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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"25" _____ 2021

ACADEMIC COURSE WORKING PROGRAM

Academic course: Computer Graphics
(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): 144 (4)
(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 develop understanding of modern devices, tools and computer graphics methods (mathematical, algorithmic, software, and technical), it's programming, and methods to increase the realism of the image formed on the screen plane; to master skills in designing graphical interfaces, systems and technologies, using them in systems and objectives of Automatic Control Systems (ACS) and robotics.

The objectives of the course are:

To study:

- principles, methods and means of formalization, algorithmization and application of graphic models; classification of graphic objects computer representation and operations; advantages and disadvantages of different ways to represent models;
- techniques, methods of graphic objects formalization, and operations over them;
- representation of graphical information and methods of manipulating objects and their properties;
- architecture, composition, and properties of graphics systems;

To form abilities of:

- drawing up a graphical model;
- representation of operations on the graphics model in algorithmic and mathematical form;
- operation by elements of the graphics model;
- development of the graphical interface;
- demonstration of the model theoretical fundamentals;

To master the skills of:

- using geometric 2D and 3D modeling technology;
- using methods of manipulating graphic information;
- using graphical interface and system development methods.

1.2 Prescribed Objects of the Course

- mathematical and algorithmic apparatus for manipulating graphic information;
- presentation forms of graphic objects on the computer;
- methods to increase realism of plane image representation;
- modern multimedia graphics and interface technologies;
- technical and virtual graphics I/O devices.

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, to master)	Indicator of Attaining Competence which the planned results of training are correlated with	Means of Assessment
PC-2.5	**IA-1$_{PC-2.5}$**	**To know** the principles and methods of calculating the basic characteristics of flexible production system components using computer graphics and design tools.	**Knows** principle of operation, technical characteristics and methods of calculating basic characteristics of flexible production system components.	Grading test
PC-2.5	**IA-2$_{PC-2.5}$**	**To be able** to develop technical projects using computer graphics and competitive product development best practices; to design graphic material for technical documentation.	**Is able to** develop technical projects using design automation and competitive product development best practices; draw up technical documentation.	Laboratory work presentation
PC-2.5	**IA-3$_{PC-2.5}$**	**To master the skills** of developing functional diagrams of flexible production systems components using computer graphics and design tools; creating graphic materials while preparing an explanatory note of flexible production systems' engineering design.	**Has mastered the skills** of developing functional diagrams of flexible production systems components; explanatory note of flexible production systems' engineering design.	Grading test

3 Full time and forms of academic work

Form of academic work	**Hours in all**	**Distribution in hours according to semesters**
		Number of semester
		3
1 Holding classes (including results monitoring) in the form: 1.1 Contact classwork, including:	58	58
- lectures (L)	18	18
- laboratory work (LW)	38	38
- practice, seminars and/or other seminar-type work (PW)		
- control of self-work (CSW)	2	2
- test		

1.2 Students' self-work (SSW)	86	86
2 Intermediate attestation		
Exam		
Grading test	9	9
Test (Credit)		
Course Project (CP)		
Course Work (CW)		
Workload in hours	**144**	**144**

4 Course contents

Name of the units with the course outline	**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**
3rd semester				
Introduction	1	0	0	0
Basic concepts, terms and definitions. Subject of the course, goals and objectives of the discipline. Application areas of computer graphics.				
Basic concepts, terms and definitions. Subject of the course, goals and objectives of the discipline. Application areas of computer graphics.	2	4	0	6
Mathematical apparatus of two- and three-dimensional computer graphics. Coordinate systems. Homogeneous coordinates. Matrix representation in the form of homogeneous coordinates. Ways to represent graphic information in a computer The concept of affine transformations. The main coordinate systems (world, view, screen), transformation methods and addressing. Basic graphic operations (reflection, scale, translation, rotation, projection), their synthesis within affine transformations. 2D and 3D modeling within the graphics system. Problems of geometric modeling; types of geometric models and their properties, geometric operations on models.				
Projection	2	4	0	8
Problem of three-dimensional space image on a two-dimensional plane. Classical and special projections (parallel, central, stereographic, plane, spherical, and cylindrical). Classification of reflections and transformations. Mathematical methods of projections calculation. Isometric, diametric, and trimetric projection. Interaction of projection and coordinate systems in computer graphics programs. Finding vanishing points and vanishing point traces.				
Graphics transformations	2	4	0	6
Types of graphical information transformations. The most important formulas of transformations and calculating parameters of basic geometric objects (line, plane, curve, and window). Formulas of influence,				

phasing, and mixing of objects images. Morphing. Transformations of graphic objects in spaces of different dimensions and different curvature. Concept of object topology.				
Increase the realism of synthesized computer images	2	4	0	8
Mathematical apparatus for smoothing broken lines and surfaces (two-dimensional spline, three-dimensional spline, B-splines, cubic interpolation, Coons method of surface smoothing).				
Presentation and storage of graphical information	1	4	0	8
Presentation and storage of graphical information. Model parameterization. Graphics formats. GUI formation methods. Principles of building "open" graphics systems.				
Computer graphics fundamentals	2	4	0	16
Computer graphics tools, physical principals of displaying graphics information on modern technical devices (monitor, graphics adapter, plotters, printers, graphics processors, scanner, digitizer, virtual reality helmet, mouse, joystick, acoustic, contact, and ultrasonic sensors, touch-panel, video hardware). Ways to organize the resources required for computer graphics (time and memory). Resources calculation and their interaction with image quality, including dynamic one. The advanced hardware solutions in computer graphics (buses, I/O cards, digital-to-analog converters, graphics signal conversion path), the concept of graphic information input and output pipelines, hardware implementation of graphics functions. Principles of building "open" graphics systems. Current graphics trends: graphics core, applications, application writing tools; and standards for graphics development. Main functionality of modern graphics systems; dialogue system in graphics; the concept of a graphical interface; the development of graphical interfaces; classification and review of modern graphics systems.				
Approximate continuous space in a discrete implementation	1	2	0	8
Approximate continuous space in a discrete implementation, methods of representation (Bresenham and Floyd-Steinberg methods). Image quality interaction with method settings.				
Methods for improving image realism	1	4	0	8
Photorealistic imaging methods. Fractal methods enhancing the realism of the image. The concept of fractal. Methods of fractal geometry for forming landscape architecture and vegetation (the examples). Example of recursive algorithm of fractal formation.				
Space display on a plane	1	4	0	6
Concept of space dimensions and topology of shapes, their characteristics. Space properties. The types of images on the plane (drawing, scheme). Understanding of geometry and projection types, their classification.				

Interaction of distortion and space accuracy of the image plane (straight, axonometric, reverse perspective). The origin and role of illusions in the perception of space on the computer screen.				
Methods for removing invisible lines	1	2	0	6
Classification of algorithmic methods for removing invisible lines. Visualizing algorithms: cutting, unfolding, removing invisible lines and surfaces, filling). Methods of z-buffering, floating horizon, painter. Resources for the method of removing invisible lines.				
Color and light models	1	2	0	6
Introduction to the physics of light and color perception. The concept of light flow characteristics. The concept of reflection and transparency. Reflection types (diffuse, glossy). Lambert's Law, Phong model. Phong and Gouraud methods for smoothing surface lighting. The main color systems of RGB and CMYK. Classification of color systems used in technology. Color operation, color mixing math. CIE diagram. Shadow calculation. Texture application.				
Conclusion	1	0	0	0
Methods for implementing computer graphics algorithms. Classification and review of modern graphics systems. Application of computer graphics in automated systems for information processing and robotics. Main functionality of modern graphics systems. Prospects of development and use of geometric modeling in automated systems for information processing and robotics.				
Total with regard to 3rd semester	**18**	**38**	**0**	**86**
Total with regard to the course	**18**	**38**	**0**	**86**

Topics of exemplary laboratory work

№	Topic of laboratory work
1	The concept of graphical output interface.
2	Building shape vectors and basic manipulations.
3	Building the active GUI.
4	Creation of a sheet graphics system and animate objects.
5	Graph a surface function of two variables.
6	The geometric modeling of fractal objects.
7	Building and manipulation techniques of a three-dimensional frame figure.
8	Manipulation techniques of lighting on a 3D shape.
9	Preparation of graphic materials by means of modern graphic editors and animators.
10	Technology to perform 2D object in advanced graphics.
11	Technology for developing 3D objects and scenes in advanced graphics.
12	Technology for controlling 3D objects in advanced graphics.
13	Technology for developing interactive open graphics.

5 Organizational and Pedagogical Conditions

5.1 Educational Technologies Used for Competences Formation

Holding lectures in the discipline is based on the active method of training in the process of which students are not passive but active participants of the lesson answering questions of the teacher. Teacher's questions are aimed at activating the process of learning material as well as at the development of logical thinking. The questions stimulating associative thinking and connecting new material with the previous one are formulated by the teacher in advance.
Laboratory classes are based on an interactive learning method in which students communicate not only with the teacher but also with each other. At the same time, students' activity in the learning process dominates. The teacher's place in interactive classes is reduced to orienting students' activities to achievement of the goals of studies.
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 under-standing 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	Rogers D. F., Adams J. A. Mathematical elements for Computer Graphics, 2nd Edition, Tata McGraw-Hill, New Delhi, 2002	
	2 Additional literature	
	2.1 Educational and scientific literature	
1	Hearn D., Baker M.P., Carithers W.R. Computer Graphics with openGL, 4th Edition, Pearson Education, 2011	
2	Rogers D. F. Procedural elements for Computer Graphics, 2nd Edition, Tata McGraw-Hill, New Delhi, 2001	
	2.2 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	Introduction to Computer Graphics	https://math.hws.edu/eck/cs424/downloads/graphicsbook-linked.pdf	internet, free access

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)
Office applications	LibreOffice 6.2.4. OpenSource
Imaging Software	Adobe Photoshop CS3 Russian (PNRPU 2008)
Imaging Software	Corel CorelDRAW Suite X4 (PNRPU 2008)
General Purpose Application Software	MATHCAD 14 Academic (PNRPU 2009)
Project, research, development, design, modeling and implementation management systems	3ds Max 2018
Project, research, development, design, modeling and implementation management systems	Autodesk AutoCAD 2019 Education Multi-seat Stand-alone (s/n 564-23877442)
Project, research, development, design, modeling and implementation management systems	SOLIDWORKS Education Edition

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

Branding	Reference to information resource
Elsevier "Freedom Collection" Database	https://www.elsevier.com/
Scopus Database	https://www.scopus.com/
Electronic library system Database (eLIBRARY.RU)	https://elibrary.ru/
Scientific Library of Perm National Research Polytechnic University	http://lib.pstu.ru/
Lan' Electronic library system	https://edanbook.com/
IPR books Electronic library system	http ://www.iprbookshop.ru/
Information resources of the Network ConsultantPlus	http://www.consultant.ru/
Information and Reference System of Regulatory and Technical Documentation "Technical Expert: Norms, Rules, Standards and Legislation of Russia"	https://техэксперт.сайт/

7 Logistics of the Course Educational Process

Type of classes	Name of the necessary basic equipment	Number of units
Laboratory class	Personal computer	20
Lecture	Multimedia projector	1

8 Fund of the Course Evaluating Tools

Described in a separate document