Course title: KNOWLEDGE BASES AND SEMANTIC WEB

Lecturers	Full Prof. Sandra Lovrenčić, Ph.D. Vlatka Sekovanić, mag. educ. inf. Assoc. Prof. Renata Mekovec, Ph.D.
Language of instruction	Croatian and English
Study level	Master
Study programme	Databases and Knowledge Bases
Semester	3rd (winter)
ECTS	5
Goal	Goal of course Knowledge Bases and Semantic Web is to teach students about two important, intertwined areas that are dealing with intelligent structuring and intelligent data (information) processing in the Web environment. Structured data, in mutual dynamic interaction, with combination of classic search and deductive derivation, result in knowledge bases. Lately, the concept of knowledge base is replaced by the concept of ontology. Semantic Web is placed in Web context and ensures an intelligent approach to heterogeneous, distributed information content. Application areas are constantly spreading and today comprise knowledge management (including business rules systems), electronic commerce (including automatic negotiation systems), information exchange, natural language processing etc. The course will give students necessary theoretical knowledge, teach them about modern programming languages and tools, and train them through practical work on computers to use and develop Semantic Web systems. After the completion of the course, the students should be able to: 1. Be able to identify and explain the constituent elements of Semantic Web applications 2. To be familiar with the latest technologies and tools for knowledge bases development within the Semantic Web 3. Understand and describe the basic principles, goals and structure of the Semantic Web 4. Understand the concept of knowledge bases and describe their structure 5. Understand the concept of ontology as a knowledge base and adopt the method of ontology development and validation 6. Understand the purpose and possibilities of knowledge bases and explain their use 7. Know how to carry out structural subsumption and Tableau algorithm for reasoning over knowledge bases 8. Know how to develop a knowledge base (ontology) with standardised languages using description logics
General and specific learning outcomes	
Content	**Semantic Web Vision – Current Web.** From initial vision of Web towards Semantic Web - historical development. Development phases. Fundamental principles of Semantic Web. Application areas.

	Semantic Web Layers (technologies) - Purpose and interconnection of Semantic Web technologies. Technology and languages pyramid: URI/IRI, XML, data exchange, ontologies, queries, rues, logic, proof, trust, user interface and application, cryptography. Other technologies and standards of Semantic Web. **Architecture for knowledge management within Semantic Web** -knowledge representation with ontologies (knowledge bases). Ontology definition. Types of ontologies. Formal representation of ontologies. Ontology development methods. Ontology examples. Tools for knowledge representation. Evaluation of knowledge bases. **Introduction to Description Logics (DL)** – Definition and development. Connection to first order logic. Knowledge representation in DL. ALC language – syntax and semantics. TBox, RBox and ABox. Extensions of ALC language. Knowledge base modelling in DL. Reasoning over knowledge base in DL: structural subsumption and tableau algorithm. **Basic format for knowledge representation within Semantic Web –** RDF and RDF Schema. RDF graph. Basic concepts – resources, properties, statements. Resource description. RDF Serializations. Data types. Reification. Containers and collections. Classes and instances. Class hierarchy and inheritance**.** **Enhancement of expressiveness and support to reasoning over knowledge bases** - OWL1 – sublanguages (layers), OWL2 – profiles. Development and current possibilities. Constraints and interconnectedness of languages. Equivalent and disjoint classes. Object and data properties. Inverse, equivalent, disjoint and negative properties. Special properties. Property restrictions. Property chains. Keys. Class combinations. Restriction of data types. **Knowledge base search** – Syntax and semantic of query language. Basic query forms. Query modifiers. Simple and complex queries. Linked open data (LOD cloud). DBpedia. Examples of search engines. **Application of knowledge bases and development of the field of Semantic Web** – Existing solutions that apply Semantic Web technologies. Examples of knowledge bases and applications from various domains (knowledge management, electronic commerce, medicine…). Knowledge bases as part of knowledge representation and reasoning in Artificial Intelligence. Web of data and graph databases.
Exercises	Exercises - As part of the exercises, students will use modern tools and languages to work with knowledge bases (ontologies) and to perform knowledge reasoning. They will develop smaller formal ontologies, as well as learn about some of the possibilities of technologies for the development of the Semantic Web. Seminars - As part of the seminars, students will compare and analyze individual topics from lectures (for example, specific sample knowledge bases or reasoning tools). They will also independently process (critical review) and present certain topics from the area covered by the subject.
Realization and examination	Class: lectures, seminars, exercises Examination: written exam, seminar paper, exercises, activity
Related courses	1. Ontology Engineering for the Semantic Web, University of Manchester, School of Computer Science, http://syllabus.cs.manchester.ac.uk/pgt/2021/COMP62342/

	2. Semantic Web and Linked Data,University of Jyväskylä, Faculty of Information Technology, http://www.mit.jyu.fi/ai/vagan/itks544.html 3. Ontology Engineering, Tetherless World Constellation (TWC) at Rensselaer Polytechnic Institute, https://tw.rpi.edu/web/Courses/Ontologies/2020 4. Semantic Web, Maastricht University, https://www.maastrichtuniversity.nl/meta/415108/semantic-web 5. Semantic Web Techniques, University of New Brunswick: Faculty of Computer Science, http://www.unb.ca/academics/calendar/graduate/current/courses-/fredericton-courses/computer-science-courses/cs-6795.html
Literature	Basic: C. M. Keet, An Introduction to Ontology Engineering, London: College Publications, 2020 M. Uschold, Demistifying OWL for the Enterprise, San Rafael, CA: Morgan & Claypool, 2018 Additional: F. Baader et al., An Introduction to Description Logic, Cambridge, UK: Cambridge University Press, 2017 R. Arp, B. Smith and A. D. Spear, Building Ontologies with Basic Formal Ontology, Cambridge, MA: The MIT Press, 2015 P. Szeredy, G. Lukácsy and T. Benkő, The Semantic Web explained: the technology and mathematics behind Web 3.0, Cambridge, UK: Cambridge University Press, 2014 D. Wood et al., Linked Data: Structured Data on the Web, Shelter Island, NY: Manning Publications, 2014 RDF, RDFS; OWL and SPARQL standards Lecture materials