# COURSE DESCRIPTION

| **General information** | | |
|---|---|---|
| Lead instructor | Associate Professor Zoran Levnajič<br>Professor Riste Škrekovski<br>Assistant Professor Davor Davidović<br>Associate Professor Robert Kopal | |
| Course name | **CDS-20: Modeling and analysis of complex networks** | |
| Study programme | **Computer and Data Science, third cycle Doctoral Study Programme** | |
| Course status | Optional | |
| Year | First or Second | |
| Number of credits and mode of delivery | ECTS student workload coefficient | 10 |
| | Number of hours (L+P+S) | 40/-/260 |

| **Course description** |
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| *1.1. Course goals* |
| Learning unit contributes to development of the following general competencies:<br><br>- ability to identify a research problem, analyze it, and offer possible solutions.<br>- ability to create new knowledge, which represents a contribution to science<br>- mastery of standard research methods, procedures, and processes in diverse scientific fields<br><br>and subject-specific competencies:<br><br>- ability to solve concrete research problems in scientific field of network analysis<br>- development of skills and abilities in usage of knowledge in the scientific field of doctoral dissertation<br>- ability to innovatively use and combine diverse research methods<br>- skills in identifying research problems that can be formulated as network science problems<br>- mastery in extracting scientifically relevant information from a given network by selecting the most suitable methodology |
| *1.2. Course enrolment requirements* |
| There is none. |
| *1.3. Intended course learning outcomes* |
| Knowledge and understanding:<br><br>The student: |

- becomes familiar with a wide range of concepts in network analysis,
- learns methods and algorithms for analysis and modeling of large social and information networks
- learns how to use the existing software packages,
- is informed with theoretical basis and practical views of statistical methods in the field of large network analysis,
- is informed with methods for analysis of small vs large networks.

1.4. *Course content*

- Introduction
  - What are networks and why we study them?
  - Social, Information, and Biological Networks
  - Social media
- Bipartite networks, multiplex and multilayer networks, hypergraphs
- Complex network analysis
  - Nodes, degrees
  - Directions and weights
  - Clustering, shortest path, diameter, density of networks
  - Visualization of networks
  - Subnetworks
- Main algorithms for network analysis
  - Available software
  - Adjacency matrix and list
  - breadth-first search
  - computational complexity
  - storing network data
- Statistical network analysis
  - Measures of centrality
  - Degree distribution
  - Power laws in networks
  - closeness and betweenness
  - components
- Network models
  - Random graphs, Small worlds
  - scale-free networks, other models
  - Inference of network models from empirical data
- Community structure
  - Networks with communities, community detection, modularity and modular networks, overlapping communities
  - Network alignment, network comparison
- Dynamics on networks
  - Dispersion, diffusion, percolation
  - Temporal networks
- – Synchronization on networks

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| 1.5. *Modes of delivery (mark the appropriate boxes with an X)* | ☒ *lectures*<br>☐ *seminars and workshops*<br>☒ *practicals*<br>☐ *remote learning* | ☒ *independent work*<br>☐ *multimedia and network*<br>☐ *laboratory*<br>☐ *supervision* |

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|---|---|---|
| | ☐ *field work* | ☐ *other* _____ |

1.6. *Student obligations*

1.7. *Monitoring student work (mark the appropriate boxes with an X)*

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| Class attendance | | Participation in class | | Seminar paper | | Experimental work | |
| Written exam | | Oral exam | | Essay | | Research | |
| Project | | Continuous assessment of knowledge | | Student report | | Practical work | |
| Portfolio | | Schoolwork | | Homework | | | |

1.8. *Assessment and evaluation of student work during classes and the final exam*

Type (examination, oral, coursework, project):

- Project assignment customized for each student, 100%

1.9. *Required readings and number of copies relative to the number of students currently taking the course*

| *Title* | *Number of copies* | *Number of students* |
|---|---|---|
| Menczer, F., Fortunato, S., & Davis, C. A. (2020). A First Course in Network Science. Cambridge University Press. | | |
| Zwieg, K. (2016). Network Analysis Literacy: A Practical Approach to the Analysis of Networks. Springer. | | |
| Newman, M. (2018). Networks. 2nd edition. Oxford University Press. | | |
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1.10. *Supplementary readings*

1.11. *Methods of quality monitoring that ensure the acquisition of knowledge, skills and competences.*