DOCTORAL (PHD) STUDIES

COURSE UNIT DESCRIPTION

Course unit title	Scientific areas	Faculty	Institute, department
Modern database systems	Informatics (N 009)	Faculty of Mathematics and Informatics	Institute of Computer Science, Department of Software Engineering

Study method	Number of credits	Study method	Number of credits
Lectures	1 (Spring sem.)	Consultations	1
Individual work	4	Seminars	1

Total credits: 7 ECTS

Summary

The course aims to acquire the knowledge of modern database management theory and its applications, develop skills in domain-specific modeling, database design, development and management, and acquire skills in working with modern database management systems.

Doctoral students who choose this course should already have the basics of database management theory and practice.

The main topics:

- Evolution of database systems: database generations, transition from centralized to distributed and cloud-native architectures, functionality evolution, data distribution and integration, performance optimization, real-time processing.
- NoSQL, NewSQL and big data: CAP theorem; ACID vs. BASE; distributed consistency models; NoSQL data models; comparison with relational systems; big data architectures; batch and stream processing; lakehouse and large-scale analytics.
- XML and semi-structured data: XML databases; XQuery and XPath (XDM); querying and updating XML; JSON data management; web services and data exchange formats.
- Semantic web and graph databases: RDF data model; RDF databases; SPARQL; knowledge graphs and semantic data integration.
- Object and object-relational databases: object data model; object-relational and object-oriented databases; ODMG, ODL, OQL; object-relational mapping (ORM) and integrity management.
- Data warehouse and analytics: data warehouse architecture; normalized and dimensional models; ETL and ELT data integration processes; OLAP; columnar storage; data lakes and lakehouse systems.
- Specialized and emerging databases: temporal, time-series, spatial and multimedia databases; vector databases; active and deductive databases.
- Mobile and edge databases: mobile architectures; replication and synchronization; transaction management; security and privacy.
- Distributed databases: data fragmentation and replication; distributed query processing; transaction management and consensus; fault tolerance and scalability in cloud environments.
- Data governance, security and compliance: RBAC and ABAC access control models; encryption; auditing; data protection and privacy; metadata and regulatory compliance.

Practical exercise: choose an application (subject) area and a specific database management system, develop a data model for the subject area, implement the model by creating the necessary objects of the database, implement the main functions of data processing, prepare and present a report on the exercise.

Main literature
J.A. Hoffer, H. Topi, R. Venkataraman, H. Bala. *Modern Database Management*, Pearson; 14th ed., 2026.
A. Silberschatz, H.F. Korth, S. Sudarshan. Database System Concepts, McGraw-Hill, 7th ed. 2019.
M.T. Öszu, P. Valduriez, *Principles of Distributed Database Systems*, 4th ed., Springer, 2020.
W.Lemahieu, S. v. Broucke, B. Baesens. Principles of Database Management. Cambridge University Press, 2018.
L. Wiese. *Advanced Data Management: For SQL, NoSQL, Cloud and Distributed Databases*. De Gruyter, 2015.

Lecturer(s) (name, surname)	Science degree	Main publications
Romas Baronas	dr.	http://www.elaba.mb.vu.lt/mif/?aut=Romas+Baronas
Linas Bukauskas	dr.	http://www.elaba.mb.vu.lt/mif/?aut=Linas+Bukauskas
Saulius Ragaišis	dr.	http://www.elaba.mb.vu.lt/mif/?aut=Saulius+Ragaišis