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 PYTHON PROGRAMMING FOR SPATIAL ANALYTICS
(name of discipline/module)

Recommended for the field of study/specialty:

27.04.04 CONTROL IN TECHNICAL SYSTEMS
(code and name of the training area/specialty)

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

AIML and Space Sciences / Artificial Intelligence, Machine Learning and Space Sciences
(name (profile/specialization) of the educational institution of higher education)

2025

1. THE GOAL OF MASTERING THE DISCIPLINE

The course "Advance Python Programming for Spatial Analytics" is part of the Master's program "Artificial Intelligence, Machine Learning and Space Sciences" in the direction 27.04.04 "Control in Technical Systems" and is studied in the 2nd semester of the 1st year. The course is implemented by the Department of the Partner University. The course consists of 4 sections and 10 topics and is aimed at studying the tools and methods for designing pipelines for processing large geodata, optimizing calculations through parallelization and acceleration.

The goal of mastering the discipline is to develop skills in developing high-performance geoanalytical solutions in Python, mastering advanced methods of processing raster/vector data and spatial modeling, and preparing for the creation of complex GIS applications using modern technology stacks.

2. REQUIREMENTS TO THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the course "Advanced Python Programming for Spatial Analytics" is 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 Competence Achievement** (within the framework of this discipline)
GPC-9	Capable of developing methods and performing experiments on existing facilities with processing of results based on information technologies and technical means	GPC-9.1 Possesses modern information technologies and technical means for conducting experiments at operating facilities; GPC-9.2 Has skills in developing methods and conducting experiments at existing facilities; GPC-9.3 Has the skills to develop methods and perform experiments at existing facilities with processing of results using information technology;
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 generate documents for filing an application for an invention; PC-3.3 Participates in the analysis of research results, has the skills to formulate recommendations for improving devices and systems, as well as writing articles and submitting documents for registration of inventions;

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

Course "Advanced Python Programming for Spatial Analytics" 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 "Advanced Python Programming for Spatial Analytics".

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, practices*	Subsequent disciplines/modules, practices*
GPC-9	Capable of developing methods and performing experiments on existing facilities with processing of results based on information technologies and technical means	Introduction to Geospatial Technology;	Dynamics and Control of Space Systems; Geoinformation Systems and Applications; Undergraduate practice / Pre-graduation practice;
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	Introduction to Geospatial Technology;	Undergraduate practice / Pre-graduation practice;

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

** - elective disciplines/practices

4. SCOPE OF THE DISCIPLINE AND TYPES OF STUDY WORK

The total workload of the course "Advance Python Programming for Spatial Analytics" is "4" 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,**ac.h.		**Semester(s)**
			2
Contact work, academic hours	*34*		*34*
Lectures (LC)	17		17
Laboratory work (LW)	17		17
Practical/seminar classes (SC)	0		0
Independent work of students, academic hours	*83*		*83*
Control (exam/test with assessment), academic hours	*27*		*27*
General complexity of the discipline	**ac.h.**	***144***	*144*
	credit.ed.	***4***	*4*

5. CONTENT OF THE DISCIPLINE

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

Section number	Name of the discipline section	Section Contents (Topics)		Type of academic work*
Section 1	Advanced Spatial Analysis Libraries	1.1	- Geoprocessing:* - geopandas (spatial joins, overlay operations) - rasterio + xarray (working with multidimensional raster data)	LC, LW
		1.2	- *Performance:* - Vectorization of operations with numba - Parallel processing with dask-geopandas	LC, LW
		1.3	- Graphs and visualization:* - Interactive maps (folium, ipyleaflet) - 3D relief visualization (pyvista)	LC, LW
Section 2	Spatial databases and clouds	2.1	- PostgreSQL/PostGIS:* - Optimization of spatial queries - Integration with Python (geoalchemy2, asyncpg)	LC, LW
		2.2	- Cloud platforms:* - Working with Google Earth Engine API - Deploying pipelines on AWS Batch	LC, LW
Section 3	Specialized applications	3.1	- Analysis of changes:* - Change detection from satellite images (rasterstats, scikit-image)	LC, LW
		3.2	- City analytics:* - Calculation of service availability (isochrones with osmnx) - Traffic flow modeling (sumo-py)	LC, LW
		3.3	- Natural risks:* - Flood forecasting with hydrological models (pysheds)	LC, LW
Section 4	Development of GIS applications	4.1	- Web GIS:* - Creating dashboards (dash + plotly) - Geoservices on Flask/FastAPI	LC, LW
		4.2	- Architecture:* - Microservices for spatial analytics - Deploy to Docker/Kubernetes	LC, LW

* - filled in 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 of the discipline

Audience type	Equipping the auditorium	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
Lecture	An auditorium for conducting lecture-type classes, equipped with a set of specialized furniture; a board (screen) and technical means for multimedia presentations.	
Computer class	A computer room for conducting classes, group and individual consultations, ongoing	

Audience type	Equipping the auditorium	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
	monitoring and midterm assessment, equipped with personal computers (14 in total), a board (screen) and technical means for multimedia presentations.	
For independent work	A classroom for independent work of students (can be used for conducting seminars and consultations), equipped with a set of specialized furniture and computers with access to the Electronic Information System.	

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

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF THE DISCIPLINE

Main literature:

1. McClain BP Python for geospatial data analysis. – "O'Reilly Media, Inc.", 2022.
2. Lawhead J. Learning geospatial analysis with Python. – Packt Publishing Ltd, 2015.

Further reading:

1. Herndon KE et al. Google Earth Engine for archaeologists: An updated look at the progress and promise of remotely sensed big data //Journal of Archaeological Science: Reports. – 2023. – T. 50. – P. 104094.
2. Ngo TP et al. 3D Modeling of Geospatial Data Using PyVista: A Free and Open Source Framework //EAI International Conference on Renewable Energy and Sustainable Manufacturing. –Cham: Springer Nature Switzerland, 2023. – pp. 739-755.

Resources of the information and telecommunications network "Internet":

1. RUDN University EBS and third-party EBSs to which university students have access on the basis of concluded agreements
   - Electronic library system of RUDN - ELS RUDN https://mega.rudn.ru/MegaPro/Web
   - Electronic library system "University library online"http://www.biblioclub.ru
   - EBS "Yurait"http://www.biblio-online.ru
   - Electronic Library System "Student Consultant" www.studentlibrary.ru
   - EBS "Znanium"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 "Advanced programming onPython for Spatial Analytics".

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

DEVELOPER:

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