

Subject card

Subject name and code	Mathematical Optimization and Applications, PG_00185587						
Field of study	Mathematical Optimization and Applications						
Date of commencement of studies	October 2024		Academic year of realisation of subject		2025/2026		
Education level	Master's studies		Subject group		Obligatory subject group in the field of study Optional subject group		
Mode of study	full-time studies		Mode of delivery		at the university		
Year of study	2		Language of instruction		English English		
Semester of study	3		ECTS credits		6.0		
Learning profile	academic		Assessment form		exam		
Conducting unit							
Name and surname of lecturer (lecturers)	Subject supervisor		dr Felix Huber				
	Teachers		dr Felix Huber				
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	30.0	0.0	0.0	0.0	60
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours		Self-study	SUM
	Number of study hours	60		0.0		0.0	60
Subject objectives	The aims of the course is to get an understanding of mathematical optimization. In particular so that the student knows the theory of convex optimization methods such as linear, quadratic, and semidefinite programming as well as their applications in theory and practise. The aim is also that the student will be confident in using numerical software packages.						
Learning outcomes	Course outcome		Subject outcome		Method of verification		
	[QITL3_U02] has the skills to plan and conduct basic and advanced research and calculations in the area of quantum information theory or its applications		Knows how to use modern solvers		[SU5] realizacja zadania problemowego		
	[QITL3_W02] has in-depth knowledge in the field of advanced mathematics and mathematical and computer methods, necessary to solve physical problems of medium complexity, and advanced knowledge in the area of quantum information and its technological aspects		Knows theory and applications of linear, quadratic, and semidefinite programming.		[SW4] test/egzamin - ustny lub pisemny		
Subject contents	1 Review of linear algebra (matrix decompositions, positive semidefinite matrices, convex geometry) 2 Linear programming (duality theory, Farkas lemma, maximum weight matching) 3 Second-order cone programming 4 Semidefinite Programming (infeasibility certificates, duality theory, Lovasz theta bound on independent set size, euclidean distance matrices) 5 Approximation algorithms and randomized rounding (quadratic binary optimization, Goeman-Williamson randomized rounding) 6 Non-negative polynomials and sum-of-square certificates (Motzkin Polynomial, Putinar Positivstellensatz) 7 Polynomial optimization (Lasserre hierarchy)						
Prerequisites and co-requisites	Linear Algebra, Progammng with Python or Julia						

Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	Written or verbal exam	51.0%	80.0%
	Participation exercise classes	80.0%	20.0%
Recommended reading	Basic literature	Lecture notes by Lovász, https://sites.math.washington.edu/~thomas/teaching/m514_web/Lovasz_semidef.pdf Blekherman et al, Semidefinite Optimization and convex algebraic geometry, https://www.mit.edu/~parrilo/sdocag/	
	Supplementary literature	None.	
	eResources addresses		
Example issues/ example questions/ tasks being completed	What is a Gram matrix? What is the Löwner order? Define convex cone, convex hull, dual cone, self-dual cone. Give examples of self-dual cones. Explain Farkas Lemma and its use. What is an approximation ratio? How is the Lovasz theta number defined as an SDP? Define independence number, chromatic number. What are their computational complexities? How does the Goeman-Williamon algorithm work? What is its approximation ratio? Formulate the primal and dual standard formulations of semidefinite programs. What are the problem parameters? Show weak duality.		
Work placement	Not applicable		

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