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

Academy of Engineering

(name of the main educational unit (MEU) that developed the educational program of higher education)

WORKING PROGRAM OF THE DISCIPLINE

DATABASES

(name of discipline/module)

Recommended for the field of study/specialty:

01.04.02 APPLIED MATHEMATICS AND INFORMATICS

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

The discipline is mastered within the framework of the implementation of the main professional educational program of higher education (EP HE):

SPACE MISSION AND SYSTEM DESIGN

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

2026

1. THE GOAL OF MASTERING THE DISCIPLINE

The "Databases" course is part of the "Space mission and system design" Master's program in the "Applied Mathematics and Informatics" major (01.04.02) and is studied in the first semester of the first year. The course is offered by the Department of Mechanics and Control Processes. It consists of five sections and 27 topics and focuses on the fundamentals of physical and logical database design, types and properties of normal forms, semantic modeling of data, external memory structures, methods of index organization, client-server data organization, and database protection; analysis of the basic methods for solving typical problems and familiarity with their application in professional activities.

The goal of mastering the discipline is to form fundamental knowledge and skills of application of methods of solving problems necessary for professional activity, increase the general level of students' literacy in database design

2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline "Databases" aimed at developing the following competencies (parts of competencies) in students:

Table 2.1. List of competencies developed in students while mastering the discipline (results of mastering the discipline)

Cipher	**Competence**	**Indicators of Competency Achievement** (within this discipline)
UC-1	Able to carry out a critical analysis of problematic situations based on a systems approach and develop an action strategy	UC-1.1 Analyzes the task, identifying its basic components; UC-1.2 Searches for information to solve a given problem using various types of queries, suggests options for solving the problem, and analyzes the possible consequences of their use; UC-1.3 Analyzes ways of solving problems of ideological, moral and personal nature based on the use of basic philosophical ideas and categories in their historical development and socio-cultural context.
GPC-4	Able to combine and adapt existing information and communication technologies to solve problems in the field of professional activity, taking into account information security requirements	GPC-4.1 Analyzes problems of applied mathematics and computer science using information technology; GPC-4.2 Takes into account the basic requirements of information security; GPC-4.3 Uses modern information and communication technologies to solve problems in the field of applied mathematics and computer science, taking into account information security requirements.
PC-1	Able to formulate goals and objectives of scientific research in the field of applied mathematics and computer science, computer technology and modern programming technologies, and select methods and means for solving problems	PC-1.1 Possesses fundamental knowledge obtained in the field of mathematical and (or) natural sciences, programming and information technology; PC-1.2 Able to find, formulate and solve standard problems in his own research activities in the field of applied mathematics and computer science, computer technology and modern programming technologies; PC-1.3 Has practical experience in research activities in the field of applied mathematics and computer science, computer engineering and modern programming technologies.;
PC-2	Able to apply modern theoretical and experimental methods for developing mathematical models of objects and processes under study related to professional activities in the field of training and participate in their implementation in the form of software	PC-2.1 Knows modern theoretical and experimental methods for developing mathematical models, innovative design tools and elements of architectural solutions for information systems; PC-2.2 Able to develop and implement algorithms for mathematical models based on languages and packages of applied modeling programs; PC-2.3 Has practical experience in developing options for implementing information systems using innovative tools.

Cipher	Competence	Indicators of Competency Achievement (within this discipline)
	products	

3. PLACE OF THE DISCIPLINE IN THE STRUCTURE OF THE EDUCATIONAL EDUCATIONAL INSTITUTION

Discipline "Databases" refers to the mandatory part of block 1 “Disciplines (modules)” of the educational program of higher education.

As part of the higher education program, students also master other disciplines and/or practices that contribute to the achievement of the planned results of mastering the discipline "Databases".

Table 3.1. List of components of the educational program of higher education that contribute to the achievement of the planned results of mastering the discipline

Cipher	Name of competence	Previous courses/modules, practical training*	Subsequent disciplines/modules, practices*
UC-1	Able to carry out a critical analysis of problematic situations based on a systems approach and develop an action strategy		Advanced Methods of Remote Sensing and Geoinformation Systems; Structures & Materials Modeling; System Design; Dynamics and Control of Space Systems; Project "Drone Systems Engineering. Part 1"; Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Practical Training and Research in Dynamics and Control of Space Systems (online from RUDN Mission Control Center) / Research work; Technological Training; Pre-Graduation Internship in Industry;
GPC-4	Able to combine and adapt existing information and communication technologies to solve problems in the field of professional activity, taking into account information security requirements		Pre-Graduation Internship in Industry; Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Practical Training and Research in Dynamics and Control of Space Systems (online from RUDN Mission Control Center) / Research work; Technological Training; Project "Drone Systems Engineering. Part 1"; Project "Drone Systems En-

Cipher	Name of competence	Previous courses/modules, practical training*	Subsequent disciplines/modules, practices*
			gineering. Part 2";
PC-1	Able to formulate goals and objectives of scientific research in the field of applied mathematics and computer science, computer technology and modern programming technologies, and select methods and means for solving problems		Advanced Methods of Remote Sensing and Geoinformation Systems; System Design; Dynamics and Control of Space Systems; Pre-Graduation Internship in Industry; Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Practical Training and Research in Dynamics and Control of Space Systems (online from RUDN Mission Control Center) / Research work; Technological Training;
PC-2	Able to apply modern theoretical and experimental methods for developing mathematical models of objects and processes under study related to professional activities in the field of training and participate in their implementation in the form of software products		Pre-Graduation Internship in Industry; Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Practical Training and Research in Dynamics and Control of Space Systems (online from RUDN Mission Control Center) / Research work; Technological Training; Advanced Methods of Remote Sensing and Geoinformation Systems; System Design; Project "Drone Systems Engineering. Part 1";

* - filled in accordance with the competency matrix and the SUP EP HE

** - elective courses/practices

4. SCOPE OF THE DISCIPLINE AND TYPES OF EDUCATIONAL WORK

The total workload of the “Databases” discipline is 2 credit units.

Table 4.1. Types of educational work by periods of mastering the educational program of higher education for full-time education.

Type of academic work	**TOTAL,**academic hours		**Semester(s)**
			1
Contact work, academic hours	*20*		*20*
Lectures (LC)	10		10
Laboratory work (LW)	10		10
Practical/seminar classes (SC)	0		0
Independent work of students, academic hours	*52*		*52*
Control (exam/test with assessment), academic hours	*0*		*0*
Total complexity of the discipline	**academic hours**	***72***	*72*
	credit	***2***	*2*

5. CONTENT OF THE DISCIPLINE

*Table 5.1. Contents of the discipline (module)*types of educational work

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
Section 1	Introduction. Physical database design. Logical database design. Designing relational databases using normalization.	1.1	Aspects of database design	Overview of database design phases: conceptual, logical, and physical design. Key aspects: data requirements, functional requirements, performance considerations, and security. The role of the database administrator and designer.	LC, LW
		1.2	Automatic consistency checking of a set of integrity constraints	Definition of integrity constraints in databases. Types of constraints: domain constraints, key constraints, entity integrity, referential integrity. Methods for automatic verification of constraint consistency. Detection and resolution of constraint violations.	LC, LW
		1.3	Database design problems	Common issues in database design: data redundancy, update anomalies, insertion anomalies, deletion anomalies. The need for formal design methodologies. Trade-offs between design quality and system performance.	LC, LW
Section 2	Types of normal forms. Basic properties of normal forms.	2.1	Classical design approach in terms of relational data model by method of successive approximations to a satisfactory set of relationship schemas	Iterative approach to relational database design. Decomposition of relation schemas. Achieving a satisfactory set of schemas through successful refinement. Evaluation criteria for well-designed databases.	LC, LW
		2.2	Representation of the subject domain as one or more relations.	Mapping real-world entities and relationships to relational schemas. Identification of attributes and determination of primary keys. Handling of many-to-many, one-to-many, and one-to-one relationships.	LC, LW
		2.3	The design process as a process of normalization of relationship schemas.	Normalization as a formal method for reducing redundancy and anomalies. Step-by-step transformation of relational schemas to higher normal forms. Relationship between functional dependencies and normalization.	LC, LW
		2.4	Sequence of normal forms	Overview of the normal form hierarchy: First Normal Form, Second Normal Form, Third Normal Form, Boyce-Codd Normal Form, Fourth Normal Form, Fifth Normal Form. Conditions and requirements for each normal form. Practical guidelines for achieving appropriate normalization levels.	LC, LW
Section 3	Semantic modeling of data, ER-charts Semantic ER-model (Entity - Connections)	3.1	Limitations of the relational data model	Inability to directly represent complex relationships. Lack of mechanisms for expressing data semantics. Difficulties in modeling certain real-world structures.	LC, LW
		3.2	Insufficient representation of the meaning of	The gap between real-world semantics and relational represen-	LC, LW

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
			the data.	tations. Loss of meaning during translation from conceptual model to relational schema. Need for additional documentation and constraints.	
		3.3	The semantics of the real domain	Capturing business rules and domain constraints. Representing entity types, relationship types, attributes, and cardinalities. Expressing complex constraints such as participation constraints and exclusion constraints.	LC, LW
		3.4	Model-independent	Semantic modeling concepts that are independent of implementation models. Abstract representation of data structures. Benefits of model-independent design for communication with stakeholders.	LC, LW
		3.5	The problem of representing integrity constraints in the context of ER diagrams	Incorporating integrity constraints into entity-relationship diagrams. Notation for cardinality constraints, participation constraints, and key constraints. Handling of more complex constraints not directly expressible in basic ER notation.	LC, LW
		3.6	Varieties of ER models.	Different ER model notations: Chen notation, Crow's Foot notation, UML class diagrams. Extensions to basic ER: enhanced entity-relationship model with generalization, specialization, and aggregation.	LC, LW
		3.7	Designing the domain	Process of domain analysis and modeling. Identification of entities, attributes, and relationships. Refinement of the domain model through iterative review.	LC, LW
		3.8	Graphical diagrams.	Construction and interpretation of entity-relationship diagrams. Notation conventions. Use of ER diagrams for documentation and communication between designers, developers, and domain experts.	LC, LW
Section 4	External memory structures, methods of index organization. Methods of physical organization of data	4.1	Organization of external memory. Two-level system	Hierarchical structure of memory: main memory and secondary storage. Characteristics of external memory: capacity, access speed, persistence. Implications for database performance.	LC, LW
		4.2	The level of direct data management in the external memory.	Low-level data access and management. File organization methods: heap files, sorted files, hashed files. Buffer management strategies.Low-level data access and management. File organization methods: heap files, sorted files, hashed files. Buffer management strategies.	LC, LW
		4.3	Transaction management and logging of database changes.	Definition of transactions as units of work. Properties of transactions. Write-ahead logging for recovery. Checkpoints and re-	LC, LW

Section number	Name of the discipline section	Topic Title		Topic Contents	Type of academic work*
				covery procedures.	
		4.4	Managing the level that implements the SQL language. The organization of the lower level subsystem must manage the memory.	The role of the database management system in memory management. Implementation of SQL queries at the physical level. Optimization of memory usage for query execution.	LC, LW
		4.5	The functions of the upper level subsystem.	Query parsing and optimization. Access plan generation and selection. User interface and application interaction layers.	LC, LW
		4.6	Index-sequential and index-arbitrary data organization. Methods of accessing the data. Hashing method.	Sequential file organization with primary index. Indexed sequential access method. Arbitrary index organization. Hashing methods: static hashing, dynamic hashing, extendible hashing. Comparison of access methods.	LC, LW
		4.7	Advantages and disadvantages of the main methods of storing and retrieving data / Index-sequential and index-arbitrary data organization. Data access methods	Comparison of storage methods: heap, sequential, indexed, hashed. Performance characteristics for different operations: insert, delete, search, range query. Trade-offs between storage overhead and access speed.	LC, LW
		4.8	Advantages and disadvantages of the main data storage and retrieval methods.	Summary evaluation of data organization techniques. Selection criteria based on application requirements: read-heavy versus write-heavy workloads, need for range queries, key distribution properties.	LC, LW
Section 5	Client-server data organization. Database protection. Data protection system in Access Server data management systems	5.1	Client-server data organization models. Two-tier and tiered systems.	Client-server architecture in databases. Two-tier model: client application directly connecting to database server. Three-tier and multi-tier architectures: introduction of application servers and middleware. Benefits and trade-offs of each architecture.	LC, LW
		5.2	The main tasks to be solved in multi-user systems. Database replications.	Concurrency control: managing simultaneous access without conflicts. Locking mechanisms: shared locks, exclusive locks. Isolation levels and their effects. Database replication: master-slave, multi-master, and peer-to-peer replication. Synchronous versus asynchronous replication.	LC, LW
		5.3	Physical, organizational and cryptographic methods of data protection.	Physical protection: facility security, hardware security, backup storage. Organizational methods: access policies, user management, audit trails. Cryptographic methods: encryption at rest, encryption in transit, key management.	LC, LW
		5.4	Data protection models: discretionary and mandated. Remote user authentication	Discretionary access control: owners granting permissions to users. Mandatory access control: system-enforced security policies based on classifications and clearances. Remote user authentication methods: passwords, multi-factor authentication, certificate-based authentication. Authentication protocols and secure connections.	LC, LW

* - to be completed only for FULL-TIME education: LC – lectures; LW – laboratory work; SC – practical/seminar classes.

6. LOGISTIC AND TECHNICAL SUPPORT OF DISCIPLINE

Table 6.1. Material and technical support for the discipline

Audience type	Equipment of the auditorium	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
Lecture	A lecture hall equipped with specialized furniture, a whiteboard (screen), and multimedia presentation equipment.	
Computer class	A computer room for conducting classes, group and individual consultations, ongoing monitoring and midterm assessment, equipped with personal computers (in the amount of ____ units), a board (screen) and technical means for multimedia presentations.	
For independent work	A classroom for independent student work (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to the Electronic Information System.	

* - the classroom for independent work of students MUST be indicated!

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF THE DISCIPLINE

Main literature:

1. A. Khomenko, V. Tsygankov, M. Maltsev. Databases, 6th edition, M. Binom-Press, 2008, 736 p.

2. Glushakov, Sergey Vladimirovich. Microsoft Access 2007: the best self-study guide / S. V. Glushakov, A. S. Suryadny, M. I. Shumilov., 2nd ed., supplemented and revised, Moscow: AST, 2008, 444 p.

3. Kuzin, Aleksandr Vladimirovich. Database development in the Microsoft Access system: a textbook for students of secondary vocational education / A. V. Kuzin, V. M. Demin, 3rd ed., Moscow: Forum, 2009, 224 p.

Further reading:

1. Date K. Introduction to Database Systems: [Textbook: Translated from English] / K. Date, 6th ed., Moscow and others: Williams Publishing House, 2000, 846 p.

2. Meyer D. Theory of relational databases / D. Meyer; edited by M. Sh. Tsalenko; translated from English by M. K. Valiev [et al.], Moscow: Mir, 1987, 608 p.

Resources of the information and telecommunications network "Internet":

1. RUDN University Electronic Library System and third-party electronic library systems to which university students have access based on concluded agreements

- RUDN University Electronic Library System – RUDN University Electronic Library System https://mega.rudn.ru/MegaPro/Web
- Electronic Library System "University Library Online" http://www.biblioclub.ru
- EBS Yurayt http://www.biblio-online.ru
- Electronic Library System "Student Consultant" www.studentlibrary.ru

- EBS “Knowledge” https://znanium.ru/

2. Databases and search engines
   - Sage https://journals.sagepub.com/
   - Springer Nature Link https://link.springer.com/
   - Wiley Journal Database https://onlinelibrary.wiley.com/
   - Scientometric database Lens.org https://www.lens.org

Educational and methodological materials for independent work of students in mastering a discipline/module:*

1. Lecture course on the subject "Databases".

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

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