Taras Shevchenko National University of Kyiv
Institute of Geology
Department: Geoinformatics

"APPROVED"
Deputy director on academic work

«31» 08 2026року

WORK PROGRAMME OF DISCIPLINE
GEODATABASE DESIGN
(ПРОЄКТУВАННЯ БАЗ ГЕОДАНИХ)

First-year master students

Branch of knowledge	**G – Engineering, Manufacturing and Construction**
Program Subject Area	**G – 18 Geodesy and Land Management**
Educational level	**Master**
Educational program	**Geoinformation systems and technologies**
Type of discipline	**Obligatory**

Teaching mode	full time studies
Academic year	2026/2027
Semester	1
Number of credits ECTS	7
Language of teaching, learning and evaluation	English
Form of final control	exam

Lecturer(s): Liashenko Dmytro, ScD in geography, professor, Demydov Vsevolod PhD, physical and mathematical sciences, Department of geoinformatics

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KYIV - 2026

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"Approved"
Head of Department of Geoinformatics
(Zatserkovnyi, V.I.)
Record of the Department meeting
N 1 «31» August, 2026

Approved by Scientific-Methodical Commission of the Institute of Geology
Record of the meeting N 1 «31» August, 2026
Head of the scientific methodical commission (Demydov V.K.)

1.Aim of the Discipline: is to provide students with a comprehensive theoretical foundation and hands-on practical skills in designing, administering, and analyzing spatial databases according to modern industry standards (Cloud-Native GIS).
The curriculum is built upon a synergistic combination of two core engineering stacks: *1.Theoretical Engineering Foundation (Enterprise Backend):* Developing a deep understanding of standard corporate client-server database systems using PostgreSQL/PostGIS. This focuses on transaction management (ACID properties), spatial indexing mechanisms (GiST trees), and query optimization for high-concurrency, operational databases (OLTP).
2.Modern Analytical Toolset (Modern Data Stack & Big Data): Gaining daily, hands-on spatial data science experience using the cutting-edge, serverless DuckDB engine. This allows students to instantly query and manipulate massive datasets and work with next-generation cloud-native storage formats (GeoParquet and Cloud Optimized GeoTIFF — COG) directly from cloud object stores.

2.Requirements for Selecting the Academic Discipline:

1. Possess a basic level of information technologies;
2. Possess skills in working with a personal computer and have a basic level of programming knowledge.
3. It is desirable to have mastered the basic course "Management of Geodatabases" or an equivalent (not mandatory).

3.Annotation of the Academic Discipline / Reference: Familiarization with the basics of designing geodatabase structures, principles of optimization, and testing takes place. General paradigms of database design are studied, along with their place in modern decision support systems and data analysis. Students acquire practical skills in analyzing attribute information and creating relational geodatabases.
Academic Integrity. All learning and assessment tasks must be completed in compliance with the Charter of Academic Integrity and the current regulations of Taras Shevchenko National University of Kyiv. Any borrowing or use of data, ideas, texts, images, digital materials, and other results must be properly attributed. Violations of academic integrity will be reviewed in accordance with university procedures. Mastery of the course curriculum, as well as formative and summative assessments, are conducted based on the principles of academic integrity pursuant to Article 42 of the Law of Ukraine "On Education", the recommendations of the Ministry of Education and Science of Ukraine on the prevention of academic plagiarism (MES Letter No. 1/9-565 dated August 15, 2018), and the Regulations on the Use of Artificial Intelligence in the Implementation of Educational Programs at Taras Shevchenko National University of Kyiv (https://senate.knu.ua/?p=3466). Use of Artificial Intelligence. For this educational component as a whole, Level 2 of generative artificial intelligence use is established according to the Regulations on the Use of Artificial Intelligence in the Implementation of Educational Programs at Taras Shevchenko National University of Kyiv. For specific types of graded assignments, special restrictions are defined in Section 7.1 (Student Assessment Methods) of the syllabus. These include a complete ban on the use of generative AI during assessment activities conducted under the instructor's supervision. Recognition of Non-Formal and/or Informal Education Outcomes. Learning outcomes acquired through non-formal and/or informal education may be submitted for recognition in accordance with the procedure established by the University, provided they align with the learning outcomes of this discipline and are supported by relevant verifying documentation.

4.Objectives:

- Familiarize students with the main stages of database development;

- Familiarize students with the main paradigms of data organization and working with them;
- Acquire by students the necessary methodological and methodological knowledge and practical skills in creating databases and working with geodata;
- Assimilation by students of basic knowledge of programming fundamentals on a specialized structured query language (recommended for study: SQL programming language).

5.Learning Outcomes:

Results (1. to know; 2. to be able)		*Methods of teaching and learning*	*Assessment methods*	*Percentage in the final assessment of the discipline*
1.1	*Basic models of data organization, including geodata*	*Lecture, practic*	*Ongoing assessment*	*∂o 5%*
1.2	*Structural elements of relational databases*	*Lecture, practic*	*Ongoing assessment*	*∂o 5%*
1.3	*Interrelationships of attribute information*	*Lecture, practic*	*Ongoing assessment*	*∂o 5%*
1.4	*Data normalization and normal forms*	*Lecture, practic*	*Ongoing assessment*	*∂o 10%*
1.5	*The concept of data integrity and data anomalies*	*Lecture, practic*	*Ongoing assessment*	*∂o 5%*
1.6	*Purpose and syntax of basic SQL language operators*	*Lecture, practic*	*Ongoing assessment*	*Up to 10%*
2.1	Create basic tables and queries when solving assigned tasks	*Lecture, practic*	*Ongoing assessment*	*Up to 10%*
2.2	Determine input and output data, forms of their presentation for solving assigned tasks	*Lecture, practic*	*Ongoing assessment*	*Up to 10%*
2.3	Write and test commands in SQL, define test cases	*Lecture, practic*	*Ongoing assessment*	*Up to 10%*

2.4	Use database management systems and geographic information systems to enter and use data, including geographic data	*Lecture, practic*	*Ongoing assessment*	*Up to 10%*
3.1	Organize the presentation of information in databases in a form understandable to other users for effective solution of the assigned task	*Lecture, practic*	*Ongoing assessment*	*Up to 5%*
3.2	Formulate written reports on created databases, algorithms and commands, illustrate examples of the work of developed software tools	*Lecture, practic*	*Ongoing assessment*	*Up to 10%*
4.1	Understanding personal/personal responsibility for the personal solution of part of a common task	-	*Final work*	*Up to 5%*

6.Learning Outcomes and scheduled results of tuition:
According to program Geoinformatics

Learning Outcomes / ***Program results of the tuition***	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	3.1	3.2	4.1
PRT 05. Create and develop geospatial data infrastructures; process and publish geospatial data and metadata related to geoinformation systems for geodesy and land management.	+	+	+	+	+	+	+	+	+	+	+	+	+

Course structure: lectures and practical classes.

7.Scheme of assessment formation:

7.1Forms of assessment of students

- **Semester assessment:** Practical work on the basics of data organisation and normalisation and structured query language and database design – 60 points (milestone score 36 points)

It is permitted to use AI in the preparation of practical work as a supporting tool, provided that the author's contribution to the preparation of the program code of the practical work and calculation tasks is preserved. It is allowed to use AI for reference functions during the preparation of practical work and as a tool for checking spelling and technical formatting of the work. Declaring the fact and method of using AI is mandatory.

2. Final assessment in the form of an exam: maximum score 40 points, milestone score 24 points. During the exam, the student answers a theoretical question and performs a test task for comprehensive knowledge of relational database structures and SQL syntax. During the defense of practical works, the use of AI is prohibited. During the preparation of a written examination paper, the use of AI is prohibited. Final assessment in the form of an exam is mandatory.

Procedure and evaluation system

	Semesters grades	Exam	Final grade
Min	**36**	**24**	**60**
Max	**60**	**40**	**100**

Grading: For admission to the final grading, it is obligatory to prepare reports on practical work. The final grading is carried out in the form of an exam.

A student is not allowed to ***take the final assessment in the form of an exam*** *if he scored less than 20 points during the semester.*

7.2.Organisation of assessment: *Control is carried out according to a modular-rating system and includes: the performance of practical works (where students have to demonstrate the quality of the acquired knowledge and solve the tasks using the methods and tools outlined by the teacher), The final assessment is carried out in the form of a written test.*

7.3.Compliance scale

Satisfactory	60-74
Fail	0-59

8. STRUCTURE OF THE DISCIPLINE

THEMATIC PLAN OF LECTURES AND PRACTICAL CLASSES

№	Topic name	Number of hours		
		Lecture	**Practical**	**Independent work**
Section 1: *Basics of Data Organisation*				
1	**Introduction**. **Topic 1:** Basic data models.	4	4	20
2	**Topic 2.** Structural elements of relational databases	4	4	20
3	**Topic 3.** Organisation of work with spatial data, spatial indices	6	6	20
Chapter 2: *Basics of Geodatabase Design*				
4	**Topic 4.** SQL Basics	6	4	30
5	**Topic 5.** Data integrity, anomalies, and data normalisation. Normal forms.	4	4	26
6	**Topic 6.** Design, optimise, and test geodatabases	4	6	24
	TOTAL	**28**	**28**	**146**

Total volume 210 *hours, including*:

Lectures **–** ***28*** *hours.*

Practical classes - ***28*** *hours.*

Consultations - ***8*** *hours.*

Independent work **–** ***148*** *hours.*

The topics submitted for independent study

1. Topological Relations and the DE-9IM Matrix Model
2. Index-Backed Distance Queries and ST_DWithin Performance
3. Multi-Table Spatial Joins and Computational Complexity
4. Spatial Aggregations, Dissolving, and Geometry Collections
5. Geometry Validation, Error Diagnostics, and Automated Repairs
6. Query Optimisation, Cost-Based Execution Planning, and Spatial Index Tuning

RECOMMENDED SOURCES:

Main:

- **Зацерковний В.І., Ляшенко Д.О.** (2026) Геоінформаційні системи в управлінні територіями: монографія. – 447 с.
- **Ляшенко Д.** (2026) Муніципальні геоінформаційні системи. Навчальний посібник. Загальна редакція В. Зацерковний. Київ. 204 с.
- **Shekhar, S., & Chawla, S.** (2003). *Spatial databases: A tour*. Prentice Hall.
- **Smith, M.J., Goodchild, M.F. and Longley, P.A**. (2007) Geospatial Analysis, a Comprehensive Guide to Principles, Techniques and Software Tools. 2nd Edition https://freecomputerbooks.com/Geospatial-Analysis.html
- **Yeung, A. K. W., & Brent Hall, G.** (2007). *Spatial database systems: Design, implementation and project management*. Springer.

Additional:

- **Apache Software Foundation.** (2026). *SedonaSpark: Distributed spatial datasets and functions*. Apache Sedona. Retrieved September 18, 2026, from https://sedona.apache.org/latest/sedonaspark/
- **Obe, R. O., & Hsu, L. S.** (2021). *PostGIS in action* (3rd ed.). Manning Publications.
- **Open Geospatial Consortium.** (n.d.). *GeoParquet: Geospatial data in Apache Parquet*. Retrieved September 18, 2026, from https://geoparquet.org/
- **Radiant Earth Foundation.** (n.d.). *Cloud Optimized GeoTIFF: An imagery format for cloud-native geospatial processing*. Retrieved September 18, 2026, from https://cogeo.org/
- **Rigaux, P., Scholl, M., & Voisard, A.** (2002). *Spatial databases: With application to GIS*. Morgan Kaufmann.
- **Tokaj, P., Yu, J., & Sarwat, M. (2025).** *Cloud Native Geospatial Analytics with Apache Sedona: A Hands-On Guide for Working with Large-Scale Spatial Data*. O'Reilly Media.

LIST OF LINKS

1. Crunchy Data Postgres Playground

An instant, browser-based PostgreSQL environment. It includes a built-in interactive PostGIS tutorial, allowing students to learn spatial SQL directly inside the interface.

2. Database.build Sandbox

A client-side WebAssembly (WASM) PostgreSQL sandbox. It features an integrated AI assistant to help students write, debug, and understand spatial queries without creating an account.

3. Supabase Free Tier

A hosted PostgreSQL database that enables the PostGIS extension with a single click. It provides standard connection strings suitable for remote access via **QGIS**, desktop GIS software, or programming frameworks.

4. Neon.tech Serverless Postgres

A serverless cloud database with a free tier that fully supports PostGIS. It offers a unique database branching feature, enabling students to safely test queries on isolated copies of their data.

5. Official PostGIS Documentation

The primary reference manual for all spatial functions, geometry types, and installation guides.

6. Introduction to PostGIS Tutorial by Crunchy Data

The industry-standard, comprehensive web workshop covering spatial data types, geometry construction, and spatial relationships.

7. DuckDB Foundation. (2026). DuckDB installation guide. DuckDB. https://duckdb.org/install/?platform=windows&environment=cli

List of questions for the exam

1. Define a spatial database (SDB) and outline its mandatory functional requirements.
2. What core characteristics distinguish a spatial database from a traditional relational database management system (RDBMS)?
3. Name and describe the three fundamental abstractions used to model single objects in space.
4. Provide real-world examples of geographic phenomena represented by points, lines, and polygons.
5. What are spatial data types (SDT), and how does spatial algebra operate on them?
6. Explain the principle of closure within spatial data algebra.
7. Define topology in the context of spatial data structures and list its basic primitives.
8. Why is maintaining topological consistency critical for spatial data management and analysis?
9. Describe the structural geometry hierarchy defined in the OGC object model.
10. How are simple features characterised and represented within the OGC specification?
11. Provide a functional classification of spatial operators used in spatial query processing.
12. Contrast metric spatial operators with topological spatial operators, providing use cases for each.
13. Name and explain the primary classes of spatial relationships (such as containment, intersection, and disjointness).
14. Explain the execution concept and purpose of a spatial selection operation.
15. Define a spatial union operation and describe how it combines geometric inputs.
16. What are the two main parts that should ideally be included in a spatially extended SQL standard?
17. Write or describe the structural components of a conceptual spatial SQL query using geometric predicates.
18. Describe the operational purpose and outputs of spatial aggregate functions.
19. How do spatial aggregate functions differ from standard numerical SQL aggregations (like SUM or COUNT)?
20. Explain the two-step "Filter and Refine" strategy used to optimize spatial queries.
21. What specific role does the primary filter play compared to the secondary refinement step?
22. Explain the fundamental mechanism behind One-Dimensional Embedding of spatial approximations (e.g., space-filling curves).
23. How do indexing mechanisms use bounding approximations to map 2D/3D space into one-dimensional indices?
24. Define a spatial join and explain why it is computationally heavier than a standard attribute join.
25. Describe the logic behind common spatial join algorithms used in spatial DBMS engines.
26. Outline the internal architecture of an extensible spatial DBMS.
27. What are Federated Database Systems (FDBS), and how do they facilitate distributed spatial data integration?
28. What advanced data model does the ESRI Geodatabase support compared to flat file formats?
29. How does an ESRI Geodatabase use subtypes and attribute domains to enforce data integrity?
30. Compare how topological relationships are managed in an ESRI Geodatabase versus standard OGC Simple Features.