Federal State Autonomous Educational Institution of Higher Education
"Peoples' Friendship University of Russia"

Academy of Engineering
(Name of the main educational unit (MEU)- of the developer of the EP of HE)

THE WORKING PROGRAM OF THE DISCIPLINE

Artificial Neural Networks (Deep Learning)
(Name of the discipline/module)

Recommended by Methodological Council for the Education Field for the direction of training/specialization

01.04.02 Applied mathematics and computer science
(code and name of the direction of training / specialization)

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

Ballistic Design of Space Complexes and Systems
(name (profile/specialization) EP HE)

2022 г.

1. GOAL OF MASTERING THE DISCIPLINE

Goal of mastering the discipline «Artificial Neural Networks (Deep Learning)» is to study the method of constructing automatic control systems based on artificial neural networks, mastering methods for solving basic control problems using neural networks.

2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Artificial Neural Networks (Deep Learning)" is aimed at developing the following competencies:

Table 2.1. The list of competencies formed by students in the course of mastering the discipline (the results of mastering the discipline)

Code	Competence	Competence achievement indicators (within this discipline)
UC-1	Able to search, critical analysis of problem situations based on a systematic approach, develop an action strategy	UC-1.1 - Analyzes the task, highlighting its basic components; UC-1.2 - Determines and ranks the information required to solve the problem; UC-1.3 - Searches for information to solve the task for various types of requests; UC-1.4 - Offers options for solving the problem, analyzes the possible consequences of their use
UC-6	Able to identify and implement the priorities of their own activities and ways to improve it based on self-assessment	UC 6.3 - Analyzes his resources and their limits (personal, situational, temporary, etc.) for the successful completion of the task;
UC-7	Able to: search for the necessary sources of information and data, perceive, analyze, memorize and transmit information using digital means, as well as using algorithms when working with data received from various sources in order to effectively use the information received to solve problems; evaluate information, its reliability, build logical conclusions based on incoming information and data	UK-7.1 - Searches for the necessary sources of information and data, perceives, analyzes, remembers and transmits information using digital means, as well as using algorithms when working with data received from various sources of data in order to effectively use the information received to solve problems; UK-7.2 - Evaluates information, its reliability, builds logical conclusions based on incoming information and data.

Code	Competence	Competence achievement indicators (within this discipline)
PC-1	Able to formulate goals, objectives of scientific research in the field of applied mathematics and informatics, computer technology and modern programming technologies, choose methods and means of solving problems	PC-1.1 - Possesses fundamental knowledge obtained in the field of mathematical and (or) natural sciences, programming and information technology
PC-2	Able to apply modern theoretical and experimental methods for developing mathematical models of the objects and processes under study related to professional activities in the field of training and participate in their implementation in the form of software products	PC-2.1 - Knows modern theoretical and experimental methods for developing mathematical models, innovative design tools and elements of architectural solutions for information systems PC-2.2 - Able to develop and implement algorithms for mathematical models based on languages and packages of applied modeling programs PC-2.3 - Has practical experience in developing options for implementing information systems using innovative tools

3. THE PLACE OF DISCIPLINE IN THE STRUCTURE OF EP HE

Discipline "Artificial Neural Networks (Deep Learning)" belongs to obligatory part / part formed by participants in educational relations of block Б1 О.02.06 НЕ.

Students also master other disciplines and / or practices that contribute to the achievement of the planned results of mastering the discipline " Artificial Neural Networks (Deep Learning)".

Table 3.1. The list of components of the EP HE that contribute to the achievement of the planned results of the development of the discipline

Code	Competence	Previous disciplines/modules, practices*	Subsequent disciplines/modules, practices*
UC-1	Able to search, critical analysis of problem situations based on a systematic approach, develop an action strategy	Big Data Mining	Research work
UC-6	Able to identify and implement the priorities of their own activities and ways to improve it based on self-assessment		Research work
PC-1	Able to formulate goals, objectives of scientific research in the field of applied mathematics and informatics, computer technology	Big Data Mining Applied Problems of Mathematical Modeling	Research work

Code	Competence	Previous disciplines/modules, practices*	Subsequent disciplines/modules, practices*
	and modern programming technologies, choose methods and means of solving problems		
PC-2	Able to apply modern theoretical and experimental methods for developing mathematical models of the objects and processes under study related to professional activities in the field of training and participate in their implementation in the form of software products	Big Data Mining Applied Problems of Mathematical Modeling	Research work

4. ОБЪЕМ ДИСЦИПЛИНЫ И ВИДЫ УЧЕБНОЙ РАБОТЫ

The total labor intensity of the discipline "Artificial Neural Networks (Deep Learning)" is 6 credit units.

Table 4.1. Types of educational work for full-time education

Вид учебной работы		Total	Semester			
			1	2	3	4
Classroom lessons (total)		72		72		
including						
Lectures (L)		36		36		
Practical lessons (PL)		18		18		
Seminars (S)		18		18		
Laboratory work (LW)		*81*		*81*		
Control (exam/test with assessment), total		*27*		*27*		
Total labor intensity	hour	**180**		**180**		
	CU	**5**		**5**		

5. CONTENT OF THE DISCIPLINE

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

Name of discipline section	Content of the section (topics)	Types of educational work *
Section 1 Mathematical Foundations of Deep Learning for Artificial Neural Networks	Topic 1.1. Linear Algebra Scalars, Vectors, Matrices and Tensors, Multiplying Matrices and Vectors, Identity and Inverse Matrices, Linear Dependence and Span, Norms, Special Kinds of Matrices and Vectors, Eigen decomposition, Singular Value, Decomposition, The Moore-Penrose,	L, S

Name of discipline section	Content of the section (topics)	Types of educational work *
	Pseudoinverse, The Trace Operator, The Determinant, Principal Components Analysis.	
	Topic 1.2. Theory of Probability Random Variables, Probability Distributions, Marginal Probability, Conditional Probability, The Chain Rule of Conditional Probabilities, Independence and Conditional Independence, Expectation, Variance and Covariance, Common Probability Distributions, Useful Properties of Common Functions, Bayes' Rule, Technical Details of Continuous Variables	L, S
	Topic 1.3. Information theory, Structured Probabilistic Models	L, S
Section 2 Machine Learning Basics	Topic 2.1. Learning Algorithms, Capacity, Overfitting and Underfitting, Hyperparameters and Validation Sets, Estimators, Bias and Variance, Maximum Likelihood Estimation, Bayesian Statistics	L, S
	Topic 2.2. Supervised Learning Algorithms	L, S
	Topic 2.3. Unsupervised Learning Algorithms	L, S
Section 3. Deep Feedforward Networks	Topic 3.1. Example: Learning XOR, Gradient-Based Learning, Hidden Units, Architecture Design, Back-Propagation and Other Differentiation Algorithms.	L, S
Section 4. Optimization for Training Deep Models	Topic 4.1. Challenges in Neural Network Optimization, Basic Algorithms, Parameter Initialization Strategies, Algorithms with Adaptive Learning Rates	L, S
	Topic 4.2. Approximate Second-Order Methods, Optimization Strategies and Meta-Algorithms	
Section 5. Convolutional Networks	Topic 5.1. The Convolution Operation, Motivation Pooling, Convolution and Pooling as an Infinitely Strong Prior, Variants of the Basic Convolution Function, Structured Outputs, Data Types, Efficient Convolution Algorithms, Random or Unsupervised Features. The Neuroscientific Basis for Convolutional Networks	L, S
Section 6. Sequence Modeling: Recurrent and Recursive Nets	Topic 6.1. Unfolding Computational Graphs, Recurrent Neural Networks, Bidirectional RNNs, Encoder-Decoder Sequence-to-Sequence Architectures, Deep Recurrent Networks	L, S, LR
	Topic 6.2. Recursive Neural Networks, The Challenge of Long-Term Dependencies, Echo State Networks, Leaky Units and Other Strategies for Multiple Time Scales, The Long Short-Term Memory and Other Gated RNNs, Optimization for Long-Term Dependencies, Explicit Memory	

Name of discipline section	Content of the section (topics)	Types of educational work *
Section 7. Representation Learning	Topic 7.1. Greedy Layer-Wise Unsupervised Pretraining, Transfer Learning and Domain Adaptation, Semi-Supervised Disentangling of Causal Factors, Distributed Representation Exponential Gains from Depth, Providing Clues to Discover Underlying Causes	L, S
Section 8. Structured Probabilistic Models for Deep Learning	Topic 8.1. The Challenge of Unstructured Modeling, Using Graphs to Describe Model Structure, Sampling from Graphical Models, Advantages of Structured Modeling, Learning about Dependencies, Inference and Approximate Inference, The Deep Learning Approach to Structured Probabilistic Models	L, S
Section 9. Monte Carlo Methods	Topic 9.1. Sampling and Monte Carlo Methods, Importance Sampling, Markov Chain Monte Carlo Methods, Gibbs Sampling, The Challenge of Mixing between Separated Modes	L, S
Section 10. Deep Generative Models	Topic 10.1. Boltzmann Machines, Restricted Boltzmann Machines, Deep Belief Networks, Deep Boltzmann Machines, Boltzmann Machines for Real-Valued Data, Convolutional Boltzmann Machines, Boltzmann Machines for Structured or Sequential Outputs, Other Boltzmann Machines,	L, S
	Topic 10.2. Back-Propagation through Random Operations, Directed Generative Nets, Drawing Samples from Autoencoders. Generative Stochastic Networks, Other Generation Schemes, Evaluating Generative Models	

6. TECHNICAL EQUIPMENT FOR THE DIDISCIPLINE

Table 6.1. Technical equipment for the discipline

Audience type	Audience equipment	Specialized educational / laboratory equipment, software and materials for mastering the discipline (if needed)
Lection	An auditorium for lecture-type classes, equipped with a set of specialized furniture; board (screen) and technical means of multimedia presentations.	Computer classroom equipped with 25 workstations with a personal computer, specialized software for laboratory work and practical lessons
Labor	An auditorium for laboratory work, individual consultations, current control and intermediate certification, equipped with a set of specialized furniture and equipment.	Classroom equipped with 30 workstations for lectures and group lessons
Seminar	An auditorium for conducting seminar-type classes, group and individual consultations, current	Computer classroom equipped with 25 workstations with a personal

	control and intermediate certification, equipped with a set of specialized furniture and technical means for multimedia presentations.	computer, specialized software for laboratory work and practical lessons
Computer class	Computer class for conducting classes, group and individual consultations, current control and intermediate certification, equipped with personal computers (in the amount of ____ pcs.), Board (screen) and multimedia equipment презентаций.	
Individual work	An auditorium for independent work of students (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to the EIES.	

7.INFORMATION SUPPORT OF THE DISCIPLINE

Main literature:

1. I. Goodfellow, Y. Bengio, A. Courville Deep Learning. The MIT Press Cambridge, Massachusetts London, England, 2016, 800 pp, ISBN: 0262035618
2. С. Николенко, А. Кадурин, Е. Архангельская. Глубокое обучение. Погружение в мир нейронных сетей. СПб.: Питер, 2018. - 480 с.: ил. - ISBN 978-5-496-02536-2

Additional literature:

1. F. Chollet. Deep Learning with Python. Manning Shelter Island, NY 11964 2018 – 398 pp.
2. ……

Resources of the information and telecommunications network "Internet":

1. ELS of RUDN University and third-party ELS, to which university students have access on the basis of concluded agreements:

RUDN Electronic Library System - RUDN EBS http://lib.rudn.ru/MegaPro/Web
- ELS "University Library Online" http://www.biblioclub.ru
- EBS Yurayt http://www.biblio-online.ru
- ELS "Student Consultant" www.studentlibrary.ru
- EBS "Lan" http://e.lanbook.com/
- EBS "Trinity Bridge"

2. Databases and search engines:
- electronic fund of legal and normative-technical documentation http://docs.cntd.ru/
- Yandex search engine https://www.yandex.ru/
- Google search engine https://www.google.ru/
- abstract database SCOPUS http://www.elsevierscience.ru/products/scopus/

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

1. Course of lectures
2. Laboratory workshop

8. EVALUATION MATERIALS AND SCORE-RATING SYSTEM FOR ASSESSING THE LEVEL OF FORMATION OF COMPETENCES IN THE DISCIPLINE

In accordance with the requirements of the OS VO RUDN University, for attestation of students for compliance of their personal achievements with the planned discipline learning outcomes, assessment tools funds have been created (VF is presented in Annex 1).

The teacher has the right to change the number and content of assignments given to students (student), based on the contingent (their level of preparedness).

Developer:

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