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

ИСКУССТВЕННЫЕ НЕЙРОННЫЕ СЕТИ (ОБУЧЕНИЕ С ПОДКРЕПЛЕНИЕМ)/ARTIFICIAL NEURAL NETWORKS (REINFORCEMENT LEARNING)

(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 discipline "Artificial neural networks (reinforcement learning)" 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 3rd semester of the 2nd year. The discipline is implemented by the Department of Mechanics and Control Processes. The discipline consists of 4 sections and 10 topics and is aimed at studying the methods of constructing automatic control systems based on artificial neural networks, mastering the methods of solving basic control problems using neural networks, neural network architectures

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

2. REQUIREMENTS TO THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Artificial neural networks (Reinforcement learning)" 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)
UC-1	Capable of carrying out a critical analysis of problematic situations based on a systems approach and developing an action strategy	UC-1.1 Analyzes the task, identifying its basic components; UC-1.2 Defines and ranks the information required to solve the given problem; UC-1.3 Searches for information to solve the assigned task using various types of requests;
UC-7	Able to search for the necessary sources of information and data, perceive, analyze, remember and transmit information using digital means, as well as using algorithms when working with data obtained 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	UC-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 obtained from various sources in order to effectively use the information obtained to solve problems; UC-7.2 Conducts an assessment of information, its reliability, builds logical conclusions based on incoming information and data; UC-7.3 Has mastered modern digital technologies, methods of searching, processing, analyzing, storing and presenting information (in the field of management in technical systems) in the context of the digital economy and modern corporate information culture.;
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 management	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 to develop mathematical models of the objects and processes under study; PC-2.3 Has mastered modern theoretical and experimental methods for developing mathematical models of objects and processes of professional activity in the field of study.;

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

Discipline "Artificial Neural Networks (Reinforcement Learning)" refers to the part formed by the participants of educational relations 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 "Artificial Neural Networks (Reinforcement Learning)".

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***
UC-7	Able to search for the necessary sources of information and data, perceive, analyze, remember and transmit information using digital means, as well as using algorithms when working with data obtained 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	Research work / Scientific research work; History and Methodology of Science; Information Technology in Mathematical Modeling; Information Databases;	Undergraduate Training;
UC-1	Capable of carrying out a critical analysis of problematic situations based on a systems approach and developing an action strategy	Research work / Scientific research work; History and Methodology of Science; *Artificial Neural Networks (Deep Learning)***; *Artificial Neural Networks (Deep Learning)***;	Undergraduate Training;
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 management	Research work / Scientific research work; History and Methodology of Science; Virtual Reality and Computer Vision; *Artificial Neural Networks (Deep Learning)***; *Artificial Neural Networks (Deep Learning)***; Information Technology in Mathematical Modeling; Advanced Methods of Space Flight Mechanics;	Undergraduate Training;

* - 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 “Artificial Neural Networks (Reinforcement Learning)” is “5” 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,**ac.h.		**Semester(s)**
			3
Contact work, academic hours	*72*		*72*
Lectures (LC)	36		36
Laboratory work (LW)	36		36
Practical/seminar classes (SC)	0		0
Independent work of students, academic hours	*72*		*72*
Control (exam/test with assessment), academic hours	*36*		*36*
General complexity of the discipline	**ac.h.**	***180***	*180*
	credit.ed.	***5***	*5*

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	Introduction to Reinforcement Learning.	1.1	Structure of the reinforcement learning algorithm.	LC, LW
		1.2	Agent. Policy function. Value function.	LC, LW
		1.3	Model. Types of reinforcement learning environments: deterministic, stochastic with complete and incomplete information, discrete and continuous, episodic and non-episodic, single-agent and multi-agent.	LC, LW
Section 2	Theoretical foundations and methods of reinforcement learning	2.1	Markov chains and Markov processes. Markov decision process.	LC, LW
		2.2	State value functions, Q-function. Bellman equation and optimality. Derivation of the Bellman equation.	LC, LW
		2.3	Dynamic programming. Monte Carlo methods and game theory.	LC, LW
		2.4	Learning based on temporal differences. TD forecasting. TD learning.	LC, LW
		2.5	Q training. SARSA algorithm. (State-Action-Reward-State-Action)	LC, LW
Section 3	Reinforcement learning software	3.1	Software packages for implementing neural networks. Tensor Flow	LC, LW
Section 4	Development of artificial neural networks. Symbolic regression methods	4.1	Genetic programming, Cartesian genetic programming, network operator method, variational methods of symbolic regression	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		
Computer class		
For independent work		

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

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF THE DISCIPLINE

Main literature:

1. Sutton Richard S., Barto Andrew G. Reinforcement Learning =Reinforcement Learning. — 2nd edition. — M.: DMK press, 2020. — 552 p. — ISBN 978-5-97060-097-9.

2. Rosenblatt, F. Principles of Neurodynamics: Perceptrons and the Theory of Brain Mechanisms =Principles of Neurodynamics: Perceptrons and the Theory of Brain Mechanisms. - M.: Mir, 1965. - 480 p.3.

3. A.N.Vasiliev, D.A.Tarkhov. Neural modeling. Principles. Algorithms. Applications. St. Petersburg: Polytechnical Publishing House.Univ., 2009. ISBN 978-5-7422-2272-9

4. CCAggarwal. Neural Networks and Deep Learning. A Textbook. Springer International Publishing

5. D.A. Tarkhov. Neural networks. Models and algorithms. Moscow, Radio Engineering, 2005. (Scientific series "Neurocomputers and their application", ed. A.I. Galushkin. Book 18.)

Further reading:

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. 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 Yuraithttp://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 "Artificial neural networks (Reinforcement learning)".

* - 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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Position, Department	*Signature*	*Surname I.O.*

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