Non-profit joint-stock company «Kazakh National Research Technical University named after K.I. Satbayev»
Institute of Information and Telecommunication Technologies
Department of «Software Engineering»

CURRICULUM PROGRAM

"Machine Learning & Data Science"

Doctor of Philosophy (Ph.D)

based on the following specialties of the invalidated classifier of specialties:
«6D070400»

1st edition
in accordance with the state standard of higher education 2018

Almaty 2019

САТБАЕВ УНИВЕРСИТЕТІ SATBAYEV UNIVERSITY

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Квалификация:
Уровень 8 Национальной рамки квалификаций:
8D0610 – Информационно-коммуникационные технологии

Профессиональные компетенции: Анализ данных, Машинного обучения, Искусственный интелект.

Brief description of the program

1. Objectives

The main focus of the doctoral program is on in-depth study of software development technologies in artificial intelligence, data analysis, and machine learning.

The program is aimed at preparing a scientist who is able to independently conduct scientific research, develop complex software solutions, work in a team, and be well-versed in modern aspects of data science. The educational program is built taking into account the current trends in machine learning and data processing using artificial intelligence methods in conjunction with the manufacturing sector.

The development of the educational program was carried out on the basis of 3 documents defining directions and specialization in the field of IT - SWEBOK, the purpose of which is to unite knowledge in software engineering; SE2004 - Study Guide for the Training of University Professionals in Software Engineering; CC2005 Guidelines for curriculum development for IT professionals. A team of international IT specialists has identified a set of areas of study and a set of disciplines that provide quality training in IT (CC2005), as well as a thematic composition of disciplines and a set of knowledge necessary and sufficient for IT specialists (SWEBOK, SE2004).

This educational program "Software Engineering" is developed on the basis of the main regulatory documents:

- State obligatory standard technical and vocational education, approved by the Decree of the Government of the Republic of Kazakhstan dated August 23, 2012 No. 1080 (with changes as of August 15, 2017). Footnote. Clause 1 as amended by the Resolutions of the Government of the Republic of Kazakhstan dated 25.04.2015 No. 327 (shall be enforced from 09/01/2016); dated 13.05.2016 No. 292 (effective from 01.09.2017).
- Sectoral Qualifications Framework (SQF). Industry: information and communication technologies. Approved by Minutes No. 1 dated December 20, 2016 of the meeting of the Industry Commission in the field of information, informatization, communications and telecommunications.
- The Law of the Republic of Kazakhstan "On Education" dated July 27, 2007 No. 319III ЗРК;
- IEEE SWEBOK pooling knowledge of software engineering;
- CC2005 guidelines for curriculum development for IT professionals;
- SE2004 educational leadership for preparation specialists university programs in software engineering.

The program is designed to implement the principles of a democratic nature of education management, expanding the boundaries of academic freedom and powers of educational institutions, which will ensure the training of elite, highly motivated personnel for innovative and knowledge-intensive sectors of the economy.

The educational program was developed based on the analysis of the labor functions of software engineers, system administrators, data analysts, declared in professional standards.

The representatives of Kazakhstani companies in the field of software development.

2. Types of work

The program focuses on the following areas of professional activity:

- Data analysis
- Machine learning
- Artificial Intelligence

Labor activities:

- design and engineering;
- production and technological;
- experimental research;
- organizational and managerial;
- operational;
- scientific.

3. Objects of professional activity

The objects of professional activity are:

- Computing machines, complexes, systems and networks;
- Computer systems for information processing and control;
- Automated control systems;
- Computer software;
- Systems and complexes of data mining.

PASSPORT OF THE EDUCATIONAL PROGRAM

1. **Scope and content of the program**

The educational program for the preparation of a Doctor of Philosophy (PhD) has a scientific and pedagogical focus and involves fundamental educational, methodological and research training and in-depth study of disciplines in the relevant areas of science for the system of higher and postgraduate education and the scientific sphere.

Educational program preparation the doctors by profile presupposes fundamental educational, methodological and research training and in-depth study of disciplines in the relevant areas of science for the branches of the national economy, the social sphere: information telecommunication technologies.

Educational programs for doctoral studies 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 doctors or doctors by profile.
The content of the educational program of specialized doctoral studies is established by the university independently.

The main criterion for the completeness of the educational process for the preparation of doctors of philosophy (PhD) (doctor in the profile) is the mastering of at least 180 academic credits by a doctoral student, including all types of educational and scientific activities.

The term of study in doctoral studies is determined by the volume of acquired academic credits. When assimilation established volume academic credits and the achievement of the expected learning outcomes for obtaining a PhD degree or in the profile of the doctoral educational program is considered fully mastered.

The training of personnel in doctoral studies is carried out on the basis of educational master's programs in two areas:
1) scientific and pedagogical with a training period of at least three years;
2) specialized with a training period of at least three years.

EP content

- General educational complex of disciplines
- Data Analysis Disciplines
- Machine Learning Disciplines
- Artificial Intelligence Disciplines
- Disciplines of software development project management

Objectives of the educational program:

Provide practice-oriented training of specialists in scientific activity and production in the field of software development in the field of data analysis, machine learning and artificial intelligence.

Create a conditions for continuous professional self-improvement, development of social and personal competencies (wide cultural outlook, active citizenship, dedication, organization, hard work, sociability, ability to argumentation and adoption of organizational and managerial decisions, possession of modern information technologies, free possession several languages, striving for self-development and adherence to ethical values and a healthy lifestyle, the ability to work in a team, responsibility for the end result of their professional activities, civic responsibility, tolerance), social mobility and competitiveness in the labor market.

2. Requirements for applicants

Persons with a Master's degree and work experience of at least 1 (one) year or who have completed residency training are admitted to doctoral studies.

Enrollment in the number of doctoral students is carried out by the admissions committees of universities and scientific organizations based on the results of the entrance exam for groups of doctoral studies and a certificate confirming possession foreign tongue in conformity from pan-European competencies (standards) of foreign language proficiency.

When enrolling to universities doctoral students independently choose educational program from the corresponding group of educational programs.

The enrollment of persons for the targeted training of doctors of philosophy (PhD) under the state educational order is carried out on a competitive basis.

The procedure for admitting citizens to doctoral studies is established in accordance with the "Standard rules for admission to training in educational organizations that implement educational programs of postgraduate education."

The formation of the contingent of doctoral students is carried out by placing a state educational order for the training of scientific and pedagogical personnel, as well as paying for training at the expense of citizens' own funds and other sources. The state provides citizens of the Republic of Kazakhstan with the right to receive, on a competitive basis, in accordance with the state educational order, free postgraduate education, if they receive education of this level for the first time.

At the "entrance" the doctoral student must have all the prerequisites necessary for mastering the relevant professional doctoral curriculum. The list of required prerequisites is determined higher education institution itself.

In the absence of the necessary prerequisites, the doctoral student is allowed to master them on a paid basis. In this case, doctoral studies begin after the doctoral student has fully mastered the prerequisites.

3. Requirements for completing studies and obtaining a diploma

To persons who have mastered the educational program of doctoral studies and defended doctoral dissertation, at positive decision dissertation councils of a university with a special status or the Committee for Control in the Sphere of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, based on the results of the examination, the degree of Doctor of Philosophy (PhD) or Doctor in the field is awarded and a state diploma with an attachment (transcript) is issued.

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

3.1 Requirements for key competencies of doctoral graduates:

1) have an idea:
- about the main stages of development and the change of paradigms in the evolution of science;
- about subject, ideological and methodological specifics natural (social, humanitarian, economic) sciences;
- about scientific schools of the relevant branch of knowledge, theirtheoretical and practical developments;
- about scientific concepts of world and Kazakhstani science in relevant area;
- on the mechanism for introducing scientific developments into practical activity;
- about the norms of interaction in the scientific community;
- about the pedagogical and scientific ethics of the scientist-researcher;

2) know and understand:
- modern trends, directions and patterns of development of domestic science in the context of globalization and internationalization;
- methodology of scientific knowledge;
- achievements of world and Kazakhstani science in the corresponding area;
- (realize and accept) the social responsibility of science and education;
- perfect foreign language for scientific communication and international cooperation;

3) be able to:
- 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;
- conduct independent scientific research, characterized by academic integrity, based on modern theories and methods of analysis;
- generate your own new scientific ideas, communicate your knowledge and ideas to the scientific community, expanding the boundaries of scientific knowledge;
- to choose and effectively use modern research methodology;
- to plan and predict their further professional development;

4) have skills:
- critical analysis, assessment and comparison of various scientific theories and ideas;
- analytical and experimental scientific activities;
- planning and forecasting research results;
- oratory and public speaking at international scientific forums, conferences and seminars;
- scientific writing and scientific communication;
- planning, coordination and implementation of scientific processes research;
- a systematic understanding of the field of study and demonstrate the quality and effectiveness of the selected scientific methods;
- participation in scientific events, fundamental scientific domestic and international projects;
- leadership management and team leadership;
- a responsible and creative attitude towards scientific and scientific pedagogical activity;
- conducting patent search and transfer of scientific information using modern information and innovative technologies;
- protection of intellectual property rights to scientific discoveries and development;
- free communication in a foreign language;

5) be competent:
- in the field of scientific and scientific-pedagogical activity in conditions of rapid renewal and growth of information flows;
- in carrying out theoretical and experimental scientific research;
- in the formulation and solution of theoretical and applied problems in scientific research;
- in conducting a professional and comprehensive analysis of problems in the relevant area;
- in matters of interpersonal communication and human resource management;
- in matters of university training of specialists;
- in the examination of scientific projects and research;
- in ensuring constant professional growth.

3.2 Requirements for research and development work of a student under the Ph.D program:

1) compliance with the main issues of the educational program of doctoral studies, on which the doctoral dissertation is defended;
2) is relevant and contains scientific novelty and practical significance;
3) is based on modern theoretical, methodological and technological achievements of science and practice;
4) is based on modern methods of data processing and interpretation using computer technology;
5) carried out using modern scientific research methods;
6) contains research (methodological, practical) sections on the main protected provisions.

3.3 Requirements for the organization of practices:
The practice is carried out with the aim of developing practical skills in scientific, scientific, pedagogical and professional activities.
The educational program of doctoral studies includes:
1) teaching and research practice - for students in
Ph.D. program;
2) industrial practice - for students under the program of specialized doctoral studies.

During the period of teaching practice, doctoral students, if necessary, are involved in conducting classes in bachelor's and master's degrees.

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

The industrial practice of a doctoral student is carried out in order to consolidate the theoretical knowledge gained in the training process and improve the professional level.

The content of research and industrial practice is determined by the topic of the doctoral dissertation.

4. Working curriculum of the educational program

4.1. Study period 3 year

Year of study	Code	Name of discipline	Component	Credits		lec/lab/pr	Pre-requisites	Code	Name of discipline	Component	Credits		ec/lab/pr	Pre-requisites
				ECTS	RK						ECTS	RK		
	1 semester								2 semester					
1	LNG 301	English for scientific research goals	DB VK	5	3	0/0/3			Pedagogical practice	DB	11	11		
	CSE 306	Big Data Storage Systems & Computations	DB VK	5	3	2/0/1			Scientific research of doctoral student, including passing internships and performance doctoral thesis	SRWDS	19	5		
	CSE 308	Virtualization and Containerization Technologies	PD VK	5	3	2/0/1								
	CSE 307	High Load Ditributed Computing	PD VK	5	3	2/0/1								
	CSE 309	Machine Learning & Deep Learning	PD KV	5	3	2/0/1								
	CSE 285	Microservices and Cloud Computing	PD KV	5	3	2/0/1								
		Total:		**30**	**18**				**Total:**		**30**	**16**		
	3 semester							4 semester						
2		Scientific research of doctoral student, including passing internships and performance doctoral thesis	SRWDS	18	4				Scientific research of doctoral student, including passing internships and performance doctoral thesis	SRWDS	30	7		
		Research practice	PD	12	3									
		Total:		**30**	**7**				**Total:**		**30**	**7**		
	5 semester							6 semester						
3		Scientific research of doctoral student, including passing internships and performance doctoral thesis	SWRDS	30	7				Scientific research of doctoral student, including passing internships and performance doctoral thesis	SWRDS	18	4		
									Writing and defending a doctoral dissertation	IA	12	4		
		Total:		**30**	**7**				**Total:**		**30**	**8**		
									Total:		**180**	**63**		

5. Descriptors of the level and amount of knowledge, abilities, skills and competencies

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

1) demonstrate a systematic understanding of the field of study, mastery the skills and research methods used in software development;
2) demonstrate the ability to think, design, implement and to adapt the essential research process with a scientific approach;
3) contribute with their own original research to expanding the boundaries of a scientific field that 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) promote advancement in academic and professional the context of the technological, social or cultural development of a knowledge-based society.

In the process of mastering the educational program, a Ph.D. must have the following key competencies.

A - knowledge and understanding:

A1 - Programming languages and systems used for data analysis and building intelligent systems;
A2 - Models, methods and types of data analysis;
A3 - Principles and types of artificial intelligence;
A4 - machine learning methods
A5 - Techniques for modeling, composition and decomposition of systems;
A6 - Methods for designing data processing processes;
A7 - Methods and organization of scientific activities;
A8 - Data processing models;
A9 - Basic approaches, tools and models for project management;

B - application of knowledge and understanding:

B1 — Analysis of the subject area, determination of the goal, objectives and methods of achieving the planned result of the project \ research;
B2 —Determining the deadlines for completing tasks, forming a specification of requirements and technical specifications;
B3 - Formalization of tasks, prioritization of their implementation;
B4 - Selection of optimal ways to solve problems;
B5 - Planning the stages of the project;
B6 - Domain modeling;
B7 - Define functional and performance requirements for system components;
B8 - Keeping project execution protocols;

B9 - Formation of reporting documentation;
B10 - Establishment of data mining systems;
B11 - Creation of decision making systems based on Artificial intelligence models

C - formation of judgments:

C1 - About trends in IT
C2 - On the applicability of tools and technologies for solving the problem
C3 - On the adequacy of the designed model
C4 - On the effectiveness of the methods and models used
C5 - On models, methods and algorithms for intelligent data processing

D - personality ability:

D1 - Ability to set goals and plan ways to achieve them
D2 - Ability to conduct project / operational activities
D3 - Ability to conduct scientific research
D4 - Ability to organize the work of the IT department
D5 - Ability to organize work on the collection, storage and processing of information used in the field of professional activity

6. ECTS Completion Competencies

The application was developed according to the standards of the European Commission, Council of Europe and UNESCO / CEPES. This document is for academic recognition only and is not an official proof of education. Not valid without a university degree. The purpose of completing the European Supplement is to provide sufficient information about the holder of the diploma, the qualification obtained, the level of this qualification, the content of the study program, the results, the functional purpose of the qualification, as well as information about the national education system. The application model used to translate grades uses the European Credit Transfer or Transfer System (ECTS).

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

7. Description of disciplines

English for Research Purposes
CODE – LNG301
CREDIT – 6 (0/0/3)
PREREQUISIT – ENGLISH LEVEL C2/B2

PURPOSE AND OBJECTIVES OF THE COURSE

Introduce students to the world of scientific writing to better develop their scientific writing skills.

SHORT DESCRIPTION OF THE COURSE

The course focuses on developing writing, reading and speaking skills, and communicating progress in their research in support of ideas, not just taking stock of other people's work, and encouraging learners to take different approaches in self-study.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

Understand basic information and language of scientific presentations; understand how the material is organized, listen to the main points of a scientific speech, view the text in order to understand its main idea, style and purpose; predict text content, scan text for specific information, take notes and use them to write summaries, analyze research structure, recognize paragraph cohesion, organize information logically, write research studies, participate in discussions, propose and respond to opinions.

Big Data Storage Systems & Computations

CODE –
CREDIT – 4 (1/1/0)
PREREQUISIT –

PURPOSE AND OBJECTIVES OF THE COURSE

The aim of the discipline is to master the principles and acquire practical skills in the organization and technologies of storage, transformation and analytical processing of big data.

The objectives of the course are to develop skills in researching the use of tools for working with big data in information systems for solving practical problems.

SHORT DESCRIPTION OF THE COURSE

The discipline examines the theoretical and practical aspects of using big data technologies in information systems. The lecture course examines the development trends of infrastructure solutions for processing and storing big data.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

should know:
- the basic principles of using big data in enterprise architecture;
- basic methods of analytical processing of big data;

should be able to:
- use MapReduce technologies and software packages built on the basis when working with big data.

Virtualization and Containerization Technology

CODE – LNG201
CREDIT – 6 (0/0/3)
PREREQUISIT – ENGLISH LEVEL C2/B2

PURPOSE AND OBJECTIVES OF THE COURSE

The goal is to master the models for building scalable systems based on virtualization and containerization.

Study of the model of basic software models of virtual machines, study of basic software models of containers.

Objectives:
- Exploring the concept of virtualization and containerization
- Exploring the concept of orchestration

SHORT DESCRIPTION OF THE COURSE

The course examines the fundamentals of building a virtual infrastructure machines and support for hardware virtualization. As well as support for the software part of containerization. Study of the source codes of existing virtualization and containerization projects. The course is built on modern requirements and trends in the construction of loosely coupled scalable information systems. The microservice model regulates the approach of splitting complex solutions, classically built as a monolithic software module into loosely coupled elements that interact with each other through asynchronous messages. That allows you to develop each of the modules independently and focus on the point performance of the system, if necessary. Such systems are distinguished by a high degree of fault tolerance, since each component is as autonomous as possible. Such approaches require a revision of classical solutions towards the implementation of the integrity model by alternative approaches, since in most cases there is no direct connection between objects of different modules. Also, the microservices model relies as much as possible on the concept of asynchronous interaction, which imposes its own obligations on modeling the integrity and guaranteeing the execution of the operation in each case independently.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

Upon completion of the course, students will:

Understand
- What is a virtual machine
- What is a container

Know
- Virtualization and containerization platforms

Be able to
- Apply microservice architecture to build scalable information systems

High Load Distributed Computing

CODE –
CREDIT – 6 (0/0/3)
PREREQUISIT – ENGLISH LEVEL C2/B2

PURPOSE AND OBJECTIVES OF THE COURSE

The goal is to master the models for building high-load systems.

Objectives:
- Analysis of tasks where models of high-load systems are used
- Principles of operation of high-load systems and limitations
- Analysis of software products designed to solve the problems of building high-load systems

SHORT DESCRIPTION OF THE COURSE

The course is built on the basis of modern problems of building scalable systems. The main task is to get out of the systems of constraints imposed by hardware, by optimally distributing the load on each of the links of computers. Thus, defining the architecture that best meets the requirements for the number of requests processing by end systems.

Building high-load systems is not a trivial task, which led to the emergence of a large number of software products, as well as forced large companies to expand the product line and functionality of existing ones. In many tasks of building high-load systems, combinations of approaches and software products are used to maximize the efficiency of the system. It is these practical approaches that are studied within disciplines and software products such as Redis, RabbitMQ, Orleans, Ceph.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

Upon completion of the course, students will:
- Know the nature of the problem with high load systems
- Class of tasks for high-load systems
- Models for building high-load systems
- Software products for building high-load systems

Know
- Software for building high-load systems

Be able to
- Apply models and techniques for building high-load systems

Machine Learning & Deep Learning

CODE –
CREDIT – 6 (2/0/1)
PREREQUISIT - ENGLISH LEVEL C2/B2

PURPOSE AND OBJECTIVES OF THE COURSE

The aim of the course is to master the basic theory and practice of machine learning methods based on widely used open access libraries. To teach how to apply machine learning models in practical problems of software development.

The main objectives of the course:

- Explore the main machine learning models and the problems they solve
- Gain knowledge and practical skills in the application of machine learning to build classification systems, prediction and data clustering
- Explore modern models and methods of deep learning
- Get hands-on experience in applying deep learning models

SHORT DESCRIPTION OF THE COURSE

The course focuses on deep learning models. As an area within machine learning, deep learning models illustrate quantitative-qualitative transition. New models and their properties require a separate study and practice of setting metaparameters of such models.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

Upon completion of the course, students will:

Understand
- Features of deep learning models
- Current Research Areas in AI

Know
- Challenges and Applications of Deep Learning Models

Be able to
- Use machine learning models

Microservices & Cloud Computing

CODE –
CREDIT – 6 (2/1/0)
PREREQUISIT -

PURPOSE AND OBJECTIVES OF THE COURSE

The goal is to master the models for building scalable systems based on microservice technologies.

Objectives:

- Exploring the concept of microservices
- Exploring the concept of containerization and orchestration
- Exploring the Actor Model

SHORT DESCRIPTION OF THE COURSE

The course is built on modern requirements and trends in the construction of loosely coupled scalable information systems. The microservice model regulates the approach of splitting complex solutions, classically built as a monolithic software module into loosely coupled elements that interact with each other through asynchronous messages. That allows you to develop each of the modules independently and focus on the point performance of the system, if necessary. Such systems are distinguished by a high degree of fault tolerance, since each component is as autonomous as possible. Such approaches require a revision of classical solutions towards the implementation of the integrity model by alternative approaches, since in most cases there is no direct connection between objects of different modules.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

Upon completion of the course, students will:
Understand

- What is microservice and context boundaries
- What is container image and container

Know

- Application containerization platforms
- Model Actor

Be able to

- Use microservice architecture for constructing scalable information systems

The educational program of doctoral studies includes:

- research practice;
- industrial practice.

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

The industrial practice of a doctoral student is carried out in order to consolidate the theoretical knowledge gained in the learning process and improve the professional level.

The research work of a doctoral student must:

- correspond to the main problems of the specialty in which the doctoral dissertation is being defended;
- be relevant, contain scientific novelty and practical significance;
- be based on modern theoretical, methodological and technological achievements of science and practice;
- be based on modern methods of data processing and interpretation using computer technology;
- carried out using modern scientific research methods;
- contain research (methodological, practical) sections on the main protected provisions.

The experimental research work of a doctoral student should:

- correspond to the main problems of the specialty in which the doctoral dissertation is being defended;
- be relevant, contain scientific novelty and practical significance;
- be based on modern achievements of science, technology and production and contain specific practical recommendations, independent solutions to management problems of an integrated, inter-functional nature;
- performed using advanced information technologies;
- contain experimental and research (methodological, practical) sections on the main protected provisions.

Registration and defense of a doctoral dissertation

CODE –
CREDIT – 4
PREREQUISIT - No

PURPOSE AND OBJECTIVES OF THE COURSE

A dissertation is a qualifying scientific work in a specific specialty of an educational program for the preparation of a Doctor of Philosophy (PhD).

The purpose of the doctoral dissertation is to assess the scientific-theoretical and research-analytical level of the doctoral student, the formed professional and managerial competencies, the readiness to independently perform professional tasks and the compliance of its preparation with the requirements of the professional standard and the educational program of doctoral studies.

The topic of the dissertation should be related to priority areas of development of science and / or government programs, or programs of fundamental or applied research. The content of the thesis, the goals and objectives, the scientific results obtained must strictly correspond to the topic of the thesis.

The dissertation is carried out in compliance with the principles of independence, internal unity, scientific novelty, reliability and practical value.

The purpose of the preparation and defense of the thesis is to master the skills of independent research and the competent presentation of research results by the doctoral student.

The objectives of the preparation and defense of the thesis are: setting the goal of research, theoretical and experimental research of the object, development of control algorithms and synthesis of the control system.

SUMMARY OF THE DISSERTATION

The main part of the thesis should contain:
- choice of the direction of research, including justification of the direction of research, methods for solving problems and their comparative assessment, a description of the selected general methodology for conducting research work;
- setting the goal, object and subject of research, research objectives;
- the process of theoretical and (or) experimental research, including the definition of the nature and content of theoretical research, research methods, calculation methods, justification of the need for experimental work, the principles of the developed objects, their characteristics;
- generalization and assessment of research results, including an assessment of the completeness of the solution to the problem and proposals for further areas of work, an assessment of the reliability of the results obtained and their comparison with similar results of domestic and foreign works.

Each section of the thesis should end with key findings and form the basis for the next section.

The presentation in the main part of the dissertation must be strictly substantiated, holistic and logical. Spelling, grammatical and punctuation errors in the dissertation should not be allowed. The presentation style of the thesis text must be scientifically correct. Anyone's emotional judgments and statements, expressions from fiction, everyday expressions, jargon, etc. are not allowed.

ACQUIRED KNOWLEDGE, SKILLS AND SKILLS

The dissertation is written independently, contains a set of new scientific results and provisions put forward by the author for public protection and testifies to the author's personal contribution to science. New solutions proposed by the author should be reasoned and evaluated in comparison with known solutions.

The dissertation, which has applied value, provides information on the practical use of the scientific results obtained by the author, confirmed by copyright certificates, patents and other official documents, and the dissertation, which has theoretical value, provides recommendations on the use of scientific findings. The main content of the dissertation is published in scientific, scientific-analytical and scientific-practical publications.

The main scientific results of the dissertation for the degree of Doctor of Philosophy (PhD) are published in at least 7 (seven) publications on the topic of the dissertation, including at least 3 (three) in scientific publications recommended by the authorized body, 1 (one) in international scientific publication, which according to the information base of Thomson Reuters (ISI Web of Knowledge, Thomson Reuters) has a nonzero impact factor or is included in the Scopus database, 3 (three) in the materials of international conferences, including 1 (one) in materials of foreign conferences.

Content