Satbayev University
A. Burkitbayev Institute of Industrial Automation and Digitalization
The Department of "Robotics and Engineering Tools of Automation"

CURRICULUM PROGRAM

"Robotics and Mechatronics"
Doctor Ph.D of the educational program "8D07106-Robotics and mechatronics"

on the basis of the vitiated Specialty Classifier: 6D071600 - Instrumentation

1st edition
in accordance with the State Educational Standard of Higher Education 2018

Almaty 2020

The program is drawn up and signed by the parties:

from Satbayev University:

1. Head of the Department of Robotics and Engineering Tools of Automation (R&ETA), Ph.D. K. Ozhikenov

2. Director of the Institute of Industrial Automation and Digitalization, PhD B. Omarbekov

3. Chairman of the Educational and Methodological Group of the Department of "R&ETA", Ph.D, Associate Professor Zh. Ualiyev

From the employer:
Director of LLP "MedRemZavodHolding" A. K. Dzhumagulov
Deputy Director for IIT of LLP "Saiman Corporation" K. I. Baibekov

Approved at the meeting of the Educational and Methodological Council of the Satbayev University, (Protocol #3 of 19.12.2018)

Qualification:
Level 8 of the National Qualifications Framework:
8D07 Engineering (Doctor degree):
8D071 Robotics and Mechatronics

Professional competencies: in the field of research methodology; in the field of scientific and scientific-pedagogical activity in higher educational institutions; in matters of modern educational technologies; in the implementation of scientific projects and research in the professional field; in the use of modern methods and technology of scientific communication in the state and foreign languages; in the field of planning and solving the problem of their own professional and personal development.

1. Objectives

training of a highly qualified specialist in science, capable of forming his own scientific direction in the future;

training of scientific and pedagogical personnel for continuous self-improvement and self-development, mastering new knowledge, skills and abilities in innovative directions of development of robotics and mechatronics;

preparation of doctoral students for a successful career in the field of robotics and mechatronics, private, public and state organizations, educational institutions, through teaching disciplines that will provide profiling knowledge, tools, skills and abilities required in a competitive environment;

preparation of scientific and pedagogical personnel, based on the diversity and dynamism of the catalog of elective curriculum disciplines, with a predominance of practical skills in competencies, capable of performing professional functions within one or more types of activities based on the final learning outcomes, taking into account the specifics of these activities, market requirements for organizational, managerial, professional competencies;

training of scientific and pedagogical personnel as a competitive specialist in the field of robotics and mechatronics, which meets international standards and allows Kazakhstan to integrate into the world educational space.

2. Types of work

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

A doctoral student in the direction of training "Robotics and Mechatronics" should be prepared for solving professional problems in accordance with the profile direction of the doctoral program and types of professional activities:

design and engineering activities:

- analysis of the state of the scientific and technical problem and the definition of goals and objectives for the design of robotic and mechatronic systems based on the study of world experience;
- making decisions based on the results of calculations for projects and the results of a technical-economic and functional-cost analysis of the effectiveness of the designed robotic and mechatronic systems;

production and technological activities:

- development of methods for conducting theoretical and experimental research on the analysis, synthesis and optimization of the characteristics of materials used in the field of robotics and mechatronics;

- solving economic and organizational problems of technological preparation of the production of robotic and mechatronic systems and the choice of systems for ensuring the environmental safety of production;

research activities:

- construction of mathematical models for the analysis and optimization of research objects, the choice of a numerical method for their modeling or the development of a new algorithm for solving the problem;
- development and optimization of field experimental studies of robotic and mechatronic systems, taking into account the criteria of their reliability;
- preparation of scientific and technical reports, reviews, publications based on the results of research performed;
- application of the results of research activities and the use of rights to objects of intellectual property;

organizational and management activities:

- finding optimal solutions in the creation of science-intensive products, taking into account the requirements of quality, cost, deadlines, competitiveness, life safety, as well as environmental safety;
- support of a unified information space for planning and enterprise management at all stages of the life cycle of manufactured products;
- development of plans and programs for organizing innovative activities at the enterprise.
- deep knowledge and understanding of fundamental phenomena in their field of science.

scientific and pedagogical activity:

- development of programs of academic disciplines and courses based on the study of pedagogical, scientific, technical and scientific-methodical literature, as well as the results of their own professional activities;
- setting up and modernization of individual laboratory works and workshops in professional disciplines;
- conducting training sessions with students, participating in the organization and management of their practical and research work;
- application and development of new educational technologies, including computer and distance learning systems.

3. Objects of professional activity

- teaching activities in higher educational institutions according to the profile of training;
- research activities in higher educational institutions and scientific organizations according to the profile of training;
- professional activity in the field of robotics and mechatronics, requiring highly qualified personnel;

-administrative and organizational activities in higher educational institutions and scientific organizations on the profile of training.

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 problems and various processes in the relevant areas of science for the system of higher and postgraduate education and the scientific sphere.

The educational program for the preparation of a doctor in the profile assumes fundamental educational, methodological and research training and in-depth study of problems and various processes in the relevant areas of science for the branches of the national industry and economy, the social sphere: education, medicine, law, art, economics, business administration and areas of national security and military affairs.

Educational programs for doctoral studies in terms of vocational 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 amount of acquired academic credits. Upon mastering the established amount of academic credits and achieving the expected learning outcomes for obtaining a Ph.D. degree or by profile, the doctoral educational program is considered fully mastered and completed with the successful defense of a doctoral dissertation prepared in compliance with the existing rules.

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

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

The educational program for the training of a doctor in the profile consists of cycles of basic (DB) and major disciplines (PD) of disciplines, which include disciplines of the university component (VC) and components of choice (CV), practice, indicating the labor intensity of each academic discipline in academic credits and hours established by the State Compulsory Standards of Higher and Postgraduate Education, approved by order of the Ministry of Education and Science of the Republic of Kazakhstan No. 604 dated October 31, 2018.

The DB cycle includes the study of academic disciplines and the passage of professional practice. The PD cycle includes academic disciplines and types of professional practices. The programs of disciplines and modules of the DB and PD cycles are interdisciplinary and multidisciplinary in nature, providing training at the junction of a number of areas of knowledge.

Final certification is carried out in the form of writing and defending a doctoral dissertation.

Objectives of the educational program:

- the direction of its activities to contribute to the development of a knowledge-based society by providing educational programs in the system of continuing education;
- development of students through research activities, critical thinking, development of professionally oriented skills and abilities;
- the use of highly professional experience in teaching doctoral students in a variety of educational environments;
- training a new competitive generation of technical specialists for the labor market;
- developing an environment that welcomes and supports people from different cultures, and creating an atmosphere of pursuit of knowledge, academic integration and intellectual motivation;
- carrying out research work, conducting educational activities based on the best world practice, and developing its own school for training specialists;
- development of cooperation "university-industry" to meet the labor market requirements for technical specialists, to improve the quality of educational programs for training specialists for the national industry and the economy and business sector;
- development of additional educational and training programs using multimedia and new teaching technologies for organizing learning on the basis of lifelong learning;
- establishing partnerships with other universities, organizations in order to improve the quality of education, to support technical and cultural ties.

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 proficiency in a foreign language in accordance with common European competences (standards).

When enrolling in universities, doctoral students independently choose an 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 a contingent of doctoral students is carried out by placing a state educational order for the training of scientific and pedagogical personnel, as well as by 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 by the higher education institution independently.

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

Persons who have mastered the educational program of doctoral studies and defended their doctoral dissertation, with a positive decision of the dissertation councils of universities with a special status or the Committee for Control in the Field of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, based on the results of the examination, are awarded the degree of Doctor of Philosophy (PhD) or Doctor of Science in profile and issued a state diploma with an attachment (transcript).

Persons who have received a PhD degree, to deepen scientific knowledge, solve scientific and applied problems on a specialized topic, carry out a postdoctoral program or conduct scientific research under the guidance of a leading scientist of the selected 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;
- on the subject, ideological and methodological specifics of the natural (social, humanitarian, economic) sciences;
- about scientific schools of the relevant branch of knowledge, their theoretical and practical developments;
- on the scientific concepts of world and Kazakh science in the relevant field;
- on the mechanism of implementation of scientific developments in practice;
- 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 Kazakh science in the relevant field;
- (to understand 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, coordinating and implementing research processes;
- 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;
- responsible and creative attitude to scientific and scientific-pedagogical activities;
- conducting 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 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 PhD program:

1) compliance with the main problems of the educational program of doctoral studies, on which the doctoral dissertation is being 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 under the Ph.D. program;

2) industrial practice - for students under the program of specialized doctoral studies.

During the period of pedagogical practice, doctoral students, if necessary, are involved in conducting classes in undergraduate and graduate programs.

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 methods of scientific research, 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. The term of study is 3 years

MODULAR CURRICULUM

Education program *8D07106 - Robotics and Mechatronics*

Form of study: *full* Duration of training: *3 years* Academic degree*: Doctor of Philosophy (PhD)*

The cycle	Code	Name of disciplines	Semester	Acad. credits	lec.	lab.	Tutorial	IWD	Type of Final assessment	Department
Fundamental training module (12 credits)										
Mandatory disciplines										
BD 1.2.1	LNG304	Academic writing	1	6	2	0	1	3	Exam	EL
BD 1.2.2	MET321	Research methods	1	6	2	0	1	3	Exam	MPHETSM
Module of robotic and mechatronic systems (18 credits)										
Elective disciplines										
BD 1.2.3	ROB310	Methods of sensing robotic and mechatronic systems	1	6	2	0	1	3	Exam	RaETA
BD 1.2.3.1	ROB316	Automated systems for processing biomedical information	1	6	2	0	1	3	Exam	RaETA
PS 1.3.1	ROB306	Intelligent control of robotic systems	1	6	2	0	1	3	Exam	RaETA
PS 1.3.1.1	ROB313	Biomedical Intelligent Systems	1	6	2	0	1	3	Exam	RaETA
PS 1.3.2	ROB317	To design advanced humanoid robots	1	6	2	0	1	3	Exam	RaETA
PS 1.3.2.1	ROB315	Design of technical means for the removal, processing and analysis of biomedical signals	1	6	2	0	1	3	Exam	RaETA
Practice-oriented module (20 credits)										
BD 1.2.4	AAP350	Pedagogical practice	2	10	0	0	0		Report	RaETA
PS 2.3.3	AAP349	Research scientific training	3	10	0	0	0		Report	RaETA
Research Module (123 credits)										
DSRW	AAP345	Doctoral student research work, including internships and doctoral dissertations	2	24						
DSRW	AAP345	Doctoral student research work, including internships and doctoral dissertations	3	24					Report	RaETA
DSRW	AAP346	Doctoral student research work, including internships and doctoral dissertations	4	25					Report	RaETA
DSRW	AAP346	Doctoral student research work, including internships and doctoral dissertations	5	25					Report	RaETA

DSRW	AAP346	Doctoral student research work, including internships and doctoral dissertations	6	25					Report	RaETA
Module of final attestation (12 credits)										
FA	ECA303	Writing and defending doctoral dissertation	4	12					Defense of dissertation	RaETA
Total				**185**						

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, mastering the skills and research methods used in this field of robotics and mechatronics;

2) Demonstrate the ability to think, design, implement and adapt an essential research process with a scientific approach;

3) contribute with their own original research to expand the boundaries of the 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) to promote, in an academic and professional context, the technological, social or cultural development of a knowledge-based society.

6 Competencies at the end of training

Universal, social and ethical competencies (USEC)	
U-1	Have an idea of the pedagogical and scientific ethics of a research scientist
U-2	Have an understanding of the norms of interaction in the scientific community
U-3	to Know and understand the methodology of scientific knowledge
U-4	Ability to critically use the methods of modern science in practical activities
U-5	ggenerate your own new scientific ideas, communicate your knowledge and ideas to the scientific community, expanding the boundaries of scientific knowledge
Special and managerial competencies (S&MC)	
S-1	Independently manage and control the processes of labor and educational activities within the framework of the strategy, policy and goals of the organization, discuss problems, argue conclusions and competently operate with information
S-2	Organize the activities of the production team, make organizational and managerial decisions in the context of different opinions and evaluate the consequences of decisions

S-3	ToTo conduct independent scientific research, characterized by academic integrity, based on modern theories and methods of analysis
S-4	Readiness to lead and participate in the preparation of a feasibility study of projects for creating robotic and mechatronic systems, their subsystems and individual modules
S-5	Ability to critically analyze, present, protect, discuss and disseminate the results of their professional activities
Professional competencies (PC)	
PC-1	Analyze the state of scientific and technical problems and determine the goals and objectives of designing robotic and mechatronic systems based on the study of the world experience
PC-2	Decision-making based on project calculations and results of technical-economic and functional-cost analysis of the effectiveness of projected robotic and mechatronic systems
PC-3	Develop a methodology for conducting theoretical and experimental studies on the analysis, synthesis and optimization of the characteristics of materials used in the field роботоof robotics and mechatronics
PC-4	Build mathematical models for analyzing and optimizing research objects, choose a numerical method for modeling them, or develop a new algorithm for solving
PC-5	Find optimal solutions for creating high-tech products, taking into account the requirements of quality, cost, deadlines, competitiveability , life safety, and environmental safety
PC-6	Develop curricula of academic disciplines and courses based on the study of pedagogical, scientific, technical and scientific-professional activities in the field of robotics and mechatronics

Matrix of competencies of the educational program "Robotics and mechatronics"

Discipline index	Name of the discipline	Universal, social and ethical					Special and managerial					Professional services					
		U-1	U-2	U-3	U-4	U-5	S-1	S-2	S-3	S-4	S-5	PC-1	PC-2	PC-3	PC-4	PC-5	PC-6
Required component																	
ROB309	Optimization methods and theory	x		x		x	x		x	x	x			x	x	x	x
ROB311	Management in biotechnical systems		x		x			x				x		x	x		x
ROB308	Control systems of mechatronic and robotic complexes				x			x				x	x	x			x
ROB312	Automated systems for processing biomedical information									x			x		x	x	
ROB310	Methods of sensing robotic and mechatronic systems					x			x	x		x		x		x	x
ROB313	Biomedical intelligent systems										x	x			x	x	x
ROB306	Intelligent control of robotic systems										x	x			x	x	x
ROB314	Methods of mathematical processing of biomedical data					x			x	x			x	x		x	
ROB305	Microprocessor technology in mechatronics and robotics										x	x	x			x	x
ROB315	Design of technical means for capturing, processing and analyzing biomedical signals					x		x	x	x		x			x		x
ROB303	Designing mechatronic systems on Matlab/Simulink					x		x	x	x		x		x		x	x
State final certification																	
ECA303	Writing and defending a doctoral dissertation	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Additional types of training																	

AAP345 AAP346	The research work of the doctoral student, including internship and her doctoral dissertation	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
AAP350	Teaching practice	x					x										x
AAP349	Research practice	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

7 ECTS Diploma Supplement

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 that will be 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 will be required. The European Diploma Supplement is completed in English upon individual request and is issued free of charge.

8 Brief description of courses

Optimization methods and theory
CODE - ROB309
CREDIT - 5
PRE-REQUISIT – no

PURPOSE AND OBJECTIVES OF THE COURSE
The purpose of teaching the discipline is to master the methods of creating and researching optimal systems for automatic and automated control of both individual industrial units and technological production processes of any degree of complexity for doctoral students; mastering the static and dynamic modes of operation of automatic systems, the peculiarities of their functioning and the possibility of using them to control objects in any technical environment.
SHORT DESCRIPTION OF THE COURSE
The training course "Methods and Theory of Optimization" is focused on the formation of doctoral students' understanding of methods for constructing and researching optimal control systems for mechatronic and robotic devices. General optimization concepts. Automatic optimization systems. Extreme regulation systems. Study of the dynamic regime of an extreme system. Foundations of the theory of optimal control. Optimal control systems. Optimality criteria. Automatic control is optimal in terms of speed. Synthesis of the time-optimal control law. Dynamic programming. Optimality principle. Bellman equation. Dynamic programming method for solving the problem of synthesis of an optimal control device. Optimal systems with incomplete information about the controlled object. The problem of synthesizing an optimal control law in terms of accuracy and its solution by the method of dynamic programming. Methods for the development of optimal laws and control systems for electric drives.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students must:
know:
theory and foundations of setting optimal control problems;
be able to:
understand optimal control problems, optimization and optimality criteria;
own:
analytical design of optimal controllers and practical methods for determining the coefficients of stabilizing control.

Control systems of mechatronic and robotic complexes
CODE - ROB308
CREDIT - 5
PRE-REQUISIT – no

PURPOSE AND OBJECTIVES OF THE COURSE

The purpose of teaching the discipline is to systematize and integrate previously acquired knowledge in special disciplines of master's training in relation to the design problems of control systems of multicomponent robotic and mechatronic complexes, the formation of skills in the integrated design of mechatronic systems.

The objectives of the discipline are deepening and practical application of fundamental definitions, concepts, laws of higher mathematics, mechatronics and robotics tools, information systems for building control systems for robotic and mechatronic complexes; definition and formalization of the tasks facing mechatronics, drawing up requirements for the components of mechatronic systems; in-depth understanding of the problems of designing control systems for multicomponent robotic and mechatronic complexes; development of individual subsystems, devices and modules, including structural elements, drives, information sensors, microprocessor control devices, development of software for solving control and design problems.

SHORT DESCRIPTION OF THE COURSE

Discipline content: Mechatronics and robotics, their relationship and difference, the principles of their integrated development. A systematic approach to the design of mechatronic devices and complexes. Integrated mechatronic system modules and complexes. Control systems for robotic and mechatronic complexes. Controlled trajectories of robot manipulators and planning of trajectories of the manipulator gripping. Adaptive and intelligent control systems. Unity of mechanics and control in modern technological equipment. General concept and principles of constructing adaptive robotic systems. Comparative analysis of software and adaptive control systems. The structure and composition of the intelligent robotic system. Intelligent robot motion control. Intelligent human-machine interface.

KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE

As a result of studying the discipline, the student must:

know:

- principles of control of mechatronic and robotic systems;
- mechanical, electrical, pneumatic and hydraulic control systems;
- methods and stages of design of mechatronic devices (MD) and special-purpose systems;
- methods and principles of building digital controllers, methods of research and synthesis of digital control systems;
- choice of architecture and hardware of the monitoring and control system;

- features of a mobile robot as a mechatronic system and a behavior control system for a mobile robot.

be able to:

- define and substantiate requirements for complex multicomponent mechatronic systems;
- to analyze the accuracy and other metrological parameters and characteristics of complex control systems;
- to carry out a structural and functional description of the control systems of robotic complexes and mechatronic motion modules;
- apply algorithms for monitoring the correct functioning of control systems of mechatronic and robotic complexes;
- systematically analyze and predict the technical and economic results of project activities for the modernization and creation of complex systems and complexes;
- it is technically and economically reasonable to choose the element base for the circuit implementation of the control of the mechatronic control system.

own:

- methods of modern research, conducting technical tests and scientific experiments, evaluating the results of the work performed;
- modern computer and information technologies in the design of control systems for robotic and mechatronic devices and complexes;
- methods of analysis and synthesis of adaptive and intelligent control systems;
- methods of assessing the reliability and quality management of design results.

Sensing methods for robotic and mechatronic systems
CODE - ROB310
CREDIT - 5
PRE-REQUISIT – no

PURPOSE AND OBJECTIVES OF THE COURSE
The goal of teaching the discipline is to form students' understanding of the principles of transforming sensory information in kinesthetic, force-moment and optical systems of robots and mechatronic devices and about the features of the functioning of their sensitive elements, as well as the ability to design and calculate elements of sensor systems of robotic complexes, the development of engineering erudition and technical intelligence ...
SHORT DESCRIPTION OF THE COURSE
The discipline "Sensing Methods for Robotic and Mechatronic Systems" studies the principles of building sensor and information-measuring systems in robotics and other industries, as well as the peculiarities of calculating and designing systems for processing, converting and transmitting signals from sensitive elements of robots. Current state and development trends of sensing devices for industrial robots. Information support for robotic and mechatronic systems. The role of information devices in increasing the level of human-robot communication. Sensor as a signal converter. Classification of information devices of robotic and mechatronic systems. Systems of measuring mechanisms and devices. Force-torque and tactile sensing systems. Locating sensing systems. Technical vision systems. Organization of the relationship between the information system and the distributed control system. Microprocessor data processing.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students must:
know:
- sensory systems, including a technical vision system as an integral part of the control system of the mechatronic device of a mobile robot;
- integration of the sensor system with other sources of navigation information (odometric sensor, inertial navigation system);
be able to:
- process images, filter and correct geometric images;
- select sensors, simulate, coordinate and test sensing means;
- solve the problems of detection, orientation determination, distinction, identification and research;
own:
- methods of detecting objects and combining their images; skills in solving problems of detection, determination of orientation, distinction, identification and research.

Intelligent control of robotic systems
CODE - ROB306
CREDIT - 5
PRE-REQUISIT – no

PURPOSE AND OBJECTIVES OF THE COURSE
The aim of the course is to study the methods and means of modern information processing technology used in the synthesis of models of intelligent control systems for solving problems of control of a poorly formalized object or a poorly formalized process of interaction with the external environment under conditions of incompletely defined input data.
SHORT DESCRIPTION OF THE COURSE
Introduction to Artificial Intelligence. History of the issue. Basic concepts and definitions. The theory of fuzzy sets. Operations on fuzzy sets. Fuzzy and linguistic variables. Fuzzy logic fundamentals. Fuzzy inference systems. Artificial neuron. Neuron McCulloch Pitts. Neuron training. Multilayer neural networks. Training multilayer neural networks. Knowledge-based systems. Building expert systems. Genetic algorithms. The environment for creating engineering applications Simulink. Application of fuzzy logic in the Simulink package. Construction and application of neural networks in the Simulink package. Application of genetic algorithms in the Simulink package. Application of hybrid intelligent control systems. Application of the built-in C ++ compiler of the MatLab system.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students must:
know:
- the current state of the theory of artificial intelligence, expert systems, applications of expert systems, agents; development of hardware and software as a prerequisite for the widespread introduction of artificial intelligence systems;
- the main methods of intelligent control of complex systems in various fields of science and technology: knowledge engineering and reasoning on knowledge; fuzzy information processing and fuzzy control; neural network information processing and neural network control; evolutionary modeling and genetic control algorithms;
be able to:
- plan the path of the robot; build a path graph, its optimization; heuristics; process images; filter and correct geometric images;
- to use the basic mechanisms specified in the previous paragraph in the developed models of intelligent control systems in the formation of control actions in conditions of uncertain or incompletely defined information;
own:

- the formation of scenarios; methods of detecting objects and combining their images; solve problems of detection, orientation determination, distinction, identification and research;
- experience in building models of intelligent control systems for controlling robotic and mechatronic systems.

Design of mechatronic systems in Matlab / Simulink
CODE - ROB303
CREDIT - 5
PRE-REQUISIT – no

PURPOSE AND OBJECTIVES OF THE COURSE
The purpose of teaching the discipline is the practical study of the means and methods used in the modeling of technical systems, systematization and integration of previously obtained knowledge in the professional disciplines of master's training in relation to the design problems of mechatronic and robotic systems for special purposes. This course is supposed to acquaint doctoral students with modern methods of imitation and mathematical modeling of complex systems, paying special attention to the methods created on the basis of artificial intelligence. Since modeling is one of the directions of using the method of computer experiment, it is planned to study and practical use of the software packages AnyLogic and Matlab / Simulink, designed for modeling complex systems.
SHORT DESCRIPTION OF THE COURSE
General questions of simulation. AnyLogic simulation system. Simple models. Modeling complex systems and processes in AnyLogic. Dynamical systems and system dynamics. Collective behavior models and multi-agent systems. Modeling of control systems in Matlab / Simulink environment. Modeling mechanical systems in Matlab / Simulink.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, students must:
know:
- modern concepts of mathematical and simulation modeling; basic methods of mathematical and simulation modeling of complex technical systems;
- modern concepts of computer-aided design;
- basic methods of designing complex technical systems;
be able to:
- to develop mathematical models of the constituent parts of mechatronic and robotic systems by methods of the theory of automatic control;
- to implement models by means of computer technology in the Matlab / Simulink environment;
- analyze the stability, accuracy and quality of management processes;
- to develop projects of components of mechatronic and robotic systems in software shells;
own:
- skills in building computer models of mechatronic complexes and their elements;
- skills of designing mechatronic complexes and their elements.

Microprocessor technology in mechatronics and robotics

CODE - ROB305
CREDIT - 5
PRE-REQUISIT – no

PURPOSE AND OBJECTIVES OF THE COURSE
The aim of the course is to teach the principles of control in mechatronic and robotic systems. Acquisition of skills in controlling various sensors and solving the problem of microprocessor control.
Objectives of the course - Studying the basic principles of building information-measuring systems and control systems based on open platforms of microcontrollers, developing skills in developing hardware and software for automated control systems and control of mechatronic and robotic systems.
SHORT DESCRIPTION OF THE COURSE
The discipline "Microprocessor technology in mechatronics and robotics" is a fundamental discipline for the study of microcontroller control of mechatronic and robotic systems. Fundamentals of the architecture of microprocessor devices. Central processor architecture. Main memory and external device interfaces. Organization of microprocessor control. Typical interfaces of microprocessor devices. Microprocessor controls and instrumentation. Design automation tools. Organization of serial communication. The technology of writing control programs for a microcontroller. Digital signal processing and control action shapers. Basics of programming microcontrollers. Interrupts. The principles of building the interrupt mechanism. Methods for organizing time delays. Features of program control. Principles of organizing serial communication.
KNOWLEDGE, ABILITY, SKILLS TO COMPLETE THE COURSE
As a result of mastering the discipline, the student must:
know:
architecture and microprocessor interface; microprocessor kit; ways, methods and cycles of exchange, types of addressing; command system; microcontrollers; modular microprocessor systems; an interface device with a control object; processes, process states, events, dispatchers and monitors; direct, sequential and parallel programming; channels, routes and packets in local networks, physical and data link layers; methods: development;
be able to:
analyze and develop structural and schematic diagrams of hardware for microprocessor systems; to develop and debug software for microprocessor systems that implement control algorithms; creation of experimental and prototypes; apply standard CAD programs to design microprocessor systems; substantiate technical requirements for microprocessor systems in accordance with the general technical specifications;
own:

the skills of using microprocessors in drives of mechatronic and robotic systems, microprocessor data processing in information systems.

Writing and defending a doctoral dissertation
CODE - ECA302
CREDIT –12

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.

SHORT DESCRIPTION

Doctoral dissertation is a scientific work of a doctoral student, which is an independent study, in which theoretical provisions are developed, the totality of which can be qualified as a new scientific achievement, or a scientific problem is solved, or scientifically grounded technical, economic or technological solutions are set forth, the implementation of which makes a significant contribution to development the country's economy.

A doctoral dissertation is the result of the research / experimental research work of a doctoral student, carried out during the entire period of study of a doctoral student.

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

- 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 dissertation, the goals and objectives, the scientific results obtained must strictly correspond to the topic of the dissertation.
- The dissertation is carried out in compliance with the principles of independence, internal unity, scientific novelty, reliability and practical value.

Content

РЕЦЕНЗИЯ

на образовательную программу
«8D07106 Робототехника и мехатроника»

Содержание образовательной программы докторантуры разработано на основе принципов непрерывности и преемственности с предыдущим уровнем образования - магистратура. Все дисциплины являются логическим продолжением дисциплин магистратуры, их содержание носит более углубленный характер.

Структура образовательной программы докторантуры по специальности Приборостроение содержит две равнозначные компоненты: образовательную и научную, определяющие содержание образования, и отражает их соотношение, измерение и учет и формируется из различных видов учебной, научно-исследовательской работы докторанта, исследовательской педагогической практики, определяющих содержание образования, отражает их соотношение, измерение и учет.

Продолжительность освоения образовательной программы докторантуры составляет 3 года.

Образовательная программа докторантов ориентирована на реализацию компетентностного подхода в обучении. В структуре образовательная программа учитывается наличие обязательных компонентов типового учебного плана государственного общеобязательного стандарта образования РК.

Программа обеспечивает изучение и исследование всех видов современных информационно-измерительных систем и комплексов.

Программа обеспечивает докторантам возможность проходить стажировку за рубежом и проводить различные исследовательские работы. Развивает у докторантов способности к пониманию современных достижений в области проблем развития приборостроения.

Заместитель директора по ИиИТ ТОО «Корпорация Сайман» Корпорация Сайман **Байбеков К.И.**