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Информация о владельце:

ФИО: Порохня Андрей Алексеевич

Должность: И.о. директора института перспективной инженерии

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MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE RUSSIAN FEDERATION
Federal State Autonomous Educational Institution of Higher Education
NORTH CAUCASIAN FEDERAL UNIVERSITY

I APPROVED BY

Acting director of the institute
advanced engineering

Ph.D. tech. Sciences , Associate Professor
A.A. Porokhnya

WORKING PROGRAM OF THE DISCIPLINE

Mathematical Modeling

Direction of training	11.03.02 Infocommunication technologies and communication systems
Profile	Intelligent Data Processing in Infocommunication Systems and Networks
Year of commencement of studies	2026
Form of study	full-time
Implemented in a semester	4

Developed by

Professor of the Department of Digital,
robotic systems and electronics
Institute of Advanced Engineering
Doctor of Technical Sciences, professor
V.P. Mochalov

1. The purpose and objectives of mastering the discipline (module) "Mathematical Modeling"

The objective of the course is to master modern mathematical methods for modeling and optimizing information and communication systems and networks in accordance with the work program of the course "Mathematical Modeling".

Upon completion of this course, students should master the ability to formulate modeling and optimal design problems, as well as select and implement solution methods. The main objectives of this course include:

- mastering the concepts and classification of modeling and optimization methods;
- mastering methods for solving linear programming problems using graphical, simplex methods, the artificial basis method, and solving transport problems;
- mastering methods for solving problems of unconditional optimization of functions of one variable and using the derivative;
- mastering direct methods of unconditional optimization of functions of several variables and using derivatives.

2. The place of the discipline (module) in the structure of the educational program.

The discipline "Mathematical modeling" is a mandatory part of the disciplines of the curriculum B1.O.20.

3. List of planned learning outcomes for the discipline (module), correlated with the planned learning outcomes for the educational program

Code, formulation of competence	Code, indicator formulation	Planned learning outcomes for the discipline (module), characterizing the stages of formation of competencies, indicators
OPK-1 . Capable of using the principles, laws, and methods of natural science and mathematics to solve engineering problems.	ID-1 OPK-1 formulates the fundamental laws of nature and the basic physical mathematical principles and methods of accumulation, transmission and processing of information.	Uses regulatory and technical documentation in the field of information and communication technologies, basic physical mathematical principles and methods of accumulation, transmission and processing of information
	ID-2 OPK-1 applies physical laws and mathematical methods to solve theoretical and applied problems in the field of infocommunications.	Defines the general principles of operation of hardware, software, and hardware-software supported by the PCICS, applies physical laws and mathematical methods to solve theoretical and applied problems in the field of infocommunications.
	ID-3 OPK-1 uses deep knowledge of physics and mathematics to solve practical problems in the field of infocommunications.	uses a deep knowledge of physics and mathematics to solve practical problems in the field of infocommunications, o defines the architecture of hardware, software, and firmware of the supported PCICS.

Code, formulation of competence	Code, indicator formulation	Planned learning outcomes for the discipline (module), characterizing the stages of formation of competencies, indicators
OPK- 2 Able to independently conduct experimental research and use basic techniques for processing and presenting the obtained data	ID-1 OPK-2 finds and critically analyzes the information necessary to solve the assigned task.	It uses the basic reference model of open systems interconnection (OSI) and protocols of all levels of the OSI model, defines the main methods of processing experimental data using modern specialized software and mathematical support when solving research problems.
	ID-2 OPK-2 develops a solution to a specific problem, selecting the optimal option and evaluating its advantages and disadvantages.	Using modern specialized software and mathematical support, it defines and analyzes the infrastructure of the network function virtualization system (PCIS), using protocols of all levels of the open systems interaction model.
	ID-3 OPK-2 understands the basic methods and means of conducting experimental research, standardization and certification systems.	ID-3 OPK-4 demonstrates methods of computer modeling and information processing using specialized software and mathematical support open systems.
	ID-4 OPK-2 selects measurement methods and tools and conducts experimental research. data and assessment of the error of measurement results.	Proficient in measurement methods and tools and conducts experimental research. Data and assessment of measurement results error.
	ID-5 OPK-2 has methods for processing and presenting the obtained measurement results.	owns methods of processing and presenting the obtained measurement results, and assessing the error of measurement results.

4. Volume of the academic discipline (module) and forms of control*

Number of lessons: total: 3_z.e., 108 academic hours	OFO, in academic hours: 108
Contact work:	16
Lectures/including practical training	0
Laboratory work /including practical training	No
Practical classes /including practical training	16.00 / 16.00
Independent work	92.00

Forms of control	
Exam	No
Credit	Yes
Credit with grade	No
Coursework	No

5. The content of the discipline (module), structured by topics (sections) indicating the number of hours and types of classes

List of hours and types of classes							
No.	Section (topic) of the discipline and brief content	Developed competencies, indicators	full-time education				Forms of the current control academic performance
			Contact work of students with a teacher/of which in the form of practical training, hours			Independent work, hours	
			Lectures	Practical classes	Laboratory work		
1.	Problems and methods of modeling and optimization. The mathematical formulation of modeling and optimization problems and the classification of methods for optimizing infocommunication systems are presented . Practical lesson #1 Development and research of a model for distributing virtual resources of a data processing system. Using a simulation platform, develop a model for optimal load distribution across data center servers.	OPK-1 ID-1 OPK-1 ID-2 OPK-1 ID-3 OPK-1 OPK-2 ID-1 OPK-2 ID-2 OPK-2 ID-3 OPK-2		4		10	Interview. Defense of practical assignments.

2.	Linear programming. The paper presents a mathematical model of linear programming, examples of problems leading to linear programming problems, models and algorithms for solving linear programming problems. Practical lesson #2 Development and research of a simulation model of an automated control system element based on the GPSS platform World . Develop a structural diagram and simulation model of an element of an information system, obtain statistical data on its functioning.	OPK-1 ID-1 OPK-1 ID-2 OPK-1 ID-3 OPK-1 OPK-2 ID-1 OPK-2 ID-2 OPK-2 ID-3 OPK-2		4		10	Interview. Defense of practical assignments.
3.	Minimization of functions of one variable . The statement of the problem of unconditional optimization of a function of one variable, direct methods and methods using the derivative are presented . Practical lesson #3 Development of a simulation model of segmentation Load Hub Super Stack Switch 1000 Mbps Develop a simulation model based on statistical data to optimize the system.	OPK-1 ID-1 OPK-1 ID-2 OPK-1 ID-3 OPK-1 OPK-2 ID-1 OPK-2 ID-2 OPK-2 ID-3 OPK-2		4		10	Interview. Defense of practical assignments.
4.	Minimization of functions of several variables . Direct methods of unconditional optimization of functions of several variables, methods using derivatives are presented. Practical lesson No. 4. Modeling and research of quality indicators of a formalized model of a single-processor computer. Develop a simulation model of a single-processor computer and obtain simulation results.	OPK-1 ID-1 OPK-1 ID-2 OPK-1 ID-3 OPK-1 OPK-2 ID-1 OPK-2 ID-2 OPK-2 ID-3 OPK-2		4		10	Interview. Defense of practical assignments.

5.	Duality and stability analysis in linear programming A linear programming problem can be compared in a certain way with another linear programming problem called the dual The initial problem is the original one. These two problems are closely related and form a single dual pair.	OPK-1 ID-1 OPK-1 ID-2 OPK-1 ID-3 OPK-1 OPK-2 ID-1 OPK-2 ID-2 OPK-2 ID-3 OPK-2				10	Interview. Defense of practical assignments.
6.	Transport problem The TZ model is a ZLP model and can be solved using the simplex method. However, specialized algorithms have been developed for its solution. The most common solution method is the potential method. The solution to the technical specifications includes two stages.	OPK-1 ID-1 OPK-1 ID-2 OPK-1 ID-3 OPK-1 OPK-2 ID-1 OPK-2 ID-2 OPK-2 ID-3 OPK-2				10	Interview. Defense of practical assignments.
7.	Unconstrained optimization methods using derivatives Methods of unconditional minimization of a function of one variable using derivatives include the methods of broken lines, tangents, Newton, and others.	OPK-1 ID-1 OPK-1 ID-2 OPK-1 ID-3 OPK-1 OPK-2 ID-1 OPK-2 ID-2 OPK-2 ID-3 OPK-2				10	Interview. Defense of practical assignments.
8.	Methods of unconstrained optimization of functions of several variables Computational procedures in which the choice of a new approximation to a minimum point is determined by comparing the values of a function at several points in space a. Practical lesson #5 Development of a simulation model managing network packet queues on IEEE 802.11 wireless routers Based on the developed simulation model, obtain statistical indicators of network packet queue management on wireless routers.	OPK-1 ID-1 OPK-1 ID-2 OPK-1 ID-3 OPK-1 OPK-2 ID-1 OPK-2 ID-2 OPK-2 ID-3 OPK-2				10	Interview. Defense of practical assignments.

9.	The method of cyclic coordinate descent Sequential minimization of the objective function first in the direction of the first basis vector, then the second, and so on in a cycle.	OPK-1 ID-1 OPK-1 ID-2 OPK-1 ID-3 OPK-1 OPK-2 ID-1 OPK-2 ID-2 OPK-2 ID-3 OPK-2				12	Interview. Defense of practical assignments.
	TOTAL for the semester			16		92	

6. Fund of assessment tools for the discipline (module) “Software-defined networks”.

The assessment toolkit (AST) for ongoing monitoring of student progress and midterm assessment in a course (module) is based on a list of competencies being mastered, indicating the stages of their development during the course (module) mastery. The AST provides objective monitoring of the achievement of planned learning outcomes. The AST includes:

- description of indicators and criteria for assessing competencies at various stages of their formation, description of assessment scales;
- methodological materials defining the procedures for assessing knowledge, skills, abilities and (or) work experience, characterizing the stages of competence development;
- standard test assignments and other materials necessary for assessing knowledge, skills and the level of mastery of the developed competencies in the process of mastering the discipline (module).

FOS is an appendix to this discipline (module) program.

7. Methodological guidelines for students on mastering the discipline

When starting work, each student should take into account the following provisions.

The discipline (module) is structured on a thematic principle, each topic is a logically complete section.

The lecture material is devoted to the examination of key, basic provisions of the courses and an explanation of the educational assignments assigned to students for independent work.

Practical classes are held with the aim of consolidating the acquired information and acquiring skills for its application in solving practical problems in the relevant subject area.

Students' independent work is aimed at independent study of additional material, preparation for laboratory work, and completion of all types of independent work.

To successfully master the course, it is necessary to complete all types of independent work using the recommended sources of information.

8. Educational, methodological and informational support of the discipline

8.1. List of basic and additional literature required for mastering the discipline (module)

List of key literature:

8.1.1. Aksyonov, E.P. Methods of optimal solutions: a textbook / Ministry of Agriculture of the Russian Federation; Federal State Budgetary Educational Institution of Higher Education. "Perm State Agricultural Academy named after academician D.N. Pryanishnikov". - Perm: IPC "Prokrost", 2020. - 90 p.

8.1.2. Attetkov, A.V. Optimization Methods: <study guide>* / A. V. Attetkov, V. S. Zarubin, A. N. Kanatnikov. - Moscow: RIOR: INFRA-M, 2023. - 269 p.

List of additional literature:

8.1.3. Goncharov, V.A. Optimization Methods: A Textbook for Bachelor's and Master's Degrees / V. A. Goncharov. - Moscow: Yurait Publishing House, 2019.

8.1.4. Dubina, I.N. Fundamentals of mathematical modeling of socio-economic processes: textbook and practical training for bachelor's and master's degrees / I.N. Dubina. - Moscow: Yurait, 2023.

8.2. List of educational and methodological support for independent work of students in a discipline (module)

8.2.1 Lecture notes on the course "Methods of modeling and optimization" / compiled by V. P. Mochalov

2. Methodological manual for practical classes in the discipline "Methods of modeling and optimization" / compiled by V. P. Mochalov

8.3. List of resources of the information and telecommunications network "Internet" required for mastering the discipline (module)

8.3.1. <http://book.itep.ru/>.

8.3.2. <http://sokolov.niits.ru/lectures.htm>

9. List of information technologies used in the implementation of the educational process in the discipline (module), including a list of software and information reference systems

When giving lectures, computer technology is used to demonstrate presentation multimedia materials.

During practical classes, students carry out modeling and research of information and communication system devices using computer modeling software and industrial laboratory setups.

Information reference systems:

Information and reference and information and legal systems used in the study of the discipline:

1. <http://book.itep.ru/>.

2. <http://sokolov.niits.ru/lectures.htm>

Software:

1. Cisco Packet Tracer

2. PTC Mathcad Prime. Perpetual license. Agreement No. 29-ea/14 dated July 8, 2014.

3 Alt Workstation 10

4 Alt Workstation K

5 Alt "Server"

6 Office suite - P7-Office

10. Description of the material and technical base necessary for the implementation of the educational process in the discipline (module)

The material and technical base ensures the implementation of all types of disciplinary and interdisciplinary training, laboratory, and research work of students (portable laptop, portable projector, computers with the necessary software and Internet access).

Lecture classes	A classroom for conducting classes, equipped with multimedia equipment and technical teaching aids.
Laboratory classes	A classroom for conducting classes, equipped with multimedia equipment, technical teaching aids and special network equipment.
Independent work	A room for independent student work equipped with computers and the ability to connect to the Internet and access the university's electronic information and educational environment.

11. Features of mastering the discipline (module) by persons with disabilities

Students with disabilities are provided with special textbooks, teaching aids and didactic materials, special technical teaching aids for collective and individual use, the services of an assistant (helper) who provides students with the necessary technical assistance, as well as the services of sign language interpreters and tactile sign language interpreters.

The acquisition of a discipline (module) by students with disabilities can be organized jointly with other students, as well as in separate groups.

The acquisition of a discipline (module) by students with disabilities is carried out taking into account the characteristics of psychophysical development, individual capabilities and health status.

In order to ensure accessibility of higher education under the educational program for individuals with disabilities, the following is provided when mastering a discipline (module):

- 1) for persons with visual impairments:
 - the presence of an assistant who provides the student with the necessary technical assistance, taking into account individual characteristics (helps to take up a workstation, move around, read and complete assignments, including taking down dictation),
 - written assignments, as well as instructions on how to complete them, are written in large print,
 - special textbooks, teaching aids and didactic materials (with large print or audio files),
 - individual uniform illumination of at least 300 lux,
 - if necessary, the student is provided with a magnifying device to complete the assignment;
- 2) for persons with hearing impairments:
 - the presence of an assistant who provides the student with the necessary technical assistance, taking into account individual characteristics (helps to take up a workstation, move around, read and complete assignments, including taking down dictation),
 - the availability of sound amplification equipment for collective use is ensured; if necessary, the student is provided with sound amplification equipment for individual use;
 - is provided with appropriate sound means for reproducing information;
- 3) for persons with disabilities who have musculoskeletal disorders (including severe impairments of the motor functions of the upper limbs or the absence of upper limbs):
 - written assignments are completed on a computer with specialized software or dictated to an assistant;
 - at the student's request, assignments can be completed orally.

12. Features of the implementation of the discipline using distance learning technologies and e-learning

According to Part 1 of Article 16 of Federal Law No. 273-FZ of December 29, 2012, "On Education in the Russian Federation," e-learning is defined as the organization of educational activities using information contained in databases and used in the implementation of educational programs, as well as information technologies, technical means, and information and telecommunications networks that facilitate the transmission of said information over communication lines, as well as interaction between students and teaching staff. Distance learning technologies are educational technologies implemented primarily using information and telecommunications networks through indirect (remote) interaction between students and teaching staff.

The course may be delivered using distance learning technologies and e-learning, in whole or in part. The components of the course's teaching and methodological kit (the course curriculum, assessment and methodological materials, and assessment forms) implemented using distance learning technologies and e-learning contain instructions for their use.

When organizing educational activities using distance learning technologies and e-learning, asynchronous and synchronous methods of interaction between participants in educational relations may be provided through the Internet information and telecommunications network.

When using distance learning technologies and e-learning, the curriculum for the discipline shall indicate: methods of interaction between participants in educational relations via the Internet (videoconferencing, electronic testing); links to the SKFU electronic information and educational

environment, to educational platforms and resources of other organizations that are openly accessible via the Internet; for synchronous learning - the time of online classes and teachers; for asynchronous learning - the authors of online courses.

When organizing midterm assessments using distance learning technologies and e-learning, the Methodological Recommendations for the Application of Technical Means Ensuring the Objectivity of Results during Midterm and State Final Assessments for Higher Education Programs—Bachelor's Degree Programs, Specialist Programs, and Master's Degree Programs Using Distance Learning Technologies—are used (Letter of the Ministry of Education and Science of the Russian Federation dated December 7, 2020, No. MN-19/1573-AN "On the Submission of Methodological Recommendations").

The implementation of the course using e-learning and distance learning technologies is carried out using the electronic information and educational environment of SKFU, to which students have access via the information and telecommunications network "Internet", or using the resources of other organizations, including platforms providing services for video conferencing, online meetings and distance learning (MTS-Link), as well as using the capabilities of social networks for communication between students and teachers.

The educational and methodological support for a discipline implemented using e-learning and distance learning technologies includes a work program, educational and methodological manuals or a course of lectures, methodological instructions for the implementation of various types of educational activities of students provided for by the discipline, and other educational and methodological materials posted in the information and educational environment of SKFU, presented in electronic form.