Convex Optimization						
Type of Module Advanced Module				**Module Code** AM-KO		
Identification Number	**Workload**	**Credit Points**	**Term**	**Offered Every**	**Start**	**Duration**
MSc-M-KO	270 Hours	9 CP	1. – 3. Semester	Every two years, WiSe	Winter semester	1 Semester

1	**Course Types**	**Contact Time**	**Private Study**	**Planned Group Size**
	a) Lecture	56 h	112 h	
	b) Exercise	28 h	56 h	b) 30 Students
	Exam preparation		18 h	

2 Module Objectives and Skills to be Acquired

In modern convex optimization, semidefinite optimization occupies a central position. Semidefinite optimization is a generalization of linear optimization, in which linear functions are optimized using positive semidefinite matrices that are subject to linear constraints. A large class of convex optimization problems can be modeled with the help of semidefinite optimization. On the one hand there are solution algorithms for semidefinite Optimizations that are efficient in theory and in practice. On the other hand, semidefinite optimization is a widely used tool of particular elegance.

The aim of the module is to provide an introduction to the theoretical basics, algorithmic techniques and mathematical applications from combinatorics, geometry and algebra. After successful participation, students will be able to

- explain the basic concepts of semidefinite optimization

- give examples from combinatorics, geometry and algebra that can be modeled with the help of semidefinite optimization

- solve semidefinite programs with the help of computer software

- optimization problems to be modeled as semidefinite programs.

Furthermore, the ability to work independently is conveyed with the help of relevant specialist literature. In addition to deepening the lecture material, the exercises also serve to acquire communication and presentation skills.

3 Module Content

1. Conical optimization: convex cones, conical programs, duality theory
2. Semidefinite optimization: eigenvalue optimization, relaxation of quadratic programs
3. The MAXCUT problem: Goemans-Williamson algorithm, Grothendieck inequality
4. Packings and colors in graphs: Lovasz theta function, perfect graphs
5. Determinant maximization: Loewner-John ellipsoid
6. The kiss number problem: The limit of Delsarte, Goethals and Seidel
7. Polynomial optimization: sums of squares, sets of positive digits
8. Algorithms: interior point method, ellipsoid method

Literature: e.g.

A. Ben-Tal, A. Nemirovski - Lectures on modern convex optimization

S. Boyd, L. Vandenberghe - Convex Optimization

M. Laurent, F. Vallentin - Semidefinite optimization: Theory and applications in combinatorics, geometry, and algebra

Further Literature will be announced in the lecture.

4	**Teaching Methods** Lecture and Exercise
5	**Prerequisites (for the Module)** Formally: None Regarding the Contents: Knowledge in the mathematics of Operations Research
6	**Type of Examination** Exam
7	**Credits Awarded** The module is passed and credit points are awarded if the 180-minute final exam is passed or the 30-45-minute oral final exam is passed. The prerequisite for admission to the exam is regular successful completion of the exercises. The respective lecturer announces the exact requirements at the beginning of the event. Registration is required to take the final exam; A resit examination is offered at the beginning of the following semester. Repeated participation in the lecture and the exercises to prepare for a repetition of the final examination is possible. The module is graded.
8	**Compatibility with other Curricula** The module is part of the master courses “Mathematik” and “Wirtschaftsmathematik”
9	**Proportion of Final Grade** 9/114
10	**Module Coordinator** Prof. Dr. F. Vallentin
11	**Further Information**