

Документ подписан простой электронной подписью  
Информация о владельце:  
ФИО: Ястребов Олег Александрович  
Должность: Ректор  
Дата подписания: 28.06.2024 13:09:12  
Уникальный программный ключ:  
ca953a0120d891083f939673078ef1a989dae18a

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

**Academy of Engineering**

(name of the main educational unit (POU) - developer of the EP HE)

## **COURSE SYLLABUS**

**ARTIFICIAL NEURAL NETWORKS (DEEP LEARNING) /  
ИСКУССТВЕННЫЕ НЕЙРОННЫЕ СЕТИ (ГЛУБОКОЕ ОБУЧЕНИЕ)**

(name of discipline/module)

**Recommended by the Didactic Council for the Education Filed of:**

**27.04.04 CONTROL IN TECHNICAL SYSTEMS**

(code and name of the area of training/specialty)

**The discipline is mastered as part of the implementation of the main professional educational program of higher education :**

**DATA SCIENCE AND SPACE ENGINEERING**

(name (profile/specialization) EP HE)

## 1. GOAL OF DISCIPLINE MASTERING

The discipline “Artificial Neural Networks (Deep Learning)” is included in the master’s program “Data Science and Space Engineering” in the direction 27.04.04 “Control in Technical Systems” and is studied in the 2nd semester of the 1st year. The discipline is implemented by the Department of Mechanics and Control Processes. The discipline consists of 6 sections and 15 topics and is aimed at studying methods for constructing automatic control systems based on artificial neural networks, mastering methods for solving basic control problems using neural networks.

The goal of mastering the discipline is to teach students methods of constructing artificial neural networks.

## 2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline “Artificial Neural Networks (Deep Learning) / Искусственные нейронные сети (Глубокое обучение)” is aimed at developing the following competencies (parts of competencies) in students:

*Table 2.1. List of competencies formed in students when mastering the discipline (results of mastering the discipline)*

<b>Cipher</b>	<b>Competence</b>	<b>Indicators of Competency Achievement (within this discipline)</b>
GC-1	Able to critically analyze problem situations based on a systematic approach and develop an action strategy	GC-1.1 Analyzes the task, highlighting its basic components;; GC-1.2 Identifies and ranks the information required to solve the task;; GC-1.3 Searches for information to solve a given problem using various types of requests;;
PC-1	Able to formulate goals and objectives of scientific research in the field of aerospace systems control, select methods and means for solving professional problems	PC-1.1 Knows methods and means of solving scientific research problems in the field of artificial intelligence systems and robotic systems;; PC-1.2 Able to formulate the purpose and objectives of scientific research in the professional field;; PC-1.3 Knows techniques for formulating the goals and objectives of scientific research, knows how to choose methods and means of solving problems of professional activity.;
PC-2	Able to apply modern theoretical and experimental methods for developing mathematical models of objects and processes under study in the field of aerospace systems control	PC-2.1 Knows modern theoretical and experimental methods used to develop mathematical models of the objects under study and processes of professional activity;; PC-2.2 Able to determine the effectiveness of the methods used for the development of mathematical models of the objects and processes under study;; PC-2.3 Masters modern theoretical and experimental methods for developing mathematical models of objects and processes of professional activity in the field of training.;

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

Discipline " Artificial Neural Networks (Deep Learning) / Искусственные нейронные сети (Глубокое обучение)" refers to the part formed by the participants in educational relations of block 1 “Disciplines (modules)” of the educational program of higher education.

As part of the educational program of higher education, students also master other disciplines and/or practices that contribute to achieving the planned results of mastering the discipline “Artificial Neural Networks (Deep Learning)”.

Table 3.1. List of components of EP HE that contribute to achieving the planned results of mastering the discipline

<b>Cipher</b>	<b>Name of competency</b>	<b>Previous disciplines/modules, practices*</b>	<b>Subsequent disciplines/modules, practices*</b>
GC-1	Able to critically analyze problem situations based on a systematic approach and develop an action strategy	History and Methodology of Science;	<i>Artificial Neural Networks (Reinforcement Learning)**;</i> <i>Artificial Neural Networks (Reinforcement Learning)**;</i> Research work / Scientific research work; Undergraduate practice / Pre-graduate practice;
PC-1	Able to formulate goals and objectives of scientific research in the field of aerospace systems control, select methods and means for solving professional problems		<i>Research work / Scientific research work;</i> <i>Undergraduate practice / Pre-graduate practice;</i> <i>Artificial Neural Networks (Reinforcement Learning)**;</i>
PC-2	Able to apply modern theoretical and experimental methods for developing mathematical models of objects and processes under study in the field of aerospace systems control	Information Technology in Mathematical Modeling; History and Methodology of Science; Virtual Reality and Computer Vision;	<i>Research work / Scientific research work;</i> <i>Undergraduate practice / Pre-graduate practice;</i> <i>Dynamics and Control of Space Systems;</i> <i>Artificial Neural Networks (Reinforcement Learning)**;</i> <i>Geoinformation Systems and Applications;</i>

\* - to be filled out in accordance with the competency matrix and SUP EP VO

\*\* - elective disciplines/practices

#### 4. SCOPE OF DISCIPLINE AND TYPES OF STUDY WORK

The total labor intensity of the “Artificial Neural Networks (Deep Learning)” discipline is “5” credit units.

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

Type of educational work	TOTAL,ac.ch.		Semester(s)
			2
<i>Contact work, ac.ch.</i>	36		36
Lectures (LC)	18		18
Laboratory work (LR)	18		18
Practical/seminar sessions (SZ)	0		0
<i>Independent work of students, ac.ch.</i>	117		117
<i>Control (exam/test with assessment), academic degree.</i>	27		27
<b>Total labor intensity of the discipline</b>	<b>ac.ch.</b>	<b>180</b>	<b>180</b>
	<b>credit units</b>	<b>5</b>	<b>5</b>

## 5. CONTENT OF DISCIPLINE

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

Section number	Name of the discipline section	Contents of the section (topic)		Type of educational work*
Section 1	Basic concepts. Typology of problems solved by machine learning methods. Multilayer perceptron	1.1	Definitions, history of development and main trends of artificial intelligence.	LK, LR
		1.2	Biological neuron and its mathematical model. Types of activation functions. Neural networks and their classification. Mathematical models of specialized neurons.	LK, LR
		1.3	Multilayer neural networks. Representation of problems of regression, approximation, identification, control, data compression in a neural network logical basis. Multilayer perceptron.	LK, LR
Section 2	Evolutionary teaching methods	2.1	Error backpropagation algorithm and its modifications.	LK, LR
		2.2	Selecting optimal network parameters	LK, LR
Section 3	Types of neural networks	3.1	Neural network with general regression.	LK, LR
		3.2	Probabilistic neural network.	LK, LR
		3.3	Neural networks with radial basis functions.	LK, LR
		3.4	Neural network and self-organizing Kohonen maps	LK, LR
Section 4	Evolutionary teaching methods	4.1	Error backpropagation algorithm and its modifications. Multilayer perceptrons. Selecting optimal network parameters	LK, LR
Section 5	Neural networks with feedback	5.1	Hopfield neural networks. Neural network methods for solving optimization-combinatorial problems. Hamming neural networks. Pattern recognition using distances.	LK, LR
		5.2	Bidirectional associative neural networks. Neural networks with feedback based on perceptron	LK, LR
Section 6	Specialized neural networks	6.1	Deep neural networks.	LK, LR
		6.2	Convolutional neural networks.	LK, LR
		6.3	Recurrent networks.	LK, LR

\* - to be filled out only for full-time education: LC – lectures; LR – laboratory work; SZ – practical/seminar classes.

## 6. MATERIAL AND TECHNICAL SUPPORT OF DISCIPLINE

Table 6.1. Material and technical support of the discipline

Audience type	Auditorium equipment	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; board (screen) and technical means of multimedia presentations.	
Computer class	A computer class for conducting classes, group and individual consultations, ongoing monitoring and intermediate certification,	

Audience type	Auditorium equipment	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
	equipped with personal computers ([Parameter] pcs.), a whiteboard (screen) and technical means for multimedia presentations.	
For independent work	An auditorium for independent work by students (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to EIOS.	

\* - the audience for independent work of students is MANDATORY!

## 7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF DISCIPLINE

### *Main literature:*

1. S. Khaikin. Neural networks: a complete course. 2nd ed. M., "Williams", 2006.
2. A.N. Vasiliev, D.A. Tarkhov. Neural modeling. Principles. Algorithms. Applications. SPb.: Publishing house Polytechnic Univ., 2009. ISBN 978-5-7422-2272-9
3. Mohamad H. Hassoun. Fundamentals of Artificial Neural Networks. MIT Press, Cambridge, Massachusetts, 1995.
4. D.A. Tarkhov. Neural networks. Models and algorithms. M., Radio engineering, 2005. (Scientific series "Neurocomputers and their application", ed. A.I. Galushkin. Book 18.)
5. CCAggarwal. Neural Networks and Deep Learning. A Textbook. Springer International Publishing

### *Additional literature:*

1. DERumelhardt, GEHinton, RJWilliams. Learning representations by back-propagating errors. Nature, 1986, V.323, pp.533-536.
2. Caudill, M. The Kohonen Model. Neural Network Primer. AI Expert, 1990, 25-31.
3. J. J. Hopfield. Neural networks and physical systems with emergent collective computational abilities. Proceedings of National Academy of Sciences of USA, 1982, V.79, No.8, pp.2554-2558.

### *Resources of the information and telecommunications network "Internet":*

1. EBS of RUDN University and third-party EBS, to which university students have access based on concluded agreements

- Electronic library system of RUDN University - EBS RUDN University <http://lib.rudn.ru/MegaPro/Web>
- EBS "University Library Online" <http://www.biblioclub.ru>
- EBS Law <http://www.biblio-online.ru>
- EBS "Student Consultant" [www.studentlibrary.ru](http://www.studentlibrary.ru)
- EBS "Trinity Bridge"

2. Databases and search engines

- electronic fund of legal and regulatory technical documentation <http://docs.cntd.ru/>
- Yandex search engine <https://www.yandex.ru/>
- search system Google <https://www.google.ru/>
- abstract database SCOPUS <http://www.elsevierscience.ru/products/scopus/>

*Educational and methodological materials for students' independent work when mastering a discipline/module\*:*

1. Course of lectures on the discipline "Artificial Neural Networks (Deep Learning) / Artificial Neural Networks (Deep Learning).”

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

## **8. ASSESSMENT MATERIALS AND POINT-RATING SYSTEM FOR ASSESSING THE LEVEL OF COMPETENCIES FOR A DISCIPLINE**

Evaluation materials and point-rating system\* for assessing the level of development of competencies (parts of competencies) based on the results of mastering the discipline “Artificial Neural Networks (Deep Learning) / Искусственные нейронные сети (Глубокое обучение)” are presented in the Appendix to this Work Program of the discipline.

\* - OM and BRS are formed on the basis of the requirements of the relevant local regulatory act of RUDN University.

**DEVELOPER:**

Assistant professor

*Position*

*Signature*

Saltykova Olga

Alexandrovna

*Last name I.O.*

**HEAD OF DEPARTMENT:**

Head of the department

*Position*

*Signature*

Razumny Yuri Nikolaevich

*Last name I.O.*

**HEAD OF EP HE:**

Professor

*Position*

*Signature*

Razumny Yuri Nikolaevich

*Last name I.O.*