UNIVERSITÄT KOBLENZ · LANDAU

List of Modules

Master of Science (M.Sc.)

„Chemistry and Physics of Functional Materials“

at the Campus Koblenz

Chemie

PHYSIK
Experimentalphysik
Materialwissenschaft

English Version: June 20, 2016
German Version: September 07, 2015

Contents

Course Guide Master Program (M.Sc.)
„Chemistry and Physics of Functional Materials“

Sem.							LP
1	Synthesis and Charac-terization of func-tional materials	Solid State Physics **6 LP**	3 in-depth modules	Compul-sory optional modules	Research Project		**30**
2	Synthesis and Charac-terization of func-tional materials **9 LP**		3 in-depth modules **Σ 18 LP**	Compul-sory optional modules **Σ 12 LP**	Reseach Project **Σ 15 LP**		**30**
3					Master thesis **25 LP**	Oral Final Exam **5 LP**	**30**
M.Sc.							**90**

Modules of the Master Program „Chemistry and Physics of Functional Materials“

The following abbreviations are used:

V: lecture
Ü: exercises
VmÜ: lecture with integrated exercises
P: practical course
K: course
S: seminar
LP: ECTS-credit points
CH: contact hours (weekly hours of 45 min of contact time per semester)
h: hour (means 60 min of work)

In the following list 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 CP = 30 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 (CP) and contact time is possible. The listed contact time is converted in time following the estimate 1 contact hour per week = 15 h.

In this master program 31 CH of pure contact time, 23 contact hours in compulsory Modules, equal 60 CP. In addition 30 CP are given for the master thesis and the oral final exam.

Teaching language is German or English. The language and possible alternative choices are indicated in each module description.

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
  „04“ Faculty 4: Computational Science

- The next two characters indicate the department in charge of this Module:
  „BI“ for the Department of Biology
  „CH“ for the Department of Chemistry
  „IM“ for the Department of Information Management
  „IN“ for the Department of Computational Science
  „GE“ for the Department of Geography
  „MA“ for the Mathematical Institute
  „PH“ for the Department of Physics
  „WI“ for the Institute for IS Research
  for soft skills modules „XX“ is used instead.

- The fifth character shows, if the Module was initially launched 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

The compulsory part consists of 2 compulsory modules with 15 LP (credit points) and 3 in-depth modules with 18 LP (credit points), whereby 1 module has to be chosen from chemistry and 1 module has to be chosen from physics. Most modules can be finished within one semester with the module exam.

Research phase consists of 3 modules: research project, master thesis, final oral exam

List of Modules

Module code	**Module name**	**credit points**
03PH2501	Solid State Physics	6
03XX2401	Synthesis and Characterization of functional materials	9
	In-depth modules in Chemistry (at least one module is obligatory)	
03CH2401	Modern concepts of inorganic chemistry	6
03CH2402	Thermochemistry	6
03CH2403	Polymer Chemistry and Ingredient Synthesis	6
	In-depth modules in Physics (at least one module is obligatory)	
03PH2503	Surface Science	6
03PH2504	Applied Theoretical Physics	6
03PH2505	Polymer Science	6
	Research orientation	
03XX2402	Research project	15
03XX2490	Master thesis	25
03XX2499	Final oral exam	5

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**		**Contact time**	**Self-study**	**Credit points**
	1. 3525011 V Solid State Physics		45 h	75 h	4 LP
	1. 3525012 Ü Solid State Physics		15 h	45 h	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 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** • crystal structure • binding mechanisms • mechanical, thermal and electronic properties • semi-conductors				
6	**Usability of the module for other programs** M.Sc. Mathematical Modeling of Complex Systems (03PH2501) M.Sc. Applied Physics (03PH2501)				
7	**Prerequisites for Participation**				
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** 6/90
11	**Frequency of Course** annually (summer semester)
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Stefan Wehner
13	**Further information** Compulsory module This module is taught in English.

Module 03XX2401 **Synthesis and Characterization of functional materials**					
Module code 03XX2401		**Workload** 270 h	**Credit points** 9 LP	**Semester** 1. and 2. Master semester	**Duration** 2 semester
1	**Courses**		**Contact time**	**Self-study**	**Credit points**
	1. 3324015/3524015 V Production and Functionalization of materials		30 h	60 h	3 LP
	2. 3324016/3524016 V Characterization of material structure and properties		30 h	60 h	3 LP
	3. 3324017/3524017 S Application of functional materials		30 h	60 h	3 LP
2	**Teaching form** Course 1: Lecture (2 CH) Course 2: Lecture (2 CH) Course 3: Seminar (2 CH)				
3	**Group size** Course 1: 30 (Lecture) Course 2: 30 (Lecture) Course 3: 30 (Seminar)				
4	**Qualification targets / Skills** The students • know the most important mechanisms for the synthesis of polymeric materials during the production process of glass, ceramics and metals as well as for the functionalization of surfaces. • understand the basic correlations between structures and properties of materials • can collect, understand, assess and present information extracted from current publications in English • are capable of participating in scientific discussions in English				
5	**Contents** Metallic materials • from substance to product material: metallic presentation • Classification of display techniques • Properties of metallic materials • Metal bonds, metal properties • Crystal structure (ideal lattice), lattice defects (real lattice) • mechanical properties (deformation, strength, stabilization) • alloys (basic terms, solubility, structure, grains, grain boundaries, construction of state diagrams)				

	• from substance to construction parts • Production processes at the example of metallic materials • Original forming, shaping, cutting, joining, coating • Changing of material properties (solidifying, heat-treating, firing, magnetizing) • Overview over material testing (and analytics) • developments Ceramics: • Synthesis of powdered raw materials – grinding, mixing, classifying • Production of various ceramic materials and components – casting, extruding, press • Characterizing typical properties – flow behavior (rheology and viscometry), pressing (strength development), structure development via microscopy, compaction behavior (sintering and volume development like shrinkage and porosity) Glass: • Raw material production and x-ray characterization • Melting processes (temperature independent viscous behavior with different glass compositions) • Characterization of the near-order via spectroscopic methods • Production of glass materials with the help of press-, pull-, blow-processes • Optical properties of various glass materials Plastic materials: • Basic mechanical knowledge of polymeric chemistry • Important mechanisms for synthesis of polymeric materials • Properties of polymers (solution, melt, solid state) • Introduction into basic characterization (molecular weight determination, diffusion, rheology) • Highlights in research of the last year • Published results and their bases Surfaces: • Description of material surfaces • Physical and chemical properties of surface boundaries • Important processes of functionalization • Important methods for characterizing surfaces
6	**Usability of the module for other programs**

7	**Prerequisites for Participation**
8	**Method of Examination** Written exam (90 min) (module exam)
9	**Requirement for Credit points** Participation in the seminar on a steady basis Passing the coursework (presentation in the seminar and participation in at least 6 further seminar or colloquium presentations within one year) Passing the module exam
10	**Percentage of grade in final mark** 9/90
11	**Frequency of Course** annually (one lecture in the winter- and summer semester each, seminar in each semester)
12	**Module Coordinator and Lecturer** Module Coordinator: N.N. Lecturers Prof. Dr. Wolfgang Imhof Prof. Dr. Peter Quirmbach Prof. Dr. Silke Rathgeber Prof. Dr. Joachim Scholz Prof. Dr. Stefan Wehner
13	**Further information** Compulsory module This module is either taught in English or German.

Module 03CH2401

Modern Concepts of inorganic chemistry

Module code	Workload	Credit points	Semester	Duration
03CH2401	180 h	6 LP	1. or 2. Master semester	1 semester

1	Courses	Contact-time	Self-study	Credit points
	1. 3324011 V Modern concepts of inorganic molecular chemistry (AC IV)	30 h	60 h	3 LP
	2. 3324012 Ü Experimental Exercises (AC IV)	30 h	60 h	3 LP

2 Teaching form

Course 1: Lecture (2 CH)

Course 2: Experimental exercises (2 CH)

3 Group size

Course 1: 30 (Lecture)

Course 2: 30 (Experimental exercises)

4 Qualification targets / Skills

The students

- are able to apply the achieved knowledge of modern concepts of inorganic and element organic molecular chemistry of main group- and transition elements as well as of perspectives of this area of chemistry in research and industry
- are able to understand the synthesis part of metal complexes for various chemical transformations and e.g. to choose the appropriate synthesis tools for the production of defined organic molecules or polymers and to use them target-oriented.
- understand the special advantages of complex catalyzed reactions during the synthesis of functional organic compounds or inorganic materials
- are able to handle the latest knowledge of the chemical literature and are capable of applying the scientific terminology actively
- have experimental abilities to apply demanding synthesis methods and modern laboratory techniques, know a wide range of chemical-analytical methods to characterize substances and to monitor reaction processes

5 Contents

In this research oriented module modern aspects of the inorganic molecular chemistry are treated. The contents base on the basic knowledge provided in the bachelor study program „Angewandte Naturwissenschaften“ (Applied Sciences) and consider current developments.

Focus is on modern inorganic and element organic chemistry of the main group- and transition elements, the coordination chemistry and metal organic catalysis, bio-inorganic chemistry as well as the homogenous catalysis. Basic questions of structure-activity relationships and reaction mechanisms will be treated as well as applications in modern chemical-technical processes.

Experimental exercises have a close relationship to the research topics of the research group Inorganic Chemistry whereby the focus is placed on preparative works.

6	**Usability of the module for other programs**
7	**Prerequisites for Participation** The following competences are required: Advanced knowledge of inorganic chemistry, especially basic preparative reactions
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** 6/90
11	**Frequency of Course** annually (summer semester)
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Joachim Scholz
13	**Further information** In-depth module This module is either taught in German or in English.

Module 03CH2402 **Thermochemistry**					
Module code 03CH2402		**Workload** 180 h	**Credit points** 6 LP	**Semester** 1. and 2. Master semester	**Duration** 2 semester
1	**Courses** 1. 3324021 V Thermodynamics of condensed phases 2. 3329081 VmÜ Thermochemistry		**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: Lecture with integrated exercises (2 CH)				
3	**Group size** Course 1: 30 (Lecture) Course 2: 30 (Lecture)				
4	**Qualification targets / Skills** The students • are capable of transforming chemical reaction processes to processes and case-studies and to transfer energetic correlations to the conditions of real processing equipment in order to calculate and model the relations between chemical reactions and the correlations with the environment • shall be enabled to understand and handle by themselves the modeling tools from the sector of application of modern computer-aided processes (Computer Aided Thermochemistry CAT) as well as by using the software to learn about and present the necessary instruments to describe material changes depending on high temperatures				
5	**Contents** • basics of chemical thermodynamics and thermodynamics • energetic consideration of heterogeneous chemical reactions • Calculation of thermo-chemical correlations with the help of the Software FactSage 6.3 • Modeling of real engineering processes				
6	**Usability of the module for other programs** The course „Thermochemistry“ (VmÜ, 03CH2402) will also be attended by students of the study program M.Eng. Ceramic Science and Engineering as part of the module W2.				
7	**Prerequisites for Participation** The following competences are recommended: • Knowledge about chemical reactions (chemical equilibria , the law of mass action, fixed phases, state diagrams) • They are familiar with the physical-chemical basic principles of heterogeneous systems (miscibility, solubility incl. steam pressure, sublimation, melting)				

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** 6/90
11	**Frequency of Course** annually (Course 1 in the winter semester, Course 2 in the summer semester)
12	**Module Coordinator and Lecturer** Module Coordinators: Prof. Dr. Peter Quirmbach Dr. Almuth Sax
13	**Further information** In-depth module This module is either taught in German or English.

Module 03CH2403

Polymer chemistry und Ingredient synthesis

Module code	**Workload**	**Credit points**	**Semester**	**Duration**
03CH2403	180 h	6 LP	1. or 2. Master semester	1 semester

1	**Courses**	**Contact time**	**Self-study**	**Credit points**
	1. 3324031 V Polymer chemistry	30 h	60 h	3 LP
	2. 3324032 V Natural products chemistry and Ingredient synthesis	30 h	60 h	3 LP

2 Teaching form

Course 1: Lecture (2 CH)

Course 2: Lecture (2 CH)

3 Group size

Course 1: 30 (Lecture)

Course 2: 30 (Lecture)

4 Qualification targets / Skills

Polymer chemistry

- The students are able to identify and differentiate the most important classes of polymer compounds.
- The can present methods of synthesis and explain their technologic importance.
- The students know the most important methods for analyzing properties of polymer materials with regard to their composition, structure and material properties.
- The students can name the technical applications of polymers and the present trends of polymer chemistry.

Natural products chemistry und Ingredient synthesis

- The students know the most important natural product classes and can present their occurrence and their physiological effects.
- The essential concepts for synthesis planning of complex molecules like e.g. retro-synthetic methods are known and can be applied.
- Using their chemical basic knowledge from modules of the bachelor study program the students are capable of developing by themselves synthesis strategies for simple example molecules.

5 Contents

Polymer chemistry:

- Polymers in solutions and in solid state
- Semi-crystalline and amorphous polymers
- Polymer analytics
- Polymers as materials
- Step-growth reaction and chain growth reaction
- Radical, ionic and catalytic polymerization

	• Technical methods of polymerization and in plastics processing • Current trends in polymer chemistry Natural product chemistry and Ingredient synthesis: • Terpenes and steroids • Biogenic amines and alkaloids • Amino acids, peptides and proteins • carbonhydrates • lipids • nucleosides, nucleotides and nucleic acids • antibiotics and chemotherapeutics • Retro-synthesis and synthesis planning
6	**Usability of the module for other programs**
7	**Prerequisites for Participation** The following competences are recommended: The students know the materials types introduces in the modules of organic chemistry 1 to 3 of the bachelor study program „Angewandte Naturwissenschaften“ (Applied Sciences) and are able to describe their typical reactivity.
8	**Method of Examination** Written exam (90 min) or oral exam (30 min) (module exam)
9	**Requirement for Credit points** Passing the module exam
10	**Percentage of grade in final mark** 6/90
11	**Frequency of Course** annually (winter semester)
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Wolfgang Imhof
13	**Further information** In-depth module This module is either taught in German or English.

Module 03PH2503

Surface Science

Module code	**Workload**	**Credit points**	**Semester**	**Duration**
03PH2503	180 h	6 LP	1. or 2. master semester	1 semester

1	**Courses**	**Contact time**	**Self-study**	**Credit points**
	1. 3525031 VmÜ Vacuum Technology	30 h	60 h	3 LP
	2. 3525032 VmÜ Surface Science	30 h	60 h	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

- 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
- are able to transfer their knowledge to technical solutions and develop their own experimental schemes.

Surface Science

The students

- 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 their own experimental schemes.

5 Contents

Vacuum Technology

- equations of state
- motion in diluted gases
- transport

	• flow • conductance and pumping speed • calculating conductance • design of vacuum systems • pumps • measuring pressure • materials for HV and UHV • flange systems and components Surface Science: • 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. Mathematical Modeling of Complex Systems (03PH2503) M.Sc. Applied Physics (03PH2503)
7	**Prerequisites for Participation** Recommended 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** 6/90
11	**Frequency of Course** Annually (winter semester)
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Stefan Wehner
13	**Further information** In-depth module This module is taught in English.

Module 03PH2504 **Applied Theoretical Physics**					
Module code		**Workload**	**Credit points**	**Semester**	**Duration**
03PH2504		180 h	6 LP	1. or 2. Master semester	1 semester
1	**Courses**		**Contact time**	**Self-study**	**Credit points**
	1. 3525041 VmÜ Applied Theoretical Physics 1		30 h	60 h	3 LP
	2. 3525042 VmÜ Applied Theoretical Physics 2		30 h	60 h	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: • 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: • modern concepts in theoretical physics • reaction-diffusion-systems • nonlinear physics • non-equilibrium thermodynamics • applications of theoretical physics in nature and technology				
6	**Usability of the module for other programs** M.Sc. Mathematical Modeling of Complex Systems (03PH2504) M.Sc. Applied Physics (03PH2504)				
7	**Prerequisites for Participation** Recommended 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** 6/90
11	**Frequency of Course** Irregularly
12	**Module Coordinator and Lecturer** Module Coordinator: N.N
13	**Further information** In-depth module This module is taught in English.

Module 03PH2505

Polymer Science

Module code	**Workload**	**Credit points**	**Semester**	**Duration**
03PH2505	180 h	6 LP	1. or 2. master semester	1 semester

1	**Courses**	**Contact time**	**Self-study**	**Credit points**
	1. 3525051 VmÜ Polymer Physics	30 h	60 h	3 LP
	2. 3525052 VmÜ Characterization methods in Polymer Science	30 h	60 h	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

Polymer Physics

The students

- 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.

Characterization methods in Polymer Science

The students

- can independently explain the characterization method covered in this course
- can identify for the most important physical properties of polymer materials (Course 1) 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

Polymer Physics

- Synthesis & molecular weight distributions

	• Chain models • Polymer solutions, polymer blends, block copolymers • Semi-crystalline state • Polymer dynamics & viscoelasticity • Networks • Glassy state Polymer Characterization • 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. Mathematical Modeling of Complex Systems (03PH2505) M.Sc. Applied Physics (03PH2505)
7	**Prerequisites for Participation** Recommended 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** 6/90
11	**Frequency of Course** Annually (summer semester)
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Silke Rathgeber
13	**Further information** In-depth module This module is taught in English.

Module 03XX2402 **Project work**					
Module code 03XX2402		**Workload** 450 h	**Credit points** 15 LP	**Semester** 1. or 2. semester	**Duration** 1 semester
1	**Courses** 1. 3324025 / 3524025 P Project work 2. 3324026 / 3524026 S seminar		**Contact time** 15 h	**Self-study** 420 h 15 h	**Credit points** 14 LP 1 LP
2	**Teaching form** Practical research work with seminar				
3	**Group size** Course 1: one or small groups (max. 5) Course 2: 5 (seminar)				
4	**Qualification targets / Skills** The project work serves the in-depth study course and helps to achieve knowledge in scientific literature and the current status in a special field. The project work intends to offer insights into recent scientific questions of a chosen topic. The students are able to achieve, adapt and apply scientific results. By means of teamwork, group discussions and presentations communication abilities and other social competences are being improved. The student has the ability to work herself/himself into a scientific field in a given time under professional guidance. She/he is able to reflect and classify the results into the status of knowledge and can document the results in English.				
5	**Contents** • The project seminar offers insight into scientific work. • Awareness of relevant questions of the subject • Awareness of relevant publications of the subject • Knowing about scientific methods for acquiring, assessing and presenting knowledge				
6	**Usability of the module for other programs**				
7	**Prerequisites for Participation**				
8	**Method of Examination** Paper in English – 4 weeks (module exam)				
9	**Requirement for Credit points** Regular participation Passing the module exam				
10	**Percentage of grade in final mark** 15/90				

11	**Frequency of Course** On demand
12	**Supervising lecturer** All lecturers that offer in-depth modules
13	**Further information** Project works can be carried out in all fields of in-depth modules but also in the industry or in extern research institutes as long as the supervisor agrees according to paragraph 12. Compulsory module

Module 03XX2490 **Master thesis**					
Module code 03XX2490		**Workload** 750 h	**Credit points** 25 LP	**Semester** 3. semester	**Duration** 1 semester
1	**Courses** 1. 3324901 / 3524901 Master thesis		**Contact time**	**Self-study** 750 h	**Credit points** 25 LP
2	**Teaching form** Largely independent production of a master thesis				
3	**Group size** Usually 1				
4	**Topic, Qualification target and expected skills** The master student must work on a given scientific topic of physics or chemistry under guidance according to scientific methods within a given time. The student has to present and interpret comprehensively and consistently the tools for solving the problem as well as the solution itself. The master thesis can only be started after successfully having finished the project work. The board of examiners may grant exemptions in justified cases. 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 that is suitable for the topic.				
5	**Contents** • Largely independent work on a research question under professional guidance • Commanding the basic techniques of scientific work and publication • Producing a paper covering the results				
6	**Usability of the module for other programs**				
7	**Prerequisites for Participation** Competences of: Module 03XX2402				
8	**Method of Examination** Master thesis				
9	**Requirement for Credit points** Successfully completed Master thesis				
10	**Percentage of grade in final mark** 25/90				
11	**Frequency of Course** As needed				
12	**Supervising Lecturers** All Lecturers who offer in-depth modules				

13	**Further information** The period provided for the Master thesis is 5 months. The master thesis can be written in all areas of in-depth modules as well as in the industry or extern research institutes both nationally or internationally provided that the supervising lecturer or a lecturer according to paragraph 12 guarantees the supervision. Compulsory module

Module 03XX2499 **Final oral exam**					
Module code 03XX2499		**Workload** 150 h	**Credit points** 5 LP	**Semester** 3. Semester	**Duration** 1 Semester
1	**Courses** 1. 3324991 / 3524991 Final oral exam		**Contact time**	**Self study** 150 h	**Credit points** 5 LP
2	**Teaching form** Oral final exam				
3	**Group size** Usually 1				
4	**Topic, Qualification target and expected skills** The Final oral exam terminates the master program. The candidate must present the results achieved in the master thesis in adequate form in an oral final exam and defend them. Examination is carried out by the supporting professor and a second auditor. Subject matter of the exam is the topic of the master thesis. The candidate has the opportunity to present her/his work within the examination time.				
5	**Contents** • Presentation of the acquired results in a form suitable for the subject matter • Defending the master thesis in the following discussion • Command of the basics of scientific work and forms of presentation				
6	**Usability of the module for other programs**				
7	**Prerequisites for Participation** Competences of: Module 03XX2402 Module 03XX2490				
8	**Method of Examination** Final oral exam (Colloquium)				
9	**Requirement for Credit points** Passing the oral exam				
10	**Percentage of grade in final mark** 5/90				
11	**Frequency of Course** As needed				
12	**Supervising Lecturers** All Lecturers who offer in-depth modules				
13	**Further information** Preparation time for the final oral exam is 4 weeks.				

	Compulsory module

Optional Compulsory Section

The optional compulsory section comprises at least 12 credit points. As a rule, the modules are structured in that way that they can be terminated within one semester including module exam.

The optional compulsory section offers of a wide range in the fields of economics, informatics, mathematics and natural sciences. Optional compulsory modules for at least 12 credit points have to be chosen.

If the requirements with regard to contents are met they can be attended in the first or second master semester. It is recommended to inform oneself about the actual opportunities already in the first semester of the Master program. Furthermore, it is recommended to inform oneself about the courses as well as about possible compulsory course works and modalities of the module exams.

List of Modules

Module code	Module name	Credit points
03BI1317	Environmental microbiology	6 LP
03CH2404	Analytical Chemistry	7 LP
03CH2405	Technical Chemistry	7 LP
03CH2406	Biochemistry	7 LP
03CH2407	Current Questions in Chemistry	7 LP
03GE2308	Soil functions and soil protection	6 LP
03MA1107	Stochastic Models	8 LP
03MA2401	Modeling and Simulating for Scientists	6 LP
03PH2402	Current Questions in Physics	6 LP
04IM2008	New Product Development	6 LP
04IM2009	Scientific Entrepreneurship and Technology Transfer	6 LP
04IN2007	Real-time systems	6 LP
04IN2026	Introduction to Web Science	8 LP
04IN2032	Basics of embedded systems	6 LP
04IN2035	Wireless communication	6 LP
04WI2001	Advanced Enterprise Information Management	6 LP
04WI2013	Modeling of Corporate Information Systems	6 LP
04WI2024	IT-Risk-Management	6 LP

Module 03BI1317

Environmental Microbiology

Module code	**Workload**	**Credit points**	**Semester**	**Duration**
03BI1317	180 h	6 LP	1. or 2. master semester	1 semester

1	**Courses**	**Contact time**	**Self study**	**Credit points**
	1. 3213171 V Microbial Ecology and Geomicrobiology	30 h	60 h	3 LP
	2. 3213172 V Biotechnology	30 h	60 h	3 LP

2 Teaching form

Course 1: Lecture (2 CH)

Course 2: Lecture (2 CH)

3 Group size

Course 1: 60 (Lecture)

Course 2: 60 (Lecture)

4 Qualification targets / Skills

- In-depth knowledge of microorganisms and their performance in the ecological system, geochemical processes and global cycles of elements.
- In-depth knowledge of the abilities and ecological performance of microorganisms.
- Knowledge of market-oriented relevant products and processes in biotechnology including bioremediation and the corresponding microorganisms.
- In-depth knowledge of biotechnological processes and products as well as the microorganisms involved.
- Ability to gather valid scientific data in the field and in the laboratory

5 Contents

Microorganisms play an essential role in the global energy- and material cycles. Their metabolic and physiological abilities are often used in biotechnological processes as well as to manufacture products on an industrial scale and for cleaning waste water and remediating contaminated soils.

- The lecture *Microbial Ecology and Geomicrobiology* offers knowledge of the autecology of bacteria like movement and taxis, communication, structure and function of microbial communities with focus on the observation of aquatic bioceonosis, the biofilms as natural life form of microbial life and the interactions between bacteria and higher organisms, their interaction with the abiotic environment in the sense of mineral formation and weathering as well as the importance of microorganisms for biogeochemical material cycles.
- The lecture *Biotechnology* provides knowledge about the use of microorganisms in biotechnological processes.

6 Usability of the module for other programs

The courses can also be attended by students of the bachelor study program BioGeo-Sciences (B.Sc. BioGeoWissenschaften).

7	**Prerequisites for Participation** Required competences: • Basic knowledge in microbiology • Basic biological-ecological knowledge • Basic chemical knowledge
8	**Method of Examination** Written exam (90 min) (module exam)
9	**Requirement for Credit points** Passing the module exam
10	**Percentage of grade in final mark** 6/90
11	**Frequency of Course** annually (winter semester)
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Werner Manz
13	**Further information** Optional compulsory module

Module 03CH2404

Analytical Chemistry

Module code	**Workload**	**Credit points**	**Semester**	**Duration**
03CH2404 | WPCH01	210 h	7 LP	1. and 2. master semester	2 semester

1	**Courses**	**Contact time**	**Self study**	**Credit points**
	1. 3311085 V Analytical Chemistry 1	30 h	90 h	4 LP
	2. 3321143 V Analytical Chemistry 2	30 h	60 h	3 LP

2 Teaching form

Course 1: Lecture (2 CH)

Course 2: Lecture (2 CH)

3 Group size

Course 1: 80 (Lecture)

Course 2: 80 (Lecture)

4 Qualification targets / Skills

Analytical Chemistry 1:

- Knowledge and understanding of important environmental chemical processes and and environmental analytics and their basic principles
- Ability to critically assess analysis results
- Basics and applications to explain structures of organic compounds with chosen spectroscopic methods

Analytical Chemistry 2:

- Knowledge of physical basis of chosen methods in surface analysis and their field of application
- Knowledge of the basic principles of the electron microscopy (REM, TEM, ...), atomic force microscopy (STM, AFM, …), UHV-electron spectroscopy (PES, XPS, AES, EELS, …) and secondary ion mass spectrometry (SIMS)
- Ability to choose apt methods according to specific questions
- qualitative and quantitative assessment of achieved results

5 Contents

Analytical Chemistry 1:

- Qualitative and quantitative analyses
- Methods for sample collection of environmental samples
- Processes of sample preparation
- Chromatographical analysis methods
- Quality assurance in analytical chemistry
- Assessment of environmental analytical results
- Basics in modern spectroscopy methods

	• Application of modern spectroscopic methods in chosen groups of substances • Deductions from structure property relationships • Structure information and structure models Analytical Chemistry 2: • Surface analytics in UHV: Basics in electron spectroscopy, electron detectors to measure photoelectron spectra, evaluation of XPS-spectra, intensities, chemical shifts, applications of XPS-analyses in material research • Overview of modern techniques in surface and layer analytics: mass spectroscopic methods in surface analysis, ion scattering, special analysis methods for nanometer layers, examples for the application and performance of surface analytical methods; methods of optical microcopy: SEM (Scanning Electron Microscopy), EDX Analysis (Energy Dispersive X-Ray Spectroscopy), scanning probe microscopy and UHV-surface analysis (XPS)
6	**Usability of the module for other programs** The courses can also be attended by student of the study program Education with the subject Chemistry.
7	**Prerequisites for Participation**
8	**Method of Examination** Written exam (90 min) or oral exam(20 min) (Module exam)
9	**Requirement for Credit points** Passing the module exam
10	**Percentage of grade in final mark** 7/90
11	**Frequency of Course** annually
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Joachim Scholz Lecturers: Prof. Dr. Peter Quirmbach Dr. A. Sax Dr. E. Burbach apl. Prof. Dr. T. Ternes
13	**Further information** Optional compulsory module

Module 03CH2405 **Technical Chemistry**				
Module code 03CH2405 | WPCH02	**Workload** 210 h	**Credit points** 7 LP	**Semester** 1. and 2. master semester	**Duration** 2 semester

1	**Courses**	**Contact time**	**Self study**	**Credit points**
	1. 3311086 V Technical Chemistry 1	30 h	90 h	4 LP
	2. 3321103 V Technical Chemistry 2	30 h	60 h	3 LP
2	**Teaching form** Course 1: Lecture (2 CH) Course 2: Lecture (2 CH)			
3	**Group size** Course 1: 80 (Lecture) Course 2: 80 (Lecture)			
4	**Qualification targets / Skills** Technical Chemistry 1: Structural description of solids (e.g. glass, ceramics, metals, alloys); Understanding of the correlation between microscopic structure and macroscopic properties; Knowledge about the relevance of properties of solids for technical applications and processes in daily life; knowledge of basics and practical execution of chemical substance conversions on industrial scale and abilities to present chemical-industrial processes with their complex interrelations of materials and energy; Technical Chemistry 2: The students are able to explain the physical-chemical and technological reasons for corrosion processes. They know various types of corrosion and their critical boundary conditions. They know about the laws as to how corrosion processes work and can demonstrate them with the help of pattern materials as an example.			
5	**Contents** Technical Chemistry 1: • Ceramic materials and glass • metallic materials • new materials • mechanical properties, ductility, strength and abrasion resistance, corrosion; • Principles of thermal and mechanical separation processes; • Kinetic and thermodynamic principles of chemical reaction technology; • Reactor models; • chemical production processes			

	Technical Chemistry 2: • Corrosion reactions at metallic and non-metallic materials • Corrosion laws and kinetic descriptions • Effects of corrosion on material- and component resistance • Behavior of material compounds following corrosion effects • Effects of corrosion on further material properties • Corrosion testing devices and possibilities • Modeling of corrosion processes
6	**Usability of the module for other programs** The courses can also be attended by students of the study program Education with the subject chemistry.
7	**Prerequisites for Participation**
8	**Method of Examination** Written exam (90 min) or oral exam (20 min) (module exam)
9	**Requirement for Credit points** Passing the module exam
10	**Percentage of grade in final mark** 7/90
11	**Frequency of Course** annually
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Peter Quirmbach Lecturers: Dr. A. Sax
13	**Further information** Optional compulsory module

Module 03CH2406 **Biochemistry**					
Module code 03CH2406 | WPCH03		**Workload** 210 h	**Credit points** 7 LP	**Semester** 1. and 2. master semester	**Duration** 2 semester
1	**Courses**		**Contact time**	**Self study**	**Credit points**
	1. 3311081 V Biochemistry 1		30 h	90 h	4 LP
	2. 3321104 V Biochemistry 2		30 h	60 h	3 LP
2	**Teaching form**				
	Course 1:	Lecture (2 CH)			
	Course 2:	Lecture (2 CH)			
3	**Group size**				
	Course 1:	80 (Lecture)			
	Course 2:	80 (Lecture)			
4	**Qualification targets / Skills** Biochemistry 1: In addition to the basic understanding of biochemical questions the students should know about the molecular basis of biochemical processes and explain them. Especially enzyme-catalyzed reactions and the principles of metabolism are relevant, whereby chosen enzymes serve as target structures and shall be discussed with regard to strategies and intervention possibilities in case of misregulated processes (therapeutic potential). Biochemistry 2: The students gain a deep understanding in modern biochemistry focusing on regulatory processes and mechanisms of hormonal communication between different cell compounds. They learn about modern modes of operation in today`s biochemistry. Target is to learn how to evaluate independently original literature and how to apply relevant methods to work on a scientific problem on the sector of biochemistry.					
5	**Contents** Biochemistry 1: • Learning about biomolecules, their way of building and degrading in the organism (metabolism) and principles of intra- and intercellular signal transfer. • Chosen current problems and research trends in biochemistry, above all regarding investigating pathophysiological conditions (development of diseases) and the use of this knowledge for drug development Biochemistry 2: • regulatory mechanisms of signal transfer and processing (hormons, hormon receptors, hormonal regulation, signal transduction, membrane receptors, kinase cascades, intracellular network of signal ways (crosstalk), transcriptional regulation, covalent modification of signal proteins and transcription factors.					

	• Important strategy and methods of analytic biochemistry (e.g. sequencing DNA/protein, protein analytics, qualitative and quantitative demonstration of protein-protein-interactions, use of databases) and their application.
6	**Usability of the module for other programs** The courses can also be attended by students of the study program Education with the subject chemistry.
7	**Prerequisites for Participation**
8	**Method of Examination** Written exam (90 min) or oral exam (20 min) (module exam)
9	**Requirement for Credit points** Passing the module exam
10	**Percentage of grade in final mark** 7/90
11	**Frequency of Course** annually
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Wolfgang Imhof Lecturers: N.N.
13	**Further information** Optional compulsory module

Module 03CH2407 **Current Issues in Chemistry**					
Module code 03CH2407 | WPCH07		**Workload** 210 h	**Credit points** 7 LP	**Semester** 1. and 2. master semester	**Duration** 2 semester
1	**Courses** **2 out of 2 have to be chosen** 1. 3321123 V Metal Chemistry 2. 3321092 Ü Structure analysis in organic Chemistry		**Contact time** 30 h 30 h	**Self study** 90 h 60 h	**Credit points** 4 LP 3 LP
2	**Teaching form** Course 1: Lecture (2 CH) Course 2: Exercise (2 CH)				
3	**Group size** Course 1: 80 (Lecture) Course 2: 25 (Exercise)				
4	**Qualification targets / Skills** The students acquire comprehensive knowledge about complex chemistry of main group- and transition metals. They apply basic structure-activity-principles on relevant complex formation reactions and recognize the relationship between properties and the reaction behaviour of complex compounds. They are able to explain the results of modern methods of the structural-analytical characterization of complex compounds and to collect the corresponding data from the scientific literature. The students understand the most important analytical methods regarding functioning and significance. Starting with specific questions they can define expected products and confirm their expectations due to various analytical findings. Alternatively unexpected results can be analyzed.				
5	**Contents** • Structure and properties of complexes • Complex formation reactions • Kinetic and thermodynamic stability as well as the nomenclature of complexes • Complexes of main group- and transition metals • Participation of d-orbitals in bonding • Ligand properties • Ligands as electron donors and acceptors • Speciality of metal-carbon-bonds • metallic-organic chemistry of transition metals • metallic-organic σ- and π-complexes				

	• Application of concepts in binding theory (e.g. Isolobal-Concept, ligand field theory, Dewar-Chatt-Duncanson-Model) • Organo-metallic compounds in chemical technical processes The most important spectroscopic analysis methods (UV-, IR- and NMR-spectroscopy, Mass spectrometry) are dealt with and are applied on the results of sample reactions. In this context important reaction types of the organic chemistry will be repeated and explained practically A separate part deals with crystal-structure analysis.
6	**Usability of the module for other programs** The courses can also be attended by students of the study program Education with the subject chemistry.
7	**Prerequisites for Participation**
8	**Method of Examination** Written exam (90 min) or oral exam (20 min) (module exam)
9	**Requirement for Credit points** Participation in course 2 on a steady basis Passing the module exam
10	**Percentage of grade in final mark** 7/90
11	**Frequency of Course** annually
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Joachim Scholz Prof. Dr. Wolfgang Imhof Lecturers: N.N.
13	**Further information** Optional compulsory module

Module 03GE2308

Soil functions and soil protection

Module code	**Workload**	**Credit points**	**Semester**	**Duration**
03GE2308	180 h	6 LP	1. or 2. master semester	1 semester

1	**Courses**	**Contact time**	**Self study**	**Credit points**
	1. 3423081 S Soil functions and soil protection	60 h	120 h	6 LP

2 Teaching form

Course 1: Seminar (4 CH)

3 Group size

Course 1: 30 (Seminar)

4 Qualification targets / Skills

- Ability to implement and transfer soil- and ecosystem-related knowledge
- Independent research work and analysis of scientific literature
- Ability to deal critically with the contents of scientific literature in a larger scale
- Capability to write a scientific critical review
- Ability to comprehend and analyze complex ecological relationships
- Ability to present results of scientific analyses and prognoses in writing and orally

5 Contents

Soils are a critical zone of interactions between geo-, hydro-, bio-, and atmosphere. Protection and sustainable use of the soils is of great importance for the eco-systemic service (nutrient retention a.s.o.) or the storage of CO_2 in relation to the climate change for the human being.

In this module current research issues will be introduced and discussed in form of seminar contributions. Participating in the seminar includes independent literature research (including database research) about a current geological topic and the production of a review.

The topics comprise soil-physical and chemical properties of terrestrial and semi-terrestrial ecosystems as well as their endangerment by man-made hazards.

6 Usability of the module for other programs

M.Sc. BioGeoWissenschaften (BioGeo Sciences) (03GE2308)

7 Prerequisites for Participation

8 Method of Examination

Seminar paper – 6 weeks (module exam)

9 Requirement for Credit points

Passing the module exam

10	**Percentage of grade in final mark** 6/90
11	**Frequency of Course** annually (summer semester)
12	**Module Coordinator and Lecturer** Module Coordinator: N.N.
13	**Further information** Optional compulsory module

Module 03MA1107 **Stochastic Models**					
Module code 03MA1107 | WPMA05 | BA07		**Workload** 240 h	**Credit points** 8 LP	**Semester** 1. or 2. master semester	**Duration** 1 semester
1	**Courses** 1. 3611071 V Stochastics 2. 3611072 Ü Exercises to Stochastics		**Contact time** 60 h 15 h	**Self study** 120 h 45 h	**Credit points** 6 LP 2 LP
2	**Teaching form** Course 1: Lecture (4 CH) Course 2: Exercises (1 CH)				
3	**Group size** Course 1: 100 (Lecture) Course 2: 53 (Exercises)				
4	**Qualification targets / Skills** The students • Know about stochastic terms, the basic principles of probability theory and statistics • Are able to apply stochastic methods on simple practical problems				
5	**Contents** Introduction to stochastics: • Basics of probability theory (Terms of P-theory; Distribution of real-valued random variables; expected value, variance, covariance; law of large numbers; central limit theorem); • Basics of statistics (parameter estimates; interval estimates; tests)				
6	**Usability of the module for other programs** Education Mathematics and Double-Subject-Bachelor (03MA1107) B.Sc. Mathematical Modeling (03MA1107)				
7	**Prerequisites for Participation** Necessary competences: - founded knowledge in analysis and linear algebra				
8	**Method of Examination** Written exam (90 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** 8/90				

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 03MA2401 **Modeling and Simulation for Scientists**					
Module code 03MA2401		**Workload** 180 h	**Credit points** 6 LP	**Semester** 1. or 2. semester	**Duration** 1 semester
1	**Courses** 1. 3615011 V Modeling and Simulating		**Contact time** 60 h	**Self study** 120 h	**Credit points** 6 LP
2	**Teaching form** Course 1: Lecture (4 CH)				
3	**Group size** Course 1: 30 (Lecture)				
4	**Qualification targets / Skills** The students are able to deal with part aspects of exemplary application problems of industry and economy independently; this refers especially to the choice of the mathematical model, the choice of suitable solution methods as well as the interpretation of the results. By participating in the lecture the students learn to know about the basic principles of mathematical modeling.				
5	**Contents** • Theoretical and practical basics of mathematical modeling and model building, e.g. concepts of the discrete and continuous modeling, stochastic models, Monte-Carlo-simulations, cellular automata, recursion equation, neuronal nets, natural-analog Optimization- and Modeling methods, graphs and networks, stability analysis • Exemplary demonstration of the modeling cycle using specific problems of industry and technology.				
6	**Usability of the module for other programs** M.Sc. Applied Physics (Modul 03MA2401) The course „Modellieren und Simulieren“(Modeling and Simulation) (V 3615011) can also be attended by students of the study program B.Sc. Mathematische Modellierung (Mathematical Modeling) as part of the module 03MA1501.				
7	**Prerequisites for Participation** Necessary competences: - founded knowledge in linear algebra, analysis and numerics.				
8	**Method of Examination** Written exam (90 min) or oral exam (30 min) (module exam)				
9	**Requirement for Credit points** Passing the module exam				
10	**Percentage of grade in final mark** 6/90				
11	**Frequency of Course** annually (winter semester)				

12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Thomas Götz Prof. Dr. Stefan Ruzika
13	**Further information** Optional compulsory module

Module 03PH2402

Current Issues in Physics

Module code	**Workload**	**Credit points**	**Semester**	**Duration**
03PH2402 | WPPH02	180 h	6 LP	1. and 2. master semester	2 semester

1	**Courses** **2 of 5 have to be chosen** **(partly irregular offer)**	**Contact time**	**Self study**	**Credit points**
	1. 3524021 S/P Physical material analysis	30 h	60 h	3 LP
	2. 3524022 VmÜ Processes on material boundaries	30 h	60 h	3 LP
	3. 3524023 VmÜ Physical basis of medicine technology in diagnostics and therapy	30 h	60 h	3 LP
	4. 3524024 VmÜ Introduction into biophysics	30 h	60 h	3 LP
	5. 3521164 VmÜ Applied Microcontrollers	30h	60h	3 LP

2 Teaching form

Course 1:	Seminar/Practical work (2 CH)
Course 2:	Lecture with integrated exercises (2 CH)
Course 3:	Lecture with integrated exercises (2 CH)
Course 4:	Lecture with integrated exercises (2 CH)
Course 5:	Lecture with integrated exercises (2 CH)

3 Group size

Course 1:	10 (Seminar/Practical work)
Course 2:	30 (Lecture with integrated exercises)
Course 3:	30 (Lecture with integrated exercises)
Course 4:	30 (Lecture with integrated exercises)
Course 5:	30 (Lecture with integrated exercises)

4 Qualification targets / Skills

The students learn about important measurement methods for specific problems.

They know about their physical basic principles and are capable of choosing them and applying them.

5 Contents

3524021/3524022:

- Measurement methods for material analysis
- Physical basics of measurement methods
- Restrictions caused by the equipment and error sources
- Typical application examples and fields
-

	3524023: • Interaction between x-radiation and substance, detection of x-rays, • Image production by x-rays, x-ray device, computer tomography • Physics and technology of radio therapy, linear accelerator, irradiation planning • Magnetic resonance (MR) • positron emissions tomography (PET) 3524024: • Introduction into biophysics 3521164: • Basics of microcontrollers using practical examples
6	**Usability of the module for other programs** M.Sc. Applied Physics (03PH2402)
7	**Prerequisites for Participation**
8	**Method of Examination** Written exam - 90 min or oral exam- 30 min (module exam)
9	**Requirement for Credit points** Participation in seminar, practical work and exercises on a steady basis Passing the module exam
10	**Percentage of grade in final mark** 6/90
11	**Frequency of Course** irregularly
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Stefan Wehner Lecturers:
13	**Further information** Optional compulsory module

Module 04IM2008 **New Product Development**				
Module code 04IM2008	**Workload** 180 h	**Credit points** 6 LP	**Semester** 1. or 2. master-semester	**Duration** 1 semester

1	**Courses**	**Contact time**	**Self study**	**Credit points**
	1. 4220081 V New Product Development	30 h	60 h	3 LP
	2. 4220082 S/Ü New Product Development	30 h	60 h	3 LP

2 Teaching form

Course 1: Lecture (2 CH)

Course 2: seminar/exercise (2 CH)

3 Group size

Course 1: 6 – 90 (Lecture)

Course 2: 6 – 24 (seminar/exercise)

4 Qualification targets / Skills

The lecture is devoted to the development of new products (including new services) with a strong focus on the new product development process and technology marketing. In particular, the aim of the course is to understand the new product development process, to learn how to integrate the customer and knowledge of the customer into this process, to learn and apply concepts and tools appropriate for new product development analysis, and to develop specific recommendations and action plans for companies facing difficult decisions about bringing new products to market.

5 Contents

- Introduction to new product development: Invention vs. Innovation, New products in consumer markets, business to business markets
- The new product development process: Idea phase, conceptual phase, development phase, launch
- Intellectual Property, Outsourcing and Out-Licensing
- Strategic Product Development: Blue Ocean Strategy, Niche Markets, Two sided platforms
- Product Development with Communities
- Product Portfolio Management
- Technology Marketing

6 Usability of the module for other programs

M.Sc. Informationsmanagement (Module 04IM2008)

7 Prerequisites for Participation

Broad understanding of issues related to technology and innovation management

8 Method of Examination

The module consists of a lecture and a seminar with independent exams.

Lecture: Test (60 min) and Case work

	Seminar: Assignment for a particular topic (approx. 5000 words) and presentation (15 min) plus discussion
9	**Requirement for Credit points** Passing the module exam
10	**Percentage of grade in final mark** 6/90
11	**Frequency of Course** Every third semester
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Mario Schaarschmidt Lecturers: Prof. Dr. Mario Schaarschmidt
13	**Further information** Optional compulsory module This module is taught in English.

Module 04IM2009 **Entrepreneurship, Technology- and Innovation Management**					
Module code 04IM2009 | WPWI08		**Workload** 180 h	**Credit points** 6 LP	**Semester** 1. or 2. master semester	**Duration** 1 semester
1	**Courses** 1. 4220091 V Entrepreneurship, Technology- and Innovation Management 2. 4220092 Ü Entrepreneurship, Technology- and Innovation Management		**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: Exercise (2 CH)				
3	**Group size** Course 1: 6 – 90 (Lecture) Course 2: 6 – 24 (Exercise)				
4	**Qualification targets / Skills** The objective of this module is to provide an in-depth experience of the methodology of "entrepreneurial design thinking" for scientific entrepreneurship and the broader framework of technology transfer. Students will get to know the basics of scientific entrepreneurship's challenges, the process and related instruments of design thinking, as well as the technology transfer framework. During the entrepreneurial design thinking process, the will be able to self-detect problems which offer opportunities for entrepreneurial activities. Also, they are challenged to implement artefacts in terms of problem solutions and to elaborate on a business canvas. In addition, they will present their solutions in a professional setting simulating venture capitalists potential interests in investing into their solutions. The technology transfer framework will offer additional insights into other ways of how to transfer scientific knowledge into value-creating products and services.				
5	**Contents** • Scientific Entrepreneurship • Entrepreneurial Design Thinking • Technology Transfer				
6	**Usability of the module for other programs** M.Sc. Informationsmanagement (Information Management) (Module 04IM2009)				
7	**Prerequisites for Participation** Broad interest and understanding of scientific processes and knowledge transfer issues				
8	**Method of Examination** Seminal work (ca. 5000 words) and presentation in workshop; Presentations and small seminal works (ca. 2.500 words) in exercises (module exam)				
9	**Requirement for Credit points** Passing the module exam				

10	**Percentage of grade in final mark** 6/90
11	**Frequency of Course** Every third semester
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Harald von Korflesch Lecturers: Prof. Dr. Harald von Korflesch
13	**Further information** Optional compulsory module

Modul 04IN2007

Real-time Systems

Module code	**Workload**	**Credit points**	**Semester**	**Duration**
04IN2007	180 h	6 LP	1. or 2. Master-Semester	1 Semester

1	**Courses**	**Contact time**	**Self study**	**Credit points**
	1. 4320071 V Real-time systems	30 h	60 h	3 LP
	2. 4320072 Ü Real-time systems	30 h	60 h	3 LP

2 Teaching form

Course 1: Lecture (2 CH)

Course 2: Exercise (2 CH)

3 Group size

Course 1: 6 – 90 (Lecture)

Course 2: 6 – 24 (Exercise)

4 Qualifikationsziele/Kompetenzen

The students understand the cross-sectional character of the subject real-time systems. This means that they comprehend and classify the unifying properties of the subject like timeliness, predictability and reliability. They apply the characteristic methods of the subjects planning, synchronization, networking and distribution in the first place. They assess as to what extent the strongly abstracting methods can be applied to the specific application scenarios.

5 Contents

- Introduction
  - Basic model of a real-time system, process model, times and clocks, application examples
- Basics of process planning
  - Model building, cyclic planning, basic planning procedures, planning according to scopes for action, server-oriented planning methods, Comparison of different planning methods
- Synchronization and Real-time
  - Real-time operating systems, Concepts of synchronization of processes, Priority inversion, Priority Inheritance Protocol and Priority ceiling
- Computer networks and Real-time
  - Real-time specific classification of computer networks, time-rated bus protocols, time-rated network protocols, integration in process planning
- Further topics
  - Computer architecture, multiprocessor architecture, planning with multiprocessor systems

6 Usability of the module for other programs

M.Sc.- study programs of Faculty 4 (module 04IN2007)

7	**Prerequisites for Participation** none
8	**Method of Examination** Written exam (90 min) or oral exam (20 min) (module exam)
9	**Requirement for Credit points** Participation in Course 2 on a steady basis Passing the module exam
10	**Percentage of grade in final mark** 6/90
11	**Frequency of Course** Every third semester
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Dieter Zöbel Lecturers: Prof. Dr. Dieter Zöbel
13	**Further information** Optional compulsory module This module is either taught in German or English.

Module 04IN2026

Introduction to Web Science

Module code	Workload	Credit points	Semester	Duration
04IN2026	240 h	8 LP	1. or 2. master semester	1 semester

1	Courses	Contact time	Self study	Credit points
	1. 4320261 V Web Engineering	30 h	60 h	3 LP
	2. 4320262 V Semantic Web	30 h	60 h	3 LP
	3. 4320263 Ü Semantic Web	30 h	30 h	2 LP

2 Teaching form

Course 1:	Lecture (4 CH)
Course 2:	Lecture (4 CH)
Course 3:	Exercise (2 CH)

3 Group size

Course 1:	6 – 90 (Lecture)
Course 2:	6 – 90 (Lecture)
Course 3:	6 – 24 (Exercise)

4 Qualification target / Skills

The student should acquire an understanding of the Web as a complex socio-technical system. He should be able to relate problems and opportunities incurred in this system to the technical, social and economical foundations of the Web. He should be capable of choosing different research methods suitable for various challenges in understanding and engineering the Web.

5 Contents

- History of the Web
  - Pre-Web: Memex, Hypertext, Internet, usenet, ftp, gopher
  - Web 1.0, Web 2.0, Web 3.0
  - Social and economic growth
- Web Science and Web Science Methodologies
  - Descriptive, prescriptive, normative scientific methods:
  - What are descriptions and models of the Web?
  - What are the prerequisites for specific objectives (e.g. no government by single institution)?
  - Quantitative analytical and predictive methods
  - Simulation
- Web Architecture and Major Applications
  - http, HTML, Internet, web server, browser, transactions
  - User generated content, blogs, wikis, folksonomies, social networks

	- Semantic Web summary: XML, RDF, OWL, microformats, microdata - Web security • Web Government - Institutions: W3C, IETF, ICANN - Government: Privacy laws, Copyright laws - Principles and attacks: net neutrality, censorship • Web Content - Media and standards - Language and cultural diversity - Generative models - Rhetoric models in the Web - Web annotations (Tagging, metadata, Rich Snippets) • Web and User Behavior/HCI - Navigation behavior - Search behavior - Recommendations • Web and Social Behavior - Web reflecting social behavior - Web affecting social behavior • Web Structure - Link Structure, small world - Social network sites - Blogosphere • Web Analysis - Web measurements (size, performance,…) - Crawlers - Search engines - Web archiving • Web Economics - Advertisement, including cross site advertisements and search - Auctioning in search and online auctions
6	**Usability of the module for other programs** M.Sc.-study programs of Faculty 4 (module 04IN2026)
7	**Prerequisites for Participation** Basic understanding of computer science as is taught in a type-2 bachelor program. Expected knowledge will include basic capabilities of programming in a language like Java or C, algorithmic understanding, knowledge about basic data structures and basic internet networking.
8	**Method of Examination** Written exam (90 min) or oral exam (20 min) (module exam)

9	**Requirement for Credit points** Participation in Course 3 on a steady basis Passing the study work in Course 3 Passing the module exam
10	**Percentage of grade in final mark** 8/90
11	**Frequency of course** annually (summer semester)
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Steffen Staab Lecturers: Prof. Dr. Steffen Staab Ansgar Scherp Sergej Sizov York Sure
13	**Further information** Optional compulsory module This module is taught in English.

Module 04IN2032

Basics of embedded systems

Module code	**Workload**	**Credit points**	**Semester**	**Duration**
04IN2032	180 h	6 LP	1. or 2. master semester	1 semester

1	**Courses**	**Contact time**	**Self study**	**Credit points**
	1. 4320321 V Basics of embedded systems	30 h	60 h	3 LP
	2. 4320322 Ü Basics of embedded systems	30 h	60 h	3 LP

2 Teaching form

Course 1: Lecture (2 CH)

Course 2: Exercise (2 CH)

3 Group size

Course 1: 6 – 90 (Lecture)

Course 2: 6 – 24 (Exercise)

4 Qualification target / Skills

After attending the course the students are able to understand the hardware and software structure of simple embedded systems. The students should understand which relevant sectors of technological competences must come together and be implanted so that a functioning embedded system is generated. Especially basic processes and techniques of modeling will be applied and assessed. The students recognize that embedded systems must fulfill safety-relevant functions and their risk is to be assessed systematically. The course enables the students to open a scientific access to this subject.

5 Contents

- Introduction
  - motivation, definition of terms, delimitation, application examples
- Basics of embedded systems
  - Regulation technology, Kalman-Filter, Petri-Nets, Transformations, Fuzzy-Logic
- Hardware embedded systems
  - Processor and interface, energy-keeping operation, sensors and actors, bus systems
- Software embedded systems
  - Software architecture, Software technique, Model-based Software-development, basics of process planning (deadline scheduling, rate monotonic scheduling)
- Further topics
  - Safety norms, risk analysis, Wireless Sensor Networks, Cyber-Physical Systems

6 Usability of the module for other programs

M.Sc.-study programs of Faculty 4 (module 04IN2032)

7	**Prerequisites for Participation** Basic knowledge in operating systems
8	**Method of Examination** Written exam (90 min) or oral exam (20 min) (module exam)
9	**Requirement for Credit points** Participating in Course 2 on a steady basis Passing the module exam
10	**Percentage of grade in final mark** 6/90
11	**Frequency of Course** Every third semester
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Dieter Zöbel Lecturers: Prof. Dr. Dieter Zöbel
13	**Further information** Optional compulsory module This module is either taught in German or English.

Module 04IN2035

Wireless communication

Module code	Workload	Credit points	Semester	Duration
04IN2035	180 h	6 LP	1. or 2. master semester	1 semester

1	Courses	Contact time	Self study	Credit points
	1. 4320351 V Wireless communication	45 h	75 h	4 LP
	2. 4320351 Ü Wireless communication	15 h	45 h	2 LP

2 Teaching form

Course 1: Lecture (3 CH)

Course 2: Exercise (1 CH)

3 Group size

Course 1: 6 – 90 (Lecture)

Course 2: 6 – 24 (Exercise)

4 Qualification targets / Skills

The students know the basics of wireless communication. They are able to assess wireless systems analytically or simulatively. They know how special wireless communication forms are to be used and where the limits are. Last not least they can estimate the potential of wireless communication for exciting new applications.

5 Contents

- Deduction of physical models for wireless communication (e.g. Log- Rician-Fading and Rayleigh-Fading)
- Coding techniques that can be used especially for wireless communication (e.g. Convolutional codes)
- Special wireless media access control mechanisms (e.g. energy efficient MAC-Layer for wireless sensor nets)
- Mobile communication nets (e.g. GSM, UMTS, LTE)
- Wireless local nets (e.g. WLAN, Bluetooth, Infrared)
- Radio-Frequency-Identification (RFID)
- Mobile and wireless internetworking (e.g. MobileIP und TCP-adaption)

6 Usability of the module for other programs

M.Sc.-study programs of Faculty 4 (module 04IN2035)

7 Prerequisites for Participation

Knowledge of the layer model for communication systems and general processes of bit transfer, connection securing, media access control, networking level and transport layer

8 Method of Examination

Written exam - 90 min (module exam)

9	**Requirement for Credit points** Participating in Course 2 on a steady basis Passing the module exam
10	**Percentage of grade in final mark** 6/90
11	**Frequency of Course** irregularly
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Hannes Frey Lecturers: Prof. Dr. Hannes Frey
13	**Further information** Optional compulsory module

Module 04WI2001 **Advanced Enterprise Information Management**					
Module code 04WI2001		**Workload** 180 h	**Credit points** 6 LP	**Semester** 1. or 2. master semester	**Duration** 1 semester
1	**Courses**		**Contact time**	**Self study**	**Credit points**
	1. 4420011 V Advanced Enterprise Information Management		30 h	60 h	3 LP
	2. 4420012 S/Ü Advanced Enterprise Information Management		30 h	60 h	3 LP
2	**Teaching form** Course 1: Lecture (2 CH) Course 2: Seminar/Exercise (2 CH)				
3	**Group size** Course 1: 6 – 90 (Lecture) Course 2: 6 – 24 (Seminar/Exercise)				
4	**Qualification targets / Skills** On completion of this course a good student will understand the range of user-centred design approaches and be able to apply them to the design of digital information products and services. Specifically students should be able to: - select and apply appropriate methods for the design, development and management of digital information products - take an holistic user-centered approach to information design and management that takes into account design, use and organizational requirements - demonstrate an understanding of relevant information design and management theory and the limitations of such theory in practice				
5	**Contents** This course builds on the Bachelor course to provide an advanced course in Enterprise Information Management. The course focuses on methods and techniques for the analysis, design and management of digital information products and services. Topics covered include: - Digital content management & content re-use methods - Information needs analysis and information audit - Information design & information organization - Content management systems, mashups, information services - User-centered design methodologies & usability testing				
6	**Usability of the module for other programs** M.Sc. Informationsmanagement (Module 04WI2001)				
7	**Prerequisites for Participation** Basic knowledge of business administration in particular organizational forms and business processes as well as foundations of information systems.				
8	**Method of Examination** Lecture course: Exam paper (4 weeks) Seminar course: Information product development, technical report and presentation (30min) (Module exam)				

9	**Requirement for Credit points** Passing the module exam
10	**Percentage of grade in final mark** 6/90
11	**Frequency of Course** Annually (Summer semester)
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Sue P. Williams Lecturers: Prof. Dr. Sue P. Williams
13	**Further information** Optional compulsory module

Module 04WI2013 **Enterprise Architecture Modeling**					
Module code		**Workload**	**Credit points**	**Semester**	**Duration**
04WI2013		180 h	6 LP	1. or 2. Master-Semester	1 Semester
1	**Courses**		**Contact time**	**Self-study**	**Credit points**
	1. 4420131 V Enterprise Architecture Modeling		30 h	90 h	4 LP
	2. 4420132 Ü Enterprise Architecture Modeling		15 h	45 h	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, FEAF, 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 organizational 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 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. Maria Wimmer
13	**Further information** Optional Compulsory Module

Module 04WI2024 **IT-Risk-Management**				
Module code 04WI2024	**Workload** 180 h	**Credit points** 6 LP	**Semester** 1. or 2. master semester	**Duration** 1 semester

1	**Courses**	**Contact time**	**Self study**	**Credit points**
	1. 4420241 V IT-Risk-Management	30 h	60 h	3 LP
	2. 4420242 S/Ü IT-Risk-Management	30 h	60 h	3 LP

2	**Teaching form** Course 1: Lecture (2 CH) Course 2: Seminar/Exercise (2 CH)
3	**Group size** Course 1: 6 – 90 (Lecture) Course 2: 6 – 24 (Seminar/Exercise)
4	**Qualification targets / Skills** The students know about the safety risks of chosen applications in the information and communication technology, especially the internet. They are able to distinguish and evaluate the technical, organizational and legal actions in order to control (management) IT-risks according to the respective applications. They can select the appropriate methods for the safety analysis, evaluate the respective strengths and weaknesses and apply them on specific, moderately complex scenarios.
5	**Contents** General security risks for the use of IT are analyzed and attack scenarios are introduced. More complex security analyses are presented in detail and concepts and models for protection of IT-security are developed. Furthermore, criteria (e.g. Common Criteria, ISO/IEC 17799) for evaluating IT-security are presented. Some selected applications like data protection technology, electronic voting and fair exchange are covered in detail. • Costs and benefits of IT risk management • Security Concepts • Security Assessments • Business Continuity • Fraud Management • IT-Security Models • Media Law from the Computer Science point of view • Data protection disrupting and data protection supporting IT • Electronic Voting • Penetration of computers and networks • Fair Exchange and general equilibrium models
6	**Usability of the module for other programs** M.Sc. Information Management (Module 04WI2024)

7	**Prerequisites for Participation** Basic knowledge in IT-security. Especially applying encryption-, signature- and authorization procedures related with the classical security demands of information- and communication applications in networks.
8	**Method of Examination** Written exam (90 min) (module exam)
9	**Requirement for Credit points** Qualified participation (maximum 2 absences) Passing the module exam
10	**Percentage of grade in final mark** 6/90
11	**Frequency of Course** annually (summer semester)
12	**Module Coordinator and Lecturer** Module Coordinator: Prof. Dr. Rüdiger Grimm Lecturers: Prof. Dr. Rüdiger Grimm
13	**Further information** Optional compulsory module