Federal State Autonomous Educational Institution for Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA
(RUDN University)
Academy of Engineering

(Name of the main educational unit (MEU)- of the developer of the EP of HE)

COURSE SYLLABUS

Automated Design of Control Means and Systems

(наименование дисциплины)

Recommended by Methodological Council for the Education Field for the direction of training/specialization

27.04.04 Управление в технических системах

(код и наименование направления подготовки)

The development of the discipline is carried out within the framework of the implementation of the main professional educational program of higher education (EP HE):

Искусственный интеллект и робототехнические системы

(наименование (направленность/профиль) ОП ВО)

2022 г.

1. GOALS AND OBJECTIVES OF THE DISCIPLINE

The purpose of mastering the discipline of Automated Design of Control Means and Systems is to gain knowledge, skills, skills and experience in the field of development and application of models, methods and means of computer-aided design of technical systems, and management tools with integrated computerization of the design stage, characterizing the stages of competence formation and ensuring the achievement of the planned results of the development of the educational program.

2. LEARNING OUTCOMES

The development of the discipline "Design of automated control systems" is aimed at the formation of the following competencies (parts of competencies) in students:

Table 2.1. The list of competencies formed by students in the course of mastering the discipline (the results of mastering the discipline)

Competence code	Competence	Competence formation indicators
УК-2	Able to manage the project at all stages of its life cycle	УК-2.1. Formulates a problem, the solution of which is directly related to the achievement of the project goal; УК-2.2. Defines the links between the tasks set and the expected results of their solution;
ОПК-3	Able to independently acquire new knowledge, skills and abilities to solve management problems in technical systems	ОПК-3.1. Knows the main approaches to solving management problems in technical systems
ОПК-6	Able to collect and analyze scientific and technical information, summarize domestic and foreign experience in the field of automation and control	ОПК-6.1. Knows the basic methods of collecting and analyzing scientific and technical information
ПК-3	He is able to analyze the results of theoretical and experimental research, make recommendations for improving devices and systems, prepare scientific publications and applications for inventions	ПК-3.1. Is able to analyze the results of theoretical and experimental studies

3. COURSE IN HIGHER EDUCATION/ACADEMIC PROGRAMME STRUCTURE

The discipline *Automated Design of Control Means and Systems* refers to the basic part of block B1.

Within the framework of the educational program, students also master other disciplines and/or practices that contribute to achieving the planned results of mastering.

Table 3.1. The list Higher Education Programme components / disciplines that contribute to expected learning outcomes

Competence code	Competence	Previous disciplines	Subsequent disciplines
УК-2	Able to manage the project at all stages of its life cycle	Computer technologies in technical systems System analysis and multi-criteria optimization	Additional chapters of mathematical modeling Artificial neural networks in management

			Research work Introductory practice Project practice Organizational and managerial practice Pre-graduate practice Preparation for passing and passing the state exam Execution, preparation for the protection procedure and protection of the final qualifying work
ОПК-3	Able to independently acquire new knowledge, skills and abilities to solve management problems in technical systems	Computer technologies in technical systems System analysis and multi-criteria optimization	Additional chapters of mathematical modeling Artificial neural networks in management Research work Introductory practice Project practice Organizational and managerial practice Pre-graduate practice Preparation for passing and passing the state exam Execution, preparation for the protection procedure and protection of the final qualifying work
ОПК-6	Able to collect and analyze scientific and technical information, summarize domestic and foreign experience in the field of automation and control	Computer technologies in technical systems System analysis and multi-criteria optimization	Additional chapters of mathematical modeling Artificial neural networks in management Research work Introductory practice Project practice Organizational and managerial practice Pre-graduate practice Preparation for passing and passing the state exam Execution, preparation for the protection procedure and protection of the final qualifying work
ПК-3	He is able to analyze the results of theoretical and experimental research, make recommendations for improving devices and systems, prepare scientific publications and applications for inventions	Computer technologies in technical systems System analysis and multi-criteria optimization	Additional chapters of mathematical modeling Artificial neural networks in management Research work Introductory practice Project practice Organizational and managerial practice Pre-graduate practice Preparation for passing and passing the state exam Execution, preparation for the protection procedure and protection of the final qualifying work

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total course workload is 6 credit units.

Table 4.1. Types of academic activities during the period of the HE programme mastering

Types of academic activities		Total, ac. hours	Semester	
			3	
Contact academic hours		51	51	
including:		-	-	
Lectures (L)		17	17	
Seminars (S)		-	-	
Lab work (LW)		34	34	
Course project / course work		-	-	
Self-study		57	57	
Evaluation and assessment (exam/pass/fail grading)			exam	
Course workload	academic hours	108	108	
	credit units	3	3	

5. COURSE MODULES AND CONTENTS

Table 5.1. The content of the discipline (module) by type of academic activities

№ п/п	Course modules/units	Contents of the module (topics)	Type of academic activities
1.	Tools and technologies for complex automation of the design stage of control facilities and systems (SSS)	Topic 1. Problems of computer-aided design of control tools and systems. The subject and objectives of the discipline. Statement of the task of automation of SSU design. A systematic approach to the design of the SSU, its interpretation and specification. Structural, block-hierarchical, object-oriented approaches in setting the task of computer-aided design of SSU. Structuring of the SSU design process. Iterative nature of SSU design. Typification and unification of design solutions and SSU design tools. Classification of CAD. Classification of CAD by application, purpose, scale (complexity of the tasks to be solved), the nature of the basic subsystem - the CAD core, by the complexity of the design object. Overview of modern universal CAD systems, specialized CAD systems. CAD development trends. CAD SU. Topic 2. Functions of CAE/CAD/CAM systems. The composition of integrated CAD systems. Procedures for analysis, modeling, optimization of design solutions in SAE systems. Functions of CAD systems: functions of two-dimensional (2D) and three-dimensional (3D) design. The main licensed cores of geometric modeling. Geometric modeling kernels available in the source code. Integrated CAE/CAD/CAM systems. Interfaces, languages, formats of inter-program exchanges: IGES, DXF, Express, STEP, SAT (ACIS core format), etc. CALS	L, LW

		technologies and information support of the SSU lifecycle. Functions of automated control systems (ERP systems). Functions of SCADA systems. Functions of document management and document management systems. Aspects of the problem of CALS. Functional composition of integrated CAD systems: mathematical, software, technical, linguistic, informational, organizational and methodological support. The structural composition of integrated CAD systems: designing and servicing subsystems; CAD software and hardware complexes, CAD software and methodological complexes.	
2	Models and methods of SSU analysis in the automation of the design stage	Topic 3. Model representation of management tools and systems (SSS). Model representation of control systems and SSU elements as design objects. Statement of the problem of SSU analysis as an object with distributed parameters. Methods for solving boundary value problems in the design of SSU. Spatial discretization methods: finite element methods (FEM); boundary element methods (MGE); finite difference methods (MCR); finite volume methods (MCO); spectral method; free wall method. Statement of the problem of SSU analysis as an object with concentrated parameters. Stages of construction of differential models. Representation of the structure of technical control systems in the form of equivalent circuits. Establishing links between heterogeneous subsystems in the management system. Methods for obtaining models of technical control systems in the description with varying degrees of detail. Formal methods for obtaining control system models: generalized method, variable state method, tabular method, nodal method. Topic 4. Computer-aided design methods: methods of SSU analysis. Methods of analysis of technical systems in CAD. Types of analysis as a design procedure in the automated design of SSU. Single-variant analysis. Multivariate analysis. Features of the mathematical description of the SSU in computer-aided design: high dimensionality of the mathematical description of the SSU; poor conditionality of the model representation of the SSU. Requirements for the methods of SSU analysis in CAD: accuracy, efficiency, reliability, stability. General principles of the organization of the computing process. Methods of analysis in the frequency domain, their main characteristics. Methods of SU analysis in the time domain. The main characteristics of methods for analyzing the dynamic characteristics of nonlinear systems. Methods for evaluating the accuracy of SSU analysis methods in the time domain. Methods for assessing the stability of SSU analysis methods in the time domain. SSU	L, LW

		sensitivity analysis. Absolute and relative sensitivity coefficients. Formation of the sensitivity matrix. Determination of the technological spread of SU parameters based on the method of statistical tests. The main statistical characteristics of the SSU output parameters are: distribution density, mathematical expectation, variance, correlation coefficient. The worst-case method. The algorithm of the working stage of the Monte Carlo method. Evaluation of the accuracy of the statistical test method.	
3	Methods of SSU synthesis and verification of design solutions in the automation of the design stage	Topic 5. Computer-aided design methods: methods of SSU synthesis. Methods and algorithms of technical optimization of means and control systems, their main characteristics. Formalization of the SSU parameter optimization problem. Formulation of the parametric optimization problem. Working conditions of the SSU. Optimality criteria as a function of the quality of the SU. Additive, multiplicative, maximin optimality criteria. Normalization of the controlled and output parameters of the SSU. Structural synthesis of technical systems in CAD. Classification of structural synthesis procedures of SU: according to the goals of synthesis and the content of the results; according to the difficulties of formalization of synthesis procedures; according to the type of synthesized structures. Formalization of information about SSU as objects of structural synthesis. Methods of structural synthesis. Methods of artificial intelligence as a means of automating the tasks of structural synthesis of SU. AI systems used in CAD: information retrieval systems with a natural language interface; intelligent application software packages for engineering calculations; intelligent software and methodological complexes (PMCs) for modeling and analysis of systems; expert systems. Adaptive genetic algorithms as algorithms for solving problems of synthesis of SU devices. Topic 6. Automation of design design of SSU. Automation of design design within the framework of complex automation of the design stage of the SSU: basic concepts. Levels and tasks of design and technological design of SSU. Tasks of the synthesis of structures: layout, placement, tracing. Tasks of control of the received constructive solutions; execution of design documentation (CD) and technological (TD). Mathematical models of SU elements in design automation. Mounting space models: graph model, discrete model, volume model. Algorithms of design design of control system elements: constructive (sequential and parallel-sequential), iterative. Solving problems of layout, placement and tracing based on evolutionary	L, LW

		methods. Control of the received design solutions of the SSU. DRC-, ERC-utilities. Topic 7. Automation of SSU tests. SU test methods: based on semi-natural modeling; physically real SU equipment. Testing algorithms. Methods and algorithms for processing test results. The functionality of modern CAD systems for the development of automated control systems for testing electronic and electromechanical devices SU. Industry-specific automated SU testing systems.	

6. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 6.1. Classroom equipment and technology support requirements.

Classroom for academic activity type	**Classroom equipment**	**Specialized educational / laboratory equipment, software and materials for mastering the discipline (if necessary)**
Lecture	An auditorium for lecture-type classes, equipped with a set of specialized furniture; board (screen) and technical means of multi-media presentations.	
Seminar	An auditorium for conducting seminar-type classes, group and individual consultations, current control and intermediate certification, equipped with a set of specialized furniture and technical means for multimedia presentations.	
Computer class	Computer room for classes, group and individual consultations, current monitoring and interim certification, equipped with personal computers (at least 12 pcs.), blackboard (screen) and technical means of multimedia presentations.	Matlab
For students self-studies	An auditorium for independent work of students (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to the EIEE.	Matlab

7. RECOMMENDED SOURCES FOR COURSE STUDIES

Basic literature:

1. Норенков, И.П. Основы автоматизированного проектирования / И.П. Норенков, М., Изд-во МГТУ им. Н.Э. Баумана, 2009, 335 с. ISBN 978-5-7038-3275-2.

2. Божко, А. Н. Основы автоматизированного проектирования / А.Н. Божко, Т.М. Волосатова, С.В. Грошев и др.; под редакцией А. П. Карпенко, Москва: ИНФРА-М, 2019 - 327с., ISBN 978-5-16-014441-2.

3. Жигалова, Е.Ф. Автоматизация конструкторского и технологического проектирования: учебное пособие / Е.Ф. Жигалова; Министерство образования и науки Российской Федерации, Томский Государственный Университет Систем Управления и Радиоэлектроники. - Томск: ТУСУР, 2016. - 201 с.: ил.,табл., схем. - Библиогр.: с.196-197; То же [Электронный ресурс].

4. Крысова, И.В. Основы САПР: учебное пособие / И.В. Крысова, М.Н. Одинец, Т.М. Мясоедова, Д.С. Корчагин; Минобрнауки России, Омский государственный технический университет. - Омск : Издательство ОмГТУ, 2017. - 92 с. : табл., граф., схем, ил. - Библиогр. в кн. - ISBN 978-5-8149-2423-0;

5. Елизаров, И.А. Интегрированные системы проектирования и управления: SCADA-системы: учебное пособие / И.А. Елизаров, А.А. Третьяков, А.Н. Пчелинцев и др.; Министерство образования и науки Российской Федерации, Федеральное государственное бюджетное образовательное учреждение высшего профессионального образования «Тамбовский государственный технический университет». - Тамбов: Издательство ФГБОУ ВПО «ТГТУ», 2015. - 160 с.: ил., табл., схем. - Библиогр. в кн. - ISBN 978-5-8265-1469-6;

Additional literature

6. Лисяк, В.В. Разработка САПР электронной аппаратуры: учебное пособие / В.В. Лисяк; Министерство образования и науки Российской Федерации, Федеральное государственное автономное образовательное учреждение высшего образования «Южный федеральный университет», Инженерно-технологическая академия. - Ростов-на-Дону; Таганрог: Издательство Южного федерального университета, 2017. - 94 с.: ил. - Библиогр.: с. 89 - 90 - ISBN 978-5-9275-2518-8;

7. Тугов, В.В. Проектирование автоматизированных систем управления в TRACE MODE: учебное пособие / В.В. Тугов, А.И. Сергеев, Н.С. Шаров; Министерство образования и науки Российской Федерации, Федеральное государственное бюджетное образовательное учреждение высшего образования «Оренбургский государственный университет», Кафедра управления и информатики в технических системах, Кафедра систем автоматизации производства. Оренбург : ОГУ, 2017. - 203 с.: ил. - Библиогр. в кн. - ISBN 978-5-7410-1857-6 ;

8. Герасимов, А.В. SCADA система Trace Mode 6: учебное пособие / А.В. Герасимов, А.С. Титовцев; Министерство образования и науки Российской Федерации, Государственное образовательное учреждение высшего профессионального образования «Казанский государственный технологический университет». - Казань : КГТУ, 2011. - 128 с.: ил., табл. - Библиогр. в кн. - ISBN 978-5-7882-1103-9 ;

Electronic libraries with access for RUDN students

- RUDN ELS and third-party ELS, to which university students have access on the basis of concluded agreements: - RUDN Electronic Library System
- RUDN EBS http://lib.rudn.ru/MegaPro/Web - ELS "University Library Online" http://www.biblioclub.ru
- EBS Yurayt http://www.biblio-online.ru
- ELS "Student Consultant" www.studentlibrary.ru
- EBS "Lan" http://e.lanbook.com/ - EBS "Trinity Bridge"

Databases and search engines:

- electronic fund of legal and normative-technical documentation http://docs.cntd.ru/
- Yandex search engine https://www.yandex.ru/
- Google search engine https://www.google.ru/
- abstract database SCOPUS http://www.elsevierscience.ru/products/scopus/

Internet-(based) sources:

1. Interregional public organization for promoting the development of the market for geoinformation technologies and services Web site of the GIS Association: http://www.gisa.ru
2. Association of developers, manufacturers and consumers of equipment and applications based on global navigation satellite systems "GLONASS / GNSS-Forum": http://aggf.ru/
3. Intersectoral journal of navigation technologies Vestnik GLONASS: http://vestnik-glonass.ru/
4. State and prospects of the Russian satellite navigation market in 2010: an analytical review. – M: 2011 http://aggf.ru/analitika/AGGF_2011.pdf

5. Introduction to geoinformation systems / Web-site "GIS-Lab and authors" (http://gis-lab.info/docs/giscourse), Aug. 2007
6. Basic GIS - RECOD platform. http://ssc.rekod.ru/content/services/3

*Learning toolkits for self- studies in the RUDN LMS TUIS *:*

1. A course of lectures on the discipline "Application of Geographic Information Systems / Workshop on the use of geographic information systems".
2. Tasks for laboratory work.
3. Software instructions.

* - all educational and methodological materials for independent work of students are placed in accordance with the current procedure on the page of the discipline in TUIS.

8. MID-TERM ASSESSMENT AND EVALUATION TOOLKIT

Evaluation materials and a point-rating system* for evaluating the level of competencies (parts of competencies) based on the results of mastering the discipline "Practical work on the use of geographic information systems" are presented in the Appendix to this Work Program of the discipline. * - OM and BRS are formed on the basis of the requirements of the relevant local normative act of RUDN University (regulations / order).

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