assessment is given if the applicant: 1) has an idea: about scientific schools of the corresponding branch of knowledge, their theoretical and practical developments; on the scientific concepts of Kazakhstani science in the relevant field; on the mechanism for introducing scientific research into practical activities. 2) knows and understands: current trends, directions and patterns of development of domestic science in the context of globalization and internationalization; perfectly knows a foreign language for the implementation of scientific communication and international cooperation. 3) can: organize, plan and implement the process of scientific research; analyze, evaluate and compare various theoretical concepts in the field of research and draw conclusions; analyze and process information from various sources; plan and predict your further professional development. 4) has the skills: evaluation and comparison of various scientific theories and ideas; analytical and experimental scientific activity; planning and forecasting research results; oratory and public speaking at international scientific forums, conferences and seminars
B+	3,33	85-89	Good	This assessment is given if the applicant: 1) has an idea: about scientific schools of the corresponding branch of knowledge, their theoretical and practical developments; about scientific concepts of Kazakhstan science in the relevant field. 2) knows and understands: current trends, directions and patterns of development of science in the context of globalization and internationalization; knows a foreign language for the implementation of scientific communication and international cooperation. 3) knows how to: organize and implement the process of scientific research; analyze and compare various theoretical concepts in the field of research and draw conclusions; analyze information from various sources; plan and predict your further professional development. 4) has the skills: assessment of various scientific theories and ideas; analytical and experimental scientific activity; planning and forecasting research results; oratory and public speaking at international scientific forums, conferences and seminars.
B	3,0	80-84		This assessment is given if the applicant: 1) has an idea: about scientific schools of the corresponding branch of knowledge, their theoretical and practical developments. 2) knows and understands: current trends, directions and patterns of development of science in the context of globalization and internationalization; knows a foreign

				language for the implementation of scientific communication and international cooperation. 3) knows how to: organize and implement the process of scientific research; analyze and compare various theoretical concepts in the field of research and draw conclusions; analyze information from various sources; plan and predict your further professional development. 4) has the skills: assessment and comparison of analytical and experimental scientific activities; planning and forecasting research results; oratory and public speaking at international scientific forums, conferences and seminars.
B-	2,67	75-79		This assessment is given if the applicant: 1) has an idea: about scientific schools of the corresponding branch of knowledge, their theoretical developments; about scientific concepts of Kazakhstan science in the relevant field. 2) knows and understands: current trends, directions and patterns of development of science in the context of globalization and internationalization; knows a foreign language for the implementation of scientific communication and international cooperation. 3) knows how to: organize and implement the process of scientific research; analyze various theoretical concepts in the field of research; analyze information from various sources; plan your further professional development. 4) has the skills: assessment and comparison of analytical and experimental scientific activities; oratory and public speaking at international scientific forums, conferences and seminars.