Disciplines (modules) are studied within the framework of the EP HE «Data Science and Space Engineering » in the direction of 27.04.04 Control in technical systems

ANNOTATIONS OF DISCIPLINES (MODULES) OF THE EP HE

Disciplines (modules) are studied within the framework of the EP HE «Data Science and Space Engineering » in the direction of 27.04.04 Control in technical systems

Federal State Autonomous Educational Institution of Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA
NAMED AFTER PATRICE LUMUMBA
RUDN University

ANNOTATIONS OF DISCIPLINES (MODULES) OF THE EP HE

The study of disciplines is conducted within the framework of mastering the basic professional educational program of higher education (EP HE)

Data Science and Space Engineering

(Name (profile/specialization) EP HE)

implemented in the field of training/specialty:

27.04.04 Control in technical systems

(the code and name of the field of study/specialty)

2024

Disciplines (modules) are studied within the framework of the EP HE «Data Science and Space Engineering » in the direction of 27.04.04 Control in technical systems

Name of the discipline	*Russian language (as a foreign language) in professional activity*
The scope of the discipline	6 credits (216 hours)
Summary of the discipline	
The name of the sections (topics) of the discipline:	**Summary of the sections (topics) of the discipline:**
Russian language as a means of mastering a profession.	Prestigious and in-demand professions in the engineering and technical field (profile). Professional portrait of a specialist. Qualities, properties, abilities. Acquaintance with texts from professional magazines and websites, texts-information of recruitment agencies. Preparation of an autobiography and resume. Linguistic means of self-presentation. Role Lesson: Job Interview.
Reading professionally oriented texts	Reading authentic texts on professional topics using various strategies (studying, browsing, informative). Structural and semantic analysis of texts in the specialty: highlighting key words, information center; basic and additional information. The concept of text compression. Formulas for expanding and compressing text material. Transformation of texts by specialty: comprehension, processing of content, presentation of basic information. Preparation of reports for a project on the topic.
Professional dialogue: communicative strategies, speech tactics and behavior in a business conversation, the structure of a business dialogue	Reading and listening to dialogues-conversations / interviews in the specialty in order to adequately understand professionally significant information and form the linguistic apparatus of dialogical speech. Communicative means of achieving the goals of professional dialogue: exchange of greetings, introduction to the topic of the dialogue, presentation of one's opinion on the topic. Questions to the participant of the dialogue, request for his opinion. End of the professional dialogue. Role-playing: participation in a dialogue on one of the professional topics.
Preparation of business documents in professional activities. Genres of Written Business Speech	The main features and typical linguistic means of an official business text. Functional and structural-linguistic features of documents. Define a document. Classification of documents by origin, purpose, design. The concept of requisites. Basic details and their design.
Speech etiquette in professional activity	The content of the concept of "speech etiquette". Basic standards of etiquette of a business person. Standards of etiquette of a business person and tactics of reaction when participating in business conversations, negotiations. Features of a business telephone conversation, standard speech formulas. Role Lesson: Talking on the phone on a professional topic.

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Name of the discipline	**History and Methodology of Science**
Volume of discipline, credits/ac. hours	2/72
CONTENT OF THE DISCIPLINE	
Section 1 Introduction to the theory of scientific research in informatics and computer engineering. Statement of the scientific problem, goals and objectives of the study. Methods of scientific research.	Topic 1.1 Theory and genesis of its development. Conceptual apparatus: theory, scientific research. Thinkers of the Ancient World and their development of the main worldview concepts and approaches to the analysis of the world around them. Topic 1.2 Theoretical sources as the basis for the development of thought. Genesis of the theory. Theory and science. Topic 1.3 Types of scientific research. Theoretical postulates and their representatives. Choosing the main direction of theory development. Priority of analysis among and unsolved problem. Topic 1.4 Possibilities of theoretical forecasting of processes and phenomena. Formation of an evidence base for theoretical forecasting. Topic 1.5 Comparative analysis of theoretical approaches to science of Western and Eastern cultures. Topic 1.6 Similar, different features and uniqueness in the choice of research topic, methods of its consideration and the ultimate goal.
Section 2 The main types of scientific results in research. Approbation of research results. Rules for the preparation of research papers.	Topic 2.1 The main stages of scientific research in physical and mathematical sciences. Observation and its features. Observation as the basis for choosing a research topic. Topic 2.2 Types of observation. Determination of the relevance of the choice of topic in physical and mathematical sciences. Search for an innovative niche. Proof of the practical significance of the chosen topic. Definition of the purpose and objectives of the study. Search for monographs, materials of scientific conferences, round tables, articles in specialized scientific journals to form a general picture in the field of the proposed scientific research. Topic 2.3 Work with Internet resources and statistical sources. Methods of collecting theoretical and empirical data. Formation of the database and verification of its reliability. Formatting quotations. Topic 2.4 The role of hypothesis in scientific research in physical and mathematical sciences. Hypothesis as a form of forecasting in scientific research in the field of physical and mathematical sciences. Topic 2.5 Evidence and experimental base to confirm the hypothesis. PEST analysis as a method of studying the scientific environment for the development of new technologies. Topic 2.6 Types of models. Innovative Approaches to Model Formation in Physical and Mathematical Sciences. Formation of graphs, schemes, tables. Comparability of data.

Section 3 Reviewing, opposing and other forms of evaluation of research papers. Implementation and effectiveness of scientific research. Dissertation research, its structure and defense.	Topic 3.1 The structure of the dissertation. Topic 3.2 Article. Presentations at regional, national and international conferences. Topic 3.3 Approbation of the results of scientific investigations. Topic 3.4 Participation in innovative projects in the field of physical and mathematical sciences. Topic 3.5 Requirements for writing an abstract. Mailing deadlines. Topic 3.6 Requirements for internal and external reviews. Search for reviewers. Topic 3.7 Requirements for PowerPoint presentations. Diagrams and table in presentations. Requirements for speaking at the defense of a dissertation. PowerPoint speeches.

Name of the discipline	**Information Technology in Mathematical Modelling**
Volume of discipline, credits/ac. hours	3/108
CONTENT OF THE DISCIPLINE	
Section 1 Interpolation and approximation.	Topic 1.1 Basic concepts of approximate computation theory Topic 1.2 Methods of approximate solution of computational problems Topic 1.3 Gaussian method. Inversion of the matrix according to the Gaussian method. Running Method
Section 2 Solving equations	Topic 2.1 Iterative methods for solving nonlinear equations. Newton's method Topic 2.2 Simple iteration and compression mapping. Interpolation and approximation by polynomials Topic 2.3 Formulation of the simplest interpolation problems. Lagrange interpolation polynomial Topic 2.4 Newton's interpolation polynomial for unequal intervals Topic 2.5 Finite Differences and Interpolation Newtonian Polynomials for Equidistant Nodes
Section 3 Solution of systems of equations	Topic 3.1 Elements of numerical integration Topic 3.2 Quadrature formulas of Nton-Kotes and their special cases Topic 3.3 Quadrature formula of the trapezoid. The geometric meaning of the trapezoid Topic 3.4 Simpson's quadrature formula
Section 4 Solving differential equations	Topic 4.1 Elements of numerical solution of differential equations. Topic 4.2 Difference approximation of differential operators. Method of first-order accuracy Topic 4.3 Methods for solving ordinary differential equations. Second-order accuracy methods Topic 4.4 Methods for solving ordinary differential equations. Fourth-order precision methods
Section 5 Information Models in Physics	Topic 5.1 Boundary Line Tasks. Variational Difference Schemes for Boundary Value Problems Topic 5.2 Mesh approximation. Euler's method for a system of equations Topic 5.3 Error and stability of the Euler method. Elements of numerical differentiation Topic 5.4 Numerical differentiation formula for non-equidistant nodes Topic 5.5 Total error in numerical differentiation. Method of least squares Topic 5.6 Elements of Operations Research Theory

Section 6 Computer Simulation Concept	Topic 6.1 Mathematical programming. Elements of linear programming Topic 6.2 The Canonical Problem of Linear Programming Topic 6.3 Geometric meaning of the system of linear inequalities. The Geometric Meaning of the Two-Dimensional Linear Programming Problem Topic 6.4 Simplex Method Idea. Simplex tables. Geometric Characteristics in Problems and methods of linear programming. Reciprocal Dual Problems of Linear Programming Topic 6.5 Elements of nonlinear programming. Indeterminate Lagrange Factor Method

Name of the discipline	**Numerical Methods for Solving Mathematical Modeling Problems**
Volume of discipline, credits/ac. hours	5/180
CONTENT OF THE DISCIPLINE	
Section 1 Methods for minimizing functions of a single variable	Topic 1.1 Problem statement. Classic method Topic 1.2 Bisection method Topic 1.3 The Golden Section Method Topic 1.4 The method of broken Topic 1.5 Coating method Topic 1.6 Convex functions of a single variable Topic 1.7 Tangent method
Section 2 Classical theory of extremum of functions of many variables	Topic 2.1 Problem statement Topic 2.2 Weierstrass's theorem Topic 2.3 Classical method of solving problems for unconditional extremum Topic 2.4 Problems for conditional extremum Topic 2.5 Prerequisites of the first and second order Topic 2.6 Sufficient extremum conditions
Section 3 Methods for minimizing the functions of many variables	Topic 3.1 Gradient method Topic 3.2 Gradient projection method Topic 3.3 Conditional Gradient Method Topic 3.4 Possible Directions Method Topic 3.5 Proximal method Topic 3.6 Linearization method Topic 3.7 Quadratic Programming Topic 3.8 Conjugate Direction Method Topic 3.9 Newton's method Topic 3.10 Continuous Variable Metric Methods Topic 3.11 Coordinate descent method Topic 3.12 Coverage Method in Multidimensional Problems Topic 3.13 Modified Lagrange function method Topic 3.14 Method of penalty functions Topic 3.15 Proof of Necessary Conditions for First- and Second-Order Extremes Using Penalty Functions Topic 3.16 Barrier Function Method Topic 3.17 The Loaded Function Method Topic 3.18 Random search method
Section 4 Dynamic programming	Topic 4.1 Bellman's diagram Topic 4.2 The Problem of Synthesis for Discrete Systems Topic 4.3 Moiseev's scheme Topic 4.4 The Problem of Synthesis for Systems with Continuous Time Topic 4.5 Sufficient optimality conditions

Section 5 Pontryagin maximum principle	Topic 5.1 Formulation of the optimal control problem Topic 5.2 Formulation of the maximum principle Topic 5.3 Proof of the maximum principle Topic 5.4 Maximum Principle for Optimal Control Problems with Phase Constraints Topic 5.5 The Relationship Between the Maximum Principle and the Classical Calculus of Variations
Section 6 Applying the Maximum Principle to Optimization Problems	Topic 6.1 Reduction of the optimization problem to the boundary value problem of the maximum principle Topic 6.2 Firing method for numerical solution of the boundary value problem of the maximum principle Topic 6.3 Modifications of the Newtonian method: Isaev-Sonin modification, Fedorenko normalization Topic 6.4 Runge-Kutt method for solving Cauchy problems

Name of the discipline	**Programming Technology**
Volume of discipline, credits/ac. hours	8/288
CONTENT OF THE DISCIPLINE	
Section 1 Basic elements of Python syntax	Topic 1.1 Basic syntax of the Python 3 language. Memory model and basic data types Topic 1.2 Cycles and lists. Functions.
Section 2 Elements of the theory of algorithms	Topic 2.1 The concept of an algorithm. Turing machine. Computability. Complexity theory. Exponentiation: Analysis of the algorithm (smart exponentiation). Topic 2.2 The problem is about the backpack. Greedy algorithm. The gradient descent method as an example of a greedy algorithm. Divide and conquer strategy. Recursive algorithm.
Section 3 Programming paradigms. Object-oriented programming	Topic 3.1 Basic principles of programming. Procedural programming. Topic 3.2 Object-oriented programming (OOP). Functional programming. Topic 3.3 Features of PLO. Classes and objects. Inheritance. Implementing OOP in Python
Section 4 Sorting and search algorithms	Topic 4.1 Sorting by selection. Sorting by inserts. Bubble Method Sorting. Merge sorting. Quick sorting Topic 4.2 Finding the median. Sequential search. Methods of narrowing the area. Sorting in Python.
Section 5 Algorithms on graphs	Topic 5.1 Graphs and their analysis. Graph representation. Traversal of the graph in depth and width Topic 5.2 Restoration of the shortest path. The problem of moving a chess knight Topic 5.3 Dijkstra's algorithm. Queue and stack. Queue and stack in Python
Section 6 Dynamic programming	Topic 6.1 Bellman's principle of optimality. The concept of bottom-up and top-down decision. Topic 6.2 The problem is about the number of routes. Similarities and differences between dynamic programming and the concept of divide and conquer Topic 6.3 ATM problem. Dynamic programming and games
Section 7 Parallel algorithms	Topic 7.1 Background. Classification of computing systems. CPU and GPU processors. Topic 7.2 Characteristics of parallel algorithms. Types of non-sequential programming in Python. Topic 7.3 Processes and Flows in Python. Asynchronous programs.

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Section 8 Program optimization	Topic 8.1Methods for optimizing and speeding up Python programs. Profiling programs in Python. Topic 8.2 Module line_profiler. Python compilation: Ahead-of-time and Just-in-time compilation. Numba module. Topic 8.3 Cython as an extension of the Python language. Features of developing a program on Cython
Section 9 C\C++. Introduction	Topic 9.1 C and C++ language features, history and evolution. Machine-oriented programming languages and computer operating principles. Topic 9.2 Code translation. Types of broadcasting. Differences between interpreters and compilers. Topic 9.3 Mapping Python and C/C++ programs. Scope of C/C++ languages as well.
Section 10 Basic elements of syntax	Topic 10.1 Block structure of programs in C/C++ languages, syntactic rules for block allocation and their types. Topic 10.2 Basic instructions: branching (or conditional statement), loops (while, do while and for), unconditional jump operator, multiple choice operator. Topic 10.3 Syntactic constructs for working with functions: declaration, definition, call. Call stack. Comparison of goto and return
Section 11 Arrays and pointers	Topic 11.1 Signs and addresses. Work with signs and addresses. Array as a data structure: storage in memory, access to elements. Topic 11.2 Creating static arrays. Address arithmetic
Section 12 Static and dynamic memory.	Topic 12.1 Rules for creating static arrays, initializing it, and using it. One-dimensional and multidimensional static arrays. Dynamic memory (C style). Topic 12.2 Dynamic memory (C++ style). Functions for working with dynamic memory, memory allocation and deallocation operations Topic 12.3 Creating One-Dimensional and Multidimensional Dynamic Arrays
Section 13 Structured data types	Topic 13.1 Arrays, character strings, structs, union, enumerated data type, bit fields. Syntactic features of declaration, initialization, and operation. Topic 13.2 Features of the "packaging" in memory. Examples of use. Dynamic data structures: vector, queue (stack), list, as examples of organizing work with structured data in a dynamic mode.
Section 14 Error Catching	Topic 14.1 The syntax of the exception handling operation. Examples of use.
Section 15 Data I/O	Topic 15.1 The concept of a stream and a buffer. Keyboard, screen and file as a data source and receiver. Organize data input and output flows in C++. Topic 15.2 Write data to the stream and read data from the stream. Positioning of data in the flow. Modes of working with files: read-write, character-text format and their combinations Topic 15.3 Text and binary files, and the feature of data storage in them. Direct Access Files
Section 16 Object Oriented programming in C++	Topic 16.1 Create classes and features. Configure access modifiers: public, private, and protected. Friendly functions and classes. Topic 16.2 The this. Organizing an inheritance operation in the C++ language. Virtual functions and overloading of functions and operators.
Section 17 Using libraries	Topic 17.1 STL and BOOST Overview & Usage Examples

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Section 18 Parallel algorithms and systems	Topic 18.1 Classification of computing systems. CPU and GPU processors. Characteristics of parallel algorithms Topic 18.2 Types of non-sequential programming. Parallel computing standards: interaction between supercomputer nodes, interaction between cores of the same CPU within one node, accelerators within one node
Section 19 Algorithms in external memory	Topic 19.1 Organization of calculations taking into account the hierarchical structure of memory. Buffering on reads and writes. Topic 19.2 Complex and dynamic data structures. Algorithms on graphs in external memory (BFS, DFS, cohesive component search, MST)
Section 20 OpenMP technology	Topic 20.1 Parallel computing using the OpenMP standard. Topic 20.2 Basic information. Threads and processes. Parallel and Serial Regions Topic 20.3 Parallel loops and parallel regions. Automatic parallelization of loops.
Section 21 MPI technology	Topic 21.1 Parallel computing using the MPI standard. Basic information. Basic MPI procedures. Topic 21.2 MPI data types. Methods of message transmission. Receiving and Sending Messages by Processes
Section 22 OpenACC technology	Topic 22.1 Parallel computing using the OpenACC standard Topic 22.2 An overview of GPU performance in various applications. Compare Computing Accelerators. Basic principles for achieving high productivity Topic 22.3 Benefits of OpenACC. Execution model: gangs, workers, vectors. Paralallel, kernels, loop directives Topic 22.4 Data attributes. Data regions: data, enter data, exit data. Additional data management constructs: cache, update, declare Topic 22.5 Asynchronous execution - async and wait. Atomic operations. Global variables. OpenACC in C++
Section 23 CUDA Hardware and Software Architecture	Topic 23.1 GPU architecture. GPU memory hierarchy. CUDA program model. Topic 23.2 Using C++ libraries for OpenCL and CUDA programming
Section 24 Introduction to Distributed Object Technologies	Topic 24.1 The concept of a distributed information processing system. Types and properties of distributed systems. Topic 24.2 Architecture of information systems software. Manage the interoperability of heterogeneous applications Topic 24.3 Basic mechanisms of distributed object technologies.
Section 25 Basic Models of Distributed Object Technologies	Topic 25.1 Types of distributed applications. Cloud. Definition of cloud computing. Multi-layered architecture of cloud-native applications. Components of cloud applications. Topic 25.2 Advantages and disadvantages of cloud Calculations. The most common cloud platforms. GRID technologies. Topic 25.3 GRID architecture. GRID Standards. GRID parametric performance models. Comparison of GRID and Cloud Computing.
Section 26 Application Integration Challenges	Topic 26.1 Application integration issues. End-to-end application integration. Message brokers. Publish/subscribe interaction model Topic 26.2 Workflow management systems. Application servers.

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Name of the discipline	**Machine Learning and Big Data Mining**
Volume of discipline, credits/ac. hours	5/180
CONTENT OF THE DISCIPLINE	
Section 1 Introduction to machine learning and data science. Data Mining and Machine Learning software tools.	Topic 1.1 Introduction to machine learning and data science. Formulation of the main classes of tasks in machine learning. Topic 1.2 Regression and classification; clustering, dimensionality reduction Topic 1.3 Word processing; image processing
Section 2 The main apparatus of combinatorics and mat. Statistics. Regression analysis and data compression.	Topic 2.1 The main apparatus of combinatorics and mat. Statistics. Basic concepts of mathematical Statistics Topic 2.2 Statistical estimates, their properties, testing hypotheses. Regression analysis and data compression. Topic 2.3 Regression problem. Minimize the square of the deviation. Regression function: conditional expectation Topic 2.4 Linear regression and the k nearest neighbor method. Overtraining and undertraining Topic 2.5 Error decomposition into noise, displacement, and dispersion
Section 3 Detection of outliers and anomalies. Data cleansing and regularization technologies.	Topic 3.1 Detection of outliers and anomalies. What are emissions, types of emissions Topic 3.2 Methods for detecting outliers. Anomaly search Topic 3.3 Censoring the sample. Screening of outliers, removal of outliers Topic 3.4 Data cleansing and regularization technologies. Main types of regularization Topic 3.5 Dimensionality reduction method. Methods of Feature Selection
Section 4 Clustering and classification technologies. Neural networks. Genetic algorithms.	Topic 4.1 Clustering and classification technologies. K- means. EM algorithm Topic 4.2 Other clustering methods. Classification tasks. Bayesian classifier Topic 4.3 Linear methods for classification. Logistic regression, maximizing likelihood Topic 4.4 Neural networks: a common architecture. Multilayer networks. Backpropagationerror Topic 4.5 Stochastic gradient descent. Genetic Algorithms
Section 5 Feature detection; Data normalization. Fuzzy sets. Bayesian networks.	Topic 5.1 Feature detection Topic 5.2 Feature transformations. Data normalization. Data normalization methods Topic 5.3 Normalization according to the minimax method. Normalization by Z-score. Decimal scaling Topic 5.4 Fuzzy sets. Bayesian networks. Bayesian inference problems. Method for building a fuzzy bayesian network

Name of the discipline	**Virtual Reality And Computer Vision**
Volume of discipline, credits/ac. hours	5/180
CONTENT OF THE DISCIPLINE	
Section 1 Principles of building virtual reality (VR) systems	Topic 1.1 Overview of SDR systems Topic 1.2 History of the development of SDR systems Topic 1.3 Human-User Interaction and Reality Models Topic 1.4 Simulate operations possible with real objects Topic 1.5 Immersive perception of the reality model
Section 2 Principles of building augmented reality (AR) systems	Topic 2.1 Three-dimensional object models used to augment real-world scenes Topic 2.2 Establishing the correspondence of the user's real space with the data of three-dimensional models Topic 2.3 Track the user's position to determine their point of view in real space. Topic 2.4 Real-time display of real-world scenes combined with computer graphics generated from the model.

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Section 3 Remote control	Topic 3.1 Sensors, Effectors, Communication Channels for Virtual Reality Systems.
Section 4 Devices for virtual and augmented reality systems	Topic 4.1 Head-up display. Topic 4.2 Stereoscopic image output device. Topic 4.3 Audio input/output devices. Topic 4.4 Sensors for the spatial location of human body parts or tools. Topic 4.5 Devices for input-output of tactile information. Topic 4.6 Motion information input/output devices.
Section 5 Generation of three-dimensional models and images	Topic 5.1 Types of three-dimensional models. Rendering is the creation of images based on object models. Topic 5.2 Define model surfaces. Compute the pixel values of the generated image.
Section 6 A combination of real and artificial images	Topic 6.1 Texture mapping. Topic 6.2 Image-based rendering.
Section 7 Examples of virtual reality applications	Topic 7.1 Inspection of architectural structures. Flight simulation. Interactive segmentation of anatomical structures.
Section 8 Examples of applications of augmented reality systems	Topic 8.1 Augmented reality systems used in surgery. PCB inspection. Projection of the car's dashboard onto the windshield.
Section 9 Psychophysiological Aspects of the Human-Machine Interface in Virtual and Augmented Reality Systems	Topic 9.1 Provide an immersive virtual experience. The need for individual configuration of devices and parameters of virtual and augmented reality systems. Topic 9.2 Side effects of virtual and augmented reality systems on humans.

Name of the discipline	**Advanced methods of space flight mechanics**
Volume of discipline, credits/ac. hours	8/288
CONTENT OF THE DISCIPLINE	
Section 1 Methods for calculating the perturbed motion of spacecraft in the force field of several celestial bodies	Topic 1.1 Two-Body Problem. Kepler's Empirical Laws. The first integrals of the Kepler problem. Phase portrait. Osculating elements. Equations of Perturbed Motion in Occupying Elements Topic 1.2 Three-body problem. Bounded circular problem of three bodies. Hill areas. Sitnikov's problem. Gravitational potential of the Earth. Euler's problem of two stationary attracting centers. A generalized problem of two fixed centers. Topic 1.3 Problem of N-bodies. Stability of the Solar System. Laplace's theorem. KAM theory. Studies by Jacques Laskar.
Section 2 Motion of a Solid Body in a Central Gravitational Field	Topic 2.1 Satellite proximity. Limited formulation of the satellite motion problem. Relative equilibriums. The problem of Leonov and the plug. Topic 2.2 Influence of light pressure on the motion of a spacecraft. Solar sail.

Name of the discipline	**Advanced methods of Earth remote sensing**
Volume of discipline, credits/ac. hours	6/216
CONTENT OF THE DISCIPLINE	
Section 1 Introduction.	Topic 1.1 Identify and review the history of remote sensing and the evolution of remote sensing and remote sensing systems. Topic 1.2 Electromagnetic radiation (EMR), terms and definitions, radiation laws, EM spectrum, EMR sources.

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Section 2 Remote sensing systems	Topic 2.1 Active and passive systems, mapping and other systems, the concept of resolution in remote sensing - spatial, spectral, radiometric and temporal. Topic 2.2 Orbits and platforms for Earth observation.
Section 3 Image reception and processing	Topic 3.1 Reception, processing and creation of information products. Topic 3.2 Mastering the freely distributed MultiSpec program for analyzing multispectral Landsat data (on the example of various objects and industries).
Section 4 Application	Topic 4.1 Applications of remote sensing in Earth, Ocean, atmosphere, emergency and climate change sciences.

Name of the discipline	**Geoinformation systems and applications**
Volume of discipline, credits/ac. hours	6/216
CONTENT OF THE DISCIPLINE	
Section 1 Fundamental Concepts of Geoinformatics	Topic 1.1 Geographic Information System: Overview, Software and Data, Spatial and Attribute Data, Vector and Raster Data, Layers, Networks, and Web Clients. Topic 1.2 Open and Commercial GIS. Topic 1.3 Thematic GIS applications.
Section 2 Geographic Information Systems and Spatial Data	Topic 2.1 Data sources for GIS. Data entry issues. Topic 2.2 Remote sensing as a data source. Topic 2.3 Georeferencing and map projections in GIS.
Section 3 Thematic Mapping, Surfaces, and Digital Elevation Model (DEM)	Topic 3.1 Compilation of thematic maps, types of digital terrain models, algorithms for working with DEMs, creation of 3D terrain models. Topic 3.2 Integrated Use of Remote Sensing Data and Geoinformation Technologies in Industry Management
Section 4 Analytical functions of GIS	Topic 4.1 Typical queries. Overlay. Topic 4.2 Spatial queries in GIS
Section 5 Design the style of the project	Topic 5.1 Create a map layout

Name of the discipline	**Dynamics and control of space systems**
Volume of discipline, credits/ac. hours	8/288
CONTENT OF THE DISCIPLINE	
Section 1 Methods for optimizing the orbital structures of satellite systems	Topic 1.1 General principles for satellite systems design. Methods for constructing systems for global continuous observation of the Earth's regions. Ballistic design of systems for continuous zonal monitoring of the Earth's surface. Topic 1.2 Determination of the time gap in the monitoring of one frontal group of the entire surface of the Earth. Methods for constructing satellite systems for periodical observation of the Earth's surface. Construction of ballistic structures for monitoring systems of the entire surface of the Earth with small gaps in observation. Construction of systems for periodical monitoring of an area on the Earth's surface. Ballistic design of spacecraft probabilistic systems. Topic 1.3 Spacecraft communication systems. Satellite radio navigation systems. Features of the construction of meteorological satellite systems. Construction of outer space monitoring systems. Ballistic design of systems using ballistically coupled spacecraft groups. Topic 1.4 Space tether systems. Orbital functioning of the connected space objects. Rapprochement in space using tether systems. The method of forming optimal modes of tether systems controlled movement in solving practical problems.

Section 2 Numerical and analytical methods for optimizing orbital maneuvers	Topic 2.1 Equations of spacecraft motion in deviations from motion along the circular reference orbit. Singleimpulse maneuvers. Changes in the shape of the orbit as a result of the application of velocity impulse. Estimation of the magnitude of the maneuvers, the choice of the initial deviation along the orbit at the spacecraft start. Necessary optimality conditions. The main types of tasks for spacecraft optimal maneuvering. Topic 2.2 Optimal maneuvering in the space debris problem. Spacecraft avoidance maneuvers from collision with space debris. Assessment of maneuvers performed by an active space object. Topic 2.3 Optimal maneuvering in the space service problem. Planning the optimal service for a constellation of spacecraft in non-coplanar orbits. Assessment of maneuvers performed by active spacecraft when transferring to the vicinity of serviced objects.
Section 3 Methods for calculating the disturbed motion of spacecraft in the force field of several celestial bodies	Topic 3.1 The two-body problem. Kepler's empirical laws. First integrals for the Kepler problem. Phase portrait. Osculating elements. Equations of indignant motion in the occupying elements. Topic 3.2 The three-body problem. The circular restricted three-body problem. Stability of libration points. The Hill's problem. The Sitnikov problem. The gravitational potential of the Earth. The Euler problem of two fixed attracting centers. Generalized problem of two fixed centers. Topic 3.3 The N-body problem. The stability of the solar system. Laplace's theorem. KAM theory. Jacques Lascard's research. Topic 3.4 The motion of a rigid body in a central gravitational field. Satellite approximation. Limited formulation for the satellite motion problem. Relative equilibria. The problem of Leonov and the stub. Topic 3.5 Influence of light pressure on the motion of a spacecraft. Solar sail.

Name of the discipline	**Artificial neural networks (deep learning)**
Volume of discipline, credits/ac. hours	5/180
CONTENT OF THE DISCIPLINE	
Section 1 Concepts. Typology of problems solved by machine learning methods. Multilayer Perceptron	Topic 1.1 Definitions, history of development and main trends of artificial intelligence. Topic 1.2 Biological neuron and its mathematical model. Types of activation functions. Neural networks and their classification. Mathematical models of specialized neurons. Topic 1.3 Multilayer neural networks. Representation of regression, approximation, identification, control, and data compression problems in a neural network logical basis. Multilayer perceptron.
Section 2 Evolutionary Teaching Methods	Topic 2.1 An algorithm for backpropagation of an error and its modification. Topic 2.2 Selection of optimal network parameters
Section 3 Types of neural networks	Topic 3.1 A neural network with general regression. Topic 3.2 Probabilistic neural network. Topic 3.3 Neural networks with radial basis functions. Topic 3.4 Neural Network and Kohonen Self-Organizing Maps
Section 4 Evolutionary Teaching Methods	Topic 4.1 An algorithm for backpropagation of an error and its modification. Multilayer perceptrons. Selection of optimal network parameters
Section 5 Neural networks with feedback	Topic 5.1 Hopfield neural networks. Neural network methods for solving optimization-combinatorial problems. Hamming neural networks. Pattern recognition using distances. Topic 5.2 Bidirectional associative neural networks. Perceptron-based neural networks with feedback
Section 6 Specialized neural networks	Topic 6.1 Deep neural networks. Topic 6.2 Convolutional neural networks. Topic 6.3 Recurrent networks.

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Name of the discipline	**Artificial neural networks (deep learning)**
Volume of discipline, credits/ac. hours	5/180
CONTENT OF THE DISCIPLINE	
Section 1 Concepts. Typology of problems solved by machine learning methods. Multilayer Perceptron	Topic 1.1 Definitions, history of development and main trends of artificial intelligence. Topic 1.2 Biological neuron and its mathematical model. Types of activation functions. Neural networks and their classification. Mathematical models of specialized neurons. Topic 1.3 Multilayer neural networks. Representation of regression, approximation, identification, control, and data compression problems in a neural network logical basis. Multilayer perceptron.
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Section 6 Specialized neural networks	Topic 6.1 Deep neural networks. Topic 6.2 Convolutional neural networks. Topic 6.3 Recurrent networks.

Name of the discipline	**Artificial neural networks (reinforcement learning)**
Volume of discipline, credits/ac. hours	5/180
CONTENT OF THE DISCIPLINE	
Section 1 Introduction to reinforcement learning.	Topic 1.1 Structure of the reinforcement learning algorithm. Topic 1.2 Agent. Policy function. The function of value. Topic 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.
Section 2 Theoretical Foundations and Methods of Reinforcement Learning	Topic 2.1 Markov chains and Markov processes. Markov decision-making process. Topic 2.2 Functions of state value, Q-function. Bellman's equation and optimality. Derivation of the Bellman equation. Topic 2.3 Dynamic programming. Monte Carlo methods and game theory. Topic 2.4 Learning based on Temporary Differences. TD forecasting. TD training. Topic 2.5 Q training. SARSA algorithm. (State-ActionReward-State-Action)
Section 3 Reinforcement Learning Software	Topic 3.1 Software packages for the implementation of neural networks. Tensor Flow
Section 4 Development of artificial neural networks. Symbolic Regression Techniques	Topic 4.1 Genetic programming, Cartesian genetic programming, network operator method, variational symbolic regression methods

Disciplines (modules) are studied within the framework of the EP HE «Data Science and Space Engineering » in the direction of 27.04.04 Control in technical systems

Name of the discipline	**Artificial neural networks (reinforcement learning)**
Volume of discipline, credits/ac. hours	5/180
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HEAD OF EDUCATIONAL DEPARTMENT:

Professor of the Department of Mechanics and Control Processes		**Yu.N. Razoumny**
Position		