Graduate School Digital Technologies and Construction

Department «Automation and Information Technologies»

The program of the entrance exams to PhD-doctoral studies in the group of educational programs D100 Automation and Control

Semey – 2026

1 DEVELOPED

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2 DISCUSSED

At the meeting of the department of Automation and Information Technologies
Protocol № 7 "20 " 02. 2026

Head of the Department _____ "20" 02 2026 R. Sovetbayev
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1. Introduction

The entrance examination program for the PhD doctoral specialty discipline is developed within the scope of the programs of the preceding levels of higher education (bachelor's degree) and postgraduate education (master's degree).

Doctoral candidates should have an understanding of:

- on the measurement of technological parameters and their specificity;
- on the elements of modern theory of automatic control,
- about problems, tasks, methods of their solution, advantages and disadvantages;
- the main goals and tasks of network and system administration;
- on the main characteristics of management objects;
-on standard automatic regulators, principles of setting industrial regulation systems, methods of calculating optimal regulators for objects with delays;

Know:

- basic principles of functioning of modern integrated systems of automated design;
- the fundamental principles of building governance systems;
- principles of action and mathematical description of component parts of mechatronic and robotic systems (information, electromechanical, electrohydraulic, electronic elements and means of computing technology;
- principles of construction of modern automated control systems in technical systems, their composition and structure, the content of types of software and hardware management systems, their relationship;
- organization and architecture of automation and automated control and management systems for objects and processes in various industries; prospects and trends in the development of tools and automation and management systems;
- principles, methods and ways of combining hardware and software to create automation and control systems;
- rules, methods and means of preparing technical documentation.

Learn:

- in practice to implement automatic management under conditions of incomplete prior information during the functioning of the system in the current environment and situation;
- be able to determine the main parameters of automated systems in statics and dynamics by known characteristics of elements;
- synthesize the functional and algorithmic schemes of technical systems management systems;
- to be proficient in methods of investigation of complex technological processes using modern computer technology;
- programming microcontrollers and industrial controllers.

Have skills:

- on the design of autonomous mathematical, informational, linguistic, programmatic subsystems, technical, organizational, ergonomic provision of APCS.
- be able to work with network equipment, customize it to the needs of specific users in the conditions of operation of the given operating systems.

- obtain practical skills in the use of principles of system approach, basic provisions of problems of automation of technical systems, main methods and algorithms of analysis and synthesis of analog and discrete (digital) systems of technological process management.
- choice of industrial instruments and means of automation and control systems.

Be competent:

- in the development of management algorithms that ensure the quality of technical systems;
- in the rational choice of methods for calculating and determining the optimal parameters of instruments and equipment;
- in the use of instruments for experimental research;
- to develop computer models of the processes and systems under investigation and apply them to determine optimal options for design, engineering and technological solutions.

The doctoral entrance exam is conducted in written or computer format in accordance with the Model Regulations for admission to studies in educational organization, implementing educational programs of technical and vocational education, approved by the Order of the Minister of Education and Science of the Republic of Kazakhstan of October 31, 2018 № 600.

2. The name of the discipline and its main sections

1. Discipline "Modern methods and means of creating SWR"

Topics:

1. **Methods for describing control objects in state-space coordinates**
The concept of state space. Methods for obtaining mathematical models of processes and systems in state-space coordinates. Structural representations of systems described in state space.

2. **Stability of processes in state space. Methods of absolute stability theory**
Concepts of stability in state space. Criteria for motion stability “in the large.” Criteria for motion stability “in the small.” Statism and astatism of systems in state space. Invariance in control theory. Methods of absolute stability theory.

3. **Methods and algorithms for estimating dynamic processes**
Classification of estimation problems. General provisions of the applied theory of estimation for continuous processes. Algorithm for estimating continuous processes. Mathematical description of discrete processes. Algorithms for estimating discrete-time processes. Continuous algorithms for field estimation.

4. **Methods and algorithms for identification of dynamic systems**
General classification of identification problems. Classical methods of nonparametric identification of linear dynamic systems. Direct methods of parametric identification. Non-search identification algorithms with an adaptive model. Search-based identification

algorithms with an adaptive model. Identification algorithms based on process estimation theory. Recursive identification algorithms under correlated noise. Optimal joint estimation and parametric identification in discrete linear systems.

5. **Control optimization criteria**
Single-criterion and multi-criterion optimization. Methodology for selecting the minimized functional. Expanded forms of functionals for optimizing continuous deterministic processes. Expanded forms of functionals for optimizing continuous deterministic processes with discrete time. Functionals for optimizing control of stochastic processes.

6. **Some general methods of optimal control theory**
Classical calculus of variations and modern problems of dynamic system optimization. Maximum principle.

7. **Optimal control algorithms**
Classification of optimal automatic control algorithms. Synthesis of control laws for continuous deterministic processes under classical forms of functionals. Synthesis of control laws for deterministic discrete-time processes under classical forms of functionals. Synthesis of control laws for stochastic processes under classical-type functionals. Solution of the generalized work criterion minimization problem in general form. Synthesis of optimal and suboptimal nonlinear control laws at the system design stage under generalized work functionals. Synthesis of control laws for linear processes under the generalized work functional (ACOR method). Optimal control synthesized in real time during system operation (combined synthesis). Model-based control algorithms.

8. **Optimization of dynamic systems with random structure**
Basic definitions. Equations of systems with random structure. Optimal filtering of processes with random structure. Control in systems with random structure.

9. **Algorithms of adaptive automatic control systems**
Classification of adaptive automatic control systems. Adaptive optimal control systems with a full model of controlled processes. Adaptive suboptimal control systems with simplified models. Non-search direct adaptive control systems. Non-search adaptive systems with an implicit reference model. Non-search adaptive systems with linear estimation based on a reference model.

10. **Method of recurrent target inequalities in adaptive control**
Formal description of an adaptive system. Description of the method of recurrent target inequalities. Basic finitely convergent algorithms for solving an infinite system of recurrent inequalities. Adaptive suboptimal control of a minimum-phase object. Adaptive systems with a reference model. Adaptive stabilization of a non-minimum-phase object and adaptive modal control. Adaptive control of nonlinear static objects.

11. **Extremum control systems**
General concepts. Influence of drift on stability. Transient processes and periodic motions. Improvement of performance quality.

12. **Methods of sensitivity theory**
Sensitivity models of continuous and discrete systems. Solutions of boundary-value sensitivity problems. Time-independent functions and sensitivity coefficients.

Performance characteristics and optimality indices of control systems. Sensitivity invariants. Applied problems of sensitivity theory.

13. **Search methods for computer-aided design**

Problem formulation for automating the design process of control systems. Structure of a search optimization algorithm. Local parametric search algorithm. Accounting for constraints in random search processes. Global search. Optimization under random disturbances. Structural optimization.

14. **Computer-aided design of automatic control systems**

Principles of automation in the design of control systems. Methods for constructing computer-aided design systems.

Questions:

1. Concept of state space
2. Methods for obtaining mathematical models of processes and systems in state-space coordinates
3. Concepts of stability in state space. Criteria for motion stability “in the large”
4. Concepts of stability in state space. Criteria for motion stability “in the small”
5. Methods of absolute stability theory
6. Classification of estimation problems
7. Algorithm for estimating continuous processes
8. Algorithms for estimating discrete-time processes
9. General classification of identification problems
10. Classical methods of nonparametric identification of linear dynamic systems
11. Direct methods of parametric identification
12. Non-search identification algorithms with an adaptive model
13. Search-based identification algorithms with an adaptive model
14. Single-criterion and multi-criterion optimization
15. Methodology for selecting the minimized functional
16. Classical calculus of variations and modern problems of dynamic system optimization
17. Classification of optimal automatic control algorithms
18. Synthesis of optimal and suboptimal nonlinear control laws at the system design stage under generalized work functionals
19. Synthesis of control laws for linear processes under the generalized work functional
20. Optimal filtering of processes with random structure
21. Classification of adaptive automatic control systems
22. Adaptive optimal automatic control systems with a full model of controlled processes
23. Formal description of an adaptive system
24. General concepts of extremum control systems
25. Methods and algorithms for estimation in correlation-extremum systems

Literature:

1. Ротач В.Я. Теория автоматического управления.- М.:-МЭИ, 2004.-400с.

2. Теория автоматического управления/Под редакцией Ю.М. Соломенцева. - М: Высшая школа, 2007. - 268 с.

3. Плетнев Г.П. Автоматизация технологических процессов и производств в теплоэнергетике.- М.:-МЭИ, 2005.-352с.

4. Дорф Р. Бишоп Р. Современные системы управления: - М.: Лаборатория Базовых знаний, 2010.- 832 с.

5. Стефани Е.П. Основы расчета настройки регуляторов теплоэнергетических процессов.- М.: Энергия, 1972. -376 с.

6. Стефани Е.П., Панько М.А., Пикина Г.А. Сборник задач по основам автоматического регулирования теплоэнергетических процессов. - М.: Энергия, 1973.-336 с.

7. Теория автоматического управления. Часть 1, 2. /Воронов А.А. - М.: Высшая школа, 1986.

8. Цыпкин ЯЗ. Основы теории автоматических систем. - М.: Наука, 1977.

9. Первозванский А.А. Курс теории автоматического управления. - М.: Наука, 1986.

10. Справочник по теории автоматического управления. Под ред. А.А. Красовского. М.: Наука. 1987.

11. Ю.И. Топчеев Атлас для проектирования систем автоматического регулирования. М.: Машиностроение. 1989.

12. Имаев Д.Х., Красношпорина А.А., Яковлев В.Б. Теория автоматического управления. Часть 1. Линейные системы автоматического управления. -Киев: Выща школа. 1992.

13. Алексеев А.А., Имаев Д.Х., Кузьмин Н.Н., Яковлев В.Б. Теория управления. - СПб: Издательство ТЭТУ. 1999.

14. В.Ф. Комиссарчик. Автоматическое регулирование технологических Процессов. Тверской государственный технический университет. Учебное пособие. Тверь 2001.

15. 15.Т.Я. Лазарева, Ю.Ф. Мартемьянов. Линейные системы автоматического регулирования. Тверской государственный технический университет. Учебное пособие. Тверь 2001.

16. Е.А. Никулин. Теория автоматического управления. Анализ полиномов Методические указания к лабораторным, практическим и курсовым работам. Нижний Новгород. 1998.

17.Н. В. Клиначёв. Теория систем автоматического регулирования. Учебно- методический комплекс.

18.В.Н.Тюкин. Теория управления. Часть 1. Обыкновенные линейные системы управления. Конспект лекций Вологда. 2000.

2. Discipline "Automation of technical systems"

Topics:

1. Basic concepts of automation of technical systems. Overview of the current state and development prospects

2. Study of the quality of transient processes in combined, cascade, and multivariable automatic control systems with analog and/or digital controllers

3. Classification of control systems by levels of automation. Basic principles of automation of technical systems

4. Control objects in technical systems, their classification. Properties and characteristics of control objects in technical systems

5. Industrial automatic control systems (ACS). Principles of design. Typical automatic control and regulation systems: properties and characteristics. Principles of design, tuning, and adjustment

6. Logical control systems. Principles of design. Technical base. Design methods. Principles of construction and technical implementation

7. Industrial automatic control systems. Typical automatic control and regulation systems: properties and characteristics. Principles of design, tuning, and adjustment. Hardware and software complexes for the design and implementation of automated technical systems

8. Automation of typical technical processes. Mathematical models and mathematical modeling of control and monitoring objects

9. Integrated control systems for technological processes and production

10. Identification of technical control objects (TCO): obtaining information about the object; transformation of technological information; types and forms of signals; active and passive identification methods

11. Microprocessor devices, systems, and industrial controllers. Digital communications in control of technical objects

Questions:

1. Data transmission at the controller level of industrial process control systems (APCS). AS-i protocols

2. Data transmission at the controller level of APCS. LON protocols

3. Multiloop automatic control systems. Classification, examples of practical implementation

4. Principles of constructing APCS (centralized and decentralized)

5. Algorithms for synthesis of combinational control systems

6. Development of requirements for automation systems of technological processes

7. Functional diagrams of automation of technological processes

8. Algorithms for synthesis of sequential circuits based on transition tables and Karnaugh maps

9. Data transmission at the controller level of APCS. PROFIBUS protocols

10. Composition and content of design documentation for automation of technological processes

11. Transient processes. Main performance indicators of control quality

12. Industrial network of APCS. Principles of industrial network design

13. Methods for describing technological processes as control objects

14. Data transmission at the controller level of APCS. Ethernet protocols

15. Typical transient processes

16. Concept of identification of automatic control objects

17. Methods for tuning automatic control systems with standard controllers for monotonic objects with delay

18. Improving the reliability of initial information

19. Principles of technical and software implementation of automatic control systems using SCADA systems

20. Methods for calculating cascade automatic control systems

21. Principles of constructing automation systems considering the advantages of different branches of technical means

22. Methods for calculating combined automatic control systems

23. Interconnected control systems

24. Data transmission at the controller level of APCS. CAN protocols

List of recommended literature on the discipline:

1. Технические средства автоматизации и управления. Под редакцией О. Колосова, М.: Юрайт – 2017, 290с.

2. Густав Олсон, Джангуидо Пиани. Цифровые системы автоматизации и управления. – СПб.: Невский Диалект, 2011. – 557с.

3. Дорф Р. Современные системы управления / Р.Дорф, Р. Бишоп. Пер. с англ. Б.И. Копылова. - М.: Лаборатория Базовых Знаний, 2012. – 832с.

4. Автоматизация типовых технологических процессов и установок: Учебник для вузов / А.М. Корытин, Н.К. Петров, С.Н. Радимов, Н.К.Шапарев. – М.: Энергоатом-издат, 1988. – 432.

5. Деменков Н.П. SCADA-системы как инструмент проектирования АСУ ТП:
Учебное пособие. – М.: Изд-во МГТУ им.Н.Э.Баумана, 2004.– 328с

6. Проектирование систем автоматизации технологических процессов: Справочное пособие / [А.С. Клюев, Б.В. Глазов, А.Х. Дубровский, А.А. Клюев]; Под ред. А.С. Клюева. – М.: Энергоатомиздат, 1990. – 464 с.: ил.

7. Техника чтения схем автоматического управления и технологического контроля / [А.С. Клюев, Б.В. Глазов, М.Б. Миндин, С.А. Клюев]; Под ред. А.С. Клюева. – М.: Энергоатомиздат, 1990. – 432 с.: ил.

3 Discipline "Industrial Robot Executive Systems"

Topics:

1. General information about drives of mechatronic and robotic devices
2. Types of drives for industrial robots
3. Actuating devices based on electric drives
4. Electric drives of industrial robots
5. Drives based on electromagnetic clutches (EMC)
6. Actuating devices based on pneumatic drives
7. Pneumatic drives of industrial robots
8. Actuating devices based on hydraulic drives
9. Actuating systems of industrial robots
10. Composition and purpose of actuating systems of industrial robots
11. Features of different types of automatic control systems for industrial robots
12. Types of control systems for industrial robots
13. Control systems for electric drives of industrial robots
14. Control systems for pneumatic drives of industrial robots
15. Control systems for hydraulic drives of industrial robots
16. Control systems for micro-displacements based on piezoceramics
17. Cyclic control systems and their features
18. Position control systems
19. Contour (trajectory) control systems
20. Adaptive control systems for industrial robots

Questions:

1. What is a robot and a robotic system?
2. Purpose of robots
3. Classification of robots
4. Generalized scheme of the control system of an intelligent robot
5. Adaptation and learning in robotics
6. Main modeled procedures in robot automation
7. Classification of adaptive control systems for robots
8. Tasks of adaptation and learning of robots
9. Problems of creating adaptive robots
10. Pneumatic drive of robots
11. Functional composition of the pneumatic drive of robots
12. Actuating motors of pneumatic drives of robots. Purpose and types
13. Relay-type pneumatic actuator systems of industrial robots
14. Servo (tracking) pneumatic drives of industrial robots
15. Damping of pneumatic drives. Types and purpose
16. Hydraulic drives of robots. Application area
17. Composition of hydraulic drives of robots
18. Control systems of gyro drives of robots

19. Piezoelectric motors. Application area
20. Cyclic control systems of robots
21. Actuating systems based on electric drives
22. Actuating system based on an induction motor
23. Actuating system based on a DC motor
24. Actuating system based on a stepper motor
25. Role and place of the actuating system in the robot structure

List of recommended literature on the discipline:

1. Усольцев А.А. Электрический привод/Учебное пособие. — СПб: НИУ ИТМО, 2012. 238 с.
2. Борисов А.М. Программируемые устройства автоматизации: Учебное пособие / А.М. Борисов, А.С. Нестеров, Н.А. Логинова. – Челябинск: Издательский центр ЮУрГУ, 2010. - 186 с.
3. Булгаков А.Г., Воробьев В.А. Промышленные роботы. Кинематика, динамика, контроль и управление. Серия "Библиотека инженера". — М.: СОЛОН-ПРЕСС, 2008. — 488 с.: ил.
4. Попов Е.П., Письменный Г.В. Основы робототехники: Введение в специальность: Учеб. для вузов по спец. «Роботехнические системы и комплексы» – М.: Высш. шк., 1990. – 224 с.
5. Кочтюк В.И., Гавриш А.П., Карлов А.Г. Промышленные роботы: Конструирование, управление, эксплуатация: Вища. шк. Головне издательство, 1985.
6. Усольцев А.А. Электрический привод/Учебное пособие. [Электронный ресурс]. URL: http://e.lanbook.com/view/book/71195/. Дата обращения 28. 07. 2019.
7. Булгаков А.Г., Воробьев В.А. Промышленные роботы. Кинематика, динамика, контроль и управление. Серия "Библиотека инженера". [Электронный ресурс]. URL: http://e.lanbook.com/view/book/13760/page475/.. Дата обращения 28. 07. 2019.