Federal State Autonomous Educational Institution of Higher Education

PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA
RUDN University

Faculty of Physics, Mathematics and Natural Sciences

educational division (faculty/institute/academy) as higher education programme developer

COURSE SYLLABUS

«Introduction to Neural Networks, Big Data Analysis and Machine Learning»
course title

Recommended by the Didactic Council for the Education Field of:

01.04.01 Mathematics
field of studies / speciality code and title

The course instruction is implemented within the professional education programme of higher education:

«Functional methods in differential equations and interdisciplinary research»

higher education programme profile/specialisation title

2025

1. COURSE GOAL(s)

The purpose of mastering the discipline is to form an understanding of modern mathematical packages that allow solving applied problems in mathematics and physics. In practical classes, in the process of solving the assigned problems from the field of mathematical physics, optimization and random processes, to instill skills in using the mathematical packages corresponding to the problems. The implementation of this goal includes a consistent acquaintance and mastering of mathematical software and practicing problem solving techniques in practical and laboratory classes; midterm and final control reveal the degree of assimilation of the acquired skills. As a result, the course should demonstrate the connection between linear algebra, programming and solving current problems of data analysis.

2. REQUIREMENTS FOR LEARNING OUTCOMES

Mastering the discipline "Non-Euclidean geometries and their applications" is aimed at developing the following competencies (parts of competencies):

Table 2.1. List of competences that students acquire through the course study

Code	Competence	Competence achievement indicators (within this discipline)
PC-1	Able to conduct scientific research and obtain new scientific and applied results independently and as part of a scientific team	PC-1.1. Draws up a general research plan and detailed plans for individual stages
		PC-1.2. Selects experimental and computational-theoretical methods for solving the problem based on the available material and time resources

3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The discipline refers to the part formed by the participants in the educational relations of block B1 of the EP HE. As part of the EP HE, students also master other disciplines and / or practices that contribute to the achievement of the planned results of mastering the discipline.

Table 3.1. The list of the higher education programme components/disciplines that contribute to the achievement of the expected learning outcomes as the course study results

Code	Competence	Previous disciplines/modules, practices	Subsequent disciplines/modules, practices*
PC-1	Able to conduct scientific research and obtain new scientific and applied results independently and as part of a scientific team	-	Research work, Undergraduate practice, State examination

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total labor intensity of the discipline is 3 credits.

*Table 4.1. Types of academic activities during the periods of higher education programme mastering (**full-time training**)**

Type of study work		TOTAL, a.h.	Semester			
			1	2	3	4
Contact work, academic hours		*72*	*72*			
Lectures (LC)		36	36			
Lab work (LW)						
Seminars (workshops/tutorials) (S)		36	36			
Self-studies		*36*	*36*			
Evaluation and assessment (exam/passing/failing grade)						
Course workload	a.h.	**108**	**108**			
	credits	**3**	**3**			

5. COURSE CONTENTS

Table 5.1. Course contents and academic activities types

№	Course Module Title	Brief Description of the Module Content	Type of study work
1	Introduction. Basics of programming in Python. Data types and working with them, working with the file system.	The main types of mathematical packages used in modern applied mathematics and physics, the pros and cons of the Matlab package and the Python language. Simple data types, complex data types, operations and functions for working with them, reading and writing from files. Working with strings, lists, solving problems in https://py.checkio.org/	Lecture, seminar
2	Working with strings and lists in python	Solving the Sudoku problem. Caesar, Vigenere, RSA encryption algorithms. Writing a messenger, the Flask library. Writing and running tests	Lecture, seminar
3	Basics of working with Jupyter Notebook. Mathematical expressions and functions, linear algebra.	Studying the interface, editing and running scripts, plotting graphs. Working with numpy, pandas, matplotlib libraries, plotting graphs.	Lecture, seminar
4	Analysis of functional dependencies and data processing.	Solution of systems of linear equations. Least squares method. Principal component method. Interpolation of functions by polynomials.	Lecture, seminar
5	Singular Value Decomposition of Matrices, Principal Component Analysis	Multivariate Gaussian Distribution. Covariance and Correlation Matrix. Singular Value Decomposition of Matrices. Principal Component Analysis. Data Visualization.	Lecture, seminar
6	Working with tabular data in	Introduction to the concept of classical machine learning. Tabular data. The pandas library, methods	Lecture, seminar

	pandas	head, tail, info, describe, loc, iloc, apply, groupby, unique, nunique, drop, dropna	
7	Classical machine learning	Classification and regression problem. Linear regression. Loss function. Regularization. Lasso and Ridge regression. Working with the scikit-learn library. Cross-validation, retraining, estimation of algorithm hyper-parameters.	Lecture, seminar
8	Basics of Classification and Regression	Linear discriminant analysis. Decision rule, separating hyperplane. Linear and quadratic programming. Support vector machine. Explicit and implicit coordinate transformation. Kernel trick.	Lecture, seminar
9	Optimization methods in machine learning	Gradient descent, Newton's method. Logistic regression. Gradient and Hessian calculation. Linear step search.	Lecture, seminar
10	Non-metric classification methods	Logical classification methods, decision trees, information gain criterion	Lecture, seminar
11	Ensemble Algorithms	Ensemble Algorithms. Random Forest and Gradient Boosting over Decision Trees. CATBoost Algorithm.	Lecture, seminar
12	Pytorch Basics	Pytorch and Neural Networks	Lecture, seminar

. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 6.1. Classroom equipment and technology support requirements

Classroom type	**Classroom equipment**	**Specialized educational/laboratory equipment, software and materials for mastering the discipline**
Lecture	An auditorium for lecture-type classes, equipped with a set of specialized furniture; board (screen) and technical means of multimedia presentations.	-
Seminar	An auditorium for conducting seminar-type classes, group and individual consultations, current control and intermediate certification, equipped with a set of specialized furniture and technical means for multimedia presentations.	-
For independent work of students	An auditorium for conducting seminar-type classes, group and individual consultations, current control and intermediate certification, equipped with a set of specialized furniture and technical means for multimedia presentations.	-

7. RESOURCES RECOMMENDED FOR COURSE STUDY

Main literature:

1. *Swaroop C.H.* A Byte of Python. 2013.
2. *Muhammad Yasoob Ullah Khalid.* Intermediate Python [electronic resource]. URL: https://github.com/lancelote/interpy-ru
3. Gayle Laakmann McDowell. Cracking the Coding Interview.

Additional literature:

1. *Robert Sedgewick, Kevin Wayne, Robert Dondero. Introduction to Programming in Python: An Interdisciplinary Approach*
2. *Wes McKinney. Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter.*
3. *Chollet F.* Deep Learning with Python.

Resources of the information and telecommunications network "Internet":

Software – Python, Jupyter Notebook, numpy, pandas, cvxopt, sklearn.

8. ASSESSMENT TOOLKIT AND GRADING SYSTEM* FOR EVALUATION OF STUDENTS' COMPETENCES LEVEL UPON COURSE COMPLETION

Evaluation materials and a point-rating system* for evaluating the level of formation of competencies (parts of competencies) based on the results of mastering the discipline "Non-Euclidean geometries and their applications" are presented in the Appendix to this Work Program of the discipline

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