

**DOCTORAL (PHD) STUDIES
COURSE UNIT DESCRIPTION**

Course unit title	Scientific areas	Faculty	Institute, department
Semantic Systems Engineering	Informatics engineering (T 007)	Faculty of Mathematics and Informatics	Institute of Data Science and Digital Technologies

Study method	Number of credits	Study method	Number of credits
Lectures	1 (autumn)	Consultations	1
Individual works	4	Seminars	1

Summary
Prerequisites. The module requires master's-level knowledge of informatics and mathematics courses offered to students of informatics study programmes. The aim of the course is to deepen knowledge of methods for designing and developing semantic systems that enable the effective use and contextualisation of information. Main topics: 1. Semantic systems architecture. The knowledge graph concept; analysis of the RDF, RDFS, SPARQL and related standards. 2. Ontology engineering and knowledge modelling. Description logics, OWL profiles, ontology design patterns, knowledge modelling. 3. Knowledge graph construction and information extraction. Construction from structured and unstructured sources, entity and relation extraction. 4. Knowledge integration and linked data. Data and entity alignment (entity resolution), data space architectures. 5. Information contextualisation. Context modelling, provenance and traceability. 6. Knowledge graph representation learning and graph-based models. Embedding models, graph neural networks, link prediction. Graph Transformer (GT) and GNN architectures combined with LLMs. 7. Neuro-symbolic artificial intelligence. Knowledge graphs and language models. Integration of LLMs and knowledge graphs. 8. Semantically enhanced search with knowledge graphs. Semantic and exploratory search, GraphRAG, context-aware retrieval. 9. Knowledge graph quality, reliability and uncertainty. Quality dimensions, knowledge graph refinement. Practical assignments: a report on selected methods for designing and developing semantic systems, related to the topic of the doctoral dissertation.
Main literature
Kejriwal, M., Knoblock, C. A., & Szekely, P. (2021). <i>Knowledge graphs: Fundamentals, techniques, and applications</i> . MIT Press
Lippolis, A. S., Saeedizade, M. J., Keskisärkkä, R., Zuppiroli, S., Ceriani, M., Gangemi, A., Blomqvist, E., Nuzzolese, A. G. (2025, June). Ontology generation using large language models. In <i>European Semantic Web Conference</i> (pp. 321-341). Cham: Springer Nature Switzerland.

He, X., Tian, Y., Sun, Y., Chawla, N. V., Laurent, T., LeCun, Y., Bresson X., Hooi B. G-Retriever: Retrieval-Augmented Generation for Textual Graph Understanding and Question Answering, 2024. <i>Advances in Neural Information Processing Systems</i> , 37, 132876-132907.
Hitzler, P., Dalal, A., Mahdavi, M. S., & Norouzi, S. S. (Eds.). (2025). <i>Handbook on neurosymbolic ai and knowledge graphs</i> . ISBN 978-1-64368-578-6 (print) 978-1-64368-579-3

Lecturer(s) (name, surname)	Science degree	Main publications
Asta Slotkienė	Dr.	http://www.elaba.mb.vu.lt/dmsti/?aut=Asta+Slotkienė
Jolanta Miliauskaitė	Dr.	http://www.elaba.mb.vu.lt/dmsti/?aut=Jolanta+Miliauskaitė
Haroldas Giedra	Dr.	https://elaba.mb.vu.lt/mif/?aut=Haroldas+Giedra