Subject card

Subject name and code	Mathematical Optimization and Applications, PG_00185587		
Field of study	Quantum Information Technology		
Date of commencement of studies	October 2026	Academic year of realisation of subject	2026/2027
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	1	Language of instruction	English
Semester of study	2	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_U01] is able to formulate and test hypotheses related to research problems in quantum information technologies		
[QITL3_W02] knows and understands on deepened level key and selected advanced detailed issues in the field of quantum information technology, including methods of their research and development, and their applications in the context of dynamic technological changes, in particular in the area of information processing, cryptography and the development of advanced computing systems		

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)

<table>
<tr><td>Prerequisites and co-requisites</td><td colspan="3">Linear Algebra, Progamming with Python or Julia</td></tr>
<tr><td>Assessment methods and criteria</td><td colspan="3">
<table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>Participation exercise classes</td><td>80.0%</td><td>20.0%</td></tr>
<tr><td>Written or verbal exam</td><td>51.0%</td><td>80.0%</td></tr>
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<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td colspan="2">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/</td></tr>
<tr><td>Supplementary literature</td><td colspan="2">None.</td></tr>
<tr><td>eResources addresses</td><td colspan="2"></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td colspan="3">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 indepedence 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.</td></tr>
<tr><td>Work placement</td><td colspan="3">Not applicable</td></tr>
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