COURSE DESCRIPTION

General information		
Lead instructor	Professor Janez Povh Assistant Professor Davor Davidović Assistant Professor Hrvoje Jerković	
Course name	**CDS-11: Selected chapters from mathematical optimization in computing**	
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

1.1. Course goals

The instructional unit contributes to the development of the following general competences:

- Familiarity with the notion of quality and strive for professional quality through autonomy, (self-) criticism, (self-) reflection and (self-) evaluation.
- Ability to create new knowledge, which represents a contribution to science.
- Mastery of standard research methods, procedures and processes in diverse scientific fields.
- Commitment to professional ethics.

and subject-specific competences:

- familiarity with topics of mathematical optimization,
- ability to solve optimization problems,
- ability to use mathematical optimisation tools to solve problems in data science.

1.2. Course enrolment requirements

- Knowledge of linear algebra: matrices, norms, eigenvalues, eigenvectors, scalar products,
- Analysis of real multivariate functions: gradient, Hessian matrix, directional derivatives, Taylor approximation of multivariable functions,
- Knowledge of basic data models: regression, classification, clustering.

1.3. Intended course learning outcomes

Knowledge and understanding:

The student:

- becomes familiar with the foundations of mathematical optimisation,

- becomes familiar with the convex optimisation problems and different ways of solving them,
- has a clearer picture of how mathematical optimisation can serve them in the preparation of their PhD thesis.

1.4. Course content

The basics of convex analysis: convex sets, convex functions, local and global extremes.
Convex optimization problems: linear, quadratic, semidefinite programming, optimality conditions, dual theory, examples.
Solving convex optimization problems with gradient descent method: steepest descent, line search, conditional gradient method, accelerated gradient method, conjugate-gradient,
Solving convex optimization problems with Newton and quasi-Newton method.
Usage of mathematical optimisation tools to solve the following data science problems:

- The maximum cut problem on networks,
- The problem of shortest paths in networks,
- The clustering problem in networks,
- Graph/Network coloring problem,
- non-negative matrix factorization problem: definition, solution, application to clustering,
- matrix completion problem,
- problem of calculating (sparse) principal components.

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

1.6. Student obligations

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

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 work, 50%
- oral exam, 50%

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*
Mahoney, M. W., Duchi, J. C., & Gilbert, A. C. (Eds.). (2018). The Mathematics of Data, 25. American Mathematical Soc.		

Snyman, J. A., & Wilke, D. N. (2018). Practical Mathematical Optimization: Basic Optimization Theory and Gradient-Based Algorithms. Germany: Springer International Publishing.		
Calafiore, G. C., & El Ghaoui, L. (2019). Optimization models. Cambridge university press.		
1.10. Supplementary readings		
1.11. Methods of quality monitoring that ensure the acquisition of knowledge, skills and competences.		