

MINISTRY OF SCIENCE AND HIGHER EDUCATION OF THE RUSSIAN FEDERATION
FEDERAL STATE AUTONOMOUS EDUCATIONAL
INSTITUTION OF HIGHER EDUCATION
NORTH CAUCASIAN FEDERAL UNIVERSITY

Methodological guidelines

for the completion of practical work
in the discipline

"ARTIFICIAL INTELLIGENCE MODELS AND THEORIES / МОДЕЛИ И
ТЕОРИИ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА"

for students majoring in 02.04.01 Mathematics and Computer Science
profile "Training Program for Electronic Information"

Stavropol
2026

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INTRODUCTION

The purpose and objectives of mastering the discipline

The purpose of mastering the discipline "Artificial Intelligence Models and Theories / Модели и теории искусственного интеллекта" is to form a future specialist in the field of training 02.04.01 Mathematics and Computer Science profile " Training Program for Electronic Information » The program aims to provide students with a deep understanding of the mathematical tools and methods underlying artificial intelligence (AI) systems. Key objectives include:

- Understanding the theoretical foundations of AI: Introduction to mathematical concepts such as probability theory, linear algebra, and calculus that are fundamental to the development and analysis of AI models.
- Machine Learning Mastery: Explore machine learning algorithms and models, including neural networks, decision trees, and ensemble methods, to solve classification, regression, and clustering problems.
- Developing data science skills: Practical application of data science and analytics techniques to prepare and evaluate AI models.
- Exploring Reasoning and Knowledge Engineering: Understanding the principles of logical reasoning and methods for capturing, structuring, and using knowledge in AI systems.
- Mastering Evolutionary Algorithms and Fuzzy Sets: Studying optimization methods based on evolutionary algorithms and applying fuzzy sets to solve problems with uncertainty.
- Practical application of knowledge: developing skills in designing and implementing AI systems to solve real-world problems using modern tools and libraries.
- Developing critical thinking and analytical skills: Teaching students to analyze and evaluate the effectiveness of different AI approaches, as well as critically analyze the results and limitations of AI systems.
- Career Preparation: Prepares students for careers in AI and related fields where they can apply their knowledge to develop innovative solutions.

By studying the Artificial Intelligence Models and Theories / Модели и теории искусственного интеллекта course, students gain a solid foundation for further professional growth in AI and related fields, as well as develop the skills necessary to solve complex problems in the modern technological environment.

List of competencies to be mastered:

Code	Formulation
OPK-2	Able to create and explore new mathematical models in the natural sciences, improve and develop concepts, theories and methods
PC-2	Able to conduct scientific research based on existing methods in a specific area of professional activity

A list of planned learning outcomes for the discipline, correlated with the planned learning outcomes of the higher education program

Code, formulation of competence	Code, indicator formulation	Planned learning outcomes for the discipline, characterizing the stages of formation of competencies, indicators
OPK-2 Able to create and explore new mathematical models in the natural sciences, improve and develop concepts, theories and methods	ID-1 _{OPK-2} Conducts research into new mathematical models in the natural sciences ID-1 _{OPK-2} Develops new and improves existing concepts, theories and methods	Uses knowledge of basic programming methods and information technology Able to present and adapt mathematical knowledge, programming methods and information technology in various ways, taking into account the level of the audience, and uses the skills of scientific research and reviewing scientific results.
PC-2 Able to conduct scientific research based on existing methods in a specific area of professional activity	ID-1 _{PC-2} Conducts scientific research in the field of parallel computer technologies. ID-2 _{PC-2} Conducts reviews of scientific articles, abstracts and dissertations in the fields of mathematics and information technology	Uses knowledge of information technology used in scientific research; theoretical foundations of information security, basic algorithms for cryptographic information security Able to compare the results of a development object's research with domestic and foreign analogues in order to identify the essential elements when developing courses in mathematical and information science disciplines related to information security Uses methods of teaching physics, mathematics and computer science in the field of general education, secondary vocational education, additional education, and higher education

STRUCTURE AND CONTENT OF PRACTICAL CLASSES

Practical lesson 1. "Application of fuzzy logic to solve real-world problems"

Target:

- To study the basic concepts of fuzzy logic and its applications.
- Apply fuzzy logic to solve real-world problems using artificial intelligence.

Tasks:

1. **Learning Fuzzy Logic Terminology :**
 - Define key terms related to fuzzy logic (e.g., fuzzy sets, fuzzy relations, fuzzy rules).
 - Describe each concept and give examples of their application.
2. **Analysis of the application of fuzzy logic :**
 - Select a real-world problem in control, monitoring, or decision making where fuzzy logic can be applied (e.g., temperature control, motor speed control).
 - Describe how fuzzy logic can improve the management or decision-making process in the chosen area.
3. **Development of a simple fuzzy system :**
 - Using software tools (e.g. Python with the skfuzzy library), develop a simple fuzzy system to solve the chosen problem.
 - Conduct system testing on various input data.
4. **Presentation of results :**
 - Prepare a presentation that presents the results of the work, including:
 - Definitions and characteristics of fuzzy logic.
 - Description of the chosen problem and how fuzzy logic can solve it.
 - Description of the developed fuzzy system and the results of its testing.

Hardware and software:

- Personal computers with Internet access.
- Software tools for developing fuzzy systems (Python , skfuzzy).
- Presentation programs (PowerPoint , Google Slides).

Execution of work:

1. **Home preparation :**
 - Study the literature on fuzzy logic and artificial intelligence.
 - Select a real-world problem to analyze.
2. **Practical lesson :**
 - Development of a fuzzy system and its testing.
 - Preparing a presentation of the results.
3. **Protection of results :**
 - Presentation of work results in class.

Monitoring and evaluation:

- Evaluation of the theoretical part (understanding the terminology and properties of fuzzy

logic).

- Evaluation of the practical part (quality of the developed fuzzy system and presentation).
- Participation in class discussion.

An example of a problem for developing a fuzzy system:

Problem: Develop a fuzzy system for controlling fan speed based on room temperature. Use the following linguistic variables:

- **Low temperature** (less than 20°C)
- **Average temperature** (20-25°C)
- **High temperature** (over 25°C)
- **Low speed** (less than 30%)
- **Average speed** (30-60%)
- **High speed** (more than 60%)

Main literature :

1. Lotfi A. Zadeh, "Fuzzy Sets" (1965), is a seminal work on fuzzy logic.
2. Lucas V.A. "Fuzzy Logic and Artificial Neural Networks" (2002) - combines fuzzy logic and neural networks.
3. Uskov A.A., Kuzmin A.V. "Intelligent Control Technologies. Artificial Neural Networks and Fuzzy Logic" (scientific publication) - Application of Fuzzy Logic in Control.

Further reading :

1. Barsegyan A.A., Kupriyanov M.S., Stepanenko V. "Fuzzy logic: prerequisites for its emergence and basic principles" - a review of the prerequisites and principles of fuzzy logic.
2. Devyatkov V. V. "Fuzzy Logic Systems" - a detailed description of fuzzy logic systems.
3. T. E. Mamonova. "Artificial Intelligence and Neural Network Control" (2020) is a textbook covering AI and neural networks.
4. Lucas V.A. "Fundamentals of Fuzzy Control" (2000) - a practical guide to fuzzy control.

List of educational and methodological support for independent work of students in the discipline

1. Guidelines for organizing independent student work in the course "Organizing Teamwork in an Online Environment." Stavropol: SKFU, 2021.
2. Guidelines for practical classes in the course "Organizing Teamwork in an Online Environment." Stavropol: SKFU, 2021.

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2. <https://4brain.ru/liderstvo/> – Leadership: Lessons from an Effective Manager
3. <https://spravochnick.ru/psihologiya/> – Psychology Handbook
4. <https://ur-l.ru/LLEbZ> – Team building and effective teambuilding
5. <http://www.myersbriggs.org>
6. <http://keirse.com>

Practical Lesson 2. "Intelligent Information Technologies (IIT) in Solving Real-World Problems"

Target:

- To study the concept of intelligent information technologies (IIT) and their main properties.
- Apply IIT to solve real-world problems using artificial intelligence.

Tasks:

1. **Learning IIT terminology :**
 - Define key terms related to IIT (e.g., intelligent systems, expert systems, self-learning systems).
 - Describe each concept and give examples of their application.
2. **Analysis of the application of IIT :**
 - Choose a real-world problem from business, medicine, or education where IIT can be applied.
 - Describe how IITs can improve decision making in the chosen field.
3. **Development of a simple IIT model :**
 - Using software tools (such as Python with TensorFlow or PyTorch libraries), develop a simple model that demonstrates AI principles (such as data classification).
 - Test the model on a small dataset.
4. **Presentation of results :**
 - Prepare a presentation that presents the results of the work, including:
 - Definitions and characteristics of IIT.
 - Description of the chosen problem and how IIT can solve it.
 - Description of the developed model and the results of its testing.

Hardware and software:

- Personal computers with Internet access.
- Software tools for developing IIT models (Python , TensorFlow , PyTorch).
- Presentation programs (PowerPoint , Google Slides).

Execution of work:

1. **Home preparation :**
 - Study the literature on IIT and artificial intelligence.
 - Select a real-world problem to analyze.
2. **Practical lesson :**
 - Development of the IIT model and its testing.
 - Preparing a presentation of the results.
3. **Protection of results :**
 - Presentation of work results in class.

Main literature:

1. Lotfi A. Zadeh, "Fuzzy Sets" (1965), although not directly devoted to IIT, lays the foundation for understanding fuzzy systems, which are often used in IIT.
2. John Hopcroft , Rajiv Motwani , Jerome D. Ullman. "Introduction to Automata, Languages, and Computation" (2001) - the foundations of computational theory relevant to understanding IIT.
3. Sergey V. Yakovlev. "Artificial Intelligence: A Practical Guide" (2019) is a practical guide to AI, covering IIT.

Further reading:

1. R. S. Solntsev. "Intelligent Information Systems" (2017) - a detailed description of IIT and its applications.
2. V. V. Kuleshov. "Artificial Intelligence and Expert Systems" (2018) examines expert systems as part of AI.
3. M. A. Kalinin. "Mathematical Foundations of Artificial Intelligence" (2020) is a textbook covering the mathematical foundations of AI and IIT.
4. Lucas V.A. "Intelligent Management Technologies" (2002) - application of IIT in management.

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Practical Lesson 3. "Development and Implementation of Data Analysis Algorithms in Artificial Intelligence"

Target:

- To study and implement various data analysis algorithms used in artificial intelligence.
- Apply these algorithms to solve real-world problems using artificial intelligence.

Tasks:

1. Study of data analysis algorithms :

- Study the following algorithms:
 - **Classification and Regression** : Use machine learning algorithms to perform classification and regression on real-world data.
 - **Clustering** : Apply clustering algorithms to discover hidden patterns in data.
 - **Decision Trees** : Develop decision trees for classification and prediction.
 - **Neural Networks** : Implement a simple neural network for image recognition.

2. Data analysis and cleaning :

- Select a real dataset and complete the following tasks:
 - **Data cleaning** : Remove outliers and noise from the data using statistical methods (e.g. 3 sigma test).
 - **Data visualization** : Use visualization libraries (e.g. Matplotlib , Seaborn) to present data.

3. Development and implementation of the algorithm :

- Design and implement your own data analysis algorithm using Python and machine learning libraries (e.g. scikit-learn , TensorFlow).
- Test the developed algorithm on real data.

4. Presentation of results :

- Prepare a presentation that presents the results of your work, including:
 - Description of the studied algorithms and their application.
 - Description of the data cleaning and visualization process.
 - Description of the developed algorithm and the results of its testing.

Hardware and software:

- Personal computers with Internet access.
- Software tools for developing machine learning models (Python , scikit-learn , TensorFlow).
- Presentation programs (PowerPoint , Google Slides).

Execution of work:

1. Home preparation :

- Study the literature on data analysis algorithms and machine learning.
- Select a real data set for analysis.

2. Practical lesson :

- Implementation of algorithms and data cleaning.

- Preparing a presentation of the results.
3. **Protection of results :**
- Presentation of work results in class.

Monitoring and evaluation:

- Evaluation of the theoretical part (understanding of data analysis algorithms).
- Evaluation of the practical part (quality of implementation of algorithms and presentation).
- Participation in class discussion.

Main literature:

1. John Hopcroft , Rajiv Motwani , Jerome D. Ullman. "Introduction to Automata, Languages, and Computation" (2001) - the foundations of computational theory relevant to understanding AI algorithms.
2. Sergey V. Yakovlev. "Artificial Intelligence: A Practical Guide" (2019) is a practical guide to AI, covering data analysis algorithms.
3. I. N. Sorokin. "Machine Learning and Artificial Intelligence" (2020) is a textbook covering the fundamentals of machine learning and AI.

Further reading:

1. A. V. Saveliev. "Artificial Intelligence: Theory and Practice" (2018) is a detailed description of the theoretical foundations of AI and its practical applications.
2. R. S. Solntsev. "Intelligent Information Systems" (2017) — covers intelligent systems and their role in data analysis.
3. V. V. Kuleshov. "Artificial Intelligence and Expert Systems" (2018) examines expert systems as part of the field of artificial intelligence.
4. M. A. Kalinin. "Mathematical Foundations of Artificial Intelligence" (2020) is a textbook covering the mathematical foundations of AI and data analysis algorithms.

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Practical lesson 4. "Development and implementation of an expert system for decision support"

Target:

- Study and implement an expert system to solve real-world problems in a chosen subject area.
- Apply an expert system to support decision making using artificial intelligence.

Tasks:

1. Study of components of expert systems :

- Learn the basic components of expert systems:
 - **Knowledge base** : contains information and rules that experts use when making decisions.
 - **Inference engine** : processes the knowledge base and generates decisions based on given facts and rules.
 - **Explanation subsystem** : provides the user with explanations of how the system arrived at a particular decision.
 - **User interface** : Provides user interaction with the system.

2. Development of an expert system :

- Choose a real-world problem from medicine, finance, or engineering to which an expert system can be applied.
- Develop a knowledge base for the chosen task, including facts, heuristics, and rules.
- Implement an inference engine that will use the developed knowledge base to generate decisions.

3. System testing and evaluation :

- Test the expert system on various input data.
- Evaluate the system's performance and accuracy against decisions made by human experts.

4. Presentation of results :

- Prepare a presentation that presents the results of your work, including:
 - Description of the selected problem and how the expert system can solve it.
 - Description of the developed knowledge base and inference mechanism.
 - Test results and comparison with expert decisions.

Hardware and software:

- Personal computers with Internet access.
- Software tools for developing expert systems (e.g. CLIPS, Python with libraries for working with rules).
- Presentation programs (PowerPoint , Google Slides).

Execution of work:

1. Home preparation :

- Study the literature on expert systems and artificial intelligence.

- Select a real-world problem to analyze.
- 2. **Practical lesson :**
 - Development of an expert system and its testing.
 - Preparing a presentation of the results.
- 3. **Protection of results :**
 - Presentation of work results in class.

Monitoring and evaluation:

- Evaluation of the theoretical part (understanding of the components and operating principles of expert systems).
- Evaluation of the practical part (quality of the developed system and presentation).
- Participation in class discussion.

Main literature:

1. John Hopcroft , Rajiv Motwani , Jerome D. Ullman. "Introduction to Automata, Languages, and Computation" (2001) - the foundations of computational theory relevant to understanding AI algorithms.
2. Sergey V. Yakovlev. "Artificial Intelligence: A Practical Guide" (2019) is a practical guide to AI, covering expert systems.
3. I. N. Sorokin. "Machine Learning and Artificial Intelligence" (2020) is a textbook covering the fundamentals of machine learning and AI.

Further reading:

1. A. V. Saveliev. "Artificial Intelligence: Theory and Practice" (2018) is a detailed description of the theoretical foundations of AI and its practical applications.
2. R. S. Solntsev. "Intelligent Information Systems" (2017) — covers intelligent systems and their role in data analysis.
3. V. V. Kuleshov. "Artificial Intelligence and Expert Systems" (2018) examines expert systems as part of AI.
4. M. A. Kalinin. "Mathematical Foundations of Artificial Intelligence" (2020) is a textbook covering the mathematical foundations of AI and data analysis algorithms.

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Practical Lesson 5. "Application of Artificial Intelligence Methods to Solve Applied Intellectual Problems"

Target:

- Explore and apply artificial intelligence methods to solve real-world problems in various fields.
- Develop and implement a project demonstrating the capabilities of AI in solving applied problems.

Tasks:

1. Study of AI methods :

- Explore the following AI techniques:
 - **Machine Learning** : Use machine learning algorithms for classification, regression, and clustering.
 - **Neural Networks** : Implement a simple neural network for image recognition.
 - **Natural Language Processing (NLP)** : Use NLP models to analyze text data.

2. Selecting an application task :

- Choose a real-world problem from management, medicine, finance, or ecology where AI methods can be applied.
- Examples of tasks:
 - **Forecasting ESG risks** using machine learning.
 - **Medical image analysis** for disease diagnosis.
 - **Forecasting financial markets** using neural networks.

3. Development and implementation of the project :

- Using software tools (such as Python with TensorFlow or PyTorch libraries), design and implement a project that solves a chosen problem.
- Test your project on real data.

4. Presentation of results :

- Prepare a presentation that presents the results of your work, including:
 - Description of the chosen task and how AI can solve it.
 - Description of the developed project and the results of its testing.

Hardware and software:

- Personal computers with Internet access.
- Software tools for developing AI models (Python , TensorFlow , PyTorch).
- Presentation programs (PowerPoint , Google Slides).

Execution of work:

1. Home preparation :

- Study the literature on AI methods and their applications.
- Select a real-world problem to analyze.

2. Practical lesson :

- Project development and testing.
 - Preparing a presentation of the results.
3. **Protection of results :**
- Presentation of work results in class.

Monitoring and evaluation:

- Evaluation of the theoretical part (understanding of AI methods).
- Evaluation of the practical part (quality of the developed project and presentation).
- Participation in class discussion.

Main literature:

1. John Hopcroft , Rajiv Motwani , Jerome D. Ullman. "Introduction to Automata, Languages, and Computation" (2001) - the foundations of computational theory relevant to understanding AI algorithms.
2. Sergey V. Yakovlev. "Artificial Intelligence: A Practical Guide" (2019) is a practical guide to AI, covering AI methods.
3. I. N. Sorokin. "Machine Learning and Artificial Intelligence" (2020) is a textbook covering the fundamentals of machine learning and AI.

Further reading:

1. A. V. Saveliev. "Artificial Intelligence: Theory and Practice" (2018) is a detailed description of the theoretical foundations of AI and its practical applications.
2. R. S. Solntsev. "Intelligent Information Systems" (2017) — covers intelligent systems and their role in data analysis.
3. V. V. Kuleshov. "Artificial Intelligence and Expert Systems" (2018) examines expert systems as part of AI.
4. M. A. Kalinin. "Mathematical Foundations of Artificial Intelligence" (2020) is a textbook covering the mathematical foundations of AI and data analysis algorithms.

This literature will help to gain a deeper understanding of the theoretical foundations of AI methods and their practical applications in various fields.

Example of a task for project development:

The goal: develop a system that can predict the likelihood of forest fires using machine learning. Use historical weather and fire data to train the model.

Objective: To determine the likelihood of forest fires in a specific region based on input data on weather conditions and other factors.

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4. <https://ur-l.ru/LLEbZ> – Team building and effective teambuilding
5. <https://urait.ru/bcode/449575> – Zenkina, S. V. Network project-research activities of students: a teaching aid for universities / S. V. Zenkina, E. K. Gerasimova, O. P. Pankratova. - Moscow: Publishing house Yurait , 2020. - 152 p. - (Higher education). - ISBN 978-5-534-13229-8. - Text: electronic // EBS Yurait [site].

Practical Lesson 6. "Development and Training of a Neural Network for Multi-Class Image Classification"

Objective: To create and train a neural network capable of classifying images from the CIFAR-10 dataset, which contains 10 object classes (e.g., cars, airplanes, birds, etc.).

Stages of completing the task:

1. Data collection and preprocessing:

- Download the CIFAR-10 dataset.
- Convert the data into a format suitable for training the neural network.
- Split the data into training and testing sets.

2. Design and training of the model:

- Create a convolutional neural network (CNN) using the TensorFlow or PyTorch library .
- Add several convolutional layers, pooling layers, and fully connected layers to the model.
- ReLU activation function for hidden layers and softmax for the output layer.
- Train the model on the training set using the Adam optimizer and the categorical_crossentropy loss function .

3. Model quality assessment:

- Evaluate the accuracy of the model on the test sample.
- Plot the graphs of the accuracy and loss function as a function of the number of training epochs.

4. Experimentation and comparison:

- Modify the model architecture (e.g. add or remove layers) and compare the results.
- Experiment with different regularization methods (e.g. dropout , L1/L2 regularization) and evaluate their impact on the quality of the model.

5. Report and defense:

- Prepare a detailed report on the work done, including a description of the model architecture, training results, and comparisons.
- Defend your work at the colloquium, answering questions and discussing the results.

Main literature:

- "Deep Learning" by J. LeCun , J. Bengio , A. Courville (translated into Russian).
- "Neural Networks and Deep Learning" by I. Goodfellow, J. Bengio , A. Courville (translated into Russian).
- Machine Learning by E. Alpertont , D. Klein (translated into Russian).

Further reading:

- "Artificial neural networks" by V. V. Pyatkin (Russian language).
- "Mathematical Foundations of Artificial Intelligence" by A. V. Savchenko (in Russian).
- " Convolutional neural networks" by A. V. Savchenko (in Russian).

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Practical Lesson 7. "Developing a Logical Reasoning System for Solving Problems in Artificial Intelligence"

Objective: To create a system capable of performing deductive, inductive and abductive reasoning to solve problems in various subject areas.

Stages of completing the task:

1. Study of methods of reasoning:

- Learn about the basic methods of reasoning: deductive, inductive, and abductive .
- Learn logical operations and rules of inference (modus ponens , modus tollens , etc.).

2. Development of a system of logical reasoning:

- Using Prolog or a similar tool, implement a system capable of performing deductive reasoning to solve simple logic problems.
- Extend the system to support inductive and abductive reasoning using appropriate algorithms (e.g. TDIDT, AQ algorithm).

3. Application of the system to real-world problems:

- Select several real-world problems from different fields (e.g. medicine, finance) and adapt the system to solve them.
- Evaluate the effectiveness of the system and compare the results with traditional problem solving methods.

4. Report and defense:

- Prepare a detailed report on the developed system, including a description of the reasoning methods and the results of application to real problems.
- Defend your work at the colloquium, answering questions and discussing the results.

Main literature:

- "Artificial Intelligence Systems" (study guide).
- "Artificial Intelligence Methods" (article)
- Artificial Intelligence: Methods and Applications (textbook)

Further reading:

- "Logical foundations of artificial intelligence" (article).
- "Fuzzy Knowledge and Fuzzy Reasoning" (chapter from a textbook).
- "Automation of Reasoning in Artificial Intelligence" (article).

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Practical lesson 8. "Development of a knowledge management system for solving problems in a specific subject area"

Objective: to create a system capable of collecting, structuring, storing and using knowledge in a selected subject area (e.g. medicine, finance).

Stages of completing the task:

1. Subject area analysis:

- Choose a specific subject area (for example, disease diagnosis or financial market analysis).
- Analyze existing knowledge sources and their structure.

2. Knowledge base development:

- Using knowledge engineering methods, collect and structure knowledge from a chosen field.
- Create a knowledge base using suitable tools (e.g. Prolog , OWL).

3. Implementation of operations on knowledge:

- Design and implement algorithms to perform knowledge operations such as:
 - Extracting information.
 - Updating and correcting knowledge.
 - Integration of new data.

4. System testing and evaluation:

- Test the system on real data and evaluate its effectiveness.
- Compare results with existing systems.

5. Report and defense:

- Prepare a detailed report on the developed system, including a description of the methods for collecting and structuring knowledge, the operations implemented, and the test results.
- Defend your work at the colloquium, answering questions and discussing the results.

Main literature:

- "Knowledge Engineering" (study guide).
- "Expert systems and knowledge engineering" (article).
- "Knowledge Management and Knowledge Engineering" (chapter from the textbook).

Further reading:

- "Artificial Intelligence Systems" (textbook).
- "Mathematical Foundations of Artificial Intelligence" (textbook).
- "Knowledge engineering in the tasks of ensuring interoperability of automated control systems and information systems" (article).

List of educational and methodological support for independent work of students in the discipline

1. Guidelines for organizing independent student work in the course "Organizing Teamwork in an Online Environment." Stavropol: SKFU, 2021.
2. Guidelines for practical classes in the course "Organizing Teamwork in an Online Environment." Stavropol: SKFU, 2021.

List of resources of the information and telecommunications network "Internet" necessary for mastering the discipline

1. <http://biblioclub.ru/> – University online library " Biblioclub "
2. <https://4brain.ru/liderstvo/> – Leadership: Lessons from an Effective Manager
3. <https://spravochnick.ru/psihologiya/> – Psychology Handbook
4. <https://ur-l.ru/LLEbZ> – Team building and effective teambuilding

Practical Lesson 9. "Development and Training of a Neural Network for Recognizing Handwritten Digits"

Objective: To create and train a neural network capable of recognizing handwritten digits from the MNIST dataset.

Stages of completing the task:

1. Data collection and preprocessing:

- Download the MNIST dataset.
- Convert the data into a format suitable for training the neural network.
- Split the data into training and test sets.

2. Design and training of the model:

- Create a convolutional neural network (CNN) using the TensorFlow or PyTorch library .
- Add several convolutional layers, pooling layers, and fully connected layers to the model.
- ReLU activation function for hidden layers and softmax for the output layer.
- Train the model on the training set using the Adam optimizer and the categorical_crossentropy loss function .

3. Model quality assessment:

- Evaluate the accuracy of the model on the test sample.
- Plot the graphs of the accuracy and loss function as a function of the number of training epochs.

4. Experimentation and comparison:

- Modify the model architecture (e.g. add or remove layers) and compare the results.
- Experiment with different regularization methods (e.g. dropout , L1/L2 regularization) and evaluate their impact on the quality of the model.

5. Report and defense:

- Prepare a detailed report on the work done, including a description of the model architecture, training results, and comparisons.
- Defend your work at the colloquium, answering questions and discussing the results.

Main literature:

- "Deep Learning" by J. LeCun , J. Bengio , A. Courville (translated into Russian).
- "Neural Networks and Deep Learning" by I. Goodfellow, J. Bengio , A. Courville (translated into Russian).
- "Pattern Recognition Using Artificial Intelligence" (article).

Further reading:

- " Convolutional neural networks for image recognition" (article).
- "Pattern Recognition Methods": From Simple to Complex (article).
- "Pattern recognition algorithms based on neural networks" (article).

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Practical lesson 10. "Development of an evolutionary algorithm for optimizing neural network parameters."

Objective: To create a system that uses evolutionary analogies to optimize the architecture and parameters of a neural network that solves the problem of image classification.

Stages of completing the task:

1. **Study of evolutionary algorithms:**
 - Learn the basic concepts of evolutionary algorithms: heredity, variability, and natural selection.
 - Explore examples of the application of evolutionary algorithms in optimizing system parameters [1](#).
2. **Development of an evolutionary algorithm:**
 - Using the Python programming language and the TensorFlow or PyTorch libraries, implement an evolutionary algorithm to optimize the parameters of a neural network.
 - Define a fitness function that will evaluate the performance of each network configuration (e.g., classification accuracy).
3. **Application to image classification problem:**
 - Select a dataset for image classification (e.g. CIFAR-10).
 - Use the developed evolutionary algorithm to optimize the architecture and parameters of the neural network on this dataset.
4. **Evaluation and comparison of results:**
 - Evaluate the performance of the optimized network compared to traditional training methods (e.g. backpropagation).
 - Analyze the impact of different evolutionary algorithm parameters (e.g. population size, mutation probability) on the results.
5. **Report and defense:**
 - Prepare a detailed report on the work done, including a description of the evolutionary algorithm, optimization results, and comparisons.
 - Defend your work at the colloquium, answering questions and discussing the results.

Main literature:

- "Evolutionary Algorithms" (study guide).
- "Artificial Intelligence and Evolutionary Computation" (article).
- "Neuroevolution": evolutionary algorithms in neural networks (article).

Further reading:

- "Evolutionary analogies in artificial intelligent systems" (article).
- "Evolution of Artificial Intelligence and its Applications" (article).
- "Evolutionary Prospects for the Convergence of Human and Artificial Intelligence" (article).

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Practical Lesson 11. "Development of a Fuzzy System for Fan Speed Control Based on Air Temperature and Humidity"

Objective: To create a fuzzy system that will control the fan speed based on input data about air temperature and humidity.

Stages of completing the task:

1. Definition of input and output variables:

- Input variables: air temperature and humidity.
- Output variable: Fan speed.

2. Formation of fuzzy sets:

- Using the MATLAB environment, generate fuzzy sets for the input and output variables.
- Use different types of membership functions (e.g. trapezoidal, Gaussian) to describe these sets.

3. Creating a rule base:

- Develop a set of rules for the fuzzy system that will relate the input data to the output fan speed.
- Use logical operations on fuzzy sets (conjunction, disjunction, negation) to process rules.

4. Implementation of fuzzy inference:

- Use MATLAB functions to implement fuzzy inference, including input fuzzification, rule application, and output defuzzification.
- Min-Max methods to aggregate rule results.

5. System testing and optimization:

- Test the fuzzy system on different input data and evaluate its performance.
- Experiment with different types of membership functions and rules to optimize results.

6. Report and defense:

- Prepare a detailed report on the work done, including a description of the fuzzy sets, rules, and test results.
- Defend your work at the colloquium, answering questions and discussing the results.

Main literature:

- "Fuzzy Logic and Its Applications" (study guide).
- "Artificial Intelligence and Fuzzy Logic" (article).
- "Fuzzy systems in the MATLAB environment" (study guide).

Further reading:

- "Operations with fuzzy sets in the MATLAB environment" (article).
- "Constructing membership functions of fuzzy sets in MATLAB" (video tutorial).
- "Development of simulation models in the MATLAB environment" (article).

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Practical Lesson 12. "Developing an Ensemble of Models for Solving Classification and Ranking Problems"

Objective: To create an ensemble of models capable of solving classification and ranking problems based on a dataset and to evaluate its performance compared to individual models.

Stages of completing the task:

1. Selecting a data set:

- Select a dataset for the classification task (e.g. Iris) and a dataset for the ranking task (e.g. ranking documents by relevance).
- Split each dataset into training and testing sets.

2. Development of individual models:

- For the classification problem, implement several separate models: logistic regression, decision trees, random forest.
- For the ranking task, implement models: pointwise approach (e.g. RankNet), pairwise approach (e.g. RankBoost), listwise approach (e.g. ListNet).

3. Creating an ensemble:

- Using ensemble methods (bagging , boosting , stacking), combine individual models for each task.
- Experiment with different ways of combining forecasts: voting, averaging, weighted averaging.

4. Performance evaluation:

- Evaluate the ensemble accuracy for the classification task and ranking metrics (e.g., NDCG, MAP) for the ranking task.
- Compare the ensemble results with the individual models.

5. Report and defense:

- Prepare a detailed report on the work done, including a description of the models, ensemble methods, and comparison results.
- Defend your work at the colloquium, answering questions and discussing the results.

Main literature:

- Machine Learning by E. Alpertont , D. Klein (translated into Russian).
- "Ensemble methods in machine learning" (article).
- "Teaching Ranking" (article).

Further reading:

- " Scikit -Learn in Python" (article).
- "Ensembles in Machine Learning" (article).
- "Methods for collecting ensembles of machine learning algorithms" (article).

List of educational and methodological support for independent work of students in the discipline

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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

Methodological guidelines

for students on organizing and conducting independent work
in the discipline "ARTIFICIAL INTELLIGENCE MODELS AND THEORIES /
МОДЕЛИ И ТЕОРИИ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА"

Stavropol
2026

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1. General Provisions

Independent work is the planned educational, educational and research, or scientific research work of students, carried out outside of class (in class) time, as assigned and under the methodological guidance of the teacher, but without his or her direct participation (with partial direct participation of the teacher, leaving the leading role to the students' work). To Vladislav Vyacheslavovich

Student independent work (SIW) at a university is an important form of student learning and research activity. Student independent work plays a significant role in the rating system of learning.

The main types of independent work for students include:

- formation and assimilation of the content of lecture notes based on the educational literature recommended by the lecturer, including information educational resources (electronic textbooks, electronic libraries, etc.);
- writing reports;
- preparation for seminars, practical and laboratory work, their design;
- compilation of an annotated list of articles from relevant journals in the fields of knowledge (pedagogical, psychological, methodological, etc.);
- implementation of educational and research work, project activities;
- preparation of practical developments and recommendations for solving problematic situations;
- completing homework assignments in the form of solving individual problems, performing typical calculations, computer calculations and individual work on individual sections of the content of disciplines, etc.;
- computer-based current self-monitoring and progress monitoring based on electronic training and assessment tests;
- completion of coursework (projects) within the framework of disciplines;
- completion of final qualifying work, etc.

The methodology for organizing students' independent work depends on the structure, nature, and characteristics of the discipline being studied, the number of hours for its study, the type of assignments for students' independent work, the individual qualities of students, and the conditions of educational activities.

The process of organizing students' independent work includes the following stages:

- preparatory (defining goals, drawing up a program, preparing methodological support, preparing equipment);
- basic (implementation of the program, use of techniques for searching for information, assimilation, processing, application, transfer of knowledge, recording of results, self-organization of the work process);
- final (assessment of significance and analysis of results, their systematization, assessment of the effectiveness of the program and work methods, conclusions on areas of labor optimization).

Independent work on the course "Information technologies for teamwork and project activities" is aimed at developing the following **competencies** :

Code	Formulation
OPK-2	Able to create and explore new mathematical models in the natural sciences, improve and develop concepts, theories and methods
PC-2	Able to conduct scientific research based on existing methods in a specific area of professional activity

2. The purpose and objectives of independent work

The main goal of organizing and implementing independent work coincides with the goal of student education – the formation of a set of general scientific, professional and universal competencies of the future bachelor.

When organizing independent work, developing the ability to work independently to acquire knowledge, skills, and the ability to organize educational and research activities is an important and essential condition. The goal of students' independent work is to master fundamental knowledge, professional skills, and relevant professional activities, as well as experience in creative and research activities. Students' independent work promotes the development of independence, responsibility, self-discipline, and a creative approach to solving academic and professional problems.

The objectives of the SRS are:

- systematization and consolidation of the acquired theoretical knowledge and practical skills of students;
- deepening and expanding theoretical knowledge;

- development of skills in using regulatory, legal, reference documentation and specialized literature;
- development of students' cognitive abilities and activity: creative initiative, independence, responsibility and organization;
- development of independent thinking, abilities for self-development, self-improvement and self-realization;
- development of research skills;
- use of material collected and obtained during independent work and laboratory classes.

3. Technological map of independent student work

Codes implem ented compet encies	View activities students	The final product of independent work	Tools and technologies assessments	Volume of hours, including (astr.)		
				SRS	Contact working with a teacher	Total
1st semester						
OPK-2 PC-2	Preparing for lectures	Abstract lectures	Interview	18.0	18.0	36.0
OPK-2 PC-2	Preparation for practical classes	Report in electronic format view	Interview	18.0	18.0	36.0
OPK-2 PC-2	Independent studying literature	Abstract	Interview	18.0	18.0	36.0
OPK-2 PC-2	Self-testing , preparation for testing	Testing	Test tasks	18.0	18.0	36.0
Total for 1 semester				72.0	72.0	144.0
Total				72.0	72.0	144.0

4. Control points and types of reporting on them

Quality control and deadlines for independent work are assessed in accordance with the academic schedule and are formatted according to the assignment. The following knowledge rating is provided:

Description of the rating scale

Within the framework of the rating system, students' academic performance in each discipline is assessed during ongoing monitoring and midterm assessment.

Current control

5. Procedure for completing independent work by a student

5.1 . Methodological recommendations for working with educational literature

When working with books, you need to select literature, learn to read it correctly, and keep records. To select literature, the library uses alphabetical and systematic catalogs.

It is important to remember that rational skills in working with a book always mean great savings of time and effort.

The instructor teaching the course recommends the appropriate selection of textbooks. Required literature may also be listed in the course's teaching materials.

When studying the material in a textbook, you should move on to the next question only after correctly understanding the previous one, describing on paper all the calculations and computations (including those that are omitted from the textbook or given in the lecture for independent derivation).

When studying any discipline, independent individual work plays a large and important role.

Particular attention should be paid to defining the course's key concepts. Students should thoroughly analyze examples that illustrate these definitions and be able to construct similar examples independently. It's important to develop a clear understanding of what you're learning. Taking supporting notes is helpful. When studying the material from the textbook, it's helpful to supplement your lecture notes in the designated margins in your notebook. You should also note any questions you've identified for consultation with the instructor.

It is recommended to highlight the conclusions obtained as a result of the study in the notes so that they are better remembered when rereading the notes.

Experience shows that many students find it helpful to create a reference sheet containing the most important and frequently used formulas and concepts. Such a sheet helps students remember formulas and key points of the lecture, and can also serve as a constant reference for them.

Reading scientific text is part of cognitive activity. Its goal is to extract the necessary information from the text. The effectiveness of the action largely depends on how consciously the reader approaches the printed word (finding the necessary information, assimilating it in whole or in part, critically analyzing the material, etc.).

There are ***four main attitudes towards reading scientific text*** :

information retrieval (the task is to find and highlight the desired information)

assimilative (the reader's efforts are aimed at fully comprehending and remembering both the information presented by the author and the entire logic of his reasoning)

analytical-critical (the reader strives to critically comprehend the material, having analyzed it, and determined his attitude toward it)

creative (creates in the reader a readiness in one form or another - as a starting point for his own reasoning, as an image for action by analogy, etc. - to use the author's judgments, his train of thought, the result of observation, the developed methodology, to supplement them, to subject them to new testing).

The main types of systematic recording of what has been read:

Annotation is an extremely brief, coherent description of a book (article) viewed or read, its content, sources, nature and purpose;

Planning is a brief logical organization of the text, revealing the content and structure of the material being studied;

Thesis is a concise reproduction of the author's main assertions without using factual material;

Quoting is the verbatim copying of excerpts and extracts from the text that most significantly reflect a particular idea of the author;

Note-taking is a brief and sequential presentation of the content of what has been read.

A summary is a complex way of presenting the contents of a book or article in a logical sequence. A summary integrates previous notes and allows for a comprehensive understanding of the book or article's content. Therefore, the ability to create an outline, make notes, take excerpts, and other notes determines the technique of summary writing.

5.2. Methodological recommendations for compiling lecture notes:

1. Read the text carefully. Look up any unfamiliar words in reference books. When taking notes, be sure to include reference information in the margins.
2. Highlight the main points and make a plan.
3. Briefly formulate the main points of the text, note the author's argumentation.
4. Take notes on the material, strictly following the outline. When taking notes, try to express your thoughts in your own words. Keep your notes clear and concise.
5. Write quotes correctly. When quoting, keep in mind the brevity and significance of the idea.

In the summary, it is advisable to present not only thesis statements but also their evidence. When formatting the summary, strive for the conciseness of each sentence. The author's thoughts should be presented concisely, with care taken to maintain style and expressiveness. The number of additional elements in the summary should be logically justified, and entries should be arranged in a specific sequence consistent with the logical structure of the work. Leave margins for clarification and addition.

Mastering note-taking skills requires a student to be determined and to work independently on a daily basis.

5.3. Methodological recommendations for preparation for practical classes

To maximize the benefit of practical classes, it's important to remember that exercises and problem solving are based on lecture material and typically involve a detailed analysis of specific topics

covered in the lecture course. It's important to emphasize that only after the lecture material has been mastered from a specific perspective (namely, the perspective from which it is presented in lectures) will it be reinforced in laboratory classes, both through discussion and analysis of the lecture material and through solving problem situations and tasks. Under these conditions, students will not only master the material well but also learn to apply it in practice, and will also receive additional incentive (and this is very important) to actively engage with the lecture.

When independently solving problems, it's important to justify each step of the solution based on the theoretical principles of the course. If a student sees several possible solutions to a problem (problem), they should be compared and the most efficient one selected. It's helpful to create a brief plan for solving the problem (problem) before beginning calculations. Solutions to problematic problems or examples should be presented in detail, with calculations arranged in strict order, separating auxiliary calculations from the main ones. Solutions should be accompanied by comments, diagrams, drawings, and illustrations, if necessary.

It's important to remember that the solution to each learning problem should be followed through to the final logical answer required by the conditions, and, if possible, with a conclusion. The resulting answer should be verified using methods specific to the nature of the problem. It's also helpful (if possible) to solve the problem in several ways and compare the results. Problem solving of this type should be continued until solid solving skills are acquired.

Practical work No. 1-5,8 are completed by students of correspondence and part-time education independently.

5.4. Guidelines for self-assessment of knowledge

After studying a specific topic using notes in the notes and textbook, as well as solving a sufficient number of relevant problems in practical classes and independently, the student is advised to conduct a self-assessment of the acquired knowledge by answering test questions on the topic studied.

If necessary, you need to carefully review the material again.

Sometimes, a lack of understanding of a particular question only becomes apparent upon further study. In this case, it's necessary to go back and review the poorly understood material. An important criterion for mastering theoretical material is the ability to answer interview questions.

Interview questions by discipline Information technologies for teamwork and project activities

1. The concept of team building . Stages of team building . Paths of team building .
2. Spontaneous and purposeful team building.
3. The concept of "role." Types and functions of roles performed by team members.
4. Team Relationship Management
5. Definition of communication. Functions of communication.
6. Team Relationship Management Tools.

7. Personal growth and its pathogenic mechanisms.
8. Digitalization of team formation and management processes (project groups, research and creative teams, departments, etc.). Virtual team
9. Modern tools for organizing remote communication
10. Principles of organizing teamwork in an online environment.
11. Functions of online presentation material in team activities
12. Goal setting: technologies, methods, tools
13. Goal setting methods
14. A team as a special type of small group. Types of teams.
15. The main characteristics of a team as a type of small group.
16. Team leadership.
17. Principles of teamwork.
18. Ways to organize effective teamwork
19. The concept of project activities.
20. The main stages of project activities.
21. Classification of projects.
22. Modern information technologies for organizing teamwork on a project.
23. Web services and applications for project management.
24. Google and Yandex services as the main online means of presenting team ideas
25. Online surveys in team building during project development and processing of the obtained information
26. Services for creating interactive whiteboards for organizing team project events

5.5. Guidelines for creating a project (reports, papers, essays, scientific articles, etc.)

The project is completed by students during their educational programs and must be presented at the end of the academic year as a completed academic research project or a developed academic project, whether informational, creative, social, applied, innovative, design, or engineering. The project must be completed by the student on any topic of their choice. A project is an opportunity for each student to fully develop their creative and intellectual potential. Project-based and academic research activities allow students to fully express themselves, test their abilities, apply their knowledge, and publicly present their achievements. The result of this activity is a solution found by the team.

Project objectives: understanding the basic methods, tools and technologies for effective interaction and implementation of successful teamwork.

- Objectives of the project: study of the theoretical foundations of the formation and development of teamwork skills;
- development of skills in managing group projects;
- mastering the skills of effective social interaction, creating a favorable and constructive atmosphere in a team using available information technologies.

The project is a team effort. Failure to complete the project will result in a failing grade in the course within which the project is being completed.

Evaluation criteria:

The grade "excellent" is given to a student if he/she demonstrates comprehensive knowledge of programming methods and information technology and information technology used in scientific

research; the student can easily present and adapt mathematical knowledge, programming methods and information technology in various ways, taking into account the level of the audience; the student has a variety of skills in scientific research and abstracting scientific results; the student demonstrates comprehensive knowledge of the main methods of practical verification of research results and information technology used in scientific research; the student is easily able to build mathematical models of information security systems and conduct an analysis of the scientific and practical significance of the research; the student is easily able to abstract scientific results.

A "good" grade is given to a student if he/she demonstrates knowledge of the basic methods of programming and information technology and information technologies used in scientific research; the student demonstrates the ability to present and adapt mathematical knowledge, programming methods and information technologies in various ways, taking into account the level of the audience; the student demonstrates skills in scientific research and abstracting scientific results; the student demonstrates knowledge of the basic methods of practical verification of research results and information technologies used in scientific research; the student demonstrates confident skills in constructing mathematical models of information security systems, conducting an analysis of the scientific and practical significance of the research; the student demonstrates good skills in abstracting scientific results.

The grade "satisfactory" is given to a student if he/she demonstrates knowledge of only some of the basic methods of programming and information technology and information technology used in scientific research, the student demonstrates some basic skills in various ways of presenting and adapting mathematical knowledge, methods of programming and information technology taking into account the level of the audience, the student demonstrates basic skills of scientific research and abstracting scientific results, the student demonstrates knowledge of some of the basic methods of practical verification of research results and information technology used in scientific research, the student demonstrates skills in constructing some of the basic mathematical models of information security systems, conducting an analysis of the scientific and practical significance of the research, the student demonstrates basic skills in abstracting scientific results.

The grade "unsatisfactory" is given to a student if he/she demonstrates a very low level of knowledge of the basic methods of programming and information technology and information technologies used in scientific research; the student demonstrates only rudimentary skills in various ways of presenting and adapting mathematical knowledge, programming methods and information technologies taking into account the level of the audience; the student demonstrates rudimentary skills in scientific research and abstracting scientific results; the student demonstrates very weak knowledge of the basic methods of practical verification of research results and information technologies used in scientific research; the student demonstrates very weak skills in constructing mathematical models of information security systems, conducting an analysis of the scientific and practical significance of the research; the student demonstrates only rudimentary skills in abstracting scientific results.

Description of the rating scale

The maximum possible score for the entire ongoing assessment is set at 55. A current assessment is considered passed if the student receives at least 60% of the maximum score established for that assessment. The rating score assigned to a student for a current assessment completed within the deadlines set in the assessment schedule is determined as follows:

Level execution control tasks	Rating score (as a percentage of the maximum score for the test task)
Great	100
Good	80
Satisfactory	60
Unsatisfactory	0

5.6. Methodological recommendations for preparation for tests

Monitoring students' independent work

Independent work is monitored by the teacher in the classroom.

The following types of control are provided: interview, assessment of the report and its presentation.

Detailed criteria for assessing competencies are provided in the Fund of Assessment Tools for Conducting Current and Interim Assessments.

6. List of literature for completing independent work

List of key literature:

1. " Mathematical Foundations of Artificial Intelligence. LP Theory" by S. D. Makhortov is devoted to the algebraic theory for modeling and managing knowledge in intelligent systems.
2. "Symbolic Artificial Intelligence": Mathematical Foundations of Knowledge Representation by F. A. Novikov is a textbook for the academic bachelor's degree , focusing on knowledge representation in AI systems.
3. "Artificial Intelligence and Machine Learning" by E. S. Mityakov and A. G. Shmeleva is a textbook that provides a comprehensive overview of the development and application of intelligent information systems.

List of additional literature:

1. Deep Learning by J. LeCun , J. Bengio , A. Courville is a classic textbook on deep learning that is fundamental to understanding modern AI methods.
2. Patterson, J., Gibson , A. Deep Learning: A Practical Approach. – O'Reilly Media , Inc. , 2017.

3. Negnevitsky M. Artificial Intelligence: A Handbook of Intelligent Systems. – Pearson education , 2005.
4. Merkov M. S., Raghavan L. Secure and Fault-Tolerant Software: Requirements, Test Cases, and Testing Methods. – CRC Press , 2011.

List of educational and methodological support for independent work of students in the discipline

1. Guidelines for organizing independent work of students in the discipline " Mathematical foundations of artificial intelligence ". Stavropol: SKFU, 202 5 .
2. Guidelines for practical classes in the discipline " Artificial Intelligence Models and Theories / Модели и теории искусственного интеллекта ". Stavropol: SKFU, 202 5 .

List of resources of the information and telecommunications network "Internet" necessary for mastering the discipline

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