Ministry of Science and Higher Education of the Russian Federation
Federal State Autonomous Educational Institution of Higher Education
Perm National Research Polytechnic University

APPROVED BY
Pro-rector for Academic Affairs
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ACADEMIC COURSE WORKING PROGRAM

Academic course: Mechatronic and Robotic Systems Software
(Name)

Form of education: Full-time
(full-time / part-time / correspondence)

Level of higher education: Bachelor's program
(Bachelor's program / Specialist program / Master's program)

Workload in hours (in credits): 180 (5)
(Hours (CU))

Training program (degree): 15.03.06 Mechatronics and Robotics
(Code and denomination of degree)

Direction: Mechatronics and Robotics
(Title of curriculum)

Perm 2021

1 General Provisions

1.1 Goals and Objectives of the Course

The goal of the course is to form a knowledge and skills system in the use of a systematic approach and mathematical methods in solving complex system management problems.

Discipline objectives:

Studying the basic:

- control devices architecture for robots and robotics system (RS);
- syntactic constructions of modern programming languages;
- design patterns for high-level software used in RS management and modeling;
- control algorithms;

Forming the ability:

- to apply the acquired knowledge in program creation that implement robot management systems and RS;
- to analyze the architecture of robot control devices and RS;
- to apply complex software systems basic design techniques;
- to use robotic software for effective robotic operations management;

Mastering the skills:

- of basic control algorithms application;
- of working with integrated software development environments;
- of writing algorithms in modern programming languages;
- of complex systems design;
- of technical vision basic techniques.

1.2 Prescribed Objects of the Course

The content of the course covers the following aspects:

- mechatronic and robotic modeling software;
- computer-aided design tools;
- symbolic and analogue system models.

1.3 Starting Conditions

Unstipulated

2 Planned Results of the Course Training

Competence	Indicator's Index	Planned Results of the Course Training (to know, to be able, to master)	Indicator of Attaining Competence which the planned results of training are correlated with	Means of Assessment
PC-2.4	**IA-1**$_{PC-2.4}$	**To know** the basic control devices architecture for robots and RS; the basic syntactic constructions of modern programming languages; the basic design patterns for high-level software used in RS management and modeling; the basic control algorithms.	**Knows** high-level programming languages and modern software environment for managing flexible production systems.	Exam
PC-2.4	**IA-2**$_{PC-2.4}$	**To be able to** apply the acquired knowledge in program creation that implement robot management systems and RS; analyze the architecture of robot control devices and RS; to apply complex software systems basic design techniques; use robotic software for effective robotic operations management.	**Is able to** develop programs in high-level programming languages and management programs for flexible production systems.	Internship report
PC-2.4	**IA-3**$_{PC-2.4}$	**To master the skills** of basic control algorithms application; working with integrated software development environments; writing algorithms in modern programming languages; complex systems design; technical vision basic techniques.	**Has mastered the skills** of choosing the optimal combination of software environment for managing flexible production systems and debugging software for the flexible production system control.	Internship report

3 Full time and forms of academic work

Form of academic work	Hours in all	Distribution in hours according to semesters
		Number of semester
		4
1 Holding classes (including results monitoring) in the form: 1.1 Contact classwork, including:	72	72
- lectures (L)	32	32
- laboratory work (LW)		
- practice, seminars and/or other seminar-type work (PW)	36	36
- control of self-work (CSW)	4	4
- test paper		
1.2 Students' self-work (SSW)	72	72
2 Interim/midterm assessment		
Exam	36	36
Grading test		
Test		
Course Project (CP)		
Course Work (CW)		
Workload in hours	**180**	**180**

4 Course contents

Course units with brief contents	Full time of classroom activity in hours according to the forms			Full time of extracurricular work in hours according to the forms
	L	LW	PW	SSW
4th semester				
Software Operations fundamentals	8	0	8	18
Basic concepts, terms and definitions. Subject and objectives of the discipline. Algorithms and magnitude. Linear computing algorithm. Loops and conditional branches in computing algorithms. Utility algorithms and task procedures. Application development project. Application structure description.				
Informational exchange with a robot	8	0	10	18
Provision of robot-computer information exchange using network connection and COM port. UPD and TCP sockets. Server and client application development using TCP and UPD protocols.				

Creation of COM port data transferring application.				
Robot programming	8	0	8	18
ROS structure. Features of program development in ROS. Graphical information processing and analysis algorithms. Parallel Computing Technology usage for increasing computer vision systems speed. Software implementation of robot algorithms in different situations.				
Robot program design	8	0	10	18
Robot management program design, which uses the odometry method for robot localization. Robot management program design, which uses the trilateration method for robot localization.				
Total with regard to 4th semester	**32**	**0**	**36**	**72**
Total with regard to the course	**32**	**0**	**36**	**72**

Topics of exemplary practical work

№	Topic of practical (seminars) work
1	Linear computing algorithm. Loops and conditional branches in computing algorithms
2	Utility algorithms and task procedures
3	Application project development Microsoft Visual Studio
4	Server and client application development using TCP and UPD protocols
5	Provision of robot-computer information exchange using network connection and COM port
6	Robot Operating System basics
7	Graphical information processing and analysis algorithms
8	Robot programming for solving an applied problems
9	Robot management program design, which uses the odometry method for robot localization
10	Robot management program design, which uses the trilateration method for robot localization

5 Organizational and Pedagogical Conditions

5.1 Educational Technologies Used for Competences Formation

Holding the course lectures is based on an active method of education, wherein students are not passive listeners, but active participants answering teacher's questions while the class. The teacher's goal is to activate the processes of learning the material by asking questions, along with the development of logical thinking. The teacher outlines a list of questions in advance that stimulate associative thinking and networking based on the material previously mastered. Practical classes are held based on the learning-by-action method: problem fields are identified and groups are formed. Seminars pursue the following goals: applying creative problem-solving methods and knowledge from individual courses to solve problems and make decisions; perfecting teamwork, interpersonal communication, and leadership skills; and reinforcing theoretical knowledge.

Interactive lectures, group discussions, role-playing games, training sessions, and analysis of situations and simulation models are used in academic studies.

5.2 Students' Manual for the Course Study

Learning the course, it is advisable for students to implement the following recommendations:

1. Learning of the discipline should be done systematically.
2. After learning one of the course units with the help of the text-book or lecture notes it is recommended to reproduce the basic terms, definitions, notions of the unit from memory.
3. Special attention should be paid to the reports on practical studies and individual complex tasks for self-work.
4. The topics list for individual study is given by the teacher at the lectures. The teacher also provides students with literary sources (first of all, new ones in the periodical scientific literature) for a more detailed understanding of the issues presented at the lectures.

6 List of Teaching Materials and Information Supply for Students' Self work in the Discipline

6.1 Paper-based courseware

№	Bibliographic entry (author, title, mode of publication, place, publishing house, year of publication, number of pages)	Number of copies in the library
	1 Basic literature	
1	Zhmud V.A. Numerical Optimization of Regulators for Automatic Control System: textbook for higher education / Zhmud V.A., Dimitrov L.V., Nosek J. NSTU, 2019, 296 p.	2
2	Kafrissen E., Stephans M. Industrial robots and robotics / Reston, Virginia: Reston Publ., 1984	3
	2 Additional literature	
	2.1 Educational and scientific literature	
1	Chugunov M.V., Polunina I.N. Interdisciplinary modelling of robots using CAD/CAE technology / Vestnik MSU. 2018. №2. pp. 181-190	15
	2.2 Periodical literature	

2.3 Standardized and Technical literature		
3 Students' manual in mastering discipline		
4 Teaching and learning materials for students' self-work		

6.2 Electronic Courseware

Kind of literature	Name of training tool	Reference to information resource	Accessibility of EBN (Internet / local net; authorized / free access)
Additional literature	Robotics Training LESSON 1: An Introduction to Robotics for Absolute Beginners	https://www.youtube.com/watch?v=eqXQ80vlgqE&list=PLGs0VKk2DiYxkoe2XNxDvVHqL5XG4dMWi&ab_channel=PaulMcWhorter	free acces
Additional literature	Kerr, D. A Methodology for Design and Appraisal of Surgical Robotic Systems. Robotica, 2010.	https://www.academia.edu/55643083/A_methodology_for_design_and_appraisal_of_surgical_robotic_systems	free acces

6.3 License and Free Distributed Software used in the Course Educational Process

Type of Software	Software branding
Operating systems	Debian (GNU GPL)
Operating systems	Windows 10 (Azure Dev Tools for Teaching)
Development, testing and debugging environments	C++ Builder 2007 Enterprise, licence PO- 398ESD, PNRPU
Development, testing and debugging environments	Microsoft Visual Studio (Azure Dev Tools for Teaching)

6.4 Modern Professional Databases and Inquiry Systems Used in the Course Educational Process

Branding	Reference to information resource
Scientific electronic library database (eLIBRARY.RU)	https://elibrary.ru/
Scopus Database	https://www.scopus.com/
Scientific Library of Perm National Polytechnic Research University	http://lib.pstu.ru/
Lan' Electronic library system	https://eJanbook.com/

IPR books Electronic library system	http://www.iprbookshop.ru/
Information resources of Consultant+ web	http://www.consultant.ru/

7 Logistics of the Course Educational Process

Type of classes	Name of the necessary basic equipment	Number of units
Lecture	Multimedia projector or TV	1
Practicals	Laptop computer	30

8 Fund of the Course Evaluating Tools

Described in a separate document