

**List of modules for the
Master's degree programme
Computational and Applied Mathematics**

for the wintersemester 2020/21

**Department of Mathematics
Friedrich-Alexander-Universität Erlangen-Nürnberg**

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1	Module name	Module 1: ModAna1: Modeling and Analysis in Continuum Mechanics I	ECTS 10
2	Courses/lectures	a) Lectures: 4 semester hrs/week b) Practical: 1 semester hr/week	
3	Lecturers	Prof. Dr. Enrique Zuazua enrique.zuazua@fau.de	MAppA
4	Module coordinator	Prof. Dr. Günther Grün gruen@math.fau.de	
5	Content	Theory of elasticity (geometrical non-linear modelling, objectivity and isotropy of energy functionals, linearised elasticity, polyconvexity, existence according to J. Ball) Non-equilibrium thermodynamics and modelling in hydrodynamics (basic concepts in thermodynamics, balance equations, constitutive relations) Parabolic function spaces and the Aubin-Lions lemma Weak solution theory for incompressible Navier-Stokes equations	
6	Learning objectives and skills	Students derive mathematical models for fluid mechanics and elasticity theory, evaluate the predictive power of models using physical modelling assumptions and the qualitative characteristics of solutions, apply analytical techniques to rigorously prove qualitative properties of solutions.	
7	Prerequisites	Basic knowledge in functional analysis and modelling is recommended.	
8	Integration into curriculum	1st semester	
9	Module compatibility	Mandatory elective module for MSc in Mathematics (“Analysis and Stochastics” or “Modelling, Simulation and Optimization”)	
10	Method of examination	oral exam (20 minutes)	
11	Grading Procedure	100% based on oral exam	
12	Module frequency	Winter semester (annually)	
13	Workload	Contact hours: 75 hrs Independent study: 225 hrs Total: 300 hrs, corresponding to 10 ECTS credits	
14	Module duration	One semester	
15	Teaching and examination language	English	
16	Recommended reading	P.G. Ciarlet: Mathematical elasticity, North-Holland, S.R. De Groot & P. Mazur: Non-equilibrium thermodynamics, Dover, C. Eck, H. Garcke & P. Knabner: Mathematical Modeling, Springer, L.C. Evans: Partial differential equations, AMS, I. Liu: Continuum mechanics, Springer, R. Temam: The Navier-Stokes equations, AMS Chelsea Publishing.	

1	Module name	Module 8: NumPDE: Numerics of Partial Differential Equations	ECTS 10
2	Courses/lectures	a) Lecture: 4 semester hrs/week b) Practical: 2 semester hr/week	
3	Lecturers	Prof. Dr. Eberhard Bänsch baensch@math.fau.de	NASi
4	Module coordinator	Prof. Dr. Eberhard Bänsch baensch@math.fau.de	
5	Content	Classical theory of linear elliptic boundary value problems (outline) Finite difference method (FDM) for Poisson's equation in two dimensions (including stability via inverse monotonicity) Finite element method (FEM) for Poisson's equation in two dimensions (stability and convergence, example: linear finite elements, implementation) Variational theory of linear elliptic boundary value problems (outline) FEM for linear elliptic boundary value problems (2 nd order) (types of elements, affin-equivalent triangulations, order of convergence, maximum principle) Iterative methods for large sparse linear systems of equations (condition number of finite element matrices, linear stationary methods (recall), cg method (recall), preconditioning, Krylov subspace methods)	
6	Learning objectives and skills	Students apply algorithmic approaches for models with partial differential equations and explain and evaluate them, are capable to judge on a numerical method's properties regarding stability and efficiency, implement (with own or given software) numerical methods and critically evaluate the results, explain and apply a broad spectrum of problems and methods with a focus on conforming finite element methods for linear elliptic problems, collect and evaluate relevant information and realize relationships.	
7	Prerequisites	Recommended: basic knowledge in numerics, discretization, and optimization	
8	Integration into curriculum	1st semester	
9	Module compatibility	* Mandatory elective module for MSc in Computational and Applied Mathematics * Mandatory elective module for BSc Mathematics (in the field Applied Mathematics) * Mandatory elective Module for BSc Technomathematics (in the field Numerical Mathematics, Modelling and Optimization), * Mathematical mandatory elective module for BSc Mathematics and Economics * Non-Physics elective module for MSc Physics	
10	Method of examination	written exam (90 minutes) with exercises	
11	Grading Procedure	100% based on written exam	
12	Module frequency	Winter semester (annually)	

13	Workload	Contact hours: 90 hrs Independent study: 210 hrs Total: 300 hrs, corresponding to 10 ECTS credits
14	Module duration	One semester
15	Teaching and examination language	English
16	Recommended reading	<ul style="list-style-type: none"> • P. Knabner & L. Angermann: Numerical Methods for Elliptic and Parabolic Differential Equations, Springer 2003 • S. Larssen & V. Thomee: Partial Differential Equations with Numerical Methods. Springer 2005 • D. Braess: Finite Elements. Cambridge University Press 2010 • lecture scripts on the homepage of the domain Modeling, Simulation, and Optimization of the department Mathematics, frequently updated

1	Module name	Module 10a: MaSe: Master's seminar MApA	ECTS 5
2	Courses/lectures	Seminar: "Topics on control and numerics of Partial Differential Equations (PDE)"	
3	Lecturers	Prof. Dr. Enrique Zuazua enrique.zuazua@fau.de	
4	Module coordinator	Prof. Dr. Günther Grün gruen@math.fau.de	
5	Content	A topic from MApA that relates to the compulsory elective modules offered.	
6	Learning objectives and skills	Students can use original literature to familiarise themselves with a current research topic, can structure the content acquired both verbally and in writing and make their own contributions to its presentation and/or substance, learn scientific content on the basis of academic lectures and actively discuss it at a plenary session. For the MApA specialisation: make use of analytical techniques to rigorously prove the qualitative characteristics of solutions to mathematical models in applied sciences.	
7	Prerequisites	All compulsory modules for the MSc in Computational and Applied Mathematics recommended	
8	Integration into curriculum	3rd semester	
9	Module compatibility	Compulsory module for MSc in Computational and Applied Mathematics Compulsory module for MSc in Mathematics Compulsory module for MSc in Mathematics and Economics	
10	Method of examination	talk/presentation (90 minutes) and handout (5-10 pages)	
11	Grading Procedure	talk/presentation 75% handout 25%	
12	Module frequency	Winter semester (annually)	
13	Workload	Contact hours: 30 hrs Independent study: 120 hrs Total: 150 hrs, corresponding to 5 ECTS credits	
14	Module duration	One semester	
15	Teaching and examination language	English	
16	Recommended reading	Depending on topic. Will be published on StudOn at the beginning of the semester.	

1	Module name	Module 10b: MaSe: Master's seminar NASi	ECTS 5
2	Courses/lectures	Seminar: "Topics on control and numerics of Partial Differential Equations (PDE)"	
3	Lecturers	Prof. Dr. Enrique Zuazua enrique.zuazua@fau.de	
4	Module coordinator	Prof. Dr. Eberhard Bänsch baensch@math.fau.de	
5	Content	A topic from NASi that relates to the compulsory elective modules offered.	
6	Learning objectives and skills	Students can structure the content acquired both verbally and in writing and make their own contributions to its presentation and/or substance, learn scientific content on the basis of academic lectures and actively discuss it at a plenary session. For the NASi specification: can solve exemplary computational problems with given or self-developed software in order to illustrate or verify numerical methods under consideration.	
7	Prerequisites	All compulsory modules for the MSc in Computational and Applied Mathematics recommended	
8	Integration into curriculum	3rd semester	
9	Module compatibility	Compulsory module for MSc in Computational and Applied Mathematics Compulsory module for MSc in Mathematics Compulsory module for Msc in Mathematics and Economics	
10	Method of examination	talk/presentation (90 minutes) and handout (5-10 pages)	
11	Grading Procedure	talk/presentation 75% handout 25%	
12	Module frequency	Winter semester (annually)	
13	Workload	Contact hours: 30 hrs Independent study: 120 hrs Total: 150 hrs, corresponding to 5 ECTS credits	
14	Module duration	One semester	
15	Teaching and examination language	English	
16	Recommended reading	Depending on topic. Will be published on StudOn at the beginning of the semester.	

1	Module name	Module 10c: MaSe: Master's seminar Opti	ECTS 5
2	Courses/lectures	Seminar: "Topics on control and numerics of Partial Differential Equations (PDE)"	
3	Lecturers	Prof. Dr. Enrique Zuazua enrique.zuazua@fau.de	
4	Module coordinator	Prof. Dr. Michael Stingl michael.stingl@fau.de	
5	Content	A topic from Opti that relates to the compulsory elective modules offered.	
6	Learning objectives and skills	Students can use original literature to familiarise themselves with a current research topic, can structure the content acquired both verbally and in writing and make their own contributions to its presentation and/or substance, learn scientific content on the basis of academic lectures and actively discuss it at a plenary session. For the Opti specialisation: model theoretical and applied tasks as optimization problems and/or develop optimization algorithms for their solution and/or put these into practice.	
7	Prerequisites	All compulsory modules for the MSc in Computational and Applied Mathematics recommended	
8	Integration into curriculum	3rd semester	
9	Module compatibility	Compulsory module for MSc in Computational and Applied Mathematics Compulsory module for MSc in Mathematics Compulsory module for MSc in Mathematics and Economics	
10	Method of examination	talk/presentation (90 minutes) and handout (5-10 pages)	
11	Grading Procedure	talk/presentation 75% handout 25%	
12	Module frequency	Winter semester (annually)	
13	Workload	Contact hours: 30 hrs Independent study: 120 hrs Total: 150 hrs, corresponding to 5 ECTS credits	
14	Module duration	One semester	
15	Teaching and examination language	English	
16	Recommended reading	Depending on topic. Will be published on StudOn at the beginning of the semester.	

1	Module name	Module 11: Master's Thesis	ECTS 25
2	Courses/lectures	Oral examination Master's Thesis	
3	Lectures	The lecturers for the degree programme in Computational and Applied Mathematics	MaPA/NASI/Opti
4	Module coordinator	Prof. Dr. Günther Grün gruen@math.fau.de	
5	Content	The master's thesis is in the field of Modelling and Analysis, or Numerical Analysis and Simulation, or Optimization, and deals with a current research topic.	
6	Learning objectives and skills	Students are capable of independently follow up a scientific question in the fields of "Modelling and Analysis", "Numerical Analysis and Simulation" or "Optimization" over an extended, specified period, develop original ideas and concepts for solving scientific problems in these fields, apply and improve mathematical methods rather independently - also in unfamiliar and interdisciplinary contexts, present and explain mathematical or interdisciplinary contents clearly in a manner appropriate for the target audience, both in writing and orally, improve their ability to plan and structure by implementing a thematic project.	
7	Prerequisites	Successful participation in all mandatory modules (35 ECTS) and at least 20 ECTS from mandatory elective modules	
8	Integration into curriculum	4th semester	
9	Module compatibility	Master's degree programme in Computational and Applied Mathematics	
10	Method of examination	Master's thesis (scope according to examination regulations) Oral exam (15 minutes)	
11	Grading Procedure	90% Master's thesis 10% Oral exam	
12	Module frequency	Summer semester (annually)	
13	Workload	Contact hours: 15 hrs Independent study: 735 hrs Total: 750 hrs, corresponding to 25 ECTS credits	
14	Module duration	One semester	
15	Teaching and examination language	English	
16	Recommended reading	Individual, depending on topic of Master's Thesis.	

1	Module name	Module 23: MaMoLS: Mathematical Modeling in the Life Sciences	ECTS 5
2	Courses/lectures	a) Lectures: 2 semester hrs/week b) Practical: 0,5 semester hrs/week	
3	Lecturers	Dr. Maria Neuss-Radu maria.neuss-radu@math.fau.de	MAppA
4	Module coordinator	Dr. Maria Neuss-Radu maria.neuss-radu@math.fau.de	
5	Content	<ul style="list-style-type: none"> • Biochemical reaction networks, enzyme kinetics • Models for interacting populations (Predator-prey, competition, symbiosis) • Diffusion, reactions, and transport in biological cell tissues and vessels • Structured population models 	
6	Learning objectives and skills	<p>Students</p> <ul style="list-style-type: none"> • have profound knowledge in the area of mathematical modeling of processes in the life sciences • are able to identify significant mechanisms and to apply suitable analytical and numerical methods for their analysis • are able to work interdisciplinary and problem-oriented. 	
7	Prerequisites	Recommended: Modeling and Analysis in Continuum Mechanics I	
8	Integration into curriculum	3rd semester	
9	Module compatibility	<ul style="list-style-type: none"> • Mandatory elective module for MSc in Computational and Applied Mathematics • Mandatory elective module for MSc in Mathematics in the field of study "Modelling, Analysis and Optimization" 	
10	Method of examination	Oral exam (15 minutes)	
11	Grading Procedure	100% Oral exam	
12	Module frequency	Winter semester (annually)	
13	Workload	<p>Contact hours: 37.5 hrs</p> <p>Independent study: 112.5 hrs</p> <p>Total: 150 hrs, corresponding to 5 ECTS credits</p>	
14	Module duration	One semester	

15	Teaching and examination language	English
16	Recommended reading	<ul style="list-style-type: none"> • J. D. Murray: Mathematical Biology I: An Introduction, Mathematical Biology II: Spatial Models and Biomedical Applications • G. de Vries, T. Hillen, et al.: A course in Mathematical Biology • J. Prüss: Mathematische Modelle in der Biologie: Deterministische homogene Systeme

1	Module name	Module 25: AnFBP: Analysis of free-boundary problems in continuum mechanics	ECTS 5
2	Courses/lectures	Lecture: 2 semester hrs/week Practical: 0.5 semester hrs/week	
3	Lecturers	Prof. Dr. Günther Grün gruen@math.fau.de	MapA
4	Module coordinator	Prof. Dr. Günther Grün gruen@math.fau.de	
5	Content	Derivation of time-dependent free boundary problems in continuum mechanics, Basic results on existence and qualitative behaviour, Optimal estimates on the propagation of free boundaries, Other approaches, e.g. relaxation by phase-field models.	
6	Learning objectives and skills	Students <ul style="list-style-type: none"> • formulate free-boundary problems in hydrodynamics and in porousmedia flow • explain analytical concepts for existence and nonnegativity results for degenerate parabolic equations as well as techniques for optimal estimates on spreading rates • validate different modeling approaches in a critical way. 	
7	Prerequisites	Recommended: Basic knowledge of analysis of partial differential equations, corresponding to the syllabus of “Modeling and applied analysis in continuum mechanics” or that one of other pde-lectures.	
8	Integration into curriculum	3rd semester	
9	Module compatibility	Mandatory elective module MSc Computational and Applied Mathematics, Elective module MSc Mathematics (Analysis and Stochastics)	
10	Method of examination	oral exam (15 minutes)	
11	Grading Procedure	100% based on oral exam	
12	Module frequency	Winter semester (not annually) To check whether the course is offered, see UnivIS univis.fau.de or module handbook of current semester	
13	Workload	Contact hours: 37.5 hrs Independent study: 112.5 hrs Total: 150 hrs, corresponding to 5 ECTS	
14	Module duration	One semester	
15	Teaching and examination language	English	
16	Recommended reading	L.C. Evans: Partial Differential Equations, AMS, Original journal articles.	

1	Module name	Module 28: AlgNLOpt: Advanced Algorithms for Nonlinear Optimization	ECTS 5
2	Courses/lectures	a) Lectures: 2 semester hrs/week b) Practical: 0.5 semester hrs/week	
3	Lecturers	Prof. Dr. Michael Stingl michael.stingl@fau.de	Opti
4	Module coordinator	Prof. Dr. Michael Stingl michael.stingl@fau.de	
5	Content	Several of the following topics: <ul style="list-style-type: none"> • Trust region methods • Iterative methods in the presence of noisy data • Interior point methods for nonlinear problems • Modified barrier and augmented Lagrangian methods • Local and global convergence analysis 	
6	Learning objectives and skills	Students <ul style="list-style-type: none"> • use methods of nonlinear constrained optimization in finite dimensional spaces, • analyse convergence behaviour of these methods and derive robust and efficient realisations, • apply these abilities to technical and economic applications. 	
7	Prerequisites	Basic knowledge in nonlinear optimization is recommended.	
8	Integration into curriculum	1st semester	
9	Module compatibility	<ul style="list-style-type: none"> • Mandatory elective module for MSc in Computational and Applied Mathematics • Mandatory elective module for MSc in Mathematics in the field of study "Modelling, Simulation and Optimization" • Mandatory elective module for the MSc in Mathematics and Economics in the field of study "Optimization and process management" 	
10	Method of examination	oral exam (15 minutes)	
11	Grading Procedure	100% based on oral exam	
12	Module frequency	Winter semester (not annually) To check whether the course is offered, see UnivIS univis.fau.de or module handbook of current semester	
13	Workload	Contact hours: 37.5 hrs Independent study: 112.5 hrs Total: 150 hrs, corresponding to 5 ECTS credits	
14	Module duration	One semester	
15	Teaching and examination language	English	
16	Recommended reading	<ul style="list-style-type: none"> • C.T. Kelley: Iterative Methods for Optimization, SIAM, • J. Nocedal & S. Wright: Numerical Optimization, Springer. 	

1	Module name	Module 29: DiscOpt I: Discrete Optimization I	ECTS 5
2	Courses/lectures	a) Lectures: 2 weekly lecture hours b) Practical: 1 weekly lecture hour	
3	Lecturers	Prof. Dr. Alexander Martin alexander.martin@fau.de	Opti
4	Module coordinator	Prof. Dr. Alexander Martin alexander.martin@fau.de	
5	Content	Theoretical and practical fundamentals of solving difficult mixed-integer linear optimization problems (MIPs) constitute the main focus of this lecture. At first, the concept of NP-completeness and a selection of common NP-complete problems will be presented. As for polyhedral theory, fundamentals concerning the structure of faces of convex polyhedra will be covered. Building upon these fundamentals, cutting plane algorithms as well as branch-and-cut algorithms for solving MIPs will be taught. Finally, some typical problems of discrete optimization, e.g., the knapsack problem, the traveling salesman problem or the set packing problem will be discussed.	
6	Learning objectives and skills	Students will gain basic theoretical knowledge of solving mixed-integer linear optimization problems (MIPs), are able to solve MIPs with the help of state-of-the-art optimization software.	
7	Prerequisites	Recommended: Linear and Combinatorial Optimization	
8	Integration into curriculum	1st or 3rd semester	
9	Module compatibility	Mandatory elective module for MSc Computational and Applied Mathematics, Elective module for MSc in Mathematics, Elective module for MSc in Mathematics and Economics, Core/research module MSc Mathematics within "Modeling, simulation, optimization", MSc Mathematics and Economics within "Optimization and process management"	
10	Method of examination	oral exam (15 minutes)	
11	Grading Procedure	100% based on oral exam	
12	Module frequency	Winter semester (not annually) To check whether the course is offered, see UnivIS: univis.fau.de	
13	Workload	Attendance: 45 h Self-study: 105 h	
14	Module duration	one semester	
15	Teaching and examination language	English	

16	Recommended reading	Lecture notes Conforti, Cornuéjols & Zambelli: Integer Programming, Springer 2014 B. Grünbaum: Convex Polytopes, Springer, 2003 B. Korte & J. Vygen: Combinatorial Optimization, Springer 2005 G. L. Nemhauser & L.A. Wolsey: Integer and Combinatorial Optimization, Wiley 1994 A. Schrijver: Theory of Linear and Integer Programming, Wiley 1986 L.A. Wolsey: Integer Programming, Wiley 1998 G. Ziegler: Lectures on Polytopes, Springer, 1995
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1	Module name	Module 33: OptPDE: Optimization with Partial Differential Equations	ECTS 5
2	Courses/lectures	a) Lectures: 2 semester hrs/week b) Practical: 0.5 semester hrs/week	
3	Lecturers	Prof. Dr. Günter Leugering guenter.leugering@fau.de	Opti
4	Module coordinator	Prof. Dr. Michael Stingl michael.stingl@fau.de	
5	Content	Several of the following topics: Optimization and control in Banach spaces Concepts of controllability and stabilization Optimal control of Partial differential equations Singular Perturbations and asymptotic analysis Numerical realizations of optimal controls Technical, medical and economic applications	
6	Learning objectives and skills	Students explain and use theory as well as numerical methods for optimization, control and stabilization in the context of partial differential equations, apply these abilities to technical and economic applications.	
7	Prerequisites	Basic knowledge in numerics, partial differential equations, and nonlinear optimization is recommended.	
8	Integration into curriculum	1 st or 3rd semester	
9	Module compatibility	Mandatory elective module for MSc in Computational and Applied Mathematics Elective module for MSc in Mathematics Elective module for MSc in Mathematics and Economics	
10	Method of examination	oral exam (15 minutes)	
11	Grading Procedure	100% based on oral exam	
12	Module frequency	Winter semester (not annually) To check whether the course is offered, see UnivIS univis.fau.de or module handbook of current semester	
13	Workload	Contact hours: 37.5 hrs Independent study: 112.5 hrs Total: 150 hrs, corresponding to 5 ECTS credits	
14	Module duration	One semester	
15	Teaching and examination language	English	
16	Recommended reading	- F. Tröltzsch: Optimal Control of Partial Differential Equations, AMS, - G. Leugering & P. Kogut: Optimal Control of PDEs in Reticulated Domains, Birkhäuser.	

1	Module name	Module 35: OptIE: Optimization in Industry and Economy	ECTS 5
2	Courses/lectures	Lecture: Optimization in Industry and Economy Exercises: Optimization in Industry and Economy	
3	Lecturers	Prof. Dr. Frauke Liers frauke.liers@math.uni-erlangen.de	Opti
4	Module coordinator	Prof. Dr. Frauke Liers frauke.liers@math.uni-erlangen.de	
5	Content	Graph routing problems consist usually of an agent that must achieve a certain goal while traversing the arcs or vertices of a graph. Practical applications of graph routing include vehicle routing, pick-up and delivery services, mail delivery, meter reading, snow plowing, waste collection, and many others. Perhaps the simplest graph routing problems are the postman problem and the traveling salesman problem (covered in "Graph routing and applications"). In this course we are going to present some more complicated graph routing problems with practical applications, we are going to cover the mathematical programming techniques used to model these problems (usually as integer programs), and we are going to describe algorithmic methods of solution for some of them.	
6	Learning objectives and skills	At the end of this course, students should be able to (a) recognize the basic arc and edge graph routing problems, (b) solve graph routing problems using well-known combinatorial algorithms, (c) model more complex graph routing problems using integer programming, (d) apply mathematical programming techniques to solve practical graph routing problems.	
7	Prerequisites	Recommended: Modul LKOpt: Linear and combinatorial optimization	
8	Integration into curriculum	Master: 1st semester or later	
9	Module compatibility	Master elective modul (M-MA, TM-MA, WM-MA, CAM-MA-NASi, CAM-MA-Opti, CAM-MA-MApA)	
10	Method of examination	Oral exam (15 min)	
11	Grading Procedure	100% based on oral exam	
12	Module frequency	Winter semester (2019/2020)	
13	Workload	150 hr as follows: Lecture: 4 SWS x 7.5 = 30 hr Exercises: 2 SWS x 7.5 = 15 hr Self-study: 105 hr	
14	Module duration	Half a semester	
15	Teaching and examination language	English	
16	Recommended reading	There is a script prepared by the lecturer which will be available on StudOn	

1	Module name	Module 37: Conic Optimization and Applications	ECTS 5
2	Courses/lectures	a) Lectures: 2 semester hrs/week b) Practical: 1 semester hr/week	
3	Lecturers	Dr. Jan Rolfes jan.rolfes@fau.de	Opti
4	Module coordinator	Dr. Jan Rolfes jan.rolfes@fau.de	
5	Content	<p>In modern „Convex Optimization“ the theory of semidefinite optimization plays a central role. Semidefinite optimization is a generalization of linear optimization, where one wants to optimize linear functions over positive semidefinite matrices restricted by linear constraints. A wide class of convex optimization problems can be modeled using semidefinite optimization. On the one hand, there are algorithms to solve semidefinite optimization problems, which are efficient in theory and practice. On the other hand, semidefinite optimization is a tool of particular usefulness and elegance.</p> <p>Overview of topics:</p> <ul style="list-style-type: none"> - Topological properties of cones - Foundations of conic optimization, theorems of the alternative, duality - Applications in Eigenvalue optimization and robust optimization - Approximations of combinatorial optimization problems such as MAXCUT, packing problems, coloring problems, Shannon capacity - Symmetry reduction of optimization 	
6	Learning objectives and skills	<p>Students</p> <ul style="list-style-type: none"> - gain insight of the fundamental concepts in conic optimization - apply algorithmic techniques to problems in the fields of combinatorics, geometry and algebra - extend their expertise in geometry, in particular about the interplay between the fields of geometry and optimization 	
7	Prerequisites	Recommended: at least one of the modules “Linear and combinatorial optimization”, “robust optimization”, “discrete optimization”	
8	Integration into curriculum	1st or 3rd semester	
9	Module compatibility	<ul style="list-style-type: none"> - Mandatory elective module for MSc Computational and Applied – Mathematics •Mandatory elective module for MSc Mathematics in the field of “Modeling, Simulation and Optimization” - Mandatory elective module for MSc Mathematics and Economics in the fields of “Optimization and Process Management” 	
10	Method of examination	oral exam (15 minutes)	
11	Grading Procedure	100% based on oral exam	

12	Module frequency	Winter semester (not annually) To check whether the course is offered in the current semester, see UnivISunivis.fau.de or module handbook of current semester
13	Workload	Contact hours: 45 hrs Independent study: 105 hrs Total: 150 hrs, corresponding to 5 ECTS credits
14	Module duration	One semester
15	Teaching and examination language	English
16	Recommended reading	<ul style="list-style-type: none"> - M. Laurent, F. Vallentin: lecture notes - http://www.mi.uni-koeln.de/opt/wp-content/uploads/2015/10/laurent_vallentin_sdo_2012_05.pdf - Further literature and scientific publications are announced during the lectures