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

Academy of Engineering

(name of the main educational unit (PMU) – developer of the educational program of higher education)

STATE FINAL CERTIFICATION PROGRAM

Recommended by the ICSC for the field of study/specialty:

27.04.04 Control in Technical Systems

(code and name of the training area/specialty)

**The state final certification is carried out within the framework of the implementation of
the main professional educational program of higher education:**

***AIML and Space Science / Artificial Intelligence, Machine Learning and Space
Science***

(name (profile/specialization) of the educational institution of higher education)

1. PURPOSE AND OBJECTIVES OF THE FINAL STATE ATTESTATION (SFC)

The goal conducting the State Final Attestation within the framework of the implementation of the educational program "AIML and Space Science / Artificial Intelligence, Machine Learning and Space Science" is to determine the compliance of the results of mastering the educational program of higher education by students with the relevant requirements of the RUDN University Educational Standards.

The objectives of the state final certification are:

- checking the quality of teaching an individual basic humanitarian knowledge, natural scientific laws and phenomena necessary in professional activities;
- determining the level of theoretical and practical preparedness of the graduate to perform professional tasks in accordance with the qualification received;
- establishing the degree of an individual's desire for self-development, improving their qualifications and skills;
- checking the formation of a graduate's sustainable motivation for professional activity in accordance with the types of professional activity tasks provided by the RUDN University Educational System;
- assessment of the level of ability of graduates to find organizational and managerial solutions in non-standard situations and their readiness to take responsibility for them;
- ensuring the integration of education and scientific and technical activities, increasing the efficiency of using scientific and technical achievements, reforming the scientific sphere and stimulating innovative activities;
- ensuring the quality of training of specialists in accordance with the requirements of the RUDN University Educational Standards Board.

2. REQUIREMENTS FOR THE RESULTS OF THE DEVELOPMENT OF THE EDUCATIONAL PROGRAM

A student who has no academic debt and has fully completed the curriculum or individual curriculum of the educational program of higher education is admitted to the State Final Attestation.

Upon completion of the EP HE, the graduate must have the following universal competencies (UC):

Code and name of the UC
UC-1 Able to carry out critical analysis of problematic situations based on a systems approach, develop an action strategy
UC-2 Capable of managing a project at all stages of its life cycle
UC-3 Able to organize and manage the work of a team, developing a team strategy to achieve the set goal
UC-4 Able to apply modern communication technologies in the state language of the Russian Federation and foreign language(s) for academic and professional interaction
UC-5 Able to analyze and take into account cultural diversity in the process of intercultural interaction
UC-6 Able to define and implement priorities of one's own activities and ways of improving them based on self-assessment
UC-7 Capable of: searching for the necessary sources of information and data, perceiving, analyzing, memorizing and transmitting 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; evaluating information, its reliability, building logical conclusions based on incoming information and data

- general professional competencies (GPC):

Code and name of the GPC
GPC-1 Capable of analyzing and identifying the natural scientific essence of control problems in technical systems based on provisions, laws and methods in the field of natural sciences and mathematics
GPC-2. Capable of formulating control problems in technical systems and substantiating methods for solving them.
GPC-3. Capable of independently acquiring new knowledge, skills and abilities to solve control problems in technical systems.
GPC-4. Capable of assessing the effectiveness of control systems developed on the basis of modern mathematical methods.
GPC-5. Capable of conducting patent research, determining forms and methods of legal protection and defense of rights to the results of intellectual activity, managing rights to them to solve problems in the field of development of science, engineering and technology.
GPC-6. Capable of collecting and analyzing scientific and technical information, generalizing domestic and foreign experience in the field of automation and control equipment.
GPC-7. Capable of making an informed choice, developing and implementing in practice circuit, system engineering and hardware-software solutions for automation and control systems.
GPC-8. Capable of selecting methods and developing control systems for complex technical objects and technological processes.
GPC-9. Capable of developing methods and performing experiments at existing facilities with processing of results based on modern information technologies and technical means.
GPC-10. Capable of managing the development of methodological and regulatory documents, technical documentation in the field of automation of technological processes and production, including the life cycle of products and their quality.

- professional competencies(PC):

PC code and name
PC-1 Able to formulate goals and objectives of scientific research in the field of aerospace systems management, select methods and means for solving professional problems
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-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-4 Capable of participating in scientific research and development of design solutions in the field of ballistics, dynamics and flight control of spacecraft

3. COMPOSITION OF THE SFC

The State Final Attestation can be conducted either in person (students and the state examination committee are at RUDN during the State Final Attestation) or using distance learning technologies (DET) available in the RUDN Electronic Information and Educational Environment (EIEE).

The procedure for conducting the State Final Attestation in person or using (DOT) is regulated by the relevant local regulatory act of RUDN.

State Final Attestation for OP VO "AIML and Space Science / Artificial Intelligence, Machine Learning and Space Science» includes:

- state exam (SE);
- defense of the final qualifying work (FQW).

4. PROGRAM OF THE GE

The volume of the state examination for the OP of HE is 3 credit units.

The state exam is conducted in two stages:

First stage– assessment of the level of theoretical training of a graduate in the form of computer testing using the tools available in the RUDN University Electronic Information and Educational Environment (EIEE);

Second stage– assessment of the practical preparation of a graduate for future professional activity in the form of solving production situational problems (cases).

In order to prepare students for passing the State Examination, the head of the higher education institution (no later than one calendar month before the start of the State Examination) is obliged to familiarize the final-year students with this State Examination program, an exhaustive list of theoretical questions included in the State Examination, examples of industrial situational tasks (cases) that will need to be solved in the process of passing the certification test, as well as with the procedure for conducting each stage of the State Examination and the methodology for assessing its results (with assessment materials).

Before the State Examination, mandatory consultations are held for students on issues and tasks included in the State Examination program (pre-examination consultation) no later than two weeks before the State Final Attestation.

Procedure for conducting computer testing within the framework of the State Final Attestation the following:

1. Before the test part of the State Examination, trial testing of students is conducted to familiarize them with the technology of computer testing, the deadline for conducting it is no later than one week before the date of computer testing.
2. Computer testing is carried out in person in the department's laboratories.
3. The test task contains 20 questions randomly selected by the RUDN University EIS from the Test Task Bank. The student has 50 minutes to complete the test task. The correct answer is worth 2 points, the wrong answer is worth 0 points.
4. Submission and consideration of an appeal at a meeting of the AC is possible on the day of passing the State Examination; adoption and communication to the student of a decision based on the results of consideration of the appeal within 3 working days from the date of filing the appeal.
5. Repeated AI (if necessary). Within 2 weeks after the AC decision to satisfy the appeal.

The procedure for conducting the second stage of the State Examination next:

1. **The second stage of the State Examination** is conducted in person using written knowledge testing using examination tickets, each examination ticket contains three questions and a task. The questions and tasks included in the examination ticket are interdisciplinary in nature and are aimed at determining the level of theoretical and practical preparedness of the graduate to solve professional problems defined by the educational standard of RUDN in accordance with the types of professional activity tasks that the educational program is focused on.
2. The total number of examination tickets is determined by the number of students admitted to the state exam. The student is given 90 minutes to prepare and defend a written answer to the ticket. The answer is assessed at a maximum of 60 points, which, in total with the maximum possible 40 points received at the first stage of the state exam, gives a maximum of 100 points.
3. During the state exam, members of the State Examination Commission may ask the student additional questions in the area of the graduate's professional activity.
4. The assessment of the results of the State Examination is carried out in accordance with the methodology set out in the assessment materials presented in the Appendix to this State Final Attestation program.
5. Announcement of the assessments based on the results of the AI (in person and/or via corporate email). Deadline: the next working day after the AI.

6. Submission and consideration of an appeal at a meeting of the AC, making a decision and informing the student of the results of the appeal review. Deadline: within 3 working days from the date of filing the appeal.
7. Repeated AI (if necessary). Within 2 weeks after the AC decision to satisfy the appeal.

The list of questions for preparation for the State Examination, as well as the criteria for assessing the results of the State Examination, are specified in the fund of assessment tools for the State Examination, provided in the appendix to this State Examination program.

5. REQUIREMENTS FOR A THESIS AND THE PROCEDURE FOR ITS DEFENSE

A final qualifying work is a work completed by a student (or several students together) demonstrating the level of readiness of the graduate for independent professional activity.

The list of topics for final qualifying papers offered to students for completion is approved by the order of the head of the educational program implementing the educational program of higher education, and is communicated by the program head to the students of the final year no later than 6 months before the start date of the State Final Attestation.

Preparation and defense of a final qualifying work on a topic proposed by the student (students) is permitted in accordance with the established procedure.

A student who has passed the state examination is allowed to defend the final qualifying work.

Only a fully completed thesis, signed by the graduate(s) who completed it, the supervisor, consultant (if any), the supervisor of the issuing BUP and OUP, which has undergone the external review procedure (mandatory for Master's and Specialist's programs) and a check for the volume of borrowings (in the Antiplagiat system) is allowed to be defended. A supervisor's review of the graduate's work in preparing the thesis is mandatory attached to the thesis admitted to defense.

In order to identify and promptly eliminate deficiencies in the structure, content and design of the final qualifying work, no later than 14 days before the date of its defense, a rehearsal of the defense of the students' work (pre-defense) is held in the presence of the head of the final qualifying work and other teachers of the graduating BUP.

The defense of the final qualifying work is carried out at an open meeting of the state examination commission (SEC).

The certification test is conducted in the form of an oral report by students with a mandatory multimedia (graphic) presentation reflecting the main content of the final qualifying work.

Upon completion of the report, the defenders give oral answers to questions raised by the members of the State Examination Commission on the subject matter, structure, content or design of the final qualifying work and the profile of the educational program of higher education. The report and/or answers to questions from the members of the State Examination Commission may be in a foreign language.

The stages of completing the final qualifying work, requirements for the structure, volume, content and design, as well as the list of mandatory and recommended documents submitted for defense are specified in the relevant methodological guidelines.

The assessment of the results of the defense of the final qualifying work is carried out in accordance with the methodology set out in the assessment materials presented in the Appendix to this State Final Attestation program.

6. MATERIAL AND TECHNICAL SUPPORT FOR THE FSC

To conduct the test part of the State Examination, a classroom equipped with at least 12 workstations with personal computers equipped with the necessary software and an Internet connection to provide access to the RUDN University Electronic Information System is used.

To conduct the main part of the State Examination and/or the defense of the final qualifying work, a room with a capacity of at least 12 people is used, in which workplaces are equipped for all members of the State Examination Committee, with the ability to listen to reports, view public presentations of speakers, keep records and protocols, there are places for listeners who wish to attend the defense of the final qualifying work. The necessary equipment of the room includes:

- equipment for public presentations of the results of the final qualifying work, including a multimedia screen, projector, and audio equipment;
- a board to illustrate answers to questions;

The student may notify in writing of any requests for additional material and technical equipment (if necessary) for the auditorium assigned for the defense of the final qualifying work no later than a week before the defense.

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT FOR THE GIA

Basic literature for preparation for the State Examination and/or completion and defense of the final qualifying work:

1. Methods of classical and modern theory of automatic control: Textbook in 5 volumes / Under the general editorship of K.A. Pupkov. - 2nd ed., revised and enlarged. - Moscow: Publishing house of Moscow State Technical University, 2004. - 656 p.
2. Pupkov K.A. Theory of nonlinear automatic control systems: Textbook for universities. - Anniversary edition. - M.: RUDN University Press, 2009. - 258 p.
3. Tolpegin, O. A. Methods of Optimal Control: Textbook and Workshop for Universities / O. A. Tolpegin. - 2nd ed., corrected and supplemented. - Moscow: Yurait Publishing House, 2021.
4. Automated design of control systems and tools: a textbook for university students / E. E. Noskova, D. V. Kapulin, S. V. Chentsov; Siberian Federal University - Krasnoyarsk: Institute of Advanced Training of SFU, 2011. - 189 p.
5. Norenkov, Igor Petrovich. Information support of science-intensive products. CALS-technologies [Text] / I. P. Norenkov, P. K. Kuzmik. - M.: Publishing house of Bauman Moscow State Technical University, 2002. - 319 p.
6. Mathematical game theory and applications. V.V. Mazalov St. Petersburg: Lan Publishing House, 2017 – 448 p.;
7. Game Theory. L.A. Petrosyan, N.A. Zenkevich, E.V. Shevkoplyas. SPb.: BHV-Petersburg, 2012 – 432 p.;
8. Combinatorial game theory. P. Deornua, M.: MCNO, 2017 – 40 p.;
9. Mathematical foundations of machine learning and forecasting. V.V. Vyugin, M.: MCNO, 2014 – 304 p.;
10. Norenkov, I.P. Fundamentals of automated design / I.P. Norenkov, M., Publishing house of Moscow State Technical University named after N.E.Bauman, 2009, 335 p. ISBN 978-5-7038-3275-2.
11. Bozhko, A. N. Fundamentals of Computer-Aided Design / A. N. Bozhko, T. M. Volosatova, S. V. Groshev, et al.; edited by A. P. Karpenko, Moscow: INFRA-M, 2019 - 327 p., ISBN 978-5-16-014441-2.
12. Zhigalova, E.F. Automation of design and technological engineering: a tutorial / E.F. Zhigalova; Ministry of Education and Science of the Russian Federation, Tomsk State

University of Control Systems and Radioelectronics. - Tomsk: TUSUR, 2016. - 201 p.: ill., table, diagram. - Bibliography: pp. 196-197; [Electronic resource]. - URL:<http://biblioclub.ru/index.php?page=book&id=480810>.

13. Krysova, I.V. Fundamentals of CAD: a tutorial / I.V. Krysova, M.N. Odinet, T.M. Myasoedova, D.S. Korchagin; Ministry of Education and Science of the Russian Federation, Omsk State Technical University. - Omsk: OmskSTU Publishing House, 2017. - 92 p.: tables, graphs, diagrams, ill. - Bibliography in the book. - ISBN 978-5-8149-2423-0; [Electronic resource]. - URL:<http://biblioclub.ru/index.php?page=book&id=493424>.

14. Elizarov, I.A. Integrated design and control systems: SCADA systems: a tutorial / I.A. Elizarov, A.A. Tretyakov, A.N. Pchelintsev et al.; Ministry of Education and Science of the Russian Federation, Federal State Budgetary Educational Institution of Higher Professional Education "Tambov State Technical University". - Tambov: Publishing House of FGBOU HPE "TSTU", 2015. - 160 p.: ill., table, diagram. - Bibliography in the book. - ISBN 978-5-8265-1469-6; [Electronic resource]. - URL:<http://biblioclub.ru/index.php?page=book&id=444643>.

15. Mohamad H.Hassoun. Fundamentals of Artificial Neural Networks. MIT Press, Cambridge, Massachusetts, 1995.

16. S. Khaikin. Neural networks: a complete course. 2nd ed. M., "Williams", 2006.

17. A.N.Vasiliev, D.A.Tarkhov. Neuronal modeling. Principles. Algorithms. Applications. SPb.: Publishing House Polytechnic. Univ., 2009. ISBN 978-5-7422-2272-9

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

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

Additional literature for preparation for the State Examination and/or completion and defense of the final qualifying work:

1. Andrievsky B.R., Fradkov A.L. Selected chapters of the theory of automatic control with examples in the MATLAB language. - St. Petersburg: NaUCa, 1999. - 475 p.

2. Knuth Donald E. The Art of Computer Programming in 3 volumes – M.: Williams Publishing House, 2008. – T.1 – 720, T.2 – 832 p., T.3 - 824 p.

3. Aho Alfred V., Hopcroft John, Ullman Jeffrey D., Data structures and algorithms – M.: Williams Publishing House, 2000. – 384 p.

4. Nikulchev E.V. Practical training in control theory in the MATLAB environment: Tutorial. - M.: MGAPI, 2002. - 88 p.

5. Information structure of the enterprise: a textbook for university students studying in the direction of "Management in technical systems" / D. V. Kapulin, A. S. Kuznetsov, E. E. Noskova; Sib. federal university, Institute of space and information technologies. - Krasnoyarsk: SFU, 2014. - 185 p.

6. Norenkov, Igor Petrovich. Fundamentals of automated design: a textbook for universities in the field of training certified specialists "Informatics and computer engineering": Approved by the Ministry of Education of the Russian Federation / I. P. Norenkov. - Moscow: Moscow Technical University [MSTU] named after N.E. Bauman, 2002. - 334 p.

7. Mathematical methods in game theory, programming and economics. S. Karlin, Moscow: Mir, 1964 – 838 p.;

8. Numerical methods of optimization. A.F. Izmailov, M.V. Solodov, Moscow: Fizmatlit, 2005 – 304 p.;

9. Applied Theory of Optimal Control. A. Bryson, Ho Yu-Shi, Moscow: Mir, 1972 – 544 p.;

10. Mathematical programming. Theory and algorithms. M. Minu, M.: NaUCa, 1990 – 488 p.;

11. Nonlinear programming. Theory and algorithms. Bazara M., Shetty K., Moscow: Mir, 1982 – 583 p.;
12. DERumelhardt, G. E. Hinton, R. J. Williams. Learning representations by back-propagating errors. Nature, 1986, V.323, pp.533-536.
13. Caudill, M. The Kohonen Model. Neural Network Primer. AI Expert, 1990, 25-31.
14. 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 Electronic Library System and third-party electronic library systems to which university students have access on the basis of concluded agreements:
 - Electronic library system of RUDN - ELS RUDN <http://lib.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 "Lan" <http://e.lanbook.com/>
 - EBS "Troitsky 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/>
 - SCOPUS abstract database <http://www.elsevierscience.ru/products/scopus/>

*Educational and methodological materials for independent work of students in preparation for passing the State Examination and/or completing the final qualifying work and preparing the work for defense *:*

1. Methodological guidelines for the implementation and design of the final qualifying work on the educational program of higher education "Artificial Intelligence and Robotic Systems".
2. The procedure for checking the final qualifying work for the volume of borrowings in the Antiplagiat system.
3. The procedure for conducting the State Final Attestation on the OP VO "AIML and Space Science / Artificial Intelligence, Machine Learning and Space Science» using DOT, including the procedure for identifying the graduate's identity.

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

8. ASSESSMENT MATERIALS AND A POINT-RATING SYSTEM FOR ASSESSING THE LEVEL OF COMPETENCE FORMATION AMONG GRADUATES

Assessment materials and a scoring and rating system* for assessing the level of development of competencies based on the results of mastering the discipline of the OP HE«AIML and Space Science / Artificial Intelligence, Machine Learning and Space Science" are presented in the Appendix to this GIA program.

* - OM and BRS are formed on the basis of the requirements of the relevant local regulatory act of RUDN (regulations/procedures).

HEAD OF THE DEPARTMENT:

Head of the Department of

Mechanics and Control Processes

Razumny Yu.N

_____	_____	_____
Name of the Department	Signature	Surname I.O.

HEAD OF THE DEPARTMENT OF HIGHER EDUCATION:

Professor of the Department of

Mechanics and Control Processes

Razumny Yu.N

_____	_____	_____
Position, Department	Signature	Surname I.O.