Federal State Autonomous Educational Institution of Higher Education
Peoples' Friendship University of Russia named after Patrice Lumumba

Academy of Engineering

(name of the main educational unit (MEU) that developed the educational program of higher education)

WORKING PROGRAM OF THE DISCIPLINE

VIRTUAL AND AUGMENTED REALITY TECHNOLOGY

(name of discipline/module)

Recommended for the field of study/specialty:

27.03.04 CONTROL IN TECHNICAL SYSTEMS

(code and name of the field of study/specialty)

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

DATA SCIENCE AND SPACE SYSTEMS

(name (profile/specialization) of the educational institution of higher education)

2026

1. THE GOAL OF MASTERING THE DISCIPLINE

The course "Virtual and Augmented Reality Technology" is part of the "Data Science and Space Systems" bachelor's program in the 27.03.04 "Control in Technical Systems" program and is studied in the 7th semester of the 4th year. The course is offered by the Department of Mechanics and Control Processes. It consists of 9 sections and 24 topics and focuses on the fundamental principles of building virtual reality (VR) systems, building augmented reality (AR) systems, remote control, devices for virtual and augmented reality systems, generating 3D models and images, combining real and artificial images, examples of virtual reality system applications, examples of augmented reality system applications, psychophysiological aspects of the human-machine interface in virtual and augmented reality systems, analysis of basic methods for solving typical problems, and an introduction to their application in professional activities.

The purpose of mastering this course is to develop fundamental knowledge and skills in applying problem-solving methods necessary for professional activity, and to improve students' overall literacy in virtual and augmented reality technologies.

2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Virtual and Augmented Reality Technology" aimed at developing the following competencies (parts of competencies) in students:

Table 2.1. List of competencies developed in students while mastering the discipline (results of mastering the discipline)

Cipher	Competence	Indicators of Competency Achievement (within this discipline)
PC-1	Capable of collecting, processing and interpreting modern scientific research data necessary to draw conclusions on relevant scientific research, including Earth remote sensing data	PC-1.1 Knows modern methods of collecting, processing and interpreting data from modern scientific research necessary for drawing conclusions on relevant scientific research; PC-1.2 Able to apply modern methods and tools for processing and interpreting scientific research data; PC-1.3 Possesses the basic skills of collecting, processing and interpreting data from modern scientific research, necessary for drawing conclusions on relevant scientific research;
PC-5	Able to develop, debug, test performance, and modify software; apply software design methods and tools, develop and coordinate software documentation	PC-5.1 Knowledge of existing system and application software, software design and development methods, database structures and structures, and software interfaces. Knowledge of regulatory and technical documentation for the development of software documentation; PC-5.2: Able to apply methods and tools for designing software, data structures, databases, and programming interfaces. Able to analyze regulatory and technical documentation for the development of software documentation; PC-5.3 Possesses basic skills in technologies for development, debugging, performance testing and modification of system application software, and modernization of technical solutions for software development;

3. PLACE OF THE DISCIPLINE IN THE STRUCTURE OF THE EDUCATIONAL EDUCATIONAL INSTITUTION

Discipline “Virtual and Augmented Reality Technology” refers to the part formed by the participants of educational relations of block 1 “Disciplines (modules)” of the educational program of higher education.

As part of the higher education program, students also master other disciplines and/or practices that contribute to the achievement of the planned results of mastering the discipline "Virtual and Augmented Reality Technology".

Table 3.1. List of components of the educational program of higher education that contribute to the achievement of the planned results of mastering the discipline

Cipher	**Name of competence**	**Previous courses/modules, practical training***	**Subsequent disciplines/modules, practices***
PC-1	Capable of collecting, processing and interpreting modern scientific research data necessary to draw conclusions on relevant scientific research, including Earth remote sensing data	Research work / Scientific research work; Technological Training; Space Flight Mechanics; Numerical Methods; Automatic Control Theory; Computer Science and Programming; Optimal Control Methods; *Discrete Mathematics***; *Discrete Mathematics***; Analysis of Geoinformation Data; Introduction to Computing Science;	Technological Training; Undergraduate Training;
PC-5	Able to develop, debug, test performance, and modify software; apply software design methods and tools, develop and coordinate software documentation	Research work / Scientific research work; Technological Training; Analysis of Geoinformation Data; *Fundamentals of Information Security and Cyber Resilience***; *Fundamentals of Information Security and Cyber Resilience***;	Technological Training; Undergraduate Training;

* - filled in accordance with the competency matrix and the SUP EP HE

** - elective courses/practices

4. SCOPE OF THE DISCIPLINE AND TYPES OF EDUCATIONAL WORK

The total workload of the "Virtual and Augmented Reality Technology" course is 3 credits.

Table 4.1. Types of educational work by periods of mastering the educational program of higher education for full-time education.

Type of academic work	**TOTAL,**academic hours		**Semester(s)**
			7
Contact work, academic hours	*36*		*36*
Lectures (LC)	18		18
Laboratory work (LW)	18		18
Practical/seminar classes (SC)	0		0
Independent work of students, academic hours	*72*		*72*
Control (exam/test with assessment), academic hours	*0*		*0*
Total complexity of the discipline	**academic hours**	***108***	*108*
	credit	***3***	*3*

The total workload of the "Virtual and Augmented Reality Technology" course is 3 credits.

Table 4.2. Types of educational work by periods of mastering the educational program of higher education for full-time education.

Type of academic work	**TOTAL,**academic hours		**Semester(s)**
			7
Contact work, academic hours	*36*		*36*
Lectures (LC)	18		18
Laboratory work (LW)	18		18
Practical/seminar classes (SC)	0		0
Independent work of students, academic hours	*72*		*72*
Control (exam/test with assessment), academic hours	*0*		*0*
Total complexity of the discipline	**academic hours**	***108***	*108*
	credit	***3***	*3*

The total workload of the “Virtual and Augmented Reality Technology” course is 3 credits.

Table 4.3. Types of educational work by periods of mastering the educational program of higher education for full-time education.

Type of academic work	**TOTAL,**academic hours		**Semester(s)**
			7
Contact work, academic hours	*36*		*36*
Lectures (LC)	18		18
Laboratory work (LW)	18		18
Practical/seminar classes (SC)	0		0
Independent work of students, academic hours	*72*		*72*
Control (exam/test with assessment), academic hours	*0*		*0*
Total complexity of the discipline	**academic hours**	***108***	*108*
	credit	***3***	*3*

5. CONTENT OF THE DISCIPLINE

Table 5.1. Content of the discipline (module) by types of academic work

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
Section 1	Principles of building virtual reality (VR) systems	1.1	Review of VDR systems.	General characteristics of virtual and augmented reality technologies. Key concepts: virtual environment, augmented environment, mixed reality. Application areas: gaming, education, medicine, industry, architecture, military training. Brief overview of modern systems.	LC, LW
		1.2	History of the development of VDR systems.	Stages of development: the first experiments with stereoscopy (19th century), early virtual reality systems (1960s), the emergence of the terms "virtual reality" and "augmented reality." Technological development in the late 20th and early 21st centuries. Current status and prospects.	LC, LW
		1.3	Interaction between a human user and a reality model.	Principles of human interaction with the virtual environment. Perception channels: vision, hearing, touch, proprioception (sensation of body position). User interactions with the virtual environment: gestures, voice, body movement, control with controllers. Feedback from the system.	LC, LW
		1.4	Simulation of operations possible with real objects.	Simulation of physical interactions in a virtual environment: object capture, translation, rotation, collisions, and deformations. Requirements for realism and responsiveness. Balancing simulation accuracy with system performance.	LC, LW
		1.5	Immersive perception of the reality model.	The concept of immersion is defined as the degree of sensation of presence in a virtual environment. Factors influencing immersion include field of view, frame rate, response time, graphics and sound realism, and haptic feedback. Methods for assessing immersion.	LC, LW
Section 2	Principles of building augmented reality (AR) systems	2.1	Three-dimensional models of objects used to complement real-life scenes.	Types of 3D models used in augmented reality include polygonal models, point cloud models, and animated models. Model requirements include realism, optimization for real-time performance, and compatibility with tracking systems.	LC, LW
		2.2	Establishing a correspondence between the user's real space and the data of three-dimensional models.	Methods for linking virtual objects to real space. Using markers for positioning. Markerless methods: based on plane recognition, scene features, and depth maps. Coordinate systems in augmented reality.	LC, LW
		2.3	Tracking the user's position to determine their	Tracking the user's head position and orientation (head tracking).	LC, LW

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
			point of observation in real space.	Tracking the camera's position. Tracking technologies: optical (infrared cameras, computer vision), inertial (accelerometers, gyroscopes), magnetic, ultrasonic. Fusion of data from various sensors.	
		2.4	Real-time display of real-world scenes combined with computer graphics generated from the model.	Principles of combining real video images with virtual objects. Rendering virtual objects taking into account the lighting of the real scene. Hiding virtual objects behind real ones (occlusion). Ensuring realistic overlays (color, shadows, highlights). Frame rate and latency requirements.	LC, LW
Section 3	Remote control	3.1	Sensors, effectors, communication channels for virtual reality systems.	Sensors: types and purposes (position, orientation, motion, and biometric sensors). Effectors: devices that interact with the user (displays, speakers, haptic devices). Communication channels: wired and wireless interfaces. Bandwidth and latency requirements for virtual reality systems.	LC, LW
Section 4	Devices for virtual and augmented reality systems	4.1	Head-up display.	Head-mounted display purpose and design. Types: displays for mobile devices, standalone headsets, PC-connected headsets. Key features: resolution, field of view, refresh rate, position tracking. Ergonomics and user comfort.	LC, LW
		4.2	Stereoscopic image output device.	Principles of creating a stereoscopic effect: separating images for the left and right eyes. Stereoscopic output methods: shutter glasses, polarized glasses, anaglyph (color coding), autostereoscopic displays (glasses-free). Specific features of each method.	LC, LW
		4.3	Audio input/output devices.	Spatial sound in virtual and augmented reality systems. Headphones: open and closed, bone conduction. Microphones: directional, microphone arrays for spatial sound capture. Surround sound technologies (binoural rendering, HRTF – head-related transfer function).	LC, LW
		4.4	Sensors for spatial location of human body parts or instruments.	Sensor types: optical (LED markers, infrared cameras), inertial (accelerometers, gyroscopes), magnetic, ultrasonic. Tracking systems: internal-output (helmet cameras) and external-input (external cameras). Tracking of hands, fingers, body, and tools (controllers, styluses).	LC, LW
		4.5	Tactile input/output devices.	The concept of haptic feedback. Device types: vibration motors in controllers and gloves; devices with force feedback (exoskeletons, force-sensitive joysticks); devices with variable surface texture; devices for simulating temperature. Applications include medical	LC, LW

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
				simulators, games, and training equipment.	
		4.6	Motion information input/output devices.	Full-body tracking: suits with sensors, optical systems with markers. Virtual reality treadmills (Virtuix Omni, Kat Walk) – devices that allow movement in virtual space by physically walking. Facial expression sensors to display the user's facial expressions.	LC, LW
Section 5	Generation of 3D models and images	5.1	Types of 3D models. Rendering is the creation of images based on object models.	Types of 3D models: polygonal (meshes), voxel, parametric (NURBS – non-uniform rational B-splines), point cloud-based models. Rendering (visualization) is defined as the process of transforming a model into an image. Rendering methods: rasterization, ray tracing, photon mapping.	LC, LW
		5.2	Determining the model's surfaces. Calculating the pixel values of the resulting image.	Representation of surfaces in 3D models: faces, vertices, edges. Surface normals. Calculation of pixel color taking into account light sources, object materials, and textures. Lighting models: Lambert (diffuse illumination), Phong (specular highlights). Shading: Gouraud (per-vertex) and Phong (per-pixel).	LC, LW
Section 6	Combination of real and artificial images	6.1	Texture mapping.	The concept of texture as a two-dimensional image superimposed on the surface of a three-dimensional model. Texture coordinates (UV unwrapping). Texture filtering methods: bilinear, trilinear, and anisotropic filtering for distortion reduction. Mipmapping (pre-calculation of textures at different levels of detail). Texturing for augmented reality: superimposing virtual textures on real objects.	LC, LW
		6.2	Image-based rendering	An approach to image generation that uses real photographs or video frames instead of full 3D modeling. Technologies used: panorama creation, image-based rendering (IBR), and light fields. Application in augmented reality systems for realistically merging virtual objects with the real scene.	LC, LW
Section 7	Examples of virtual reality system applications	7.1	Inspection of architectural structures. Flight simulation. Interactive segmentation of anatomical structures.	Architectural inspections: virtual tours of buildings before they're constructed, staff training, and presentations for clients. Flight simulation: pilot simulators, non-risk emergency training. Interactive segmentation of anatomical structures in medicine: 3D visualization of organs and tissues for surgical planning and student training. Other examples: virtual museums, gaming applications, and psychotherapy.	LC, LW
Section 8	Examples of augmented reality applications	8.1	Augmented reality systems used in surgery. Printed circuit board inspection. Projecting a car dashboard onto the windshield.	Surgery: superimposing medical images (MRI, CT) onto the patient's body during surgery, navigating surgical instruments. Printed circuit board inspection: superimposing schematics and	LC, LW

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
				prompts during electronic installation and repair. Projecting a car dashboard onto the windshield (heads-up display): displaying speed, navigation, and warnings without distracting the driver. Other examples: city navigation (complementing the camera view), virtual product try-on, and repair instructions with augmented elements.	
Section 9	Psychophysiological aspects of human-machine interface in virtual and augmented reality systems	9.1	Ensuring immersive perception of virtual environments. The need for individual configuration of devices and parameters for virtual and augmented reality systems.	Factors that contribute to deep immersion include high frame rates, wide fields of view, precise motion tracking, spatial audio, and haptic feedback. Individual user differences include interpupillary distance, visual acuity, and sensitivity to latency. Device calibration and customization are necessary.	LC, LW
		9.2	Side effects of virtual and augmented reality systems on humans.	Cyberfatigue (fatigue, headache) with prolonged use. "Cybersickness" (motion sickness) is a misalignment of signals from the vestibular system and the visual system. Symptoms: nausea, dizziness. Causes: system latency, mismatch between visual and physical movement. Risk mitigation methods: improving technical specifications, limiting session time, adaptive algorithms. Impact on vision and psychoemotional state. Contraindications.	LC, LW

* - to be completed only for FULL-TIME education: LC – lectures; LW – laboratory work; SC – practical/seminar classes.

6. LOGISTIC AND TECHNICAL SUPPORT OF DISCIPLINE

Table 6.1. Material and technical support for the discipline

Audience type	Equipment of the auditorium	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
Lecture	A lecture hall equipped with specialized furniture, a whiteboard (screen), and multimedia presentation equipment.	
Laboratory	A classroom for laboratory work, individual consultations, ongoing monitoring and midterm assessment, equipped with a set of specialized furniture and equipment.	
For independent work	A classroom for independent student work (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to the Electronic Information System.	

* - the classroom for independent work of students MUST be indicated!

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF THE DISCIPLINE

Main literature:

1. Smolin A.A., Zhdanov D.D., Potemin I.S., Mezhenin A.V., Bogatyrev V.A. Systems of virtual, augmented and mixed reality. Tutorial. – St. Petersburg: ITMO University. 2018. – 59 p.

2. Azuma, Ronald T. A Survey of Augmented Reality. Presence: Teleoperators and Virtual Environments 6, 4 (August 1997), pp. 355 - 385.

Further reading:

1. Suvorov K. A. Virtual reality systems and their application // T-Comm-Telecommunications and Transport. - 2013. - No. 9.

2. E. S. Sitnikova, T. A. Kuteneva. Virtual and augmented reality: the relationship of concepts, Sociology. – 2018, pp. 298-302.

3. Viger I. Virtual reality in industry. – 2016. – No. 5 (65). –CONTROL ENGINEERING RUSSIA, pp. 68-71.

Resources of the information and telecommunications network "Internet":

1. RUDN University Electronic Library System and third-party electronic library systems to which university students have access based on concluded agreements
   - Electronic library system of RUDN - ELS RUDN http://lib.rudn.ru/MegaPro/Web
   - Electronic Library System "University Library Online" http://www.biblioclub.ru
   - EBS Yurayt http://www.biblio-online.ru
   - Electronic Library System "Student Consultant" www.studentlibrary.ru
   - Electronic Library System "Troitsky Bridge"
2. Databases and search engines
   - electronic fund of legal and regulatory documentation http://docs.cntd.ru/
   - Yandex search engine https://www.yandex.ru/
   - Google search engine https://www.google.ru/

- SCOPUS abstract database http://www.elsevierscience.ru/products/scopus/

Educational and methodological materials for independent work of students in mastering a discipline/module:*

1. Lecture course on the subject "Virtual and Augmented Reality Technology".

* - all teaching and methodological materials for independent work of students are posted in accordance with the current procedure on the discipline page in TUIS!

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