**Syllabus**
Course Program

# Database organization

Specialty
113 - Applied mathematics

Institute
IBE of Computer Modeling, Applied Physics and Mathematics

Educational program
Computer and mathematical modeling

Department
Mathematical modeling and intelligent computing in engineering (161)

Level of education
Bachelor's degree

Course type
Special (professional), compulsory

Semester
3

Language of instruction
English

## Lecturers and course developers


**Hennadii Martynenko**

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Doctor of Technical Sciences, Professor, Professor of the Department of Mathematical Modeling and Intelligent Computing in Engineering, NTU “KhPI”


He has 18 years of experience in teaching and research. Author of more than 180 scientific and educational works.

Lecturer and instructor of the laboratory workshop in the following disciplines: “Organization of databases”, “Intelligent data analysis”, “Software systems for design and analysis”, “Software tools for modeling physical processes”, “Modeling objects and processes in CAD/CAE systems”, “Analysis of dynamic processes in CAD/CAE systems”, “Modeling in CAE systems”, “Approximate and numerical methods for solving nonlinear problems”, “Pedagogical and information technologies in applied mathematics”.

More about the lecturer on the department's website


**Kseniia Potopalska**

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D. in Engineering, Associate Professor of the Department of Mathematical Modeling and Intelligent Computing in Engineering, NTU “KhPI”.


Experience in scientific and pedagogical work - 6 years. Author of more than 30 scientific and educational works.

More about the lecturer on the department's website

# General information

## Summary

The discipline is aimed at forming the knowledge, skills and abilities necessary for the design of relational databases, development of their conceptual and logical models by various methods, the use of modern relational database management systems (RDBMS) in creating physical models of these databases, mastering modern world trends in the development of methods and tools of databases in combination with information technology for their application in practical professional work. The approaches to creating conceptual and logical models of relational databases by various methods and physical implementation of these models and data manipulation using various database management systems (DBMS), as well as the methodology and tools for their use to create information systems in various fields and industries are considered.

## Course objectives and goals

The purpose of teaching the discipline is: to study and form students' knowledge of existing modern approaches to the organization of relational databases (in particular, conceptual and logical modeling using various methods and physical implementation using both tools used in DBMS and SQL language operators with the creation of various queries and reports with the mastery of elements of relational algebra and relational calculus); acquisition of skills and abilities in the application of normal form methods and entity-relationship diagrams, program
The objectives of teaching the discipline are: providing students with in-depth knowledge of relational databases; teaching conceptual and logical design of databases for various subject areas using the relationship normalization algorithm and the entity-relationship model; learning to work with the standard SQL relational database query language; learning how to build physical models, manipulate data, and create queries and reports using a relational database, such as MySQL, MariaDB, etc. for a general example, and using the object-relational database PostgreSQL (or another free RDBMS) for an individual task.

## Format of classes

Lectures, laboratory work, term papers, consultations. The final control is an exam.

## Competencies

GC10: Skills in the use of information and communication technologies;
PC05: Ability to design databases, information systems and resources.

## Learning outcomes

PH11: Be able to apply modern technologies of programming and software development, software implementation of numerical and symbolic algorithms;
PLO 19: Collect and interpret relevant data and analyze complexities within the field of specialization to make judgments that reflect relevant social and ethical issues.

## Student workload

The total volume of the discipline is 4 credits / 120 hours: lectures - 32 hours, laboratory work - 16 hours, independent work - 72 hours.

## Course prerequisites

The course is based on the information (concepts, formulations, approaches and methods of programming, mathematical analysis and logic, modeling and data processing) considered in the disciplines of the curriculum:
PLO 8. Mathematical analysis; PLO 9. Mathematical analysis; SP 4. Linear algebra;
SP 5. Object-oriented programming and design; SP 6. Discrete mathematics;
SP 11. Mathematical logic, theory of algorithms and data structures;
GDP1.1 Programming technology.

### Features of the course, teaching and learning methods, and technologies

As part of the Database Organization course, one of the necessary components of the assessment is for students to complete coursework in the form of group complex projects (with possible combination with the information and knowledge acquired in the Programming Technology course). The project work and its defense is a mandatory element of the discipline, and the results of the defense are included in the final grade. A group of students performs collective work and writes one common explanatory note. A public defense of the work takes place, the results of which are taken into account as a separate module in the discipline "Database Organization". During the laboratory workshop, free software is used, in particular, MySQL, MariaDB, PostgreSQL, etc.

## Program of the course

### Topics of the lectures

MODULE 1. Lectures (Lecture) 2 credits / 32 hours. "THEORETICAL FOUNDATIONS OF DATABASE DESIGN AND DATA MANIPULATION"

Topic 1: Introduction to databases and basic information:

1. Principles of organization of databases and DBMS; 2. Levels of description of data elements; 3. Data models.

Topic 2. Relational model:

1. Elements of set theory; 2. Basic concepts of the relational data model.

Topic 3. Relational model:

1. Three parts of the relational model; 2. Data types; 3. Domains, relations, attributes, tuples of relations; 4. First normal form (1NF); 5. Integrity of relational data (potential keys, integrity of entities).

Topic 4. Relational model:

1. Integrity of relational data (foreign keys, foreign key integrity); 2. Operations that can violate the referential integrity and strategies for maintaining referential integrity.

Topic 5. Relational model:

1. Overview of relational algebra; 2. Relational algebra (theoretical set operators).

Topic 6. Relational model:

1. Relational algebra (special relational operators); 2. Examples of using relational operators.

Topic 7. Database design using the method of normal forms of relations:

1. Stages of database development; 2. Criteria for assessing the quality of a logical data model; 3. First normal form (1NF) and update anomalies; 4. Functional dependencies; 5. Second normal form (2NF) and third normal form (3NF); 6. Normalization algorithm (reduction to 3NF).

Topic 8. Database design by the method of normal forms of relations:

1. Analysis of criteria for normalized and non-normalized data models; 2. Stored procedures and triggers. 3. Correctness of the normalization procedure - lossless decomposition. Hez's theorem.

Topic 9: Normal forms of high orders:

1. Boyce-Codd normal form (BCNF); 2. Fourth normal form (4NF); 3. Fifth normal form (5NF); 4. Continuation of the normalization algorithm (reduction to 5NF).

Topic 10. Elements of the entity-relationship model:

1. Basic concepts of ER diagrams.

Topic 11. Elements of the entity-relationship model:

1. An example of developing a simple ER model; 2. Conceptual and physical ER models.

Topic 12: Data manipulation (elements of the SQL language):
1. SQL structured query language; 2. SQL statements; 3. Data manipulation statements; 4. Using the SELECT statement (simple selection).

Topic 13. Data manipulation (elements of the SQL language):
1. Using the SELECT statement (selection from many tables, selection using correlation names, aliases, aliases).

Topic 14. Data manipulation (elements of the SQL language):
1. Using the SELECT statement (selection using aggregate functions and aggregate functions with grouping, selection using subqueries, selection using EXISTS and NOT EXISTS).

Topic 15. Data manipulation (elements of the SQL language):
1. Use of the SELECT statement (selection using union, intersection and difference); 2. Stages of the SELECT statement; 3. Relational completeness of SQL.

Topic 16. Transactions and database integrity:
1. Introduction and basic concepts; 2. An example of a database integrity violation; 3. The concept of a transaction; 4. Integrity constraints and their classification.

## Topics of the workshops

None.

## Topics of the laboratory classes

MODULE 2. Laboratory classes (LC) 1 credit / 16 hours. "BUILDING A PHYSICAL MODEL AND DATABASE MANAGEMENT" (2 topics are considered at one lesson for 2 hours)

Topic 1: Database management systems:
1. Purpose and classification of database management systems (DBMS); 2. Applications and their classes, methods and technologies of creation.

Topic 2. Working with databases under the management of MySQL (general example):
1. Basic elements: tables, queries, forms, reports, macros, modules; 2. Using the help system. Creating an empty database.

Topic 3. Working with databases under the management of MySQL (general example):
1. Creating a table structure, assigning key fields; 2. Filling and linking tables. Data schema.

Topic 4. Working with databases under the management of MySQL (general example):
1. Building queries by sample. SQL instructions; 2. Simple queries for selecting from related tables. Queries with parameters.

Topic 5. Working with databases under the management of MySQL (general example):
1. Organization of calculations and data processing; 2. Queries for updating and creating tables; 3. Cross query.

Topic 6. Working with databases under the management of MySQL (general example):
1. Providing a user interface for interacting with the database; 2. Creating forms using the wizard and by copying queries.

Topic 7. Working with databases under the management of MySQL (general example):
1. Modifying forms in the Designer mode; 2. Adding and configuring controls on the form.

Topic 8. Working with databases under the management of MySQL (general example):
1. Graphical representation of data on the form using diagrams; 2. Compilation and modification of reports.

Topic 9. Working with databases under the management of MySQL (general example):
1. Creating and customizing the main button form.

Topic 10. Database development in PostgreSQL or other RDBMS (individual task):
1. Preparation of tables with data; 2. Creating an application; 3. Database registration.

Topic 11. Development of databases in PostgreSQL or other RDBMS (individual task):
1. Data access components; 2. Visual components for working with data.

Topic 12. Development of databases in PostgreSQL or other RDBMS (individual task):
1. Modification of component properties and event handling; 2. Displaying the contents of tables on the form.

Topic 13. Database development in PostgreSQL or other RDBMS (individual task):
1. Linking tables in different ways; 2. Navigational and relational ways to access data.

Topic 14. Database development in PostgreSQL or other RDBMS (individual task):
1. Search for information in the database; 2. Building queries with parameters.

Topic 15. Development of databases in PostgreSQL or other RDBMS (individual task):
1. Organization of computing and data processing; 2. Graphical representation of information.

Topic 16. Database development in PostgreSQL or other RDBMS (individual task):
1. Module control №1; 2. Module control №2; 3. Module control №3 (course work).

## Self-study

1. Provision of classroom classes (study of lecture material and preparation of reports on the results of laboratory work) - 16 hours.
2. Independent study of topics and issues that are not taught in lectures, according to the provided guidelines - 8 hours.
3. Providing semester control (preparation for module control) - 8 hours.
4. Provision of individual tasks (performance and design of course work) - 24 hours.

MODULE 3. Course work (CW) 1.0 credit "CREATION OF A DATABASE FOR A GIVEN SUBJECT AREA" (is part of a team project work in the discipline "Database Organization" with a possible combination with information and knowledge acquired from the course "Programming Technology"):

I. Create an information system on the topic selected in accordance with your version of the task, implemented in the form of a relational database and operations on it. Using a two-dimensional menu created for a specific database, provide:
1. Enter, delete, add and modify data using convenient screen forms;
2. Software support for data integrity;
3. Quick data search by user-defined keys;
4. Preparation of reports and their delivery to the printer;
5. Implementation of the following typical SQL queries using:
    5.1. only selection and projection;
    5.2. join, select and projection;
    5.3. grouping with and without condition;
    5.4. aggregating functions in the phrases SELECT and HAVING;
    5.5. intersection, union, difference, division.
6. Data security in the database (entering a password).

II. The term paper report should contain the following sections:
1. Description of the subject area, relationships between attributes, restrictions on attribute values, the current state of the database subject area.
2. Description of the relational database design process (conceptual, logical and physical database schema).

3. Description of the interface with user application programs (general view of the menu and the connection of programs with data).
4. Justification of the need and general description of the software implementation of data integrity support.
5. Formulation and expressions of SQL queries.
6. Formulation and expressions of reports in SQL.
7. Application: structure and content of the database, source code of programs, including SQL queries and query results and reports..

## Course materials and recommended reading

1. Мартиненко Г.Ю. Концептуальне та логічне проектування реляційних баз даних [Електронний ресурс] : навч.-метод. посібник. Харків: Нац. техн. ун-т «Харків. політехн. ін-т», 2023. 91 с. (https://repository.kpi.kharkov.ua/handle/KhPI-Press/70293)
2. Методичні вказівки до виконання лабораторних робіт засобами СУБД MySQL для студентів спеціальності 122 «Комп'ютерні науки»/ Уклад. О.Г. Сімонова, О.В. Охотська, І.Б. Шеліхова. Харків: «НТМТ», 2022. 40 с. (http://repository.kpi.kharkov.ua/handle/KhPI-Press/60637)
3. Каратанов О.В. Організація даних: навч. посіб. до лаб. практикуму. Харків: Нац. аерокосм. ун-т ім. М.Є. Жуковського «Харків. авіац. ін-т», 2020. 60 с. (http://library.khai.edu/library/fulltexts/doc/_001_Karatanov.pdf)
4. Мулеса О.Ю. Інформаційні системи та реляційні бази даних: навч. посібник. Електронне видання, 2018. 118 с.
5. Голуб Б.Л., Ящук Д.Ю. Основи організації баз даних. Київ: НУБіП України, 2017. 139 с. (http://dglib.nubip.edu.ua:8080/jspui/bitstream/ 123456789/5362/1/Golub_Jashhuk_Osnovi.pdf)
6. Трофименко О.Г., Прокоп Ю.В., Логінова Н.І., Копитчук І.М. Організація баз даних : навч. посіб.. 2-ге вид. виправ. і доповн. Одеса : Фенікс, 2019. 246 с.
7. ДСТУ 2874-94. Системи оброблення інформації. Бази даних. Терміни та визначення. – Київ : Держстандарт України, 1995. 29 с.
8. ДСТУ 2938-94. Системи оброблення інформації. Основні поняття. Терміни та визначення. – Київ : Держстандарт України, 1995. 32 с.

Additional literature

1. Connolly T.M., Begg C.E. Database Systems. A Practical Approach to Design, Implementation, and Management. Third Edition. Addison-Wesley Longman, 2002.
2. Riordan R.M. Designing Relational Database Systems. Microsoft Press, 1999.
3. Балик Н.Р., Мандзюк В.І. Бази даних MySQL: навч. посіб. Тернопіль: Навчальна книга – Богдан, 2010. 160 с. (https://bohdan-books.com/ upload/ iblock/ebe/ebe73ff67804bc6dc1f6f464a3ca4469.pdf)
4. Карпуша В.Д., Панченко Б.Є. Моделювання та проектування реляційних баз даних: навч. посіб. Суми : СДУ, 2010.
5. Покришень Д.А., Крєпкий Ю.О., Атрошенко І.Т., Дрозд О.П., Сподаренко І.Й. Основи баз даних. СКБД Access 2010 (2013): практ. посіб. Чернігів: ТОВ НВП «Інтерсервіс», 2013. 225 с.
6. Неня А.В. Організація баз даних та знань: консп. лек. для студ. заоч. форми навч. Суми: Вид-во СумДУ, 2010. 109 с. (https://essuir.sumdu.edu.ua/ bitstream-download/123456789/465/1/ Nenya%5b1%5d.pdf;jsessionid=4E0712F79E51342B0643827030D05A52)

## Assessment and grading

### Criteria for assessment of student performance, and the final score structure

Content module 1 (LC) – maximum 40 points: computer-based test (40 random short questions with 4 answer options, of which 1 is correct - 1 point for each correct answer) or exam (2 theoretical detailed questions and a practical task on relational operations in each ticket - 15 points for a correct answer to the question and 10 points for a correctly solved task).
Content module 2 (LW) – maximum 40 points: 15 laboratory works (2-4 points for each completed and submitted laboratory work).
Module 3 (CW) – maximum 20 points: completion of team-individual tasks with consulting of the supervisor from among the faculty members and evaluation based on the results of the public defense in the commission (the number of module points is 1/5 of the grade obtained based on the results of the public defense on a 100-point scale).
In total - a maximum of 100 points.
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### Grading scale

| Total points | National | ECTS |
|---|---|---|
| 90–100 | Excellent | A |
| 82–89 | Good | B |
| 75–81 | Good | C |
| 64–74 | Satisfactory | D |
| 60–63 | Satisfactory | E |
| 35–59 | Unsatisfactory (requires additional learning) | FX |
| 1–34 | Unsatisfactory (requires repetition of the course) | F |

## Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": show discipline, good manners, goodwill, honesty, responsibility. Conflict situations should be openly discussed in study groups with the teacher, and if it is impossible to resolve the conflict, they should be brought to the attention of the staff of the Institute's directorate.
Regulatory and legal support for the implementation of the principles of academic integrity of NTU "KhPI" is available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

## Approval

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|---|---|---|
| Approved by | Date, signature | Head of the department<br>Oleksiy VODKA |
| | Date, signature | Guarantor of the educational program<br>Gennadiy LVOV |