Content

Course Code	Course Name	Semester	Theory	Practice	Lab	Credit	ECTS
INF 642	Advanced Database Systems	1	3	0	0	3	8

Prerequisites	
Admission Requirements	
Language of Instruction	English
Course Type	Elective
Course Level	Doctoral Degree
Objective	The primary objective of this course is to train research-oriented doctoral students capable of contributing to the theoretical and methodological advancement of graph database systems. The course aims to develop advanced expertise in graph data models, Semantic Web technologies, and neural-symbolic integration frameworks, while strengthening students' abilities in formal reasoning, complexity analysis, and algorithmic design. It further seeks to equip students with the necessary theoretical and practical foundations to produce high-quality scientific research and publications in top-tier venues.
Content	The course covers the theoretical and methodological foundations of graph database systems, with a particular emphasis on formal semantics, query expressiveness, and computational complexity. It begins with core concepts such as graph data models, first-order logic, datalog, and graph homomorphisms, and progresses to the formal framework of the Semantic Web, including RDF semantics and advanced SPARQL query processing and optimization. The course further explores knowledge representation and reasoning through description logics, ontology-based inference, and inconsistency handling mechanisms. A dedicated component focuses on neural-symbolic integration, including differentiable reasoning over graphs and the theoretical limits of graph neural networks. Advanced topics include knowledge graph construction, information extraction models, automated ontology learning, and statistical relational learning. The course also addresses distributed graph systems, covering query processing, consistency models, and consensus mechanisms. Finally, emerging research directions such as temporal knowledge graphs, multimodal data integration, and cross-modal reasoning are examined, providing a comprehensive foundation for doctoral-level research.
References	1. Serles, U., & Fensel, D. (2024). An Introduction to Knowledge Graphs. Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-45256-7 2. Hogan, A., Blomqvist, E., Cochez, M., d'Amato, C., Melo, G. D., Gutierrez, C., Kirrane, S., Gayo, J. E. L., Navigli, R., & Neumaier, S. (2021). Knowledge Graphs. Springer Verlag. https://doi.org/10.2200/S01125ED1V01Y202109DSK022 3. Kejriwal, M., Knoblock, C. A., & Szekely, P. (2021). Knowledge Graphs: Fundamentals, Techniques, and Applications. MIT Press. https://doi.org/10.7551/mitpress/11382.001.0001 4. Additional and Recommended Readings : In addition to the core textbooks, students are encouraged to engage with recent high-impact research articles from leading conferences and journals. The list of selected papers is updated annually to reflect the latest developments and emerging research directions in graph databases, the Semantic Web, and neural-symbolic systems.

Theory Topics

Week	Weekly Contents
1	Theoretical Foundations of Graph Databases
2	Semantic Web and RDF Theoretical Framework
3	SPARQL
4	Knowledge Representation and Reasoning Systems and OWL
5	Neural-Symbolic Integration Theory
6	Advanced Knowledge Graph Construction
7	Distributed Graph Systems Theory
8	Temporal knowledge graphs: time logic, versioning theory.
9	Multimodal integration; cross-modal reasoning frameworks.
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