Course Unit Descriptor

Study Programme: Applied Mathematics – Data Science	
Course Unit Title: Network science	
Course Unit Code: MDS08	
Name of Lecturer(s): Nataša M. Krklec Jerinkić	
Type and Level of Studies: Master studies	
Course Status (compulsory/elective): Compulsory	
Semester (winter/summer): Winter	
Language of instruction: English	
Mode of course unit delivery (face-to-face/distance learning): Face-to-face	
Number of ECTS Allocated: 6	
Prerequisites: Basics of linear algebra, graph theory, probability and statistics	

Course Aims:

- Understanding of a wide range of network models, metrics, and processes
- Understanding of advantages/disadvantages of various network models for a given real-world application
- Ability to model and analyze networks using network analysis tools and libraries

Learning Outcomes:

- Ability and experience in modelling, sampling, and analyzing real-world networks
- Ability to apply the taught network concepts on research problems from a wide variety of application areas

Syllabus:

Theory

Elements of algebraic graph theory: adjacency matrix; Laplacian matrix; spectra of Laplacian matrix; Fiedler value. Graph types and representations. Network metrics and notions of connectedness, density, distance, centrality, transitivity and node similarity. Structure and evolution of complex networks: connected component analysis, k-cores, cliques and ego-networks, degree distribution analysis (identifying power-laws in empirical data and measuring of preferential attachment), assortativity mixing patterns, community structure, emergence of giant connected components, the densification law and shrinking diameters. Mathematical models of complex networks: random graphs (Erdős–Rényi, Gilbert, geometric models, the configuration model), small-world networks (Watts-Strogatz, Kleinberg) and scale-free networks (the Barabasi- Albert model and modifications, copying based models). Community detection techniques and graph clustering evaluation metrics. Link prediction. Processes on networks: diffusion; gossip; consensus; virus spreading; voter models; emergent behavior; mean-field analysis.

Practice

Application examples in telecom, electric grid (smart grid), sensor networks, social networks, medicine, etc.; Implementation of the taught methods in MATLAB/Java/R; Application of selected methods on real-world examples through the course project. Network analysis tools (e.g. Gephi, Pajek) and libraries (e.g. iGraph, Jung). Practical introduction to graph databases.

Required Reading:

E. D. K. Statistical Analysis of Network Data: Methods and Models, Springer, 2009

M. E. J. Newman: Networks - An introduction, Oxford University Press, 2010.

F. Chung: Spectral Graph Theory, CBMS Regional Conference Series in Mathematics, No. 92, 1996

D. Easley, J. Kleinberg. Networks, Crowds and Markets: Reasoning About a Highly Connected World. Cambridge University Press, 2010.

W. de Nooy, A. Mrvar, V. Batagelj. Exploratory Social Network Analysis with Pajek. Cambridge University Press, 2005.

Weekly Contact Hours:	**Lectures: 2**	**Practical work: 2**

Teaching Methods: Lectures; revisions of the material; active students' participation in problem solving; knowledge tests – colloquia; application of the taught material on real-world examples.

Knowledge Assessment (maximum of 100 points): 100

Pre-exam obligations	points	**Final exam**	points
Active class participation		written exam	40
Practical work	30	oral exam	
Preliminary exam(s)	30	Course project	
Seminar(s)			

The methods of knowledge assessment may differ; the table presents only some of the options: written exam, oral exam, project presentation, seminars, etc.