



UNIVERSITÄT
KOBLENZ · LANDAU

List of Modules

Master of Science (M.Sc.)

„Mathematical Modeling of Complex Systems“

at the Campus Koblenz

Faculty 3: Mathematics / Science



Faculty 4: Computational Science

Version: September 07, 2015

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**Course Guide Master Program (M.Sc.)
 „Mathematical Modeling of Complex Systems“
 for students starting in the winter semester**

Sem.	recommended order of study for the master program starting in winter							LP
7 W	Applied Differential Equations 9 LP			Physics in applica- tions	Computer based methods	Modules of choise	<i>possibility for studying abroad</i>	30
8 S	Optimi- zation 9 LP	Solid State Physics 6 LP	Project seminar 3 LP	Physics in applica- tions	Computer based methods	Modules of choise		30
9 W			Project seminar 12 LP	Physics in applica- tions Σ 12 LP	Computer based methods Σ 18 LP	Modules of choise Σ 21 LP		30
10 S	Master thesis 30 LP							30
M.Sc.								120

**Course Guide Master Program (M.Sc.)
 „Mathematical Modeling of Complex Systems“
 for students starting in the summer semester**

Sem.	recommended order of study for the master program starting in summer							LP
7 S	Optimi- zation 9 LP	Solid State Physics 6 LP		Physics in applica- tions	Computer based methods	Modules of choise	<i>possibility for studying abroad</i>	30
8 W	Applied Differential Equations 9 LP		Project seminar 3 LP	Physics in applica- tions	Computer based methods	Modules of choise		30
9 S			Project seminar 12 LP	Physics in applica- tions Σ 12 LP	Computer based methods Σ 18 LP	Modules of choise Σ 21 LP		30
10 W	Master thesis 30 LP							30
M.Sc.								120

Modules of the Master Program

„Mathematical Modeling of Complex Systems “

The following abbreviations are used:

V: lecture

Ü: exercises

VmÜ: lecture with integrated exercises

P: practical course

PS: project seminar

S: seminar

LP: ECTS-Credit points

CH: contact hours (weekly hours of 45 min of contact time per semester)

h: hour (means 60 minutes of work)

In the following list of all modules and the included courses are listed together with the maximum number of credit points attainable for each module of the master program.

The number of credit points per Module sums up the students' workload, contact time and private studies following the formula $1 \text{ LP} = 30 \text{ h}$.

Since the workload of the students varies in different teaching forms in terms of preparation and training/reworking, no fix factor between credit points (LP) and contact time (CH) is possible. The listed contact time is converted in time following the estimate $1 \text{ CH} = 15 \text{ h}$.

In this master program 52 CH of pure contact time, 18 CH in compulsory modules, equal 90 LP. In addition 30 LP are given for the master thesis.

Module abbreviations (Module codes)

The Modules are abbreviated according to the following pattern into a Module code:

- The first two characters are the numbers of the faculty:
„03“ Faculty 3: Mathematics / Science and
„04“ Faculty 4: Computational Science.
- The next two characters indicate the institute in charge for this Module:
„CV“ Institute for Computervisualistics,
„IN“ Institute for Computational Science
„MA“ Mathematical Institute,
„PH“ Department of Physics,
„WI“ Institute for “Wirtschafts- und Verwaltungsinformatik”;
for soft skills as well as the thesis „XX“ is used instead.
- The fifth character shows, if the Module was initially built for a bachelor program („1“) or a master program („2“).
- The last three characters are given by the teaching unit in charge.

Modules of the Master program

Compulsory Modules

List of Modules

Module Code	Module Name	Credit points
03MA2501	Applied Differential Equations	9
03MA2502	Optimization	9
03PH2501	Solid State Physics	6
03XX2501	Project seminar	15
03XX2590	Master thesis final oral exam	27 3

Module 03MA2501				
Applied Differential Equations				
Module Code	Workload	Credit points	Semester	Duration
03MA2501	270 h	9 LP	1. or 2. Master semester	1 Semester
1	Courses 1. 3625011 V Applied Differential Equations 2. 3625012 Ü/S Applied Differential Equations	Contact time 60 h 30 h	Self-study 120 h 60 h	Credit points 6 LP 3 LP
2	Teaching forms Course 1: Lecture (4 CH) Course 2: Exercises / Seminar (2 CH)			
3	Group size Course 1: 30 (Lecture) Course 2: 20 (Exercises) / 15 (Seminar)			
4	Qualification targets / Skills The students know the fundamental definitions, theorems and methods related to the theory and numerical methods for differential equations. Applying known results from calculus, linear algebra and numerics, they can tackle advanced problems, analyze them mathematically and solve them numerically. The students broaden their analytical and problem-solving skills in the field of differential equations. They are able to acquire, adapt and apply current research results.			
5	Contents e.g. <ul style="list-style-type: none"> • Elementary methods for initial value problems of ordinary differential equations • Existence and uniqueness results for initial value problems • Qualitative behavior and stability • Linear first and higher order systems of differential • One-step methods for initial value problems, consistency and convergence • Runge-Kutta methods and adaptive step size selection • Classification of partial differential equations and elementary cases 			
6	Usability of Module for other Programs M.Ed. Mathematik (Module 03MA2501)			
7	Prerequisites for Participation			
8	Method of Examination Written exam (90 min) or oral exam (30 min) (module exam)			
9	Requirement for Credit Points Regular participation in Course 2 Passing the coursework Passing examination			
10	Percentage of grade in final mark 9/120			

11	Frequency of Course annually (winter semester)
12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Thomas Götz
13	Further information Compulsory module

Module 03MA2502				
Optimization				
Module code	Workload	Credit points	Semester	Duration
03MA2502	270 h	9 LP	1. or 2. Master semester	1 Semester
1	Courses 1. 3625021 V Optimization 2. 3625022 Ü/S Optimization	Contact time 60 h 30 h	Self-study 120 h 60 h	Credit points 6 LP 3 LP
2	Teaching form Course 1: Lecture (4 CH) Course 2: Exercises (2 CH)			
3	Group size Course 1: 30 (Lecture) Course 2: 20 (Exercises) / 15 (Seminar)			
4	Qualification targets / Skills The students know fundamental methods and algorithms for optimization problems. They are able to model small real-world problems and to apply optimization techniques to solve those problems. The students broaden their analytical and problem-solving skills. They are able to acquire, adapt and apply current research results.			
5	Contents e.g. <ul style="list-style-type: none"> • Linear programs in standard form, fundamental theorem of linear optimization, Simplex-method • Duality theorem, degenerate problems • Inner point methods • Optimality conditions for unconstrained and constrained problems • One-dimensional minimization; direct methods • Descent methods in higher dimensions, cg-methods • Basics of graph theory, optimization on graphs 			
6	Usability of Module for other Programs M.Ed. Mathematik (Module 03MA2502)			
7	Prerequisites for Participation			
8	Method of Examination Written exam (90 min) or oral exam (30 min) (module exam)			
9	Requirement for Credit points Regular participation in course 2 Passing the coursework Passing Module exam			
10	Percentage of grade in final mark 9/120			

11	Frequency of Course annually (summer semester)
12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Stefan Ruzika
13	Further information Compulsory module

Module 03PH2501				
Solid State Physics				
Module code	Workload	Credit points	Semester	Duration
03PH2501	180 h	6 LP	1. or 2. Master semester	1 semester
1	Courses 1. 3525011 V Solid State Physics 1. 3525012 Ü Solid State Physics	Contact time 45 h 15 h	Self-study 75 h 45 h	Credit points 4 LP 2 LP
2	Teaching form Course 1: Lecture (3 CH) Course 2: Exercises (1 CH)			
3	Group size Course 1: 30 (Lecture) Course 2: 20 (Exercises)			
4	Qualification targets / Skills The students know basic ideas, fundamental experiments and methods of solid state physics. They understand macroscopic material properties on the basis of microscopic interactions. The students are able to describe different kinds of matter mathematically and can predict material properties, both electronic and thermal, in solids. They become familiar with the language of condensed matter and key theories and concepts. The students broaden their analytical and problem-solving skills. They are able to acquire, adapt and apply current research results.			
5	Contents <ul style="list-style-type: none"> • crystal structure • binding mechanisms • mechanical, thermal and electronic properties • semi-conductors 			
6	Usability of the module for other programs M.Sc. Chemie und Physik funktionaler Materialien (03PH2501) M.Sc. Applied Physics (03PH2501)			
7	Prerequisites for Participation Needed Competences: - experimental physics (mechanics, thermodynamics, electrodynamics, optics, quantum mechanics, atomic physics, molecular physics) - theoretical physics (mechanics, electrodynamics)			
8	Method of Examination Written exam (90 min) or oral exam (30 min) (module exam)			
9	Requirement for Credit points Participation in the exercises on a steady basis Passing the coursework Passing the module exam			
10	Percentage of grade in final mark 6/120			

11	Frequency of Course annually (summer semester)
12	Module Coordinator and Lecturer Module Coordinator: Prof. Dr. Stefan Wehner
13	Further information Compulsory module

Module 03XX2501				
Project Seminar				
Module code	Workload	Credit points	Semester	Duration
03XX2501	450 h	15 LP	2. and 3. Master semester	2 semesters
1	Courses 1. 3525015 / 3625015 Project 2. 3525016 / 3625016 Seminar	Contact time 30 h	Self-study 420 h	Credit points 12 LP 3 LP
2	Teaching form Project and seminar, where results are reported			
3	Group size Project: alone or in small groups (max. 5) Seminar: 5			
4	Qualification targets / skills The students are able to acquire, adapt and apply current research results. They can utilize computing and/or experimental facilities for the purpose of modeling, understanding and solving complex systems. Communication and social skills are trained in phases of team work, intermediate and final presentations as well as peer-group discussions.			
5	Contents The project seminar gives insight into interdisciplinary scientific work. The students work on a given scientific problem subsuming components from computer science, mathematics and/or physics. The students revisit relevant research results, adapt them to the problem at hand and derive a suitable model. Simulations, experiments and/or theoretical analysis have to be carried out based on the knowledge gained in the previous course of studies. The students validate, interpret as well as present and discuss their results.			
6	Usability of module for other programs			
7	Prerequisites for Participation			
8	Method of Examination Written portfolio (coursework) Oral presentation (approx. 30 min) (Module exam)			
9	Requirement for Credit points Participation in the seminar on a steady basis Passing the coursework Passing the oral exam			
10	Percentage of grade in final mark 15/120			
11	Frequency of Course As needed			

12	Supporting Lecturer all Lecturers of the Faculty of Computational Science all Lecturers of Mathematics all Lecturers of Physics
13	Further information Compulsory Module

Module 03XX2590				
Master thesis and oral final exam				
Module code	Workload	Credit points	Semester	Duration
03XX2590	900 h	27 + 3 LP	4. Master semester	1 semester
1	Courses 1. 3525901 / 3625901 Master thesis 2. 3525902 / 3625901 Oral final exam	Contact time	Self-study 810 h 90 h	Credit points 27 LP 3 LP
2	Teaching form 1. Largely independent production of a master thesis 2. Oral final exam			
3	Group size Usually 1			
4	Topic, Qualification target and expected skills The Master program concludes with the Master thesis. The Master thesis can be completed in all fields of Computational Science, Mathematics and Physics as well as in industry or external research institutes nationally or internationally, if a professor is in charge of the support. The master student must work on a scientific topic under guidance within a given time. The thesis must document the results in writing in an adequate form with regard to the subject and be presented in the final exam as a basis for discussion. The candidate must be able to achieve research results under guidance but largely independently, detect, solve and critically assess problems and to classify them on the basis of the given knowledge. The results have to be documented in written form (27 LP) and this work is to be defended in an oral exam (3 LP). Examination is carried out by the supporting professor and a second auditor. Content of the final exam is the topic of the Master thesis. The candidate has the opportunity to present his/her work within the given time.			
5	Contents <ul style="list-style-type: none"> • Largely independent work on a research question under professional guidance • Commanding the basic techniques of scientific work and publication 			
6	Usability of module for other programs			
7	Prerequisites for Participation			
8	Method of Examination Master thesis Oral exam (Colloquium)			
9	Requirement for Credit points Passing Master thesis Passing the oral exam			

10	Percentage of grade in final mark 30/120
11	Frequency of Course As needed
12	Departmental Coordinator All Lecturers of the Faculty Computational Science All Lecturers of Mathematics All Lecturers of Physics
13	Further information Compulsory Module

Optional Compulsory Section

It is strongly recommended to inform oneself about the actual opportunities already in the first semester of the Master program.

List of Modules

Module Code	Module Name	Credit points
	“Advanced Mathematics”	
03MA2108	Special topics of Mathematics	9
03MA2109	Special topics of Applied Mathematics	9
03MA2110	Specialization in Mathematics	9
03MA2503	Numerics for Partial Differential Equations	9
03MA2504	Integer Optimization	9
	“Physics in Applications”	
03PH2503	Surface Science	6
03PH2504	Applied Theoretical Physics	6
03PH2505	Polymer Science	6
	“Computer based Methods”	
04CV2001	Foundations of autonomous mobile systems	6
04CV2005	Pattern Recognition	6
04CV2006	Robotics and Computer Vision	6
04IN2002	Formal specification and verification	6
04IN2028	Machine Learning & Data Mining	6
04IN2035	Wireless Data Communication	6
04IN2037	Software Language Engineering	6
04WI2013	Enterprise Architecture Modeling	6
04WI2027	Mobile Systems Engineering	6

Module 03MA2108				
Special topics of Mathematics				
Module code	Workload	Credit points	Semester	Duration
03MA2108 MA 08	270 h	9 LP	1. - 3. Master semester	1 Semester
1	Courses 1. 3621081 V Special topics of Mathematics 2. 3621082 Ü Special topics of Mathematics	Contact time 60 h 30 h	Self-study 120 h 60 h	Credit points 6 LP 3 LP
2	Teaching form Course 1: Lecture (4 CH) Course 2: Exercises (2 CH)			
3	Group size Course 1: 30 (Lecture) Course 2: 20 (Exercises)			
4	Qualification targets / Skills The students know the basic concepts and results of the respective field of mathematics. The students have learned in the tutorials a precise, solid and autonomous handling of the definitions, theorems and methods presented in the lecture. The students broaden their analytical skills in one special topic of mathematics. They are able to acquire, adapt and apply current research results.			
5	Contents One field of modern mathematics related to applications, e.g. <ul style="list-style-type: none"> • applied algebra and computer algebra • differential geometry • functional analysis and inverse problems • number theory and its relevance for cryptography 			
6	Usability of Module for other Programs M.Ed. Mathematik (Module 03MA2108)			
7	Prerequisites for Participation			
8	Method of Examination Written exam (90 min) or oral exam (30 min) (module exam)			
9	Requirement for Credit points Regular participation in course 2 Passing module exam			
10	Percentage of grade in final mark 9/120			
11	Frequency of Course irregularly			
12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Rolfdieter Frank			

13	Further information Optional Compulsory Module
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Module 03MA2109					
Special topics of Applied Mathematics					
Module code		Workload	Credit points	Semester	Duration
03MA2109 MA 09		270 h	9 LP	1. - 3. Master semester	1 Semester
1	Courses 1. 3621091 V Applied Mathematics 2. 3621092 Ü Applied Mathematics		Contact time 60 h 30 h	Self-study 120 h 60 h	Credit points 6 LP 3 LP
2	Teaching form Course 1: Lecture (4 CH) Course 2: Exercises (2 CH)				
3	Group size Course 1: 30 (Lecture) Course 2: 20 (Exercises)				
4	Qualification targets / skills The students know the basic concepts and results of the respective field of applied mathematics. The students have learned in the tutorials a precise, solid and autonomous handling of the definitions, theorems and methods and algorithms presented in the lecture. The students broaden their analytical and problem-solving skills in one field of applied mathematics. They are able to acquire, adapt and apply current research results.				
5	Contents One field of applied mathematics, e.g. <ul style="list-style-type: none"> • Fourier transforms • Financial mathematics • Mathematics models in natural sciences • Asymptotic Analysis 				
6	Usability of Module for other Programs M.Ed. Mathematik (Module 03MA2109)				
7	Prerequisites for Participation				
8	Method of Examination Written exam (90 min) or oral exam (30 min) (module exam)				
9	Requirement for Credit points Regular participation in course 2 Passing Module exam				
10	Percentage of grade in final mark 9/120				
11	Frequency of Course irregularly				
12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Thomas Götz				

13	Further information Optional Compulsory Module
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Module 03MA2110				
Specialization in Mathematics				
Module code	Workload	Credit points	Semester	Duration
03MA2110 MA 10	270 h	9 LP	1. - 3. Master semester	1 Semester
1	Courses 1. 3621101 V Specialization in Mathematics 2. 3621102 Ü/S Specialization in Mathematics	Contact time 60 h 30 h	Self-study 120 h 60 h	Credit points 6 LP 3 LP
2	Teaching form Course 1: Lecture (4 CH) Course 2: Exercises / Seminar (2 CH)			
3	Group size Course 1: 30 (Lecture) Course 2: 20 (Exercises) / 15 (Seminar)			
4	Qualification targets / skills The students specialize their knowledge in a field of mathematics. The students have learned in the tutorials a precise, solid and autonomous handling of the definitions, theorems and methods presented in the lecture. The students broaden their analytical and problem-solving skills in one specialized field of mathematics. They are able to acquire, adapt and apply current research results.			
5	Contents One field of modern applied mathematics specializing and/or continuing the contents of one of the modules 03MA2501 or 03MA2502			
6	Usability of Module for other Programs M.Ed. Mathematik (Module 03MA2110)			
7	Prerequisites for Participation			
8	Method of Examination Written exam (90 min) or oral exam (30 min) (module exam)			
9	Requirement for Credit points Regular participation in course 2 Passing Module exam			
10	Percentage of grade in final mark 9/120			
11	Frequency of Course irregularly			
12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Stefan Ruzika			
13	Further information Optional Compulsory Module			

Module 03MA2503				
Numerics for Partial Differential Equations				
Module code	Workload	Credit points	Semester	Duration
03MA2503	270 h	9 LP	2. - 3. Master semester	1 Semester
1	Courses 1. 3625031 V Numerics for Partial Differential Equations 2. 3625032 Ü/S Numerics for Partial Differential Equations	Contact time 60 h 30 h	Self-study 120 h 60 h	Credit points 6 LP 3 LP
2	Teaching form Course 1: Lecture (4 CH) Course 2: Exercises / Seminar (2 CH) Alternative forms, e.g. reading course, may be possible.			
3	Group size Course 1: 30 (Lecture) Course 2: 20 (Exercises) / 15 (Seminar)			
4	Qualification targets / skills The students know the fundamental definitions, theorems and methods related to the theory and numerical methods for partial differential equations (PDEs). Applying known results from calculus, linear algebra, numerics and ordinary differential equations, they can tackle advanced problems, analyze them mathematically and solve them numerically.			
5	Contents e.g. <ul style="list-style-type: none"> • Elementary theory of PDEs (first and second order) • Method of characteristics for first order PDEs • Finite Difference Methods • Finite Element Methods 			
6	Usability of Module for other Programs			
7	Prerequisites for Participation Module 03MA2501			
8	Method of Examination Written exam (90 min) or oral exam (30 min) (module exam)			
9	Requirement for Credit points Regular participation in course 2 Passing Module exam			
10	Percentage of grade in final mark 9/120			
11	Frequency of Course annually (summer semester)			

12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Thomas Götz
13	Further information Optional Compulsory Module

Module 03MA2504				
Integer Optimization				
Module code	Workload	Credit points	Semester	Duration
03MA2504	270 h	9 LP	2. - 3. Master semester	1 Semester
1	Courses 1. 3625041 V Integer Optimization 2. 3625042 Ü/S Integer Optimization	Contact time 60 h 30 h	Self-study 120 h 60 h	Credit points 6 LP 3 LP
2	Teaching form Course 1: Lecture (4 CH) Course 2: Exercises / Seminar (2 CH) Alternative forms, e.g. reading course, may be possible.			
3	Group size Course 1: 30 (Lecture) Course 2: 20 (Exercises) / 15 (Seminar)			
4	Qualification targets / skills The students know the fundamental definitions, theorems and methods related to the theory and algorithmic methods for integer and combinatorial optimization problems. Applying known results from calculus, linear algebra, numerics and optimization, they can tackle advanced problems, analyze them mathematically and solve them algorithmically.			
5	Contents e.g. <ul style="list-style-type: none"> • Polyhedral theory • Complexity classes P and NP; NP-completeness proofs • Modeling with integer and linear programs; Relaxation and bounds • Solution strategies: dynamic programming, branch and bound, cutting planes, column generation, Lagrangian duality, approximation algorithms • Specially structured problems: matroids, TU matrices, scheduling, covering, matchings, problems on networks and graphs, packing, tours, etc. 			
6	Usability of Module for other Programs			
7	Prerequisites for Participation Module 03MA2502			
8	Method of Examination Written exam (90 min) or oral exam (30 min) (module exam)			
9	Requirement for Credit points Regular participation in course 2 Passing Module exam			
10	Percentage of grade in final mark 9/120			
11	Frequency of Course annually (winter semester)			

12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Stefan Ruzika
13	Further information Optional Compulsory Module

Module 03PH2503				
Surface Science				
Module code	Workload	Credit points	Semester	Duration
03PH2503	180 h	6 LP	1. – 3. Master semester	1 semester
1	Courses 1. 3525031 VmÜ Vacuum Technology 2. 3525032 VmÜ Surface Science	Contact time 30 h 30 h	Self-study 60 h 60 h	Credit points 3 LP 3 LP
2	Teaching form Course 1: Lecture with integrated exercises (2 CH) Course 2: Lecture with integrated exercises (2 CH)			
3	Group size Course 1: 30 (Lecture with integrated exercises) Course 2: 30 (Lecture with integrated exercises)			
4	Qualification targets / Skills Vacuum Technology The students <ul style="list-style-type: none"> • know the physical basis of vacuum technology, • can explain the basic concepts and ideas of vacuum, • develop an understanding of the countervailing effects relevant in the realization of vacuum and are able to evaluate technical problems on the basis of the resulting limitations, • can transfer their knowledge to technical solutions and develop own experimental schemes. Surface Science The students <ul style="list-style-type: none"> • know the basics of reaction kinetics and other phenomena on surfaces, • can explain the particular characteristics of surfaces and discuss related problems, • are able to describe and analyze common detection techniques and evaluate their limitations, • can evaluate existing experimental setups, • are able to transfer their knowledge to experiments for specific tasks and develop own experimental schemes. 			
5	Contents Vacuum Technology <ul style="list-style-type: none"> • equations of state • motion in diluted gases • transport • flow • conductance and pumping speed • calculating conductance • design of vacuum systems 			

	<ul style="list-style-type: none"> • pumps • measuring pressure • materials for HV and UHV • flange systems and components <p>Surface Science:</p> <ul style="list-style-type: none"> • surface structure • diffraction on surfaces • microscopy on surfaces • scattering methods • chemical surface analysis • electronic states on surfaces • vibrations on surfaces • gas adsorption on surfaces • surface reactions
6	Usability of the module for other programs M.Sc. Chemie und Physik funktionaler Materialien (03PH2503) M.Sc. Applied Physics (03PH2503)
7	Prerequisites for Participation Necessary Competences: - fundamental knowledge in experimental physics
8	Method of Examination Written exam (90 min) or oral exam (30 min) (module exam)
9	Requirement for Credit points Participation in the exercises on a steady basis Passing the module exam
10	Percentage of grade in final mark 6/120
11	Frequency of Course Annually (winter semester)
12	Module Coordinator and Lecturer Module Coordinator: Prof. Dr. Stefan Wehner
13	Further information Optional Compulsory Module

Module 03PH2504				
Applied Theoretical Physics				
Module code	Workload	Credit points	Semester	Duration
03PH2504	180 h	6 LP	1. - 3. Master semester	1 semester
1	Courses 1. 3525041 VmÜ Applied Theoretical Physics 1 2. 3525042 VmÜ Applied Theoretical Physics 2	Contact time 30 h 30 h	Self-study 60 h 60 h	Credit points 3 LP 3 LP
2	Teaching form Course 1: Lecture with integrated exercises (2 CH) Course 2: Lecture with integrated exercises (2 CH)			
3	Group size Course 1: 30 (Lecture with integrated exercises) Course 2: 30 (Lecture with integrated exercises)			
4	Qualification targets / Skills The students: <ul style="list-style-type: none"> • can name various fields, where modern concepts of theoretical physics are important for the description of real world problems in nature and technology • know the fundamental definitions, theorems and methods related to the application of theoretical physics, • can analyze the relation between parameters in given systems, • can apply mathematical methods to solve problems in these fields • can evaluate suggested solutions and develop own solving schemes. 			
5	Contents Applied Theoretical Physics: <ul style="list-style-type: none"> • modern concepts in theoretical physics • reaction-diffusion-systems • nonlinear physics • nonequilibrium thermodynamics • applications of theoretical physics in nature and technology 			
6	Usability of the module for other programs M.Sc. Chemie und Physik funktionaler Materialien (03PH2504) M.Sc. Applied Physics (03PH2504)			
7	Prerequisites for Participation Necessary Competences: - fundamental knowledge in theoretical physics			
8	Method of Examination Written exam (90 min) or oral exam (30 min) (module exam)			
9	Requirement for Credit points Participation in the exercises on a steady basis Passing the module exam			

10	Percentage of grade in final mark 6/120
11	Frequency of Course Irregularly
12	Module Coordinator and Lecturer Module Coordinator: N.N.
13	Further information Optional Compulsory Module

Module 03PH2505 Polymer Science				
Module code	Workload	Credit points	Semester	Duration
03PH2505	180 h	6 LP	1. - 3. Master semester	1 semester
1	Courses 1. 3525051 VmÜ Polymer Physics 2. 3525052 VmÜ Characterization methods in Polymer Science	Contact time 30 h 30 h	Self- study 60 h 60 h	Credit points 3 LP 3 LP
2	Teaching form Course 1: Lecture with integrated exercises (2 CH) Course 2: Lecture with integrated exercises (2 CH)			
3	Group size Course 1: 30 (Lecture with integrated exercises) Course 2: 30 (Lecture with integrated exercises)			
4	Qualification targets / Skills Course Polymer Physics: The students <ul style="list-style-type: none"> • can independently explain basic models describing the properties of different types of polymers and in different states, • are able to understand how the peculiarities of the polymer structure such as connectivity affects their physical properties and of which relevance these are for applications, • develop on the basis of the covered basic concepts their own solving schemes, • are able to transfer the discussed basic concepts to actual, scientific topics in polymer science. Course Characterization methods in Polymer Science: The students <ul style="list-style-type: none"> • can independently explain the characterization method covered in this course, • can identify for the most important physical properties of polymer materials (Course Polymer Physics) the correct characterization methods, • are aware of the technical realization and of the application potential of the different methods, • they can give an overview over representative results for typical polymer systems, • develop strategies for data analysis, presentation and interpretation, • are able to transfer the discussed basic concepts to actual, scientific topics in polymer science. 			
5	Contents Basic Concepts in Polymer Physics <ul style="list-style-type: none"> • Synthesis & molecular weight distributions • Chain models • Polymer solutions, polymer blends, block copolymers • Semicrystalline state • Polymer dynamics & viscoelasticity 			

	<ul style="list-style-type: none"> • Networks • Glassy state <p>Polymer Characterization</p> <ul style="list-style-type: none"> • Determination of molecular weights • Thermal characterization • Mechanical testing • Dielectric spectroscopy & electrical characterization • Scattering methods • Microscopy
6	Usability of the module for other programs M.Sc. Chemie und Physik funktionaler Materialien (03PH2505) M.Sc. Applied Physics (03PH2505)
7	Prerequisites for Participation Necessary Competences: - fundamental knowledge in experimental physics
8	Method of Examination Written exam (90 min) or oral exam (30 min) (module exam)
9	Requirement for Credit Points Participation in the exercises on a steady basis Passing the module exam
10	Percentage of grade in final mark 6/120
11	Frequency of Course Annually (summer semester)
12	Module Coordinator and Lecturer Module Coordinator: Prof. Dr. Silke Rathgeber
13	Further information Optional Compulsory Module

Module 04CV2001				
Foundations of autonomous mobile systems				
Module code	Workload	Credit points	Semester	Duration
04CV2001	180 h	6 LP	1. - 3. Master-Semester	1 Semester
1	Courses 1. 4120011 V Foundations of autonomous mobile systems 2. 4120012 Ü Foundations of autonomous mobile systems	Contact time 30 h 30 h	Self-study 60 h 60 h	Credit points 3 LP 3 LP
2	Teaching form Course 1: Lecture (2 CH) Course 2: Exercises (2 CH)			
3	Group size Course 1: 30 (Lecture) Course 2: 30 (Exercises)			
4	Qualification targets / skills Students understand the role of incorrect robotic control commands and of uncontrolled behavior. They can program and use real robots. They can trace the effect of the use of robots on its theoretical foundations. They can use their theoretical knowledge in order to improve fail-controlled robot. They can develop active vision through a combination of image analysis and robotics. They can evaluate the benefits of specific programming languages (e.g. Matlab (Octave)).			
5	Contents Foundations of visual navigation are mediated. Mono or stereo camera systems serve as input devices and are used with gray-scale, color or infrared sensors. Central problems of sensor data processing (filtering and fusion) are presented. Students will learn current techniques that are used in autonomous systems. Practical exercises on several types of robots with various sensors provide an impression of the real problems. I. Basics <ul style="list-style-type: none"> • Basic concepts, terminology, Statistics • Areas of application II. Sensors and their characteristics, pre-processing <ul style="list-style-type: none"> • Color infrared • Radar, Laser Range Finder • Stereo systems and distance measurement • Compass,(Differential) GPS • Odometry and vehicle sensor(Inertial sensors) III. Sensor data analysis <ul style="list-style-type: none"> • Localization • Object recognition • Motion estimation IV. Sensor data fusion <ul style="list-style-type: none"> • Kalman filter and condensation algorithm 			

	<ul style="list-style-type: none"> • Bayes Filter • Democratic Integration • Mapping and map representation • SLAM (Simultaneous localization and mapping) <p>V. Application Examples</p> <ul style="list-style-type: none"> • Motor vehicles, service robotics • Exploration, disaster relief
6	<p>Usability of module for other programs M.Sc. Computervisualistik (Module 04CV2001) M.Sc. Informatik (Module 04CV2001) M.Sc. Wirtschaftsinformatik (Module 04CV2001)</p>
7	<p>Prerequisites for Participation</p>
8	<p>Method of Examination Written exam (90 min) or oral exam(30 min) (Module exam)</p>
9	<p>Requirement for Credit points Regular participation in course 2 Passing Module exam</p>
10	<p>Percentage of grade in final mark 6/120</p>
11	<p>Frequency of Course irregularly</p>
12	<p>Module Coordinator and Lecturer Module coordinator: Prof. Dr. Dietrich Paulus</p>
13	<p>Further information Optional Compulsory Module</p>

Module 04CV2005				
Pattern Recognition				
Module code	Workload	Credit points	Semester	Duration
04CV2005	180 h	6 LP	1. - 3. Master-Semester	1 Semester
1	Courses 1. 4120051 V Pattern Recognition 2. 4120052 Ü Pattern Recognition	Contact time 45 h 15 h	Self-study 75 h 45 h	Credit points 4 LP 2 LP
2	Teaching form Course 1: Lecture (3 CH) Course 2: Exercises (1 CH)			
3	Group size Course 1: 30 (Lecture) Course 2: 30 (Exercises)			
4	Qualification targets / skills After successful completion of the course, students will be able to design a complete pattern recognition system for a specific problem, so that the optimization of its components can be carried out prior to development (based on theoretical expertise).			
5	Contents The course provides state-of-the-art algorithms and methods for automatic, computer-based pattern recognition. Pattern recognition is the ability to detect data regularities and repetitions or similarities in data. Typical examples of the countless application areas include speech recognition, text recognition, face recognition, or the automatic waste separation on the basis of spectrometric recordings. The modality of the signal is mostly separated from the particular problem, to provide general methods that can be used for images as well as audio, text, or other types of signals. The contents are divided into two categories. While the so-called supervised algorithms are shown in the first part of the course, the second part deals with unsupervised methods. The supervised learning strategy is based on well-known and manually categorized training samples. Unsupervised methods recognize the regularities in the data without prior knowledge of this. The following topics of supervised strategies are taught in the course: Bayes Classifiers, Linear Classifiers, Nonlinear Classifiers, Feature Selection, Feature Generation, Template-Matching, Context-Dependent Classification. In the unsupervised methods selected clustering algorithms are shown: Sequential Algorithms, Hierarchical Algorithms, Schemes Based on Function Optimization.			
6	Usability of module for other programs M.Sc. Computervisualistik (Module 04CV2005) M.Sc. Informatik (Module 04CV2005) M.Sc. Wirtschaftsinformatik (Module 04CV2005)			
7	Prerequisites for Participation			
8	Method of Examination Written exam (90 min) (Module exam)			

9	Requirement for Credit points Regular participation in course 2 Passing Module exam
10	Percentage of grade in final mark 6/120
11	Frequency of Course Annually (summer semester)
12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Dietrich Paulus
13	Further information Optional Compulsory Module

Module 04CV2006				
Robotics and Computer Vision				
Module code	Workload	Credit points	Semester	Duration
04CV2006	180 h	6 LP	1. - 3. Master-Semester	1 Semester
1	Courses 1. 4120061 V Robotics and Computer Vision 1. 4120062 Ü Robotics and Computer Vision	Contact time 30 h 30 h	Self-study 60 h 60 h	Credit points 3 LP 3 LP
2	Teaching form Course 1: Lecture (2 CH) Course 2: Exercises (2 CH)			
3	Group size Course 1: 30 (Lecture) Course 2: 30 (Exercises)			
4	Qualification targets / skills Students will define the function of an autonomous mobile system. Transfer established methods from statistics to problems of localization and up for navigation. Students make decisions to select appropriate methods for configuring a vision-based autonomous system.			
5	Contents The course gives deep insight into Probabilistic Robotics“. Bayesian networks, Kalman-Filter, Markov-Random fields und Conditional Random Fields are introduced to solve the SLAM-Problem (“Simultaneous Localization and Mapping“). Different sensor modalities are presented and their properties are modeled. As well-established software tool ROS is introduced.			
6	Usability of module for other programs M.Sc. Computervisualistik (Module 04CV2006)			
7	Prerequisites for Participation			
8	Method of Examination Written exam (90 min) (Module exam)			
9	Requirement for Credit points Regular participation in course Passing Module exam			
10	Percentage of grade in final mark 6/120			
11	Frequency of Course Annually (summer semester)			
12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Dietrich Paulus			
13	Further information Optional Compulsory Module			

Module 04IN2002				
Formal Specification and Verification				
Module code	Workload	Credit points	Semester	Duration
04IN2002	180 h	6 LP	1. to 3. Master-Semester	1 Semester
1	Courses 1. 4320021 V Formal Specification and Verification 2. 4320022 Ü Formal Specification and Verification	Contact time 45 h 15 h	Self-study 75 h 45 h	Credit points 4 LP 2 LP
2	Teaching form Course 1: Lecture (3 CH) Course 2: Exercises (1 CH)			
3	Group size Course 1: 30 (Lecture) Course 2: 30 (Exercises)			
4	Qualification targets / skills The students learn about various methods and languages for formal specification and can use them. They know techniques for model checking and deductive verification (e.g. of software) and understand their logical foundation. They can verify (with suitable tools) the correctness of certain classes of programs.			
5	Contents Preliminaries - Propositional logic, First-order logic Specification and analysis - algebraic specification - model-based specification - declarative modeling Verification - programming logics (Hoare logic, dynamic logic, temporal logic) - model checking - deductive verification; software model checking Examples, Applications			
6	Usability of module for other programs M.Sc. Computervisualistik (Module 04IN2002) M.Sc. Informatik (Module 04IN2002) M.Sc. Web Science (Module 04IN2002)			
7	Prerequisites for Participation Basic knowledge of logic: propositional logic, predicate logic			
8	Method of Examination Written exam (90 min) or oral exam(30 min) (Module exam)			

9	Requirement for Credit points Regular participation in course 2 Passing Module exam
10	Percentage of grade in final mark 6/120
11	Frequency of Course irregularly
12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Viorica Sofronie-Stokkermans
13	Further information Optional Compulsory Module

Module 04IN2028				
Machine Learning & Data Mining				
Module code	Workload	Credit points	Semester	Duration
04IN2028	180 h	6 LP	1. to 3. Master-Semester	1 Semester
1	Courses 1. 4320281 V Machine Learning & Data Mining 2. 4320282 Ü Machine Learning & Data Mining	Contact time 45 h 15 h	Self-study 75 h 45 h	Credit points 4 LP 2 LP
2	Teaching form Course 1: Lecture (3 CH) Course 2: Exercises (1 CH)			
3	Group size Course 1: 30 (Lecture) Course 2: 30 (Exercises)			
4	Qualification targets / skills Machine Learning is devoted to automated learning from input data. It suggests explanation models and estimates their parameters for understanding and predicting the future system behavior. Machine learning serves a formal backbone for many methods and models of computer science.			
5	Contents The lecture addresses master students in computer science, computer visualistics, information management, business informatics and Web science that want to extend and to structure their knowledge in machine learning. Lecture topics include linear discriminators, kernel-based methods, Bayesian methods, as well as common applications in Computer Science problems. Special attention is paid to morn, state of the art methods and approaches that are currently widely used in different fields of Computer Science.			
6	Usability of module for other programs M.Sc. Computervisualistik (Module 04IN2028) M.Sc. Informatik (Module 04IN2028) M.Sc. Web Science (Module 04IN2028)			
7	Prerequisites for Participation Basic knowledge in linear algebra, stochastics, data structures and algorithms.			
8	Method of Examination Written exam (90 min) or oral exam(30 min) (Module exam)			
9	Requirement for Credit points Regular participation in course 2 Passing Module exam			
10	Percentage of grade in final mark 6/120			
11	Frequency of Course Annually (summer semester)			
12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Steffen Staab			

13	Further information Optional Compulsory Module
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Module 04IN2035				
Wireless Data Communication				
Module code	Workload	Credit points	Semester	Duration
04IN2035	180 h	6 LP	1. to 3. Master-Semester	1 Semester
1	Courses 1. 4320351 V Wireless Data Communication 2. 4320352 Ü Wireless Data Communication	Contact time 45 h 15 h	Self-study 75 h 45 h	Credit points 4 LP 2 LP
2	Teaching form Course 1: Lecture (3 CH) Course 2: Exercises (1 CH)			
3	Group size Course 1: 30 (Lecture) Course 2: 30(Exercises)			
4	Qualification targets / skills After this course has been taught, students will know the fundamentals of wireless communication. They have learned to assess wireless Systems analytically and by simulation studies. Furthermore, they will know how far particular wireless communication forms are suitable for given applications. As well, they will also know the limitations of wireless communication. Last but not this course will convey students the potential of wireless communication for exciting novel IT applications.			
5	Contents <ul style="list-style-type: none"> • Derivation of physical models for wireless communication (e.g. log-normal shadowing, Ricean-Fading, Rayleigh-Fading) • Coding techniques especially for wireless communication (e.g. convolutional codes) • Special wireless media access control mechanisms (e.g. energy efficient MAC layer for wireless sensor networks) • Mobile communication systems (e.g. GSM, UMTS, LTE) • Wireless local networks (e.g. WLAN, Bluetooth) • Mobile and wireless internetworking (e.g. mobile IP, TLP adaptations) 			
6	Usability of module for other programs M.Sc. Informatik (Module 04IN2035)			
7	Prerequisites for Participation Basic knowledge of the layer model for communication systems.			
8	Method of Examination Written exam (90 min) (Module exam)			
9	Requirement for Credit points Regular participation in course 2 Passing Module exam			
10	Percentage of grade in final mark 6/120			
11	Frequency of Course irregularly			

12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Hannes Frey
13	Further information Optional Compulsory Module

Module 04IN2037				
Software Language Engineering				
Module code	Workload	Credit points	Semester	Duration
04IN2037	180 h	6 LP	1. to 3. Master-Semester	1 Semester
1	Courses 1. 4320371 V Software Language Engineering 1. 4320372 Ü Software Language Engineering	Contact time 30 h 30 h	Self-study 60 h 60 h	Credit points 3 LP 3 LP
2	Teaching form Course 1: Lecture (2 CH) Course 2: Exercises (2 CH)			
3	Group size Course 1: 30 (Lecture) Course 2: 30 (Exercises)			
4	Qualification targets / skills Students master design and implementation of languages and language-centric software components as relevant, for example, in domain-specific language engineering, model-driven engineering, compiler construction, and software re-/reverse engineering. To this end, students apply declarative programming techniques, lightweight formal and executable specification, and specialized software engineering methods.			
5	Contents Overview and motivation Grammars and parsing Grammar-based testing Interpreters and typecheckers Attribute grammars and semantic analysis Rewrite systems and software transformation Domain-specific languages Principles of language design Design patterns for language implementation Staged computation and program generation Software reverse engineering (application) Software re-engineering (application) Model-driven engineering (application)			
6	Usability of module for other programs M.Sc. Informatik (Module 04IN2037)			
7	Prerequisites for Participation Basic knowledge in declarative programming			
8	Method of Examination Written exam (90 min) or oral exam (30 min) (module exam)			

9	Requirement for Credit points Regular participation in course 2 Passing Module exam
10	Percentage of grade in final mark 6/120
11	Frequency of Course irregularly
12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Ralf Lämmel
13	Further information Optional Compulsory Module

Module 04WI2013				
Enterprise Architecture Modeling				
Module code	Workload	Credit points	Semester	Duration
04WI2013	180 h	6 LP	1. to 3. Master-Semester	1 Semester
1	Courses 1. 4420131 V Enterprise Architecture Modeling 2. 4420132 Ü Enterprise Architecture Modeling	Contact time 30 h 15 h	Self-study 90 h 45 h	Credit points 4 LP 2 LP
2	Teaching form Course 1: Lecture (2 CH) Course 2: Exercises (1 CH)			
3	Group size Course 1: 75 (Lecture) Course 2: 30 (Exercises)			
4	Qualification targets / skills Aims of module are: Students will understand and be able to mastering the concept of Enterprise Architecture as a means to develop an enterprise concept at different levels of consideration (strategic vision, business architecture, information systems architecture, technology architecture) and from distinct perspectives (processes, organizational structures, data structures, application and system structures, etc.). This includes knowing the principles of enterprise architectures, knowing different frameworks for Enterprise Architecture (e.g. Zachman Framework, TOGAF, FEA, etc.), knowing the functions and governance of EA, and knowing which Modeling notations and methods of analysis are to be applied at what level of architecture consideration. Students know distinct toolkits for enterprise architecture development (ARIS, ADONIS, Intalio, Enterprise Architect, etc.), their advantages and disadvantages, their best coverage of enterprise architecture phases, and they can master a selected tool to develop a comprehensive enterprise architecture. Students are capable of assessing and elaborating larger tasks by knowing what to do (the phases of an EA) and which techniques of analysis and Modeling to choose. They are capable of assessing the different EA tools and selecting the best suitable for the EA works they are confronted with.			
5	Contents 1. Introduction: Enterprise Architecture (EA) as an approach to model, design and analyze Information Systems & socio-technical systems in public and private sector 2. Key EA concepts: Different architecture frameworks, EA functions and governance, EA principles 3. Domain of Organization: Model of organizational networks of influence, business strategy, synthesis of technologies and domain understanding, technology trends 4. Elaborating an Enterprise Architecture for a given scenario: Applying the TOGAF framework 5. Architecture views and viewpoint design: architecture for multiple applications, interpretation of EA models and artefacts, documentation and presentation of EA 6. Commercial architectural constructs: distinct solutions of toolsets			

6	Usability of module for other programs M.Sc. Computervisualistik (Module 04WI2013) M.Sc. Informatik (Module 04WI2013) M.Sc. Informationsmanagement (Module 04WI2013) M.Sc. Wirtschaftsinformatik (Module 04WI2013)
7	Prerequisites for Participation Basic knowledge in analysis of information systems, including knowing methods of surveys, questionnaires, interviews, scenario technique, soft systems method, gap analysis, requirements engineering. Students are expected to know Modeling notations such as Event-driven-Process-Chains, Adonis process Modeling notation, Business Process Modeling Notation, Modeling organisational aspects and work environments, Modeling of data via ER-diagrams or UML class diagrams.
8	Method of Examination Written Assignment (2 weeks) (Module exam)
9	Requirement for Credit points Regular participation in course 2 Passing coursework Passing Modul exam
10	Percentage of grade in final mark 6/120
11	Frequency of Course irregularly
12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. Maria Wimmer
13	Further information Optional Compulsory Module

Module 04WI2027				
Mobile Systems Engineering				
Module code	Workload	Credit points	Semester	Duration
04WI2027	180 h	6 LP	1. to 3. Master-Semester	1 Semester
1	Courses 1. 4420271 V Mobile Systems Engineering 2. 4220272 Ü Mobile Systems Engineering	Contact time 30 h 30 h	Self-study 60 h 60 h	Credit points 3 LP 3 LP
2	Teaching form Course 1: Lecture (2 CH) Course 2: Exercises (2 CH)			
3	Group size Course 1: 75 (Lecture) Course 2: 30 (Exercises)			
4	Qualification targets / skills Students will gain the following competencies / skills: - gain an overview of the breadth of mobile applications - be motivated to dig into most recent research projects in the field - grasp the complexity and interdisciplinarity of MSE.			
5	Contents Introduction and understanding of terminology of MSE. The Lecture covers approx. 12 units where teachers from distinct disciplines will present recent research work in the field of MSE.			
6	Usability of module for other programs M.Sc. Computervisualistik (Module 04WI2027) M.Sc. Informatik (Module 04WI2027) M.Sc. Web Science (Module 04WI2027)			
7	Prerequisites for Participation Basic knowledge of computer networks that can e.g. be gained from modules "Communication systems in business environments" or "Essentials in computer networks", and which comprises: - Design aspects and areas of data communication in enterprises - protocols and applications (IP, TCP, UDP, etc.) - knowledge about network infrastructures such as LAN, WLAN, mobile radio communication, etc. - knowing the standards, norms and application scenarios of the various business data communication systems Students should bring along interest in mobile systems and in research questions of mobile contexts.			
8	Method of Examination Written exam (90 min) or oral exam(30 min) (Module exam)			

9	Requirement for Credit points Regular participation in course 2 Passing assignments in course 2 Passing module exam
10	Percentage of grade in final mark 6/120
11	Frequency of Course irregularly
12	Module Coordinator and Lecturer Module coordinator: Prof. Dr. J. Felix Hampe
13	Further information Optional Compulsory Module