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 (PMU) - the developer of the EP HE)

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 direction of training/specialty)

The state final certification is carried out as part of the implementation of the main professional educational program of higher education:

Data Science and Space Engineering

(name (profile/specialization) of the EP HE)

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

The purpose of the FSC within the framework of the implementation of the EP "Data Science and Space Engineering / Data Science and Space Engineering" is to determine the compliance of the results of the development of EP HE by students with the relevant requirements of the OS HE.

The objectives of the state final certification are:

- checking the quality of teaching the individual basic humanitarian knowledge, natural science laws and phenomena necessary in professional activity;

- determination of the level of theoretical and practical preparedness of the graduate to perform professional tasks in accordance with the qualification obtained;

- establishing the degree of the individual's desire for self-development, improving his qualifications and skills;

- checking the formation of a graduate's stable motivation for professional activity in accordance with the types of tasks of professional activity provided for by the Educational System of Higher Education of RUDN University;

- assessment of the level of graduates' ability to find organizational and managerial solutions in non-standard situations and readiness to be responsible for them;

- ensuring the integration of education and scientific and technical activities, increasing the efficiency of the use of 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 OS VO RUDN University.

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 EP HE is allowed to take the FSC.

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

Code and name of the authorized capital
GC-1 Is able to carry out a critical analysis of problem situations based on a systematic approach, to develop an action strategy
GC-2 Capable of managing a project at all stages of its life cycle
GC-3 Able to organize and manage the work of the team, developing a team strategy to achieve the set goal
GC-4 Able to apply modern communication technologies in the state language of the Russian Federation and a foreign language(s) for academic and professional interaction
GC-5 Able to analyze and take into account the diversity of cultures in the process of intercultural interaction
GC-6 Is able to determine and implement the priorities of their own activities and ways to improve them on the basis of self-assessment
GC-7 is able to: search for the necessary sources of information and data, perceive, analyze, remember and transmit information using digital means, as well as with the help of 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

- **general professional competencies** (GPC):

Code and name of the defense industry
GPC-1 Able to analyze and identify the natural science essence of control problems in technical systems on the basis of provisions, laws and methods in the field of natural sciences and mathematics
GPC-2. Is able to formulate management tasks in technical systems and substantiate methods for solving them.
GPC-3. Is able to independently acquire new knowledge, skills and abilities to solve management problems in technical systems.
GPC-4. Is able to assess the effectiveness of management systems developed on the basis of modern mathematical methods.
GPC-5. Able to conduct patent research, determine the forms and methods of legal protection and protection of rights to the results of intellectual activity, dispose of rights to them to solve problems in the field of development of science, engineering and technology.
GPC-6. Able to collect and analyze scientific and technical information, summarize domestic and foreign experience in the field of automation and control.
GPC-7. He is able to make an informed choice, develop and implement in practice circuitry, system engineering and hardware and software solutions for automation and control systems.
GPC-8. Able to choose methods and develop control systems for complex technical objects and technological processes.
GPC-9. He is able to develop methods and perform experiments at existing facilities with the processing of results based on modern information technologies and technical means.
GPC-10. Able to manage 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, objectives of scientific research in the field of aerospace systems management, choose methods and means for solving professional problems
PC-2 Is able to apply modern theoretical and experimental methods for the development of mathematical models of objects and processes under study in the field of aerospace systems control
PC-3 Able to conduct work and research on the processing and analysis of scientific and technical information obtained using geographic information systems and technologies
PC-4 Able to participate in scientific research and development of design solutions in the field of ballistics, dynamics and spacecraft flight control

3. COMPOSITION OF THE FSC

The FSC can be held both in a full-time format (students and the state examination committee are at RUDN University during the FSC), and using distance learning technologies (DLT) available in the Electronic Information and Educational Environment of RUDN University (EIOS).

The procedure for conducting the FSC in person or with the use of (DLT) is regulated by the relevant local regulatory act of RUDN University.

The State Final Exam in Data Science and Space Engineering / Data Science and Space Engineering includes:
- state examination (SE);
- defense of the final qualification work (thesis).

4. GE PROGRAM

The volume of the State Exam for EP HE is <u>3</u> credits.

The state exam is held in two stages:

The first stage is the assessment of the level of theoretical training of the graduate in the form **of computer testing** using the tools available in the Electronic Information and Educational Environment of RUDN University (EIOS);

The second stage is the assessment of the practical preparation of the graduate for future professional activity in the form **of solving production situational tasks (cases).**

In order to prepare students for the State Final Examination, the head of the Higher Education Programme (no later than one calendar month before the start of the State Final Examination) is obliged to familiarize the students of the final year with this FSC program, an exhaustive list of theoretical issues included in the State Final Examination, examples of production 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 of the stages of the State Final Examination and the methodology for assessing its results (with assessment materials).

Before the SE, students are consulted on the issues and tasks included in the SE program (pre-examination consultation) no later than two weeks before the FSC.

The procedure for conducting computer testing within the framework of the FSC is as follows:

1. Before the test part of the SE, a trial test of students is carried out to familiarize them with the technology of computer testing, the deadline is no later than one week before the date of computer testing.
2. Computer testing is carried out in a full-time format in the laboratories of the department.
3. The test task contains 20 questions selected randomly from the Bank of Test Tasks. The student is given 50 minutes to complete the test task. A correct answer is evaluated as 2 points, an incorrect one is evaluated as 0 points.
4. Filing and consideration of an appeal at a meeting of the AC is possible on the day of passing the State Exam, making and bringing to the attention of the student a decision based on the results of the consideration of the appeal within 3 working days from the date of filing an appeal.
5. Repeated AI (if necessary). Within 2 weeks after the decision of the AC to satisfy the appeal.

The procedure for conducting the second stage of the SE is as follows:

1. **The second stage of the State Exam** is conducted in a full-time format using a written test of knowledge using exam tickets, each exam ticket contains three questions and a task. The questions and tasks included in the exam ticket are interdisciplinary in nature and are aimed at determining the level of theoretical and practical preparedness of the graduate to solve professional problems determined by the educational standard of RUDN University in accordance with the types of professional tasks activities to which the educational program is oriented.
2. The total number of examination tickets is determined by the number of students admitted to the state examination. The student is given 90 minutes to prepare and defend a written answer on the ticket. The answer is evaluated at a maximum of 60 points, which, in addition to the maximum possible 40 points received at the first stage of the GE, gives a maximum of 100 points.
3. At the state exam, the members of the State Examination Commission may ask the student additional questions in the field of the graduate's professional activity.

4. The assessment of the results of the State Exam is carried out in accordance with the methodology set out in the assessment materials presented in the Appendix to this FSC program.
5. Announcement of assessments based on the results of AI (in person and/or by corporate e-mail). Deadline: on the next business day after the AI.
6. Filing and considering an appeal at a meeting of the AC, making a decision and bringing to the attention of the student the results of the appeal. Deadline: within 3 working days from the date of filing an appeal.
7. Repeated AI (if necessary). Within 2 weeks after the decision of the AC to satisfy the appeal.

The list of questions for preparing for the State Exam, as well as the criteria for evaluating the results of the State Exam, are indicated in the FSC Assessment Tools Fund, which is given in the Appendix to this FSC program.

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

A thesis is a work performed by a student (several students together), demonstrating the level of preparedness of a graduate for independent professional activity.

The list of topics for graduation qualification works offered to students for implementation is approved by the order of the head of the educational program implementing the EP, and is brought to the attention of the students of the final year by the head of the program no later than 6 months before the start date of the FSC.

It is allowed to prepare and defend a thesis on the topic proposed by students (students) in accordance with the established procedure.

A student who has passed the State Exam is allowed to defend the thesis.

Only a fully completed thesis, signed by the graduate (graduates), its performer, supervisor, consultant (if any), the head of the issuing BUP and PMO, which has passed the procedure of external review (for master's and specialist's programs is mandatory) and checked for the volume of borrowings (in the "Antiplagiat" system) are allowed to be defended. A thesis admitted to the defense must be accompanied by a supervisor's feedback on the graduate's work during the preparation of the thesis.

In order to identify and timely eliminate shortcomings in the structure, content and design of the thesis, no later than 14 days before the date of its defense, a rehearsal of the defense of the student's work (pre-defense) is held in the presence of the thesis supervisor and other teachers of the graduating thesis.

The thesis defense is held at an open meeting of the State Examination Commission (SEC).

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

At the end of the report, the defenders give oral answers to the questions that have arisen from the members of the State Examination Commission on the subject, structure, content or design of the thesis and the profile of the Civic Chamber of Higher Education. The report and/or answers to the questions of the members of the State Examination Commission may be in a foreign language.

The stages of the thesis, the 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.

Evaluation of the results of the thesis defense is carried out in accordance with the methodology set out in the assessment materials presented in the Appendix to this FSC program.

6. MATERIAL AND TECHNICAL SUPPORT FOR THE FSC

To conduct the test part of the State Exam, a classroom equipped with at least 12 workplaces with personal computers equipped with the necessary software and Internet connection to provide access to the EIOS of RUDN University is used.

For the main part of the State Examination and/or the defense of the thesis, a room with a capacity of at least 12 people is used, in which workplaces are equipped for all members of the State Examination Commission, with the opportunity to listen to reports, view public presentations of speakers, keep notes and minutes, there are seats for listeners wishing to attend the defense of the thesis. The necessary equipment of the room includes:

- equipment for public presentations of thesis results, including a multimedia screen, projector, audio equipment;
- a board to illustrate answers to questions;

The student can notify the student of the wishes for additional material and technical equipment (if necessary) of the audience appointed for the defense of the thesis by a written application no later than a week before the defense.

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATION SUPPORT OF THE STATE FINAL EXAMINATION

Basic literature for preparing for the GE and/or performing and defending a thesis:

1. Methods of classical and modern theory of automatic control: Textbook in 5 volumes. - 2nd ed., revised and supplemented - Moscow: MSTU Publ., 2004. - 656 p.
2. Pupkov K.A. Theory of Nonlinear Systems of Automatic Regulation: Textbook for Higher Educational Institutions. - Anniversary Edition. - Moscow: RUDN Publ., 2009. - 258 p.
3. Tolpegin, O. A. Methods of optimal management: a textbook and a workshop for universities. - 2nd ed., ispr. Moscow: Yurayt Publishing House, 2021.
4. Computer-aided design of means and control systems. posobie dlya studentov vuzov / E. E. Noskova, D. V. Kapulin, S. V. Chentsov ; Sib. Federal. University. - Krasnoyarsk: IPK SFU, 2011. - 189 p.
5. Norenkov, Igor Petrovich. Information support of high-tech products. CALS-technologies [Text] / I. P. Norenkov, P. K. Kuzmik. - Moscow: BMSTU Publ., 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. St. Petersburg: BHV-Petersburg, 2012 – 432 p.;
8. Combinatorial game theory. P. Deornois, Moscow: MCNMO, 2017 – 40 p.;
9. Mathematical foundations of machine learning and forecasting. V.V. Vyugin, Moscow: MCNMO, 2014 – 304 p.;
10. Norenkov I.P., M., Izd-vo MSTU im. N.E. Osnovy avtomatizirovannogo proektirovaniya [Fundamentals of Automated Design] / I.P. Norenkov, M., Publishing House of the Moscow State Technical University named after N.E. Bauman, 2009, 335 p. ISBN 978-5-7038-3275-2.
11. Bozhko A.N., T.M. Osnovy avtomatizirovannogo proektirovaniya [Fundamentals of Computer Aids Design] / A.N. Bozhko, T.M. Volosatova, S.V. Groshev et al.; edited by A.P. Karpenko, Moscow: INFRA-M, 2019 - 327p., ISBN 978-5-16-014441-2.

12. Zhigalova, E.F. Automation of Design and Technological Design: Textbook / 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., tabl., schemes. - References: p.196-197; [Electronic resource]. - URL: http://biblioclub.ru/index.php?page=book&id=480810.

13. Krysova I.V., Odinets M.N., Myasoyedova T.M., Korchagin D.S. Fundamentals of CAD: Textbook; Ministry of Education and Science of Russia, Omsk State Technical University. - Omsk: OmSTU Publishing House, 2017. - 92 p. : tabl., graph., schemes, ill. - Bibliogr. 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., Tretyakov A.A., Tretyakov A.N. Integrated Design and Control Systems: SCADA Systems: Textbook 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 TSTU, 2015. - 160 p.: ill., tabl., schemes. - Bibliogr. 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. Neural Networks: A Complete Course. 2nd ed. Moscow, "Williams", 2006.

17. A.N. Vasiliev, D.A. Tarkhov. Neurosteal modeling. Principles. Algorithms. Application. St. Petersburg: Polytechnic Publishing House. University, 2009. ISBN 978-5-7422-2272-9

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

19. D.A.Tarkhov. Neural Networks. Models and algorithms. Moscow, Radiotekhnika Publ., 2005. (Scientific series "Neurocomputers and their application", edited by A.I. Galushkin, Book 18.)

Additional literature for preparing for the GE and/or performing and defending the thesis:

1. Andrievsky B.R., Fradkov A.L. Selected Chapters of the Theory of Automatic Control with Examples in the MATLAB Language. - St. Petersburg: NaGCa, 1999. - 475 p.

2. Knut Donald E. The Art of Programming in 3 Volumes – Moscow: Izd. Williams House, 2008. – T.1 – 720, T.2 – 832 p., T.3 – 824 p.

3. Aho Alfred W., Hopcroft John, Ullman Jeffrey D., Data Structures and Algorithms - – Moscow: Izd. Williams House, 2000. – 384 p.

4. Nikulchev E.V. Practicum on Control Theory in the MATLAB Environment: Textbook. - Moscow: 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. un-t, In-t kosmich. and inform. Technologies. - Krasnoyarsk : SibFU, 2014. - 185 p.

6. Norenkov, Igor Petrovich. Fundamentals of Computer-Aided Design: A Textbook for Universities in the Direction of Training of Certified Specialists "Informatics and Computer Technology": Approved by the Ministry of Education of the Russian Federation / I. P. Norenkov. - Moscow: Bauman Moscow Technical University, 2002. - 334 p.

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

8. Numerical optimization methods. 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, Moscow: NaGCa, 1990 – 488 p.;

11.   Nonlinear programming. Theory and algorithms. Bazara M., Shetty K., Moscow: Mir, 1982 – 583 p.;

12.   D.E.Rumelhardt, 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 telecommunication network "Internet":

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

- RUDN University Electronic Library System – RUDN University Electronic Library System http://lib.rudn.ru/MegaPro/Web

- Electronic Library "University Library Online" http://www.biblioclub.ru

- EBS Urait http://www.biblio-online.ru

- EBS "Student Consultant" www.studentlibrary.ru

- EBS "Lan" http://e.lanbook.com/

- EBS "Troitsky Bridge"

2. Databases and search engines:

- Electronic fund of legal and regulatory and technical documentation http://docs.cntd.ru/

- Yandex https://www.yandex.ru/ search engine https://www.yandex.ru/

- Google search engine https://www.google.ru/

- SCOPUS http://www.elsevierscience.ru/products/scopus/ abstract database http://www.elsevierscience.ru/products/scopus/

Educational and methodological materials for students' independent work in preparation for the State Exam and/or thesis and preparation of the thesis *:

1. Guidelines for the implementation and execution of the thesis for the EP of HE "Artificial Intelligence and Robotic Systems".

2. Procedure for checking the thesis for the volume of borrowings in the "Antiplagiat" system.

3. The procedure for conducting the FSC in the EP HE "Data Science and Space Engineering / Data Science and Space Engineering" using DLT, including the procedure for identifying the personality of a graduate.

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

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

Assessment materials and a point-rating system* for assessing the level of competence formation based on the results of mastering the discipline "Data Science and Space Engineering / Data Science and Space Engineering" are presented in the Appendix to this FSC program.

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

THE HEAD OF THE ISSUING BUP:

Head of the Department of Mechanics and Control Processes		**Razumny Yu.N.**
Name of BUP	Signature	Surname I.O.

HEAD OF THE DEPARTMENT OF HIGHER EDUCATION:

Professor of the Department of Mechanics and Control Processes		**Razumny Yu.N.**
Position, BUP	Signature	Surname I.O.