

Документ подписан простой электронной подписью  
Информация о владельце:  
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Дата подписания: 01.03.2022 19:06:15  
Уникальный программный ключ:  
1cb4f9edcd6d31e931c556ddefa3b376a443365a5419c

## **SUMMARIES OF THE COURSES**

for the master's program

«Automation and Mechatronics»

Educational direction

27.04.04 «Control in Technical Systems»

### **«Nonlinear, Adaptive and Intelligent Control Systems»**

Studying the basics of the theory of nonlinear, adaptive and intelligent (fuzzy and neural network) control systems.

The material of the course set out: the method of Lyapunov functions, including elements of its design; square and circle criteria for absolute stability; the study of periodic solutions, Poincare type methods and Galerkin harmonic balance; research methods of nonlinear dynamics, linear stability analysis, stability of periodic, quasi-periodic and chaotic solutions, local and nonlocal bifurcation; searchless algorithms and adaptive control systems, basic structure, synthesis methods, speed-gradient method; variable structure system. Fuzzy and neural systems - intelligent control systems.

### **«Modern Methods of Control Theory»**

In the first part of the course material set out issues of stochastic nonlinear dynamics for deterministic systems of low order. Used the techniques of linearization for non-periodic and periodic attractors. Considered the local bifurcations of a saddle equilibrium state, a limit cycle and structures of two-dimensional torus, and nonlocal bifurcations of these attractors.

In the second part of the paper describes the construction of robust regulators for objects with limited uncertainty ( $H_\infty$ -theory) from the perspective of the external approach. Presents the main mathematical results of robust stability, the problem of robust control and robust structures of the regulators.

### **«Adaptive Control in Mechatronics and Robotics»**

The discipline familiarizes undergraduate and graduate students of technical universities with main scientific approaches to control of mechatronic and robotic systems.

The problems of analysis and design of modern adaptive control systems for multi-degree nonlinear mechanical objects with extended geometry and elastic deformations under conditions of uncertainty of their mathematical description and

external perturbations are being studied. Mathematical models of multi-degree-of-freedom rigid and elastic nonlinear mechanical objects in explicit form of Lagrange equations of the second genus are considered. The basic structures of searchless adaptive control systems for linear and nonlinear objects, their stability to additive perturbations, and dissipativity are studied. The technique of block-by-block calculation of the designed systems with direct and indirect adaptive control of nonlinear elastic objects is studied using the concept of compound programmed, linear (modal or following the reference model), and adaptive control (with signal and parametric adjustment).

### **«Foreign Language»**

This course is pointed on providing training courses for foreign citizens who had not studied the Russian language before. It includes language and speech models based on the requirements for the Elementary certification level. Achieving this level in Russian will satisfy the foreign students' basic communicative demands in social and cultural as well as in educational spheres of communication.

The content of the program involves implementation of flexible training models, depending on the communicative purposes, native language and students' individual features.

### **«Russian as a Foreign Language»**

The discipline is intended for education of master's degree non-philological foreign students, who have the bachelor diploma of Russian institute of higher education and have the knowledge of Russian Language corresponding to the B 2 level. The program includes requirements for language knowledge level in different types of speech activity as well as grammar and speech material.

The mastering of this program will allow the foreign students to handle their communicative needs in educational, social and cultural sphere, will produce the base for successful learning of special subjects, and, as a result – for successful presentation of a thesis.

The Russian Language course for master's degree students must ensure the forming of a graduate's communicative competence on the level sufficient for professional activity in Russian Language. The education is realized on the source of general scientific, country-specific, literary, social and political texts.

## **«Social Communication in a Professional Environment»**

The aim of the course is to discuss some important problems of theory and practice interpersonal communication in business environment. The following issues are discussed in the course: situational and psychological factors interpersonal communication, verbal and nonverbal practices of communication, active listening, specific ways of interpersonal pressure, influence and manipulation, emotional management, types of corporate culture and teambuilding.

## **«Energy Management»**

Content of discipline includes theoretical and practical aspects of management of energy resources of the enterprise and includes questions: 1) evolution of development of theories of management and a role and the place of EM in the enterprise management system. Special attention is paid to a conceptual framework of EM, its purposes, tasks and functions, classification; the model of a system of EM is considered; 2) management of energy resources of enterprise. EM is studied as a development of the enterprise's strategy, an functional strategy of the enterprise, its place in the corporate management pyramid is defined; the attention is focused on EM from the points of view of investment attractiveness and information and marketing providing actions which are directed to increase in energy efficiency; 3) implementation of discipline: cases (tasks solution) by economic assessment of efficiency of EM, an energy audit; on legal regulation of ensuring energy efficiency, and energy security, energy industry.

## **«History of Science and Technology in the Field of Technical Systems»**

The main aims of the course are as follows: study of a new physical phenomena discoveries new scientific theories and laws forming, basic ideas and technical solutions appearance in the field of electrical engineering, electromechanics and control, that formed the automatic control science.

## **«Electric and Hydraulic Drives Mechatronic and Robotic Systems»**

Study the principles of operation of electric and hydraulic drives of various types used in modern mechatronic and robotic devices and control methods of actuators and methods for their calculation and modeling. The examples of different types of actuators

## **«Computer-based Technologies of Control Technical System»**

The discipline "Computer technologies of technical control system" is intended to provide complete representation about modern information technologies and software used in the control systems, implemented on the basis of information and digital systems, primarily - in industrial processes. Presentation of the material is based on universal regulations applicable to the control of any complex system. Questions concerning the control of technical systems and various industrial automation systems are discussed in general terms. The functional, organizational, informational, software and hardware aspects of computer-aided control processes are given in detail. Important issues related to the development of up-to-date industrial systems - Intranet- and of Internet-technologies – are considered. Following principals of SCADA-systems construction are discussed: the implementation of human-computer interaction, hierarchical principle of systems construction, the composition of hardware and software platforms and methods of software interactions. Problems of constructing and practical use of real time operating systems are studied.

Theoretical training focused on the use of acquired knowledge in the development of practical issues related to the control tasks for contemporary industrial automation systems and technical systems for various applications. Practical development of computer technologies is carried out in a laboratory-based, consisting of research laboratory stands, equipped with the modern generation of industrial controllers and SCADA-system InfinitySuite.

## **«Mechatronic Systems and Robotics»**

The discipline includes the exposition of the mechatronic and robotic technology design foundations of complexes. Discusses drives robotic systems, questions of mathematical description and simulation of robots and mechatronic machines.

Discipline is supported by a large number of practical and laboratory classes and independent work of students on the basic sections of the program. To ensure quality control of learning the discipline of students are provided testing and current control of knowledge on sections of the program.

## **«Systems of Ensuring the Safely for Technical Control Devises»**

The discipline considers general engineering issues in complex security. Also, principles of design and construction such systems are discussed. The focus is on the safety requirements in the test instrument. The discipline covers problems related to the features of technical equipment in terms of electromagnetic compatibility, ergonomic engineering and other.

## **«Modeling and Synthesis of Nonlinear Elements of Systems»**

The discipline introduces the basis of mathematical modeling and synthesis of nonlinear devices at the input/output mapping. Different forms of nonlinear models classified as multidimensional polynomials, regression models and neural networks are investigated. The comparative analysis of nonlinear models are performed. The methods and algorithms of model building by solving the problems of nonlinear device operator approximation in the root mean square norm, using the input and output signal sets are studied. The approximation problems are solved in time, frequency, s- and z-domain. The skills of various neural network synthesis in MATLAB are given. The examples of modeling and synthesis of nonlinear transformers, filters, compensators.

## **«Mathematical Modeling of Objects and Control Systems»**

Contents comprise physical and mathematical bases of construction of models of objects and control systems, methodology of their research, the principles of creation and research models in interactive engineering software environments.

## **«Electromechatronic Complexes and Systems»**

In this course students will study the process of electromagnetic and electromechanical energy conversion processes associated with functional and design combining in EMTC electromechanical converter with electronic components. We consider the structure and operation of EMTC of an example with synchronous machines and information type EMT systems. The technique of calculating the parameters and characteristics of EMTC are considered. Practical and laboratory classes are conducted with the development of methods for the preparation and analysis of EMTC performance.

## **«Microcontroller-Based Control Systems»**

Discipline is designed to prepare masters in the field of control of technical objects. It explores the architecture of modern digital control systems with microcontrollers, the basic stages of analysis, synthesis and design of such systems. Considered the mathematical description of control systems with microcontrollers, analysis and synthesis using the methods of both classical and modern control theory. The theoretical part of the course is accompanied by practical and laboratory classes for practical mastering of the studied material.

## **«Training Practice»**

## **«Field Experience (R & D)»**

## **«Pre-Diploma Practical Training»**

### **«State Final Examination»**

The State final attestation includes defense of the graduation qualification work. The State final attestation is the last mastering stage of the basic educational program.

The training level of graduates for performance of their professional tasks and compliance of their training with the requirements of the State Standard are assessed in the course of the State final attestation.

### **«Methods and Means of Mathematical Optimization in the Field of Technical Systems»**

The discipline introduces the basics of optimization theory and decision making. Models and decision-making methods, methods and algorithms of mathematical programming, various approaches used for modeling and control in optimal systems are considered. Within the framework of the course, theoretical conclusions are considered on the basis of examples of real systems, namely: the use of linear programming for resource allocation in the planning of the production life cycle, the problem of balancing the assembly at the factory, queue problems in service systems, Markov chains in game theory, the use of filtering when direct measurements are not possible, for the case of a thermometer.

### **«Robotics System Design»**

The discipline introduces students to the basic rules of designing robotic systems, methods and means of designing robots and robotic systems. The course covers the following topics in detail: regulations and criteria for robotics design, multidisciplinary aspects of robotics design including mechanic, electronic, control

systems etc, criteria for mobile and industrial robots, robot protection against environmental conditions, EMC and safety considerations for design.