

**NJSC «Kazakh National Research Technical University  
named after K.Satpayev»  
Institute of Information and Telecommunication Technologies  
Automation and Control Department**

**8D071 Enginerring and engineering issues**

**«AUTOMATION AND ROBOTIZATION»**

Doctor of Philosophy (PhD)  
in the field of automation, robotization, artificial intelligence  
and automated control

on the basis of the invalidated specialty Classifier: "Automation and Control"

**CURRICULUM PROGRAM**




1<sup>st</sup> edition  
in accordance with the State Educational Standard of Higher Education 2018

**Almaty 2021**

Разработано:	Рассмотрено: заседание УС Института	Утверждено: УМС КазННТУ	Страница 1 из 32
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The program is compiled and signed by the parties:

from KazNITU named after K.I. Satpayev:

1. Head of the Department of Automation and Control (AaC),  
Candidate phys.-math. Sciences  N.U. Aldiyarov
2. Director of Institute of Industrial Automation  
and Digitalization (IIAD), PhD  B.O. Omarbekov
3. Chairman of the educational-methodical group of the Department of AaC,  
Doctor of Technical Sciences, Professor  B.A. Suleimenov

**From employers**

Deputy Director Saiman Corporation LLP  K.I. Baybekov

Approved at the meeting of the Academic Council\* of the Kazakh National Research Technical University named after K.I. Satpayev, (protocol No.3 th June 25, 2021)

**Qualification:**

Level 8 of the National Qualifications Framework:  
8D071 Engineering (PhD).

**Professional competencies:** Automation, robotization, artificial intelligence and digitalization of production.

## **Brief program description:**

### **1 Goals**

The purpose of the educational program is to teach doctoral students basic and specialized disciplines, the preparation and defense of the thesis with the achievement of relevant competencies.

2 The types of work activities of graduates of doctoral studies in the management of automated systems must have competencies in accordance with the types of professional activity:

*in the field of industrial and technological activities:*

- to be the head of the production division for the operation, maintenance, repair and adjustment of technical means of automated production process control systems in various industries;

*in the field of organizational and control activities:*

- to be the head of a scientific division dealing with the problems of production processes automation, of a division of the university, of a division for operation, maintenance and repair of components, automated devices and production process control systems in various industries;

*in the field of experimental research:*

- to be the head of a scientific laboratory for carrying out theoretical and experimental research of automation objects of industrial production;

*in the field of research and teaching activities:*

- to be a leading researcher or a head of a research laboratory for research and development of modern automated control systems in various industries;

- to be a teacher of undergraduate, graduate and doctoral students on special disciplines in the field of automated systems control and production processes automation;

*in the field of design activity:*

- to be the head of the division for the development and design of automated control systems for production processes in various industries.

In the field of control of robotic systems must have competence in accordance with the types of professional activities:

*in the field of industrial and technological activities:*

- to be the head of the production division on the operation, maintenance, repair and adjustment of technical means of robotic systems in various industries;

*in the field of organizational and control activities:*

- to be the head of a scientific division dealing with the production processes robotization; of a division of the university, of a division on operation, maintenance and repair of elements, devices, robotic systems in various industries;

*in the field of experimental research:*

- to be the head of a scientific laboratory for conducting experimental studies of robotization objects of industrial production;

*in the field of research and teaching activities:*

- to be a leading researcher or a head of a research laboratory on research and development of modern robotic systems in various industries;

- be a teacher of undergraduate, graduate and doctoral students on special disciplines in the field of robotic systems control and of production processes robotization;

*in the field of design activity:*

- to be the head of the division for the development of robotic systems in various industries.

3 Objects of professional activity:

- automation and process control systems;
- robotic systems and complexes;
- training of college students, undergraduate and PhD students on specialty disciplines

During the educational process there are provided production practices at such enterprises as: “Verbulak” LLP, “Siemens-Kazakhstan” LLP, “ASUTP-Honeywell” LLP, “NAT Kazakhstan” JSC, “Kazatomprom” JSC, “Kazzinc” LLP, “Kazphosphate MU” LLP, “Karachaganak Petroleum Operating” and others.

Scientific internships are also foreseen in: Lublin Technical University (Poland), St. Petersburg State Technical University (Russia), University of Grenoble (France), University of Sapporo (Japan), Kiev Aviation University (Ukraine), Slovak Technical University, University of Florence (Italy).

## EDUCATIONAL PROGRAM PASSPORT

### 1. Volume and content of the program

The Ph.D. educational program has a scientific and pedagogical orientation and involves fundamental educational, methodological and research training and in-depth study of disciplines in relevant areas of science for the system of higher and postgraduate education and science.

The educational program for the preparation of a PhD degree program involves fundamental educational, methodological and research training and in-depth study of disciplines in relevant areas of science for the sectors of the national economy, social sphere: education, medicine, law, art, economics, business administration and national security and military affairs.

PhD educational programs in terms of professional training are developed on the basis of studying the experience of foreign universities and research centers that implement accredited training programs for PhD or doctors in the profile.

The content of the educational program of specialized doctoral studies is established by the university itself.

The main completion criterion of the educational process for the preparation of PhD is a learning of at least 180 academic credits by a doctoral student, including all types of educational and scientific activities.

Срок обучения в докторантуре определяется объемом освоенных академических кредитов. При освоении установленного объема академических кредитов и достижении ожидаемых результатов обучения для получения степени доктора философии (PhD) или по профилю образовательная программа докторантуры считается полностью освоенной.

The term of study in PhD program is determined by the amount of learned academic credits. The PhD education program is considered fully mastered after training a set amount of academic credits and achieving the expected learning outcomes for obtaining a PhD degree.

Training in doctoral studies is carried out on the basis of educational programs of master degree in two directions:

- 1) scientific and pedagogical with a study period of at least three years;
- 2) specialized with a study period of at least three years.

Professional activities of graduates of the program covers the field of automation, robotization, artificial intelligence and automated control.

The program direction of specialty and specializations relates to engineering.

The content of the PhD education program consists of:

- 1) theoretical training, including the study of cycles of basic and major disciplines;
- 2) practical training of doctoral students: various types of practices, scientific or professional internships;
- 3) research work including PhD thesis implementation;
- 4) final certification;
- 5) thesis defense in the dissertation council.

### **Objectives of the educational program:**

On the basis of the achievements of modern science, technology and production, to give knowledge and skills in the field of:

- automation;
- robotization;
- artificial intelligence;
- automated control;
- preparation and defense of a PhD thesis.

Professional activities of graduates of the program are aimed at automation, robotization, artificial intelligence and automated control.

The direction of the program of specialty and specialization covers engineering.

The purpose of the educational program is to teach doctoral student basic and core disciplines, preparation and passing the dissertation work with the achievement of relevant competencies

In case of successful completion of the full doctorate's course, passing the dissertation and approval of a scientific dissertation in the MES RK - the graduate is awarded with the degree of "Doctor of Philosophy".

The undergraduate educational program "Automation and Robotization" differs from the existing educational program on the specialty 6D070200 - "Automation and Control" by a complete update of the internal content of the disciplines. It provides the training of doctoral students on two trajectories (specializations): "Automated systems control" and "Robotic systems control". This is connected to the need to deepen knowledge and skills in these two "narrow" areas obtained in the magistracy.

Along the trajectory: "Automated systems control" the program provides the study of the following innovative disciplines:

- mathematical methods of optimal control;
- intellectual automatic control systems;
- robust automatic control systems;



- mathematical methods of adaptive control;
- theory of dynamic systems;
- diagnostic subsystems in the control system (with elements of AI).

During the process of mastering the educational program, the doctor of PhD in the field of automated systems control should have the following key competencies.

Doctor of PhD must:

*have an idea:*

- about modern methods of control systems creation, from the point of view of modern control theory using digital regulators, mechanisms of adaptation to the real conditions of the system, determination of the optimal control laws, creation of multi-level microprocessor systems, application of intelligent approaches in order to improve the efficiency of systems, distributed systems control;

- about modern software means for research and modeling and for the design of automated production process control systems;

- about modern technical means used to create automated systems for production processes control;

*be able to:*

- analyze, formulate tasks, develop mathematical models, carry out simulations in order to study the functioning of automation systems of production processes using modern software products

- analyze, formulate tasks, develop algorithmic and software support for multi-level microprocessor control systems for complex production processes;

*know:*

- modern methods of creation and analysis of the automated systems functioning for technological processes and technical systems control in various industries;

- current development trends, predictive estimates of the use of technical means and systems for production processes automation;

- standards, methodological and regulatory materials accompanying the research, design, installation, adjustment and operation of automated production process control systems;

- modern methods of creation and analysis of the robotic systems functioning in various industries;

- current development trends, predictive estimates of the use of technical means and systems of production processes robotization;

- standards, methodological and regulatory materials accompanying the research, design, installation, adjustment and operation of robotic systems in various industries.

*have skills in:*

- the organization of research and development work, works on installation, adjustment and operation of automation tools and systems, and production processes control in various industries;

- the organization of work on the collection, storage and processing of information used in the field of professional activity.

Doctor of PhD in the field of automated systems control should solve the following tasks in accordance with the types of professional activity:

*in the field of industrial and technological activities:*

- to be the head of the production division for the operation, maintenance, repair and adjustment of technical means of automated production process control systems in various industries;

*in the field of organizational and control activities:*

- to be the head of a scientific division dealing with the problems of production processes automation, of a division of the university, of a division for operation, maintenance and repair of components, automated devices and production process control systems in various industries;

*in the field of experimental research:*

- to be the head of a scientific laboratory for carrying out theoretical and experimental research of automation objects of industrial production;

*in the field of research and teaching activities:*

- to be a leading researcher or a head of a research laboratory for research and development of modern automated control systems in various industries;

- to be a teacher of undergraduate, graduate and doctoral students on special disciplines in the field of automated systems control and production processes automation;

*in the field of design activity:*

- to be the head of the division for the development and design of automated control systems for production processes in various industries.

During the educational process there are provided production practices at such enterprises as: “Verbulak” LLP, “Siemens-Kazakhstan” LLP, “ASUTP-Honeywell” LLP, “NAT Kazakhstan” JSC, “Kazatomprom” JSC, “Kazzinc” LLP, “Kazphosphate MU” LLP, “Karachaganak Petroleum Operating” and others.

Scientific internships are also foreseen in: Lublin Technical University (Poland), St. Petersburg State Technical University (Russia), University of Grenoble (France), University of Sapporo (Japan), Kiev Aviation University (Ukraine), Slovak Technical University, University of Florence (Italy).

Along the trajectory: "Robotic systems control" the program provides for the study of the following innovative disciplines:

- Mathematical methods of optimal control;



- Intellectual robots;
- Mobile robots;
- Adaptive robots;
- Dynamics of control robots.

Doctor of PhD should:

*have an idea:*

- about modern methods of robotic systems creation, from the point of view of modern control theory using digital controllers, mechanisms of adaptation to the real conditions of the system functioning;

- about the determination of optimal control laws, construction of multi-level microprocessor systems, application of intelligent approaches in order to improve the efficiency of systems, the distributed systems control;

- about modern software for modeling and design of robotic systems;

- about modern technical means used to create robotic systems in various industries;

*be able to:*

- analyze the objects of robotization, formulate problem statements, develop mathematical models, carry out experimental studies and simulate the operation of robotic systems using modern software products;

- analyze, formulate tasks, develop algorithmic and software support for multi-level microprocessor control systems of robotic complexes;

*know:*

- modern methods of creation and analysis of the robotic systems functioning in various industries;

- current development trends, predictive estimates of the use of technical means and systems of production processes robotization;

- standards, methodological and regulatory materials accompanying the research, design, installation, adjustment and operation of robotic systems in various industries.

*have skills in:*

- the organization of research and development works, works on installation, adjustment and operation of control means of robotic systems in various industries;

- the organization of work on the collection, storage and processing of information used in the field of professional activity.

Doctor of PhD in the field of robotic systems control should solve the following tasks in accordance with the types of professional activity:

*in the field of industrial and technological activities:*

- to be the head of the production division on the operation, maintenance, repair and adjustment of technical means of robotic systems in various industries;

*in the field of organizational and control activities:*

- to be the head of a scientific division dealing with the production processes robotization; of a division of the university, of a division on operation, maintenance and repair of elements, devices, robotic systems in various industries;

*in the field of experimental research:*

- to be the head of a scientific laboratory for conducting experimental studies of robotization objects of industrial production;

*in the field of research and teaching activities:*

- to be a leading researcher or a head of a research laboratory on research and development of modern robotic systems in various industries;

- be a teacher of undergraduate, graduate and doctoral students on special disciplines in the field of robotic systems control and of production processes robotization;

*in the field of design activity:*

- to be the head of the division for the development of robotic systems in various industries.

During the educational process there are provided production practices at such enterprises as: “Verbulak” LLP, “Siemens-Kazakhstan” LLP, “ASUTP-Honeywell” LLP, “NAT Kazakhstan” JSC, “Kazatomprom” JSC, “Kazzinc” LLP, “Kazphosphate MU” LLP, “Karachaganak Petroleum Operating” and others.

Scientific internships are also foreseen in: Lublin Technical University (Poland), St. Petersburg State Technical University (Russia), University of Grenoble (France), University of Sapporo (Japan), Kiev Aviation University (Ukraine), Slovak Technical University, University of Florence (Italy).

## 2 Entry Requirements

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The doctoral program accepts persons with a master's degree and work experience of at least 1 (one) year or who completed residency studies.

Enrollment in the number of doctoral students is carried out by admission committees of universities and scientific organizations on the basis of the entrance exam for groups of PhD educational programs and a certificate confirming foreign language proficiency in accordance with European competencies (standards) of foreign language proficiency. When enrolling in higher education institutions, PhD candidates independently choose an educational program from the relevant group of educational programs.

Enrollment of persons for profile training of PhD under the state educational order is carried out on a competitive basis

The procedure for citizens admission to the PhD degree is established in accordance with the “Model rules for admission on study in educational organizations that implement educational programs of postgraduate education”.

At the "entrance" the PhD student should have all the prerequisites necessary for learning the corresponding educational program of the PhD degree. The list of necessary prerequisites is determined by the higher education institution independently.

In the absence of the necessary prerequisites, the undergraduate is allowed to master them on a fee basis. In this case, PhD studies begin after full training of prerequisites by the student.

Admission to the university is carried out according to the applications of the applicant who has completed the course of scientific and pedagogical magistracy on the program "Automation and robotization" in accordance with the points of the certificate issued by the results of testing in the Republican Center for English Testing, as well as passing an oral examination on special subjects.

Special requirements for admission to the program are applied to graduates of the specialized magistracy program "Automation and Robotization", as well as magistracies of related educational programs: instrumentation, information systems, computers and software, radio engineering, electronics and telecommunications, information security systems, electric power.

### 3 Requirements to complete the course and receive a diploma

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Those, who have obtained the doctoral education program and defended their doctoral thesis, with a positive decision of the dissertation councils of the university with a special status or the Committee on Control in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan on the results of the examination, are awarded the degree of PhD profile and issued a state diploma with the Supplement (transcript).

Persons who have received a PhD degree in order to deepen scientific knowledge, solve scientific and applied problems on a specialized topic, perform a post-doctoral program or conduct scientific research under the guidance of a leading scientist chosen by the university.

### 3.1 Requirements for key competencies of doctoral graduates:

#### *1) have a knowledge:*

- about the main stages of development and the change of paradigms in the evolution of science;
- about subject, world outlook and methodological specificity of natural (social, humanitarian, economic) sciences;
- about scientific schools of the corresponding branch of knowledge, their theoretical and practical developments;
- about scientific concepts of world and Kazakhstan science in the relevant field;
- about the mechanism of implementation of scientific developments into practical activities;
- about the norms of interaction in the scientific community;
- on the pedagogical and scientific ethics of a research scientist;

#### *2) know and understand:*

- modern trends and patterns of development of domestic science in the context of globalization and internationalization;
- methodology of scientific knowledge;
- achievements of world and Republic of Kazakhstan science in the relevant field;
- (to recognize and accept) the social responsibility of science and education;
- perfectly know the foreign language for scientific communication and international cooperation;

#### *3) be able to:*

- organize, plan and implement the research process;
- analyze, evaluate and compare various theoretical concepts in the field of research and draw conclusions;

- analyze and process information from various sources;
- conduct an independent scientific study, characterized by an academic integrity, based on modern theories and methods of analysis;
- generate their own new scientific ideas, communicate their knowledge and ideas to the scientific community, expanding the boundaries of scientific knowledge;
- choose and effectively use modern research methodology;
- plan and forecast their further professional development;
- 4) *to be skilled for:*
  - critical analysis, evaluation and comparison of various scientific theories and ideas;
  - analytical and experimental research activities;
  - planning and forecasting of research results;
  - oratory and public speaking at international scientific forums, conferences and seminars;
  - scientific writing and scientific communication;
  - planning, coordinating and implementing of research processes;
  - a systematic understanding of the field of study and demonstrate the quality and effectiveness of selected scientific methods;
  - participation in scientific events, fundamental scientific domestic and international projects;
  - leadership and team management;
  - responsible and creative attitude to scientific and scientific-pedagogical activity;
  - carrying out a patent search and experience in transferring scientific information using modern information and innovative technologies;
  - protection of intellectual property rights to scientific discoveries and developments;
  - free communication in a foreign language;
- 5) *be competitive:*
  - in the field of scientific and educational activities in the context of rapid updating and growth of information flows;
  - in carrying out of theoretical and experimental research;
  - in the formulation and solution of theoretical and applied problems in a scientific research;
  - in carrying out of professional and comprehensive analysis of problems in the relevant field;
  - in matters of interpersonal communication and human resource management;
  - in matters of university specialists' training;

- in the examination of scientific projects and research;
- in ensuring of continuous professional growth.

3.2 Requirements for Scientific Research Work of the PhD Student studied in the PhD program:

- 1) Compliance with the main aspects of the doctoral education program, where defends the PhD dissertation;
- 2) relevant and contains scientific novelty and practical significance;
- 3) based on modern theoretical, methodological and technological achievements of science and practice;
- 4) based on modern methods of processing and interpreting data using computer technology;
- 5) performed using modern scientific research methods;
- 6) contains scientific-research (methodical, practical) sections on the main defending provisions.

3.3 Requirements for the organization of practices:

The practice is carried out in order to develop practical skills of scientific, pedagogical and professional activities.

PhD education program includes:

- 1) pedagogical and research practice - for students studied on the program of the doctor of philosophy;
- 2) practical training - for students under the program of specialized program of doctor of philosophy.

In the period of pedagogical practice, PhD students, if necessary, are invited to conduct classes in masters and bachelor programs.

The research practice of the PhD candidate is carried out with the purpose of studying the latest theoretical, methodological and technological achievements of domestic and foreign science, as well as consolidating practical skills, applying modern methods of scientific research, processing and interpreting experimental data in the dissertation research.

The internship of a PhD candidate is carried out in order to consolidate the theoretical knowledge gained in the learning process, and to improve the professional skills.

The content of research and industrial practice is determined by the topic of the PhD thesis.

Generally compulsory standard requirements for the completion of doctoral studies and assignment of a PhD degree: mastering at least 110 academic credits of theoretical education and preparation for passing the state exam on the specialty and



dissertation work passing.

Special requirements for the completion of doctoral studies on this program  
*graduate should know:*

- modern methods of creation and analysis of the automated systems functioning for technological processes and technical systems control in various industries;

- current development trends, predictive estimates of the use of technical means and systems for production processes automation;

- standards, methodological and regulatory materials accompanying the research, design, installation, adjustment and operation of automated production process control systems;

- modern methods of creation and analysis of the robotic systems functioning in various industries;

- current development trends, predictive estimates of the use of technical means and systems of production processes robotization;

- standards, methodological and regulatory materials accompanying the research, design, installation, adjustment and operation of robotic systems in various industries.

*to be able to:*

- analyze, formulate tasks, develop mathematical models, carry out modeling of the automation systems functioning of production processes using modern software products;

- analyze, formulate tasks, develop algorithmic and software support for multi-level microprocessor control systems for complex production processes;


- analyze the objects of robotization, formulate problem statements, develop mathematical models, carry out experimental studies and simulate the operation of robotic systems using modern software products;

- analyze, formulate tasks, develop algorithmic and software support for multi-level microprocessor control systems of robotic complexes.

In order to obtain a PhD diploma a graduate must prepare and defense a scientific dissertation work approved in the MES RK.


## 4 The curriculum of the educational program

MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN  
Non-profit Joint Stock Company "KAZAKH NATIONAL RESEARCH TECHNICAL UNIVERSITY named after K.I. SATBAYEV"

 SATBAYEV UNIVERSITY



WORKING CURRICULUM for 2021-2022 academic year admission  
Educational program: ED07101 - "Automation and Robotization"  
Group of Educational programs D100 - "Automation and management"

Form of study: full-time Study duration: 3 years Academic degree: doctor of philosophy (PhD)



year of study	code	Name of discipline	Cycle	Credits	Total hours	classroom volume of lecture	SRS (including SESOP, in hours)	Prerequisites	code	Name of discipline	Cycle	Credits	Total hours	classroom volume of lecture	SRS (including SESOP, in hours)	Prerequisites
1		1 semester														
	MET222	Methods of scientific research	BD UC	5	150	2/0/1	105		AAP345	Research work of a doctoral student, including internships and the implementation of a doctoral dissertation	NIRD	24				
	LNG303	Academic writing	BD UC	5	150	0/0/3	105		AAP350	Pedagogical practice	BD	10				
	AUT314	Theories of dynamical systems	BD UC	5	150	2/0/1	105									
	CS01	Component of choice	PD CC	5	150											
	CS02	Component of choice	PD CC	5	150											
		Total		25					Total			34				
2		3 semester														
	AAP345	Research work of a doctoral student, including internships and the implementation of a doctoral dissertation	NIRD	24					AAP346	Research work of a doctoral student, including internships and the implementation of a doctoral dissertation	NIRD	25				
	AAP355	Research practice	PD	10												
		Total		34					Total			25				
3		5 semester														
	AAP346	Research work of a doctoral student, including internships and the implementation of a doctoral dissertation	NIRD	25					AAP346	Research work of a doctoral student, including internships and the implementation of a doctoral dissertation	NIRD	25				
									ECA303	Writing and defending a doctoral dissertation	FA	12				
		Total		25					Total			37				
									Total			180				

Decision of the Academic Council KNU/RTU named after K.I. Satbayev: Protocol № 3 - 25 - 06 2021.  
Decision of the Academic Council of the Institute: IAA0 Protocol № 42 - 06 2021

Vice-rector for academic affairs:  B.A. Zhurikov  
Institute Director:  N.U. Abdiyev  
Head of Department "Automation and Control": N.U. Abdiyev  
Representative of Specialty council: S.K. Abolgaipov

Total number of credits	
Cycle of disciplines	Credits
Cycle of general education disciplines	0
Cycle of basic disciplines (BD UC, BD CC)	25
Cycle of profile disciplines (PD UC, PD CC)	20
Total of theoretical study	45
NIRD	123
Writing and defending a doctoral dissertation	12
<b>OVERALL:</b>	<b>180</b>

MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN  
NJSC "KAZAKH NATIONAL RESEARCH TECHNICAL UNIVERSITY NAMED AFTER K.I. SATPAYEV"

Approved  
Director of the Institute of Industrial  
Automation and Digitalization  
B.O. Omarbekov  
2021 y.

CATALOG OF DISCIPLINES ON SELECTED DOCTORSHIP for enrollment 2021-2022 academic year

Educational program 8D07101 - "Automation and robotization"  
Group of educational programs D100 - Automation and control

Study period: 3 years

Optional Components - 15 Credits				
Elective code	discipline code	Name of disciplines	Academic credits	Lec/lab/pr/sr
1301	AUT305	Modern technical means in SU	5	2/0/1/3
	AUT316	Electronics power devices	5	1/1/1/3
	AUT317	Mathematical methods of adaptive control	5	2/0/1/3
1302	AUT302	Subsystems of diagnostics in control systems	5	2/1/0/3

Decision of the Academic Council of the Institute of Industrial Automation and Digitalization. Minutes № 12, dated "02"

Head of the Department of Automation and Control

N.U. Aldiyarov

Specialty Council Representative

S.K. Abdigaliyev

year of study	code	Name of discipline	Cycle	Credits	Total hours	classroom volume of lc/lab/pr	SRS (including SRSP), in hours	Prerequisites	code	Name of discipline	Cycle	Credits	Total hours	classroom volume of lc/lab/pr	SRS (including SRSP), in hours	Prerequisites
1	1 semester								2 semester							
	MET322	Methods of scientific research	BD UC	5	150	2/0/1	105		AAP34 5	Research work of a doctoral student, including internships and the implementation of a doctoral dissertation	NIRD	24				
	LNG305	Academic writing	BD UC	5	150	0/0/3	105		AAP35 0	Pedagogical practice	BD	10				
	AUT314	Theory of dynamical systems	BD UC	5	150	2/0/1	105									
	1301	Component of choice	PD CC	5	150											
	1302	Component of choice	PD CC	5	150											
		<b>Total</b>		<b>25</b>						<b>Total</b>		<b>34</b>				

2	3 semester							4 semester						
	AAP345	Research work of a doctoral student, including internships and the implementation of a doctoral dissertation	NIRD	24				AAP346	Research work of a doctoral student, including internships and the implementation of a doctoral dissertation	NIRD	25			
	AAP355	Research practice	PD	10										
		<b>Total</b>		<b>34</b>					<b>Total</b>		<b>25</b>			
3	5 semester							6 semester						
	AAP346	Research work of a doctoral student, including internships and the implementation of a doctoral dissertation	NIRD	25				AAP346	Research work of a doctoral student, including internships and the implementation of a doctoral dissertation	NIRD	25			
								ECA303	Writing and defending a doctoral dissertation	FA	12			
		<b>Total</b>		<b>25</b>					<b>Total</b>		<b>37</b>			
											<b>180</b>			

<b>Optional Components - 15 Credits</b>					
<b>Elective code</b>	<b>discipline code</b>	<b>Name of disciplines</b>	<b>Academic credits</b>	<b>Lec/lab/pr/sr/o</b>	<b>semester</b>
1301	AUT305	Modern technical means in SU	5	2/0/1/3	1
	AUT316	Electronics power devices	5	1/1/1/3	1
1302	AUT317	Mathematical methods of adaptive control	5	2/0/1/3	1
	AUT302	Subsystems of diagnostics in control systems	5	2/1/0/3	1



## 5 Descriptors of the level and volume of knowledge, skills, abilities and competencies

The third level descriptors within the framework of the Comprehensive Qualifications Framework of the European Higher Education Area (QF-EHEA) are reflect the learning outcomes that characterize the learner's abilities:

- 1) demonstrate a systematic understanding of the field of study, mastering the skills and research methods used in the field of automation, robotics, artificial intelligence and automated control;
- 2) demonstrate the ability to think, design, implement and adapt the essential research process with a scientific approach;
- 3) to contribute by own original research to the expansion of the boundaries of the scientific field, which deserves publication at the national or international level;
- 4) critically analyze, evaluate and synthesize new and complex ideas;
- 5) communicate their knowledge and achievements to colleagues, the scientific community and the general public;
- 6) to contribute in progress in the academic and professional context to the technological, social or cultural development of society based on knowledge.

## 6 Completion Competencies

<b>Human, social and ethical competences (HSEC)</b>	
H 1	Have an understanding of the pedagogical and scientific ethics of the research scientist
H 2	Have an understanding of the norms of interaction in the scientific community
H 3	Know and understand the methodology of scientific knowledge
H 4	Ability to critically use the methods of modern science in practice
H 5	Generate your own new scientific ideas, communicate your knowledge and ideas to the scientific community, expanding the boundaries of scientific knowledge
<b>Special and management competencies (SMC)</b>	
S 1	Willingness to lead a team in the field of their professional activities, tolerantly perceiving social, ethnic, confessional and cultural differences
S 2	Demonstrate a systematic understanding of the field of study, mastering the skills and research methods used in the field of automation, robotization, artificial intelligence and automated control
S 3	Demonstrate the ability to think, design, implement, and adapt an essential research process with a scientific approach
S 4	Contribute with your own original research to expand the boundaries of the scientific field that deserves publication at the national or international level
S 5	Critically analyze, evaluate and synthesize new and complex ideas
<b>Professional competence (PC)</b>	

PC-1	Own the methods of system analysis: data collection, research of information flows, building models and choosing structures for automated and robotic systems
PC-2	Know the basic methods of analysis and synthesis of dynamic systems (DS): bifurcation theory, fractal dimension and catastrophe theory
PC-3	Know the theoretical foundations, modern methods and tools of system analysis in automation and control systems;
PC-4	expanding and strengthening the doctoral student's knowledge in the field of automatic control theory and preparing him for the independent solution of theoretical and applied problems to create modern automatic control systems;
PC-5	Ability to develop optimal ways to solve problems in control systems;
PC-6	Ability to perform computational and research work on the design and operation of robust control systems using modern computer technology;
PC-7	Have the skills of independent construction of mathematical models of robust, bilinear and nonlinear systems, solving problems of analysis and synthesis of data systems using computer software;
PC-8	Ability to perform computational and research work on the design and operation of control systems based on modern computer technology;
PC-9	Knowledge of methods of using neural networks in control systems and be able to synthesize neural network control algorithms;

## 7Diploma Supplement by the standards of ECTS and MES RK

The Supplement is developed according to the standards of the European Commission, Council of Europe and UNESCO / CEPES. This document is for academic recognition only and does not constitute official proof of education. Without a diploma of higher education it is not valid. The purpose of completing the European Supplement is to provide sufficient information about the diploma owner, the qualifications obtained by him, the level of this qualification, the content of the training program, the results, the functional purpose of the qualification, as well as information about the national education system. In the application model, which will be used for the transfer of estimates, the European system of transfer or credit transfer (ECTS) is used.

The European Diploma Supplement provides an opportunity to continue education in foreign universities, as well as to confirm national higher education for foreign employers. When traveling abroad for professional recognition it will be required additional legalization of the diploma of education. The European Diploma Supplement is completed in English upon individual request and is issued free of charge.

## 8 Disciplines description

### Research methods

CODE - MET322

CREDIT - 2/0/1/2

PREREQUISITES - master's disciplines

### GOALS AND OBJECTIVES OF THE COURSE

The purpose of the course: "To gain knowledge about the laws, principles, concepts, terminology, content, specific features of the organization and management of research using modern methods of scientific geometry.

#### Course objectives:

acquaintance with the basic theoretical rules, laws, principles, terms, concepts, processes, methods, technologies, tools, operations of scientific activity;  
study of methods of planning and organization of scientific research;  
to get acquainted with the general methodology of scientific design, creativity, the general scheme of organization of scientific research, the practice of applying the methods of scientific knowledge in the relevant field;  
mastering and research skills in choosing a research topic;  
Practice of working with scientific databases (ORCID, SCOPUS, Google Scholar, Web of Science, Elsevier, ClarivateAnalytics, Science Direct, Wiley InterScience, Cambridge Journals Online, RSCI, ProQuest Dissertations & Theses, database of metallurgical and Canadian societies TMS and Met Soc, patented Derwent Innovations Index database, etc.), study of scientific geometry and scientometric indicators; journal selection practice (understanding of the WoS quartiles Q1, Q2, Q3, Q4, CiteScore percentiles in the Scopus database);  
research of basic methods of scientific research;  
study of procedures for setting and solving scientific problems of information processes and informatization of enterprises and organizations;  
to get acquainted with the possibilities of conducting research in the international community in the field of basic and applied metallurgy;  
study of standards and norms for registration of research results, preparation of publications for research projects, reports, seminars and conferences;  
acquaintance with procedures of approbation of results of scientific researches, preparation of publications on results of scientific researches;

methods of presentation of scientific materials and formation of the manuscript of scientific work, preparation of the candidate's dissertation.

#### KNOWLEDGE, SKILLS, SKILLS UNTIL COMPLETING THE COURSE

- professional: the ability to critically analyze and evaluate modern scientific achievements, research and practical problems, including the creation of new ideas in interdisciplinary areas;

- Introduction of complex research based on a unified systemic scientific worldview, including interdisciplinary;

- readiness to participate in the work of Kazakhstani and international research groups to address scientific and scientific-educational issues;

- be able to comply with ethical standards in professional activities;

management: the ability to plan and address their professional and personal development; mastering the methods of theoretical and experimental research in the field of professional activity.

communicative: ability to work in a team; show initiative; sequence of sentences; effective cooperation with other people, the establishment of subject-subject relationships in the process of professional activity; mastering the culture of research, including the use of modern information and communication technologies.

#### Academic writing

CODE - LNG305

CREDIT - 5 (0/0/3)

PREREQUISITES - Professional English

#### GOALS AND OBJECTIVES OF THE COURSE

Development of academic writing skills for writing research papers.

#### BRIEF DESCRIPTION OF THE COURSE

The course is aimed at developing academic writing skills and writing strategies for doctoral students in engineering and natural sciences.

The course focuses on the basics and general principles of academic writing, including:

- write effective sentences and paragraphs;
- use of tenses and punctuation marks in scientific work;
- abstract, introduction, conclusion, discussion, conclusion, written literature and resources;

- reference to the text;
- Prevention of plagiarism and conference presentations.

## KNOWLEDGE, SKILLS AND SKILLS TO BE GROWN AT THE END OF THE COURSE

Upon completion of the course, doctoral students will have the following knowledge and skills:

- recognizes the effective features of academic writing;
- improves the accuracy and clarity of personal records;
- makes adjustments to individual scientific work;
- uses reading skills and materials in writing research papers;
- analyzes scientific articles published in international journals in their field, as well as writes scientific articles in accordance with the requirements of the content of each section of the scientific article.

### **Theory of dynamic systems**

CODE - AUT314

CREDIT - 5 (2/0/1)

PREREQUISIT - Scattered control system

## GOALS AND OBJECTIVES OF THE COURSE

The purpose of the course is to train specialists who have mastered the theoretical apparatus that underlies the modern theory of dynamic systems, who can perform computational research on the analysis and synthesis of dynamic systems on the basis of modern computer technology.

Objectives: during the course to develop students' understanding of the processes of dynamic systems, the ability to model dynamic systems and apply methods of their analysis and synthesis.

## BRIEF DESCRIPTION OF THE COURSE

The course includes the following main sections of the theory of dynamic systems:

- Basic concepts of the theory of dynamic systems.
- Mathematical models and classification of dynamic systems.
- Analysis of dynamic systems in the phase plane.
- Basic concepts of the theory of features, the theory of bifurcation, fractal dimensionality.
- Chaotic dynamics and dynamic chaos.
- Structural stability of nonlinear systems and disaster theory.

## KNOWLEDGE, SKILLS, SKILLS UNTIL COMPLETING THE COURSE

During the study, students must gain theoretical knowledge, practical skills and abilities in the field of modeling and analysis of dynamic systems on the basis of modern computing.

Knowledge: the main modern directions of modeling and analysis of dynamic systems.

Must master: theoretical foundations, basic principles and mathematical methods of modeling and analysis of dynamic systems; methods for calculating dynamic systems.

### **Diagnostic subsystems in control systems**

CODE - AUT302

CREDIT - 5 (2/1/0)

PREREQUISITES - Dynamics of robot control

## GOALS AND OBJECTIVES OF THE COURSE

The main purpose is to develop methods and algorithms for diagnosing the technical condition of individual elements of the structure of the technological process, using modern methods of structural analysis of signals.

## BRIEF DESCRIPTION OF THE COURSE

Methods of local analysis of time series, data allow to identify only significant structural changes in the signals, and there is a delay in determining the moment of local changes in the signal. Wave analysis is characterized by the stability of the moment of change of structural properties of the considered time chain and the absence of delays. The study is typical for the option with measuring resistance in the analyzed data chain:

- the number of detected local features decreases with increasing dispersion of the measuring resistance;
- wave analysis without delay identifies all moments of local characteristics of the interference of distorted measurement signals.

The purpose of this diagnostic system is a joint analysis of interrelated controlled technological characteristics. The use of intelligent technologies for the synthesis of diagnostic subsystems of process equipment is considered.

## KNOWLEDGE, SKILLS, SKILLS UNTIL COMPLETING THE COURSE

Разработано:	Рассмотрено: заседание УС Института	Утверждено: УМС КазННТУ	Страница 26 из 32
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- Analysis of the main methods of structuring measurement signals
- Solve forecasting problems in diagnostic systems
- Creating a predicate model
- Modernization of diagnostic systems based on big data and the use of modern intelligent technologies.

### **Electronics of power devices**

CODE - AUT316

CREDIT - 5 (1/1/1)

PREREQUISITES - AUT

### **GOALS AND OBJECTIVES OF THE COURSE**

The purpose of this course is to give students a detailed understanding of power converters, their components, topology, mathematical characteristics, basic methods of analysis, calculation and rational selection of elements.

Objectives of the course: mastering the principles of operation of electronics of power devices; knowledge of the correct choice of electronics and power devices; training to optimize their working conditions; mastering the skills of calculating their characteristics, as well as their tuning.

### **BRIEF DESCRIPTION OF THE COURSE**

The discipline "Electronics of Power Equipment" is one of the main special courses for the specialty "Automation and Control".

The course consists of the main parts: conversion of AC to DC rectifiers; pulse regulation of direct and alternating voltage - pulse converters; voltage or current regulation - frequency converters.

### **KNOWLEDGE, SKILLS, SKILLS UNTIL COMPLETING THE COURSE**

Upon completion of the course, students should know:

- What are the power electronic devices of automation, the basic concepts of conversion of electricity;
- What are power converters and their classification, as well as the principle of operation and device of various converters;
- The main characteristics and properties of powerful electronic automation devices; must know and have skills:
- the right choice of powerful electronic automation devices;
- adjustment of power converters built on different element bases;
- optimization of working conditions in their automation systems.

### **Mathematical methods of adaptive control**

CODE - AUT317

CREDIT - 5 (2/0/1)

PREREQUISITES - Optimal control systems

### **GOALS AND OBJECTIVES OF THE COURSE**

The purpose of the course is to train specialists who have the theoretical apparatus that underlies the modern theory of adaptive control systems, who can conduct computational and research work on the design and operation of adaptive control systems on the basis of modern computer technology.

Objectives: during the course it is necessary to prepare students to work in the field of design of adaptive control systems, mastering the theoretical and practical foundations, basic principles and mathematical methods of designing adaptive systems, analysis and synthesis of adaptive systems based on modern methods.

### **BRIEF DESCRIPTION OF THE COURSE**

The course includes the following main sections of adaptive systems:

- Management in conditions of uncertainty. Basic concepts and methods of forming the concept of adaptive management.
- Tasks and methods of synthesis of adaptive control systems.
- Adaptive systems of identification type.
- Discrete adaptive systems with a model of an adjustable control object.
- Direct adaptive control. Adaptive systems with a clear and vague reference model of the main circuit.
- Adaptive neural network control systems.

### **KNOWLEDGE, SKILLS, SKILLS UNTIL COMPLETING THE COURSE**

During the study, students must gain theoretical knowledge, practical skills and abilities in the field of design of adaptive systems on the basis of modern computing devices.

Knowledge: basic principles and algorithms of adaptive control; basic schemes of adaptive control systems.

Must master: theoretical foundations, basic principles and mathematical methods of building adaptive systems; methods of calculation and design of adaptive systems; skills of independent creation of mathematical models of adaptive systems.

### **Modern technical means in control systems**

CODE - AUT305

CREDIT - 5 (2/0/1)

PREREQUISITES - no

### **GOALS AND OBJECTIVES OF THE COURSE**

The purpose of the discipline

Has the basics of research and development of optimal control systems based on classical variational computational methods, in particular, training of highly qualified personnel who know the basics of software and stabilization optimal control, elements of classical variational computation, basics of maximal and dynamic programming.

Objectives of the discipline

Methods of the theory of optimal control, elements of classical variational calculus, the basics of the principle of maximum and dynamic programming. Models and methods of software and stabilization optimal management.

### **BRIEF DESCRIPTION OF THE COURSE**

The content of the discipline "Modern technical means in control systems" includes the study of mathematical methods of optimal control on the basis of classical variational calculations, the principles of maximum principle and the method of dynamic programming. Models and methods of software and stabilization optimal management are considered. Methods of synthesizing intelligent control systems are considered separately.

### **KNOWLEDGE, SKILLS, SKILLS UNTIL COMPLETING THE COURSE**

As a result of studying the discipline you need to know:

- Mathematical models and methods for creating optimal control systems based on classical variational computational elements;
- Mathematical models and methods of optimal control based on the principle of maximum;
- Mathematical models and optimal control methods based on the method of dynamic programming;
- Mathematical models and methods of creating optimal control systems based on the method of analytical design of regulators;
- Mathematical models and methods for creating optimal control systems in the event of accidental external influences;

- Mathematical models and methods for creating optimal control systems in the presence of incomplete information about the vector of state variables.

As a result of studying the discipline must know:

- analysis of technological processes to create optimal control systems;
- based on the choice of the structure of the optimal control algorithm of the technical or technological system, depending on the specifics of the production process;
- based on the choice of the type of model and algorithm (including intelligent) for optimal control of the technical or technological system.

**The doctoral education program includes:**

- for students of the program of research practice - Doctor of Philosophy (PhD);
- internship for students of the profile doctoral program.

The doctoral student's research practice is carried out in order to study new theoretical, methodological and technological achievements of domestic and foreign science, as well as to strengthen practical skills, use modern research methods, process and interpret experimental data in dissertation research.

The internship of a doctoral student is carried out in order to consolidate the theoretical knowledge acquired in the educational process and improve their professional level.

**Doctoral research work:**

- Correspondence of the doctoral dissertation to the main problems of the defended specialty;
- relevance, scientific novelty and practical significance;
- science and practice based on modern theoretical, methodological and technological achievements;
- adherence to modern methods of data processing and interpretation using computer technology;
- performed using modern research methods;
- consists of research (methodological, practical) sections on the main protected rules.

**Experimental research work of doctoral students:**

- Correspondence of the doctoral dissertation to the main problems of the defended specialty;
- relevance, scientific novelty and practical significance;
- be based on modern achievements of science, technology and industry and include specific practical recommendations, independent solutions to complex, non-functional management tasks;
- performed with the use of advanced information technologies;

- consists of experimental (methodological, practical) sections on the main protected rules.

### **Defense of doctoral dissertation**

CODE - ECA303

CREDIT –12

The purpose of the doctoral dissertation is to assess the level of scientific-theoretical and research-analytical skills of the doctoral student, the established professional and managerial competencies, readiness to perform professional tasks independently and his training in accordance with professional standards and doctoral programs.

### **BRIEF DESCRIPTION**

The doctoral dissertation is an independent research work of a doctoral student, in which the set of theoretical rules can be classified as a new scientific achievement, or the solution of a scientific problem or the introduction of scientifically based technical, economic or technological solutions that make a significant contribution to economic development.

Doctoral dissertation is the result of research / experimental research work of a doctoral student conducted during the entire period of study.

The defense of a doctoral dissertation is the final stage of master's training. The doctoral dissertation must meet the following requirements:

- The topic of the dissertation should be related to the priorities of science development and / or government programs or programs of basic or applied research.
- The content of the dissertation, the goals and objectives, the obtained scientific results must strictly correspond to the topic of the dissertation.
- The dissertation is performed in accordance with the principles of Independence, internal unity, scientific novelty, reliability and practical value.

## Content

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