APPROVED
at the meeting of the Academic Council of NJSC Al-Farabi Kazakh National University
Protocol №14 dated 16.06.2026

The program of the entrance exam for applicants to the PhD for the group of educational programs D100 – «Automation and control»

I. 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, an exam in the profile of a group of educational programs and an interview.

Блок	Баллы
1. Interview	30
2. Essay	20
3. Exam according to the profile of the group of the educational program	50
Total admission score	100/75

3.The duration of the entrance exam is 3 hours 10 minutes, during which the applicant writes an essay and answers the electronic examination ticket. The interview is conducted at the university premises before the entrance exam.

II. Procedure for the entrance examination

1. Applicants for doctoral studies in the group of educational programs D100 – «Automation and control» write a problematic / thematic essay. The volume of the essay is at least 250words.

The purpose of the essay is to determine the level of analytical and creative abilities, expressed in the ability to build one's own argumentation based on theoretical knowledge, social and personal experience.

Types of essays:

- motivational essay revealing the motivation for research activities;
- scientific-analytical essay justifying the relevance and methodology of the planned research;
- problem/thematic essay reflecting various aspects of scientific knowledge in the subject area.

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: Methods of Automatic Control Theory

Control object in Automatic Control Theory. Formulation of Automatic Control Theory problems. Differential and difference equations for describing the dynamics of continuous and discrete systems. Frequency-domain methods and Bode plots for stability and control quality analysis. State-space methods for modeling multidimensional control systems. General optimal control problem and its mathematical model. The role of optimal process theory in solving engineering problems. Necessary and sufficient conditions in optimal control theory. Existence problem of optimal controls. Main problems of optimal process theory. Positive controllability, relative controllability, and conditional controllability. Lyapunov stability of dynamic systems. Lyapunov's first method. Equilibrium states of two-dimensional linear systems. Functional analysis methods in Kalman observability theory. Pontryagin's Maximum Principle. Bellman's Principle of Optimality in dynamic programming. Construction of Lyapunov functions for linear systems. Functional and control performance criteria. Artificial Intelligence and Machine Learning methods. Neural network-based adaptive control of processes that cannot be accurately described by mathematical equations. Fuzzy Logic control systems based on expert knowledge and rules. Genetic algorithms for optimization of complex multi-criteria parameters in automated control systems.

Discipline: Multilevel Microcontroller Automation

Modern automation in the context of Industry 4.0. Discrete and continuous technological processes. Hierarchical levels of automated microcontroller-based control systems and types of microcontrollers used at each level. Field Level, Controller Level, and SCADA Level. Analog and digital sensors for data acquisition via Ethernet networks and wireless cyber-physical IoT devices. Analog-to-Digital and Digital-to-Analog converters and their classification. GPIO libraries for control microcomputers. Machine-to-Machine (M2M) and Human-Machine Interface (HMI) interaction in multilevel automation systems. Data transmission protocols for M2M and HMI communication. The role and place of industrial controllers in IoT devices. Processing methods for analog and PWM signals in automated control systems. Transmitting and receiving devices in IoT systems. Analog and digital controllers. Specialized automatic controllers for industrial applications. Programmable industrial microcontrollers and control mini-computers. Remote control of smart industrial and household systems via the Internet using mobile devices. Concepts and examples of smart IoT automated systems. The comprehensive Internet as the next stage in IoT development. Features of implementing cyber-physical IoT devices in educational environments. Design of intelligent systems based on AVR and ESP32

microcontrollers. Principles of visualization and intelligent control through SCADA systems.

Discipline "Mathematical methods in intelligent control systems"

Neurons and artificial neural networks. Classification of neural networks. Neural network architecture. Types of multilayer neural networks. Feedback networks. Formal neuron. Neuron activation function and its functions. Neural network training. Deep learning methods. Widrow- Hoff is teaching rule. Algorithm for training a single-layer neural network. Multilayer neural network. Algorithm for training a multilayer neural network. Learning with and without a teacher. The concept of "Artificial intelligence". Modern research areas in artificial intelligence. Technology for working with expert systems. Control object of an intelligent system. Tasks of control theory. General optimal control problem and its mathematical model. The role of the theory of optimal processes in solving technical problems. Necessary and sufficient conditions in the theory of optimal processes. The problem of the existence of optimal controls. The main problems of the theory of optimal processes. Positive manageability. Relative manageability. Conditional manageability. Lyapunov stability of dynamical systems. Lyapunov's theorems in the first approximation (Lyapunov's first method). Equilibrium position of two-dimensional linear systems. Methods of functional analysis in the Kalman observability theory. Pontryagin's maximum principle. The principle of optimality of dynamic programming (Bellman). Construction of the Lyapunov function for linear systems. Functional. Management quality criterion.

III. List of references

Main:

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