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**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

ADVANCED METHODS OF EARTH REMOTE SENSING

(name of discipline/module)

Recommended for the field of study/specialty:

27.04.04 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):

Artificial Intelligence, Machine Learning, and Space Science

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

1. THE GOAL OF MASTERING THE DISCIPLINE

The course "Advanced Methods of Earth Remote Sensing" is part of the Master's program "Artificial Intelligence, Machine Learning, and Space Sciences" in the 27.04.04 "Control in Technical Systems" program and is studied in the second semester of the first year. The course is offered by the Department of Mechanics and Control Processes. It consists of four sections and seven topics and is aimed at developing practical skills in solving problems related to the acquisition, processing, and application of Earth remote sensing data from space.

The purpose of mastering the discipline is to obtain knowledge, skills, abilities and experience in the field of remote sensing of the earth, characterizing the stages of the formation of competencies and ensuring the achievement of the planned results of mastering the educational program

2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the course "Modern Methods of Remote Sensing of the Earth" 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)
GPC-1	Able to analyze and identify the natural scientific essence of control problems in technical systems based on provisions, laws and methods in the field of natural sciences and mathematics	GPC-1.1 Knows the basic laws, provisions and methods in the field of natural sciences and mathematics; GPC-1.2 Able to identify the natural scientific essence of control problems in technical systems guided by the laws and methods of natural sciences and mathematics; GPC-1.3 Proficient in tools for analyzing control problems in technical systems.
GPC-4	Capable of assessing the effectiveness of the results of development of control systems using mathematical methods	GPC-4.1 Knows the basic mathematical methods used to evaluate the effectiveness of the results of control systems; GPC-4.2 Able to apply mathematical methods to evaluate the effectiveness of the results of management systems; GPC-4.3 Proficient in methods for assessing the effectiveness of management systems.
GPC-6	Capable of collecting and analyzing scientific and technical information, generalizing domestic and foreign experience in the field of automation and control equipment	GPC-6.1 Knows the basic methods of collecting and analyzing scientific and technical information; GPC-6.2 Able to analyze and generalize domestic and foreign experience in the field of automation and control equipment; GPC-6.3 Has mastered the methods of collecting and analyzing scientific and technical information, and can also generalize domestic and foreign experience in the professional field.
PC-3	Capable of carrying out work and research on the processing and analysis of scientific and technical information obtained using geographic information systems and technologies	PC-3.1 Able to analyze the results of theoretical and experimental research; PC-3.2 Able to formulate recommendations for improving devices and systems, prepare scientific research results for publication and prepare documents for filing an invention application; PC-3.3 Participates in the analysis of research results, has the skills to formulate recommendations for improving devices and systems, as well as write articles and submit documents for registration of inventions.;
PC-4	Capable of participating in scientific research and development of design solutions in the field of ballistics, dynamics and flight control of spacecraft	PC-4.1 Familiar with the basic methods and approaches used to solve problems in the field of artificial intelligence and robotic systems; PC-4.2 Proficient in methods for solving professional problems in the field of artificial intelligence and robotic systems; PC-4.3 Able to apply mathematical methods and modern information technologies when conducting scientific research.

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

Course "Modern Methods of Remote Sensing of the Earth" refers to the mandatory part 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 "Modern Methods of Remote Sensing of the Earth."

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*
GPC-6	Capable of collecting and analyzing scientific and technical information, generalizing domestic and foreign experience in the field of automation and control equipment	Machine Learning and Big Data Mining;	Research work / Scientific research work; Undergraduate Training;
GPC-1	Able to analyze and identify the natural scientific essence of control problems in technical systems based on provisions, laws and methods in the field of natural sciences and mathematics	Virtual Reality and Computer Vision; Numerical Methods for Solving Mathematical Modeling Problems; Information Technology in Mathematical Modeling; Programming Technology;	Geoinformation Systems and Applications; Undergraduate Training;
GPC-4	Capable of assessing the effectiveness of the results of development of control systems using mathematical methods	History and Methodology of Science;	Undergraduate Training; Dynamics and Control of Space Systems;
PC-3	Capable of carrying out work and research on the processing and analysis of scientific and technical information obtained using geographic information systems and technologies	Virtual Reality and Computer Vision;	Research work / Scientific research work; Undergraduate Training;
PC-4	Capable of participating in scientific research and development of design solutions in the field of ballistics, dynamics and flight control of spacecraft	History and Methodology of Science;	Research work / Scientific research work; Undergraduate Training; Dynamics and Control of Space Systems; <i>Artificial Neural Networks (Reinforcement Learning)**;</i>

* - 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 course “Modern Methods of Remote Sensing of the Earth” is 6 credit units.

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)
			2
<i>Contact work, academic hours</i>	72		72
Lectures (LC)	36		36
Laboratory work (LW)	36		36
Practical/seminar classes (SC)	0		0
<i>Independent work of students, academic hours</i>	117		117
<i>Control (exam/test with assessment), academic hours</i>	27		27
Total complexity of the discipline	academic hours	216	216
	credit	6	6

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	Introduction.	1.1	Definition and overview of the history of remote sensing and the evolution of remote sensing and remote sensing system.	Definition of Earth remote sensing. History of development: aerial photography, early satellite systems (Landsat, SPOT, MODIS). Evolution of remote sensing systems: from film cameras to hyperspectral sensors. Modern space and aviation systems. Development trends: ultra-high resolution, satellite miniaturization (CubeSat).	LC, LW
		1.2	Electromagnetic radiation (EMR), terms and definitions, radiation laws, EM spectrum, EMR sources.	Electromagnetic radiation: nature and properties. Key terms: wavelength, frequency, quantum energy. Radiation laws: Planck's law, Wien's law, Stefan-Boltzmann law. Electromagnetic radiation spectrum: ultraviolet, visible, infrared, microwave, radio. Natural and artificial sources of EMR. Interaction of EMR with the atmosphere and the Earth's surface.	LC, LW
Section 2	Remote sensing systems	2.1	Active and passive systems, mapping and other systems, the concept of resolution in remote sensing - spatial, spectral, radiometric and temporal.	Passive systems: recording reflected or intrinsic radiation (optical, thermal sensors). Active systems: intrinsic radiation source (radars, lidars). Mapping systems (scanners, CCD arrays). Resolution concepts: spatial, spectral, radiometric, temporal. Compromise between resolution types.	LC, LW
		2.2	Earth observation orbits and platforms.	Orbit types: geostationary, polar sun-synchronous, low Earth orbit. Orbit characteristics: altitude, inclination, orbital period. Space platforms: large satellites (Landsat, Sentinel, MODIS), small satellites (CubeSat, MicroSat). Aircraft platforms: airplanes, unmanned aerial vehicles (UAVs). Ground platforms: stationary and mobile measurement systems.	LC, LW
Section 3	Reception and processing of images	3.1	Reception, processing and creation of information products.	Data acquisition: ground stations, cloud services (USGS Earth-Explorer, Copernicus Open Access Hub). Preprocessing: radiometric and atmospheric correction, geometric correction. Thematic processing: classification (supervised and unsupervised), vegetation index calculation (NDVI, SAVI), detection modification. Creation of information products: thematic maps, reports, image series.	LC, LW
		3.2	Mastering the freely distributed MultiSpec program for analyzing multi-spectral Landsat data (using various objects and industries as	Introduction to the MultiSpec interface. Loading multispectral Landsat data. Band visualization. Creating composite images. Supervised classification: selecting training sites, classification	LC, LW

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
			examples).	algorithms (maximum likelihood, minimum distance). Evaluating classification accuracy. Calculating indices. Examples of analysis for various objects and industries.	
Section 4	Applications	4.1	Applied use of remote sensing in Earth, Ocean, Atmospheric, Emergency and Climate Change Sciences.	Earth Sciences: Geological mapping, mineral exploration, volcano and earthquake studies. Ocean: Surface temperature, ocean color (chlorophyll), sea level, sea ice. Atmosphere: Temperature, precipitation, cloud cover, aerosols, ozone layer. Emergencies: Floods, forest fires, landslides, earthquakes – operational mapping and damage assessment. Climate Change: Monitoring glaciers, sea level, and the carbon cycle.	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.	
Computer class	A computer room for conducting classes, group and individual consultations, ongoing monitoring and midterm assessment, equipped with personal computers (15 in total), a board (screen) and technical means for multimedia presentations.	
Seminar	An auditorium for conducting seminar-type classes, group and individual consultations, ongoing monitoring and midterm assessment, equipped with a set of specialized furniture and technical means for multimedia presentations.	
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. George Joseph: Fundamentals of Remote Sensing; Universities Press India Pvt Ltd, Hyderabad, India
2. Editors: John D. Bossler; John R. Jensen; Robert B. McMaster; Chris Rizos, 2001. Manual of Geospatial Science and Technology, November 2001, Vol 1 Part I and II.
3. Paul M. Mather, 1999. Computer Processing of Remotely Sensed Images: An Introduction. John Wiley
4. Lillesand Thomas M. & Kiefer Ralph: Remote Sensing and Image Interpretation Third Edition John Wiley
5. Campbell John B.: Introduction to Remote Sensing Taylor & Francis
6. Floyd F. Sabins: Remote Sensing and Principles and Image Interpretation
7. Manual of Remote Sensing: American Society of Photography and Remote Sensing
8. Dozier J 1984 Snow reflectance from Landsat-4 Thematic Mapper; IEEE Transactions on Geoscience and Remote Sensing, GE-22 (3) 323
9. Peter M. Atkinson, Nicholas J. Tate, Advances in Remote Sensing and GIS Analysis.
10. Chein-I Chang, Hyperspectral Imaging: Techniques for Spectral Detection and Classification, Springer; 1 edition (July 31, 2003).

11. Andrew Skidmore, *Environmental Modeling with GIS and Remote Sensing*, Published 2002 CRC Press.

Further reading:

1. T. Takagi, T. Oguchi, J. Matsumoto, M. J. Grossman, M. H. Sarker, M. A. Matin (2007) Channel braiding and stability of the Brahmaputra River, Bangladesh, since 1967: GIS and remote sensing analyses, *Geomorphology* 85, 294–305

2. John D. Bossler; John R. Jensen; Robert B. McMaster; Chris Rizos, (Editors), 2001. Photogrammetric and remote sensing considerations; Chapter 16, *Manual of Geospatial Science and Technology*, Vol 1 Part 4 Pages 233 – 252

3. John D. Bossler; John R. Jensen; Robert B. McMaster; Chris Rizos (Editors), 2001. The remote sensing process: how do we collect the required in situ and remotely sensed data? Chapter 17, *Manual of Geospatial Science and Technology*, November 2001, Vol 1 Part 4 Pages 253 – 275

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

- RUDN University Electronic Library System – RUDN University Electronic Library System <https://mega.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
- EBS "Knowledge" <https://znanium.ru/>

2. Databases and search engines

- Sage <https://journals.sagepub.com/>
- Springer Nature Link <https://link.springer.com/>
- Wiley Journal Database <https://onlinelibrary.wiley.com/>
- Scientometric database Lens.org <https://www.lens.org>

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

1. Lecture course on the subject "Modern methods of remote sensing of the Earth".

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

DEVELOPER:

Associate Professor

Position, DEPARTMENT

Signature

Dryga Danil Olegovich

Surname I.O.

HEAD OF THE DEPARTMENT:

Head of Department

Position of the DEPARTMENT

Signature

Razumny Yuri Nikolaevich

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HEAD OF THE EP HE:

Professor

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