EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

**Mathematisch-
Naturwissenschaftliche
Fakultät**

Department of Mathematik

Module Handbook

Computer Science – Physics – Mathematics

Master of Education
Quereinstieg Lehramt Gymnasium*

Winter Semester 2025

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*This is a secondary school teaching degree with a major in two of the three subjects computer science, physics and mathematics.

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1 Description of Study Programme

1.1 Basic Information about the Study Programme

1.1.1 Fundamentals

In a letter dated 14 August 2018, the Ministry of Science, Research and the Arts called on the universities in Baden-Württemberg to allow access to the Master of Education programme in computer science and physics with a Bachelor's degree without teaching-related elements in order to counteract the acute shortage of teachers in both subjects. Mathematics is listed as a suitable second subject in the letter. This module handbook describes the study programme concept of the University of Tübingen for a separate Master of Education Teacher Training for Secondary School in the three subject combinations Computer Science-Mathematics, Computer Science-Physics and Mathematics-Physics for graduates with a Bachelor of Science degree without teaching-related components in one of the three subjects with substantial components in the chosen second subject.

The achievements of this study programme are designed in such a way that the graduates of the study programme, in combination with the achievements acquired in their Bachelor of Science degree programme, have essentially acquired the competences to be acquired in a regular consecutive teacher training course and that the content requirements of the Framework Ordinance for Teacher Training Courses (RahmenVO-KM) of 27 April 2015 have been met, as required in the letter from the Ministry.

1.1.2 Study Objective

The study programme leads to the degree Master of Education lateral entry for secondary school with one of the following subject combinations

- Computer Science and Mathematics,
- Computer Science and Physics or
- Mathematics and Physics

on the basis of the letter from the Ministry of Science, Research and the Arts dated 14 August 2018 for admission to the preparatory service for secondary school teaching in Baden-Württemberg, and it enables access to the teaching profession in the state of Baden-Württemberg after successful completion of the preparatory service. However, it must be pointed out that it cannot be guaranteed that the qualification will entitle the holder to preparatory service or subsequent employment in the teaching profession in another federal state.

1.1.3 Admission Requirements

Applicants who have completed a Bachelor of Science degree in *Computer Science* at the University of Tübingen with a grade of 2.5 or better or a degree in a related study programme with essentially the same content and qualification aims at a university may be admitted to the Master of Education Quereinstieg Lehramt Gymnasium with the subject combinations *Computer Science and Mathematics* or *Computer Science and Physics* if they fulfil the requirements set out in section 2.3 or comparable achievements in the respective second subject of Mathematics or Physics.

Applicants who have completed a Bachelor of Science degree in *Mathematics* at the University of Tübingen with a grade of 2.5 or better or a degree in a related study programme with essentially the same content and qualification aims at a university may be admitted to the Master of Education Quereinstieg Lehramt Gymnasium with the subject combinations *Mathematics and Computer Science* or *Mathematics and Physics* if they fulfil the requirements set out in section 2.3 or comparable achievements in the respective second subject of Computer Science or Physics.

Applicants who have obtained a Bachelor of Science degree in *Physics* at the University of Tübingen with a grade of 2.5 or better or a degree in a related study programme with essentially the same content and qualification aims at a university may be admitted to the Master of Education Quereinstieg Lehramt Gymnasium with the subject combinations *Physics and Computer Science* or *Physics and Mathematics* if they fulfil the requirements set out in the section 2.3 or comparable achievements in the respective second subject Computer Science or Mathematics.

If a maximum of 30 credit points (CP) are missing from the additional achievements required in the second subject, admission may be granted subject to a condition. Proof of the missing credits must then be provided by the time of registration for the Master's thesis.

In addition to the previously listed admission requirements, proof of participation in a study orientation procedure for teacher education students (teacher orientation test) must be provided. Further information can be found on the university's website for study orientation procedures.

1.1.4 Structure of the Study Programme

Starting a Master's degree programme in teaching with a Bachelor's degree without teaching-related components means that the study requirements of students will vary greatly from student to student. This requires individual counselling for each and every student with regard to the structure and design of their degree programme. All students on this degree programme should therefore attend a study consultation with the Faculty Course Advisor for the teaching degree in their chosen second subject at the beginning of their studies and discuss an individual study plan with the advisor, that takes into account the previous knowledge and special circumstances of the respective student.

1.1.5 Time Frame for Studying Abroad

It is not possible to specify a specific time frame for a study component at a foreign university for this degree programme, as the study structure will be too individual and different. This can only be planned in a personal counselling interview with the Faculty Course Advisor.

1.2 Qualification Objectives

As part of the teaching-related Master's degree programme Master of Education Quereinstieg Lehramt Gymnasium – Informatik, Physik, Mathematik graduates acquire fundamental and in-depth subject-specific and subject-related didactic knowledge and skills in the chosen subject combination, as required necessary for science-based teaching at secondary schools. These enable them to carry out targeted teaching, learning and educational processes in the selected subjects and to independently integrate new subject-specific and subject-linking developments into teaching and school development independently.

1.2.1 Qualification Objectives in Computer Science

Graduates have the following competences:

- They are able to recognise, evaluate and explain computer science issues in various application contexts and factual contexts as well as social effects.
- They are able to analyse and structure real-life situations in order to make them accessible for processing using computer science methods.
- They can transfer computer science-specific content concepts and process concepts to other fields of application and use their acquired computer science skills in non-computer science contexts.
- They know the longevity and transferability of central computer science concepts.
- They are familiar with the various perspectives and working methods of computer science, from engineering approaches such as analysis and design, to mathematical methods for gaining knowledge such as formalisation and proof, to social science and empirical methods such as experimentation and simulation.
- They can convey computer science concepts such as data modelling and data structuring when using standard applications (text, image, audio, video editors, spreadsheets).
- They can characterise computer science as a discipline and reflect on the function and image of computer science and computer science education in society.
- They can reflect on current development trends in school computer science, evaluate the content and represent a critical openness with regard to new developments in computer science.
- They can establish links between their specialised knowledge and school computer science.

1.2.2 Qualification Objectives in Mathematics

Graduates are familiar with the basic problems in linear algebra, analysis, numerical mathematics, stochastics, geometry and algebra and have mastered the central techniques for solving them. They acquire basic mathematical thinking patterns such as structuring problems, creating argumentation chains and finally proving mathematical theorems. Graduates are able to communicate mathematical facts, use suitable media and establish links to school mathematics.

Building on the fundamental issues mentioned above, they expand their material and methodological skills in a compulsory elective area from the specialisations offerd in Tübingen: Algebra and Geometry, Analysis and Differential Geometry, Mathematical Physics, Numerical Mathematics and Optimisation or Stochastics.

Graduates are proficient in the theoretical explanatory approaches as well as in principles and methods in mathematics. They are able to give exemplary descriptions of the current state of research and are able to critically scrutinise this. Graduates can apply their in-depth knowledge to develop and solve their own simple research ideas. They will be able to derive, analyse, prove and interpret specific questions from general mathematical concepts. Graduates can explain and discuss the results of their research work in depth to a scientific audience, both in writing and orally.

1.2.3 Qualification Objectives in Physics

Graduates are familiar with the fundamental issues of classical and modern physics and have mastered the basic working and cognitive methods of physics. They are familiar with the fundamental concepts, modelling and approaches of physics. They can formulate simple physical problems mathematically and solve them exactly or approximately. They can explain the social significance of physics and evaluate social discussions and developments from a physical point of view.

Graduates have specialised knowledge of physics that enables them to plan student-oriented lessons. They are able to follow recent physics research in overview presentations and introduce suitable new topics into the classroom. They are able to set up and carry out teacher and student experiments. Students understand the fundamental ways of thinking in modern physics and are able to describe the transition from classical to modern physics, also in a historical context. They are able to carry out experiments and know the relevant underlying methods of analysis and interpretation. They are able to independently find solutions to physical problems and can apply the essential principles of physics to solve specific tasks. To do so, they are familiar with the basic concepts and methods of mathematics for describing physical facts.

Students are able to communicate the ways of thinking and working in physics in an understandable way and enable active participation in social development through their physics education.

1.2.4 Qualification Objectives in Subject-Didactics

Graduates combine their subject-specific knowledge with didactic methods, use suitable media and are able to use theoretical concepts and empirical findings from subject-related teaching and learning research to analyse thought processes and ideas of pupils in approaches and to guide individual learning processes. They know and evaluate the concepts for learning and teaching the chosen subjects at school on the basis of didactic theories and empirical findings. They can analyse and plan subject lessons in the selected subjects with heterogeneous learning groups on the basis of subject didactic concepts. Graduates are familiar with gender-specific aspects of their subjects and are able to plan lessons didactically and methodically in a gender-appropriate way. They are able to explain the fundamental educational value of subject-related content and methods as well as the social significance of the chosen subjects and place them in the context of the objectives and content of the lessons.

They have mastered the didactic concepts of student-oriented teaching. They have gained initial reflective experience in planning, designing and implementing competence-oriented lessons and are able to cooperate with colleagues from other science subjects in order to plan coordinated lessons.

1.2.5 Qualification Objectives in the Educational Sciences

The Educational Science study programme (BWS) as part of the Master's degree programme for lateral entry to teaching computer science, physics and mathematics at secondary schools prepares graduates for a scientifically sound and professional career in schools and teaching. Graduates learn about fundamental and in-depth educational science issues. Through the academic introduction to the school internship semester and its reflection, graduates are able to reflect academically on their practical school experience.

The overarching objective of the degree programme is to support students in developing their educational science knowledge and their educational science skills and abilities. They acquire professional knowledge and expand their professional skills, analyse and reflect on their professional development on the basis of scientific theories, methods and empirical findings and use the portfolio as an instrument to document their competence-related and reflective professional development.

The framework regulation for teacher training formulates a competence profile in the educational sciences (Kultus und Unterricht of 13 July 2015, p. 287): *Graduates have professional competences and know the importance of contemporary education. They are familiar with educational science and psychology, as well as sociological, theological, philosophical, ethical and political science aspects of education. They know the Christian and Western educational and cultural values. At the same time, they take into account age-appropriate forms of teaching, principles of education for sustainable development, media pedagogical and gender-related findings and attach particular importance to the development of personal skills. They are able to co-operate with parents, promote intercultural competence and have diagnostic and support skills, particularly with regard to integrative and inclusive educational programmes. On this basis, they are able to organise and reflect on their educational activities. The teacher training programme guides them to develop their profession, analyse their own professional development and their future work at school on the basis of research findings. Graduates have the competence, commensurate with their level of training, to design student-oriented lessons that are characterised by appreciation and professionalism. Graduates have basic knowledge of how to organise lessons in a motivating and individually supportive way, even in heterogeneous learning groups. They see themselves as responsible actors in the education system and are familiar with the social and political framework for their actions. They have basic research methodological skills in order to analyse their actions in lessons and schools and to be able to interpret relevant research results appropriately and critically. Graduates understand the need to continuously develop their professional skills and to make use of the support and counselling services offered by institutionalised teacher training for their professional development.*

This makes it clear that students in teaching are confronted with a broad educational policy horizon that places multiple demands on teacher training in educational science. In order to prepare students for these requirements in the educational science degree programme (BWS), it cannot be the aim of the university degree programme to technically practise later professional activities nor to place directly usable skills at the centre of the discussion. Instead, flexible skills and abilities must be acquired based on knowledge. The repeatedly expressed desire for greater practical relevance in the sense of imparting practical and professional knowledge may be understandable in view of the later professional profile, but ultimately falls short: teaching and learning processes in schools and lessons are highly complex, cannot be standardised and normed and always take place in specific contexts. Prescriptive approaches cannot do justice to these processes and contradict the development of a balanced and professional attitude towards new economic, social, political or cultural developments. The teaching profession in particular is a profession that is constantly and very directly confronted with diverse social developments and has to deal with the expectation of analysing such changes on the basis of scientific findings, reflecting critically on them and, under certain circumstances, taking them up in professional action. Despite these objections to praxeological work in the study programme, the question of whether the content and skills taught in educational science studies are relevant to practice and action for graduates can be affirmed with certainty. However, their relevance is not limited to this.

The degree programme does not prescribe specific actions in certain situations, but offers the potential to develop skills for analysing, criticising and developing any practice in schools and lessons and to provide well-founded categories, theories and methods. Students are expected to acquire relevant knowledge and flexible skills and abilities in the competency areas of a) teaching, b) educating, c) assessing, and d) innovating (specification of the Ministry of Education and Cultural Affairs: Kultus und Unterricht of 13 July 2015, p. 291-292; see also portfolio work) acquire the relevant knowledge and flexible skills and abilities that are required for successful and reflective teacher behaviour in practical school situations.

The Educational Science degree programme (BWS) offers a systematic approach to the micro, meso and macro levels of schooling. The School Internship Semester is prepared and followed up with references to theories and empirical research findings and reflected on through case work in the portfolio. The Inclusion, Diversity and Heterogeneity module focuses on linguistic heterogeneity. The module Empirical Educational Research and Educational Psychology introduces basic questions of empirical educational research and key educational-psychological topics for the teaching profession.

2 Study Plans

2.1 Overview by Modules

Here we provide an overview of the modules that can be taken in the individual areas of study depending on the chosen combination of subjects and the creditable prior achievements. Detailed information on the programme structure and the study plans in the various combination options can be found below.

ST	Module Number	Module Title	Type of Course	Type of Module	Course-work	Type of Exam	ECTS-Points
Section 1: 2nd Subject Computer Science							
3-4	INFL20	Elective Module I	L+P	PMW		wr. o. or.	6
1-4	INFM2111	Practical Computer Science 3: Software Engineering	L+E	PMW	EC	wr.	6
1-3	INFM2310	Computer Engineering 2: Computer Science of Systems	L+E	PM	EC	wr.	9
1-3	INFM2410	Theoretical Computer Science 2: Formal Languages, Computability, and Complexity	L+E	PM	EC	wr.	9
1-3	INFM2420	Theoretical Computer Science 1: Algorithms and Data Structures	L+E	PM	EC	wr.	9
3-4	INFM3110	Elective Subject in Practical Computer Science	L+P	PMW		wr. o. or.	6
3-4	INFM3310	Elective Subject in Computer Engineering	L+P	PMW		wr. o. or.	6
3-4	INFM3410	Elective Subject in Theoretical Computer Science	L+P	PMW		wr. o. or.	6
Section 2: 2nd Subject Mathematics							
1	MAT-10-11	Consolidation of the Foundations of Mathematics		PM		wr. o. or.	6
		- Algebraic Structures	L+E		EC		
		- Mathematical Software	P		PC		
1-4	MAT-20-02	Introduction to Complex Analysis and Ordinary Differential Equations	L+E	PM	EC	wr. o. or.	9
1-4	MAT-20-11	Numerical Mathematics	L+E	PM	EC	wr. o. or.	9
1-4	MAT-20-12	Stochastics	L+E	PM	EC	wr. o. or.	9
2-4	MAT-20-03	Algebra	L+E	PM	EC	wr. o. or.	9
2-4	MAT-20-20	Proseminar: Presentations in Mathematics	PS	PMW	s.M.	Pr	3

2-4	MAT-50-01	Geometry	L+E	PM	EC	wr. o. or.	9
3-4	MAT-40-51	Specialisation	L+E	PMW	EC	wr. o. or.	9
Section 3: 2nd Subject Physics							
1-2	BLP03	Physics Basic Course 3	L+E+or.	PM	EC	wr.	12
2-3	BLP04	Modern Physics A	L+E	PMW	EC	wr.	12
1-2	BLP05PP1	Physics Laboratory 1	P	PM	s.M.	-	6
2-3	BLP06PP2	Physics Laboratory 2	P	PM	s.M.	-	6
3-4	MLP14	Modern Physics D	L+L	PMW		wr.	9
Section 4: Didactics							
1-2	INFL01	Subject Didactics in Computer Science I	S	PM	s.M.	K o. mP o. R o. H	3
2-3	INFL02	Subject Didactics in Computer Science II	L+E	PM		K o. mP o. R o. H	6
3-4	INFL03a	Subject Didactics in Computer Science IIIa (MEd IPM)	S	PM	s.M.	K o. mP o. R o. H	3
1-2	MAT-80-01	Subject Didactics Mathematics 1	LIC	PM	s.M.	K o. mP o. P	3
2-3	MAT-80-04	Subject Didactics Mathematics 2 (MEd-IPM)	SV	PM	s.M.	K o. mP o. R o. H	3
3-4	MAT-80-05	Subject Didactics Mathematics 3: Professional Knowledge	S	PM	s.M.	K o. mP o. R o. H	3
3-4	MAT-80-06	Subject Didactics Mathematics 3: Elective Specialisation	S	PMW	s.M.	K o. mP o. R o. H	3
1-2	BLP05F	Subject Didactics in Physics 1	S	PM	s.M.	wr. o. or.	3
2-3	BLP06F	Subject Didactics Physics 2	S	PM	s.M.	wr. o. or.	3
2-3	BLP06S	Subject Didactics in Physics 3 (MEd-IPM)	S,P	PM	s.M.	wr. o. or.	3
3-4	MLP10F	Subject Didactics in Physics 4	Sü	PM	s.M.	-	3
3-4	MLP12F	Subject Didactics in Physics 5	ü	PM	s.M.	wr. o. or.	3
Section 5: Education							
1-2	BWS-ME0	Educational Sciences 1 (MEd-IPM)	L+S	PM	-	wr. o. or.	5
1-2	BWS-ME1	School Pedagogy I	S+S	PM	-	mP o. K	6
2-3	BWS-ME3	Inclusion, Diversity, and Heterogeneity	L+L	PMW	-	wr.	6
3-4	BWS-ME4	Empirical Educational Research and Educational Psychology	L	PM	-	wr.	6
Section 6: School Practise Semester							
2-3	SP	School Practice Semester	-	PM	s.M.	-	16

Section 7: Master Thesis							
4	INFL31	Master Thesis Computer Science	MT	PM	s.M.	MT	15
4	MAT-40-53	Master Thesis	MT	PM	s.M.	MT	15
4	MLP13	Master Thesis (Physics)	MT	PM	s.M.	MT	15
Section 8: Requirements							
-	BLP01	Physics Basic Course 1	L+E	PM	EC	wr.	12
-	BLP02	Physics Basic Course 2	L+E	PM	EC	wr.	12
-	INFM1010	Mathematics for Computer Science 1: Analysis	L+E	PM	EC	wr.	9
-	INFM1020	Mathematics for Computer Science 2: Linear Algebra	L+E	PM	EC	wr.	9
-	INFM1110	Practical Computer Science 1: Declarative Programming	L+E	PM	EC	wr.	9
-	INFM1120	Practical Computer Science 2: Imperative and Object-Oriented Programming	L+E	PM	EC	wr.	9
-	INFM2010	Mathematics for Computer Science 3: Advanced Topics	L+E	PM	EC	wr.	9
-	INFM2020	Mathematics for Computer Science 4: Numerical Methods or Stochastics	L+E	PM	EC	wr.	6
-	MAT-10-01	Analysis		PM		or.	18
		- Analysis 1	L+E+T		EC		
		- Analysis 2	L+E+T		EC		
-	MAT-10-02	Linear Algebra		PM		or.	18
		- Linear Algebra 1	L+E+T		EC		
		- Linear Algebra 2	L+E+T		EC		
-	MP1	Mathematics for Physicists 1	L+E	PM	EC	wr. o. or.	9
-	MP2	Mathematics for Physicists 2	L+E	PM	EC	wr. o. or.	9
-	MP3	Mathematics for Physicists 3	L+E	PM	EC	wr. o. or.	9
-	MP4	Mathematics for Physicists 4	L+E	PM	EC	wr. o. or.	6

Abbreviations:

Type of Module : PM=compulsory module, PMW=compulsory module with choice, WPM=elective module
Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Course Work : EC=exercise certificate, PEC=practical exercise certificate, PC=practical certificate
Other : h=hours, o.=or, s.M.=see module description, ST=suggested term

2.2 Basic Programme Structure

The following table shows how the credit points are distributed across the different areas of study.

Number	Study Area	Credit Points (CP)
0	First Subject	0 CP
1–3	Second Subject	45 CP
4	Subject Didactics (1st+2nd Subject)	21 CP
5	Education Science	23 CP
6	School Practice Semester	16 CP
7	Master Thesis	15 CP
	Sum	120 CP

2.3 Programme Structure in Study Area Second Subject

In the following sections, the expected preliminary work in the second Subject and the modules to be completed are listed in tabular form for the various subject combinations, in each case indicating the first and second Subject.

2.3.1 Degree B.Sc. Computer Science, 2nd Subject Mathematics

For the second subject Mathematics, the following prior achievements from the Bachelor of Science Computer Science degree programme at the University of Tübingen or comparable achievements from another degree programme justifying admission to the degree programme are required.

Preliminary work for the second subject Mathematics*	
Mathematics for Computer Science 1: Analysis (INFM1010)	9 CP
Mathematics for Computer Science 2: Linear Algebra (INFM1020)	9 CP
Mathematics for Computer Science 3: Advanced Topics (INFM2010)	9 CP
Mathematics for Computer Science 4: Numerical Methods or Stochastics (INFM2020) (depending on choice)	6 CP
Sum	33 CP

The following modules must be completed in the second subject area. These are entire modules from the subject Mathematics in the Bachelor's and Master's of Education Lehramt Gymnasium degree programmes.

ST	Module Number	Module Title	Type of Course	Type of Module	Course-work	Type of Exam	ECTS-Points
Section 1: 2nd Subject Mathematics							
1	MAT-10-11	Consolidation of the Foundations of Mathematics		PM		Wr. o. Or.	6
		- Algebraic Structures	L+E		EC		
		- Mathematical Software	P		PN		

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*All information provided here refers to the study and examination regulations of the University of Tübingen for the Computer Science degree programme with academic final examination Bachelor of Science (B. Sc.) in the version of 25.03.2021 (Amtl.Bek.UT 10/2021, p. 293) or the study and examination regulations and Examination Regulations of the University of Tübingen for the Mathematics degree programme with academic Bachelor of Science (B. Sc.) degree programme in the version dated 5 August 2019 (Amtl.Bek.UT 15/2019, p. 443); the relevant examination board decides on the recognition of other achievements.

1-4	MAT-20-02	Introduction to Complex Analysis and Ordinary Differential Equations	L+E	PM	EC	Wr. o. Or.	9**
1-4	MAT-20-11	Numerical Mathematics	L+E	PM	EC	Wr. o. Or.	9*
1-4	MAT-20-12	Stochastics	L+E	PM	EC	Wr. o. Or.	9*
2-4	MAT-20-03	Algebra	L+E	PM	EC	Wr. o. Or.	9
2-4	MAT-20-20	Proseminar Mathematical Presentations	PS	PMW	s.M.	Pres	3
2-4	MAT-50-01	Geometry	L+E	PM	EC	Wr. o. Or.	9
3-4	MAT-40-51	Consolidation of Special Areas of Mathematics	L+E	PMW	EC	Wr. o. Or.	9**
						Sum	45 CP

* The Stochastics module can only and must be taken if Numerical Methods was taken as part of the prerequisites. The Numerical Mathematics module can only and must be taken if Stochastics has been taken as part of the prerequisites; in this case, with the approval of the examination board, the Numerical Mathematics module can also be replaced by the Mathematics for ComputerScience 4: Numerical Methods module from the Bachelor of Science - Computer Science degree programme (6 ECTS) and a further module from the Master of Science - Mathematics degree programme (3 ECTS). As the module Mathematics for Computer Science: Numerical Methods is offered in the summer semester, a more suitable study plan can be created if necessary.
** One of the modules “Introduction to Complex Analysis and Ordinary Differential Equations’ and “Consolidation of Special Topics in Mathematics’ must be taken.

Abbreviations:
Type of Module : PM=compulsory module, PMW=compulsory module with choice, WPM=elective module
Examination Type : MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Course Work : EC=exercise certificate, PEC=practical exercise certificate, PC=practical certificate
Other : h=hours, o.=or, s.M.=see module description, ST=suggested term

2.3.2 Degree B.Sc. Computer Science, second Subject Physics

For the second subject Physics, the following prior achievements from the Bachelor of Science Computer Science degree programme at the University of Tübingen or comparable achievements from another degree programme justifying admission to the degree programme are required.

Prerequisites for the second subject Physics[†]	
Two of the three modules Mathematics for Computer Science 1-3 (INFM1010, INFM1020, INFM2010)	$\geq$ 12 CP
Physics Basic Course 1 (PGK1)	12 CP
Physics Basic Course 2 (PGK2)	12 CP
Sum	36 CP
The modules Physics Basic Course 1 and Physics Basic Course 2 can be completed in the Bachelor of Science Computer Science degree programme at the University of Tübingen in the area of specialisation with 18 CP.	

[†] All information provided here refers to the study and examination regulations of the University of Tübingen for the degree programme Computer Science with academic final examination Bachelor of Science (B. Sc.) in the version of 25.03.2021 (Amtl.Bek.UT 10/2021, p. 293) or the study and examination regulations of the University of Tübingen for the degree programme Physics with academic final examination Bachelor of Science (B. Sc.) in the version dated 30 July 2013 (Amtl.Bek.UT 16/2013, p. 787); the responsible examination board decides on the recognition of other achievements.

The following modules must be completed in the 2nd subject area. These are entire modules from the subject of physics in the Bachelor's and Master's of Education Lehramt Gymnasium degree programmes.

ST	**Module Number**	**Module Title**	**Type of Course**	**Type of Module**	**Course-work**	**Type of Exam**	**ECTS-Points**
Section 1: 2nd Subject Physics							
1-2	BLP03	Physics Basic Course 3	L+E+Or.	PM	EC	Wr.	12
2-3	BLP04	Modern Physics A*	L+E	PM	EC	Wr.	12
1-2	BLP05PP1	Practical Course in Physics 1	P	PM	s.M.	-	6
2-3	BLP06PP2	Practical Course in Physics 2	P	PM	s.M.	-	6
3-4	MLP14	Modern Physics D	L+E	PM	EC	Wr.	9
						Sum	45 CP

* The module “Modern Physics A' can also be completed by successful participation in the “Basic Module Quantum Mechanics' from the Bachelor of Science - Physics programme (9 CP) as well as by completing the "Molecules, Atom, Light" part of the "Modern Physics A" module. As the "Basic Module Quantum Mechanics" is offered in the summer semester, a more suitable study plan can be created in this way. Both the module “Modern Physics A' and the “Basic Module Quantum Mechanics' require basic knowledge of analytical mechanics, which is taught, for example, in the module "Basic Physics 3". The replacement of the module “Modern Physics A' should only be done in consultation with the Faculty Course Advisor.

Abbreviations:
Type of Module : PM=compulsory module, PMW=compulsory module with choice, WPM=elective module
Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Course Work : EC=exercise certificate, PEC=practical exercise certificate, PC=practical certificate
Other : h=hours, o.=or, s.M.=see module description, ST=suggested term

2.3.3 Degree B.Sc. Mathematics, second Subject Computer Science

For the second subject Computer Science, the following prior achievements from the Bachelor of Science Mathematics degree programme at the University of Tübingen or comparable achievements from another degree programme justifying admission to the degree programme are required.

Prerequisites for the second subject Computer Science[‡]	
Analysis (MAT-10-01)	9 CP
Practical Computer Science 1: Declarative Programming (INFM1110)	9 CP
Practical Computer Science 2: Imperative and Object-Oriented Programming (INFM1120)	9 CP
Sum	27 CP

The modules Practical Computer Science 1 and Practical Computer Science 2 can be completed in the Bachelor of Science Mathematics degree programme at the University of Tübingen as part of the section Elective Specialisation.

The following modules must be completed in the 2nd subject area. These are entire modules from the subject Computer Science in the Bachelor's or Master's of Education Lehramt Gymnasium programmes.

[‡] All information provided here refers to the study and examination regulations of the University of Tübingen for the degree programme Computer Science with academic final examination Bachelor of Science (B. Sc.) in the version dated 23 May 2021 (Amtl.Bek.UT 10/2021, p. 293) or the study and examination regulations of the University of Tübingen for the degree programme Mathematics with academic final examination Bachelor of Science (B. Sc.) in the version dated 05.08.2019 (Amtl.Bek.UT 15/2019, p. 443); the responsible examination board decides on the recognition of other achievements.

ST	**Module Number**	**Module Title**	**Type of Course**	**Type of Module**	**Course-work**	**Type of Exam**	**ECTS-Points**
Section 1: 2nd Subject Computer Science							
1-4	INFM2111	Practical Computer Science 3: Software Engeneering	L+E	PM	EC	Wr.	6
1-3	INFM2310	Computer Engeneering 2: Computer Science of Systems	L+E	PM	EC	Wr.	9
1-3	INFM2410	Theoretical Computer Science 2: Formal languages, computability and complexity	L+E	PM	EC	Wr.	9
1-3	INFM2420	Theoretical Computer Science 1: Algorithms and Data Structures	L+E	PM	EC	Wr.	9
3-4	INFL20	Compulsory Elective Module I	L+E	PMW	EC	Wr. o. Or.	6
3-4	INFM3110	Elective Subject Practical Computer Science	L+P	PMW		Wr. o. Or.	6*
3-4	INFM3310	Elective Subject Computer Engeneering	L+P	PMW		Wr. o. Or.	6*
3-4	INFM3410	Elective Subject Theoretical Computer Science	L+P	PMW		Wr. o. Or.	6*
						Sum	45 CP

*Only one of the compulsory elective modules Practical Computer Science, Computer Engineering and Theoretical Computer Science needs to be taken.

Abbreviations:

Type of Module	: PM=compulsory module, PMW=compulsory module with choice, WPM=elective module
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Course Work	: EC=exercise certificate, PEC=practical exercise certificate, PC=practical certificate
Other	: h=hours, o.=or, s.M.=see module description, ST=suggested term

2.3.4 Degree B.Sc. Mathematics, second Subject Physics

For the second subject Physics, the following prior achievements from the Bachelor of Science Mathematics degree programme at the University of Tübingen or comparable achievements from another degree programme justifying admission to the degree programme are required.

Prerequisites for the second subject Physics[§]	
Analysis (MAT-10-01) + Linear Algebra (MAT-10-02)	$\geq$ 12 CP
Physics Basic Course 1 (PGK1)	12 CP
Physics Basic Course 2 (PGK2)	12 CP
Sum	36 CP

The modules Physics Basic Course 1 and Physics Basic Course 2 can be completed in the Bachelor of Science Mathematics degree programme at the University of Tübingen as part of the section Elective Specialisation.

[§] All information provided here refers to the study and examination regulations of the University of Tübingen for the degree programme Physics with academic final examination Bachelor of Science (B. Sc.) in the version of 30 July 2013 (Amtl.Bek.UT 16/2013, p. 787) or the study and examination regulations of the University of Tübingen for the degree programme Mathematics with academic final examination Bachelor of Science (B. Sc.) in the version dated 05.08.2019 (Amtl.Bek.UT 15/2019, p. 443); the responsible examination board decides on the recognition of other achievements.

The following modules must be completed in the 2nd subject area. These are entire modules from the subject of physics in the Bachelor's and Master's of Education Lehramt Gymnasium degree programmes.

ST	Module Number	Module Title	Type of Course	Type of Module	Course-work	Type of Exam	ECTS-Points
Section 1: 2nd Subject Physics							
1-2	BLP03	Physics Basic Course 3	L+E+Or.	PM	EC	Wr.	12
2-3	BLP04	Modern Physics A*	L+E	PM	EC	Wr.	12
1-2	BLP05PP1	Practical Course in Physics 1	P	PM	s.M.	-	6
2-3	BLP06PP2	Practical Course in Physics 2	P	PM	s.M.	-	6
3-4	MLP14	Modern Physics D	L+E	PM	EC	Wr.	9
						Sum	45 CP

* The module “Modern Physics A' can also be completed by successful participation in the “Basic Module Quantum Mechanics' from the Bachelor of Scinece - Physics programme (9 CP) as well as by completing the "Molecules, Atom, Light" part of the "Modern Physics A" module. As the "Basic Module Quantum Mechanics" is offered in the summer semester is offered in the summer semester, a more suitable study plan can be created in this way. Both in the module “Modern Physics A' and in the “Basic Module Quantum Mechanics' basic knowledge of analytical mechanics is required, which is taught, for example, in the module "Basic Physics 3". The replacement of the module “Modern Physics A' should only be only be done in consultation with the Faculty Course Advisor.

Abbreviations:

Type of Module	: PM=compulsory module, PMW=compulsory module with choice, WPM=elective module
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Course Work	: EC=exercise certificate, PEC=practical exercise certificate, PC=practical certificate
Other	: h=hours, o.=or, s.M.=see module description, ST=suggested term

2.3.5 Degree B.Sc. Physics, second Subject Computer Science

For the second subject Computer Science, the following prior achievements from the Bachelor of Science Physics degree programme at the University of Tübingen or comparable achievements from another degree programme justifying admission to the degree programme are required.

Prerequisites for the second subject Informatik[¶]	
Mathematics for Physicists 1 (MP1)	9 CP
Practical Computer Science 1: Deklarative Programming (INFM1110)	9 CP
Practical Computer Science 2: Imperative and Object-Oriented Programming (INFM1120)	9 CP
Sum	27 CP
The modules Practical Computer Science 1 and Practical Computer Science 2 can be completed in the Bachelor of Science degree programme at the University of Tübingen as part of the supplementary modules 1-4.	

The following modules must be completed in the 2nd subject area. These are entire modules from the subject Computer Science in the Bachelor's or Master's of Education Lehramt Gymnasium degree programmes.

[¶] All information provided here refers to the study and examination regulations of the University of Tübingen for the degree programme Computer Science with academic final examination Bachelor of Science (B. Sc.) in the version of 25.03.2021 (Amtl.Bek.UT 10/2021, p. 293) or the study and examination regulations of the University of Tübingen for the degree programme Physics with academic final examination Bachelor of Science (B. Sc.) in the version dated 30 July 2013 (Amtl.Bek.UT 16/2013, p. 787); the responsible examination board decides on the recognition of other achievements.

ST	Module Number	Module Title	Type of Course	Type of Module	Course-work	Type of Exam	ECTS-Points
Section 1: 2nd Subject Computer Science							
1-4	INFM2111	Practical Computer Science 3: Software Engeneering	L+E	PM	EC	Wr.	6
1-3	INFM2310	Computer Engeneering 2: Computer Science of Systems	L+E	PM	EC	Wr.	9
1-3	INFM2410	Theoretical Computer Science 2: Formal Languages, Computability and Complexity	L+E	PM	EC	Wr.	9
1-3	INFM2420	Theoretical Computer Science 1: Algorithms and Data Structures	L+E	PM	EC	Wr.	9
3-4	INFL20	Compulsory Elective Module I	L+E	PMW	EC	Wr. o. Or.	6
3-4	INFM3110	Elective subject Practical Computer Science	L+P	PMW		Wr. o. Or.	6*
3-4	INFM3310	Elective subject Computer Engeneering	L+P	PMW		Wr. o. Or.	6*
3-4	INFM3410	Elective subject Theoretical Computer Science	L+P	PMW		Wr. o. Or.	6*
						Sum	45 CP

*Only one of the compulsory elective modules Practical Computer Science, Computer Engineering and Theoretical Computer Science needs to be taken.

Abbreviations:

Type of Module : PM=compulsory module, PMW=compulsory module with choice, WPM=elective module
Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Course Work : EC=exercise certificate, PEC=practical exercise certificate, PC=practical certificate
Other : h=hours, o.=or, s.M.=see module description, ST=suggested term

2.3.6 Degree B.Sc. Physics, seconnd Subject Mathematics

For the second subject Mathematics, the following prerequisites from the Bachelor of Science Physics degree programme at the University of Tübingen, which is the basis for admission to the degree programme, or comparable achievements from another degree programme that is the basis for admission to the degree programme are required.

Preliminary work for the second subject Mathematics[‖]	
Mathematics for Physicists 1 (MP1)	9 CP
Mathematics for Physicists 2 (MP2)	9 CP
Mathematics for Physicists 3 (MP3)	9 CP
Mathematics for Physicists 4 (MP4)	6 CP
Sum	33 CP

[‖] All information provided here refers to the study and examination regulations of the University of Tübingen for the degree programme Physics with academic final examination Bachelor of Science (B. Sc.) in the version of 30 July 2013 (Amtl.Bek.UT 16/2013, p. 787) or the study and examination regulations of the University of Tübingen for the degree programme Mathematics with academic final examination Bachelor of Science (B. Sc.) in the version dated 05.08.2019 (Amtl.Bek.UT 15/2019, p. 443); the relevant examination board decides on the recognition of other achievements.

The following modules must be completed in the 2nd subject area. These are entire modules from the subject of physics in the Bachelor's and Master's of Education Lehramt Gymnasium degree programmes.

ST	Module Number	Module Title	Type of Course	Type of Module	Course-work	Type of Exam	ECTS-Points
Section 1: 2nd Subject Mathematics							
1	MAT-10-11	Consolidation of the Foundations of Mathematics		PM		Wr. o. Or.	6
		- Algebraic Structures	L+E		EC		
		- Mathematical Software	P		PN		
1-4	MAT-20-11	Numerical Mathematics	L+E	PM	EC	Wr. o. Or.	9
1-4	MAT-20-12	Stochastics	L+E	PM	EC	Wr. o. Or.	9
2-4	MAT-20-03	Algebra	L+E	PM	EC	Wr. o. Or.	9
2-4	MAT-20-20	Proseminar Mathematical Presentations	PS	PMW	s.M.	Pres	3
2-4	MAT-50-01	Geometry	L+E	PM	EC	Wr. o. Or.	9
						Sum	45 CP

Abbreviations:

Type of Module	: PM=compulsory module, PMW=compulsory module with choice, WPM=elective module
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Course Work	: EC=exercise certificate, PEC=practical exercise certificate, PC=practical certificate
Other	: h=hours, o.=or, s.M.=see module description, ST=suggested term

2.4 Programme Structure in Study Area Subject Didactics

In the following sections, the modules to be completed in the Subject Didactics programme area are listed in tabular form for the various subject combinations.

2.4.1 Combination of Computer Science and Mathematics

In the case of the subject combination Computer Science and Mathematics, the following modules must be completed in Subject Didactics.

ST	Module Number	Module Title	Type of Course	Type of Module	Course-work	Type of Exam	ECTS-Points
Section 4: Subject Didactics (Computer Science – Mathematics)							
1-2	INFL01	Subject Didactics Computer Science I**	S	PM	s.M.	Pres	3
2-3	INFL02	Subject Didactics Computer Science II	L+E	PM		TP+Pres	6
3-4	INFL03a	Subject Didactics Computer Science III (MEd IPM)	S	PM	s.M.	-	3*

1-2	MAT-80-01	Subject Didactics Mathematics 1	SV	PM	s.M.	Wr. o. Or.	3
2-3	MAT-80-04	Subject Didactics Mathematics 2 (MEd-IPM)	SV	PM	s.M.	Wr. o. Or. o. Pres o. TP	3
3-4	MAT-80-05	Subject Didactics Mathematics 3: Professional Knowledge	S	PM	s.M.	Wr. o. Or. o. Pres o. TP	3
3-4	MAT-80-06	Subject Didactics Mathematics 3: Elective area	S	PMW	s.M.	Wr. o. Or. o. Pres o. TP	3*
						Sum	21 CP

*Only one of the modules “Subject Didactics Computer Science III’ and “Subject Didactics Mathematics 3: Elective Area’ needs to be taken.

**It is strongly recommended to take the module "Subject Didactics Computer Science I" before the modules "Subject Didactics Computer Science II" and "Subject Didactics Computer Science III". Should a different constellation appear necessary for reasons relating to the course of study, the possible options should be discussed in advance with the Faculty Course Advisor.

Abbreviations:

Type of Module : PM=compulsory module, PMW=compulsory module with choice, WPM=elective module
Examination Type : MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Course Work : EC=exercise certificate, PEC=practical exercise certificate, PC=practical certificate
Other : h=hours, o.=or, s.M.=see module description, ST=suggested term

2.4.2 Combination of Computer Science and Physics

In the case of the subject combination Computer Science and Physics, the following modules must be completed in Subject Didactics.

ST	**Module Number**	**Module Title**	**Type of Course**	**Type of Module**	**Course-work**	**Type of Exam**	**ECTS-Points**
Section 4: Subject Didactics (Computer Science – Physics)							
1-2	INFL01	Subject Didactics Computer Science I**	S	PM	s.M.	Pres	3
2-3	INFL02	Subject Didactics Computer Science II	L+E	PM		TP+Pres	6
3-4	INFL03a	Subject Didactics Computer Science III (MEd IPM)	S	PM	s.M.	-	3*
1-2	BLP05F	Subject Didactics Physics 1	S	PM	s.M.	Wr. o. Or.	3*
2-3	BLP06F	Subject Didactics Physics 2 (MEd-IPM)	S	PM	-	Wr. o. Or.	3*
2-3	BLP06S	Subject Didactics Physics 3 (MEd-IPM)	S	PM	-	Wr. o. Or.	3*
3-4	MLP10F	Subject Didactics Physics 4	SÜ	PM	s.M.	-	3*
3-4	MLP12F	Subject Didactics Physics 5	SÜ	PM	s.M.	Wr. o. Or.	3*
						Sum	21 CP

*Four of the modules “Subject Didactics Physics 1’, “Subject Didactics Physics 2 (MEd-IPM)’, “Subject Didactics Physics 3 (MEd-IPM)’, “Subject Didactics Physics 4’, “Subject Didactics Physics 5’ and “Subject Didactics Computer Science III’ must be taken. It is recommended to take the module “Subject Didactics Physics 1’.

**It is strongly recommended to take the module "Subject Didactics Computer Science I" before the modules "Subject Didactics Computer Science II" and "Subject Didactics Computer Science III". Should a different constellation appear necessary for reasons relating to the course of study, the possible options should be discussed in advance with the Faculty Course Advisor.

Abbreviations:

Type of Module	: PM=compulsory module, PMW=compulsory module with choice, WPM=elective module
Examination Type	: MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Course Work	: EC=exercise certificate, PEC=practical exercise certificate, PC=practical certificate
Other	: h=hours, o.=or, s.M.=see module description, ST=suggested term

2.4.3 Combination of Mathematics and Physics

In the case of the subject combination Mathematics and Physics, the following modules must be completed in the subject didactics area.

ST	Module Number	Module Title	Type of Course	Type of Module	Course-work	Type of Exam	ECTS-Points
Section 4: Subject didactics (mathematics – physics)							
1-2	MAT-80-01	Subject Didactics Mathematics 1	SV	PM	s.M.	Wr. o. Or.	3
2-3	MAT-80-04	Subject Didactics Mathematics 2 (MEd-IPM)	SV	PM	s.M.	Wr. o. Or. o. Pres o. TP	3
3-4	MAT-80-05	Subject Didactics Mathematics 3: Professional Knowledge	S	PM	s.M.	Wr. o. Or. o. Pres o. TP	3
3-4	MAT-80-06	Subject Didactics Mathematics 3: Elective area	S	PMW	s.M.	Wr. o. Or. o. Pres o. TP	3*
1-2	BLP05F	Subject Didactics Physics 1	S	PM	s.M.	Wr. o. Or.	3*
2-3	BLP06F	Subject Didactics Physics 2 (MEd-IPM)	S	PM	-	Wr. o. Or.	3*
2-3	BLP06S	Subject Didactics Physics 3 (MEd-IPM)	S	PM	-	Wr. o. Or.	3*
3-4	MLP10F	Subject Didactics Physics 4	SÜ	PM	s.M.	-	3*
3-4	MLP12F	Subject Didactics Physics 5	SÜ	PM	s.M.	Wr. o. Or.	3*
						Sum	21 CP

*Four of the modules “Subject Didactics Physics 1’, “Subject Didactics Physics 2 (MEd-IPM)’, “Subject Didactics Physics 3 (MEd-IPM)’, “Subject Didactics Physics 4’, “Subject Didactics Physics 5’ and “Subject Didactics Mathematics 3: Wahlbereich’ must be taken. It is recommended to take the module "Subject Didactics Physics 1".

Abbreviations:

Type of Module : PM=compulsory module, PMW=compulsory module with choice, WPM=elective module
Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Course Work : EC=exercise certificate, PEC=practical exercise certificate, PC=practical certificate
Other : h=hours, o.=or, s.M.=see module description, ST=suggested term

2.5 Programme Structure in Study Area Education Science

The modules to be completed in the Education Science programme area are listed in the following table. These are complete modules from the Education Science study area of the Bachelor's and Master's of Education Lehramt Gymnasium degree programmes or new modules that are made up of parts of such modules.

ST	**Module Number**	**Module Title**	**Type of Course**	**Type of Module**	**Course-work**	**Type of Exam**	**ECTS-Points**
Section 5: Education Science							
1-2	BWS-ME0	Education Science 1 (MEd-IPM)	L+S	PM	-	Wr. o. Or.	5
1-2	BWS-ME1	School Pedagogy I	S+S	PM	-	Wr. o. Or.	6
2-3	BWS-ME3	Inclusion, Diversity and Heterogeneity	L+L/S	PMW	-	Wr.	6
3-4	BWS-ME4	Empirical Educational Research and Educational Psychology	V	PM	-	Wr.	6
						Sum	23 CP

Abbreviations:

Type of Module : PM=compulsory module, PMW=compulsory module with choice, WPM=elective module
Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Course Work : EC=exercise certificate, PEC=practical exercise certificate, PC=practical certificate
Other : h=hours, o.=or, s.M.=see module description, ST=suggested term

2.6 Exemplary Study Plans

As expected, the study requirements of students on this degree programme are very heterogeneous and, depending on the subject combination, there is also a certain degree of freedom with regard to the choice of modules. For this reason, it is not possible to specify binding study pathways for the subject combinations. However, in order to show that the degree programmes can be studied and, if applicable, how they can be studied, we will provide exemplary study plans for each subject combination on the following pages, both for students starting in the winter semester and for students starting in the summer semester. Since many of the compulsory courses are only offered in the winter or summer semester and since the school practice semester blocks half a semester, it is not possible to achieve an even distribution of credit points with exactly 30 CP per semester. We therefore recommend that prospective students discuss a possible individual study plan with the Faculty Course Advisor of their chosen second subject in an academic counselling session if possible before starting their studies. However, this should be done at the latest upon commencement of the degree programme.

2.6.1 Degree B.Sc. Computer Science, second Subject Mathematics

Degree B.Sc. Computer Science, second Subject Mathematics (with Numerical Mathematics as prerequisite)

Possible Study Plan for Students Starting in the Winter Semester

FS	CP	Module Achievements					
1	29	Consolidation of the Foundations of Ma (6 CP)		Geometry (9 CP)	Subject Didactics Mathematics 2: Geometry (3 CP)	Subject Didactics Computer Science II* (6 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	34	Algebra (9 CP)	Stochastics (9 CP)	Subject Didactics Mathematics 1 (3 CP)	Subject Didactics Computer Science I* (3 CP)	Empirical Educational Research and Educational Psychology (6 CP)	School Pedagogy 1 (4+2=6 CP)
3	24	School Practise Semester (16 CP)			Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	Subject Didactics Computer Science III (3 CP)	
4	33	Master thesis (15 CP)			Introduction to Complex Analysis and Ordinary Differential Equations (9 CP)	Proseminar Mathematical Presentations (3 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:
*It is strongly recommended that the Subject Didactics Computer Science I module is taken before the Subject Didactics Computer Science II and Subject Didactics Computer Science III modules. Should a different constellation appear necessary due to the course of study, the possible options should be discussed with the Faculty Course Advisor beforehand.

Degree B.Sc. Computer Science, second Subject Mathematics (with Numerical Mathematics as prerequisite)

Possible Study Plan for Students Starting in the Summer Semester

FS	CP	Module Achievements					
1	29	Consolidation of the Foundations of Mathematics (6 CP)	Stochastics (9 CP)	Proseminar Mathematical Presentations (3 CP)	Subject Didactics Mathematics 1 (3 CP)	Subject Didactics Computer Science I (3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	24	School Practise Semester (16 CP)			Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	Subject Didactics Computer Science III (3 CP)	School Pedagogy 1 (2+4=6 CP)
3	31	Introduction to Complex Analysis and C (9 CP)		Algebra (9 CP)	Subject Didactics Mathematics 2: Algebra (3 CP)	Empirical Educational Research and Educational Psychology (6 CP)	
4	36	Master thesis (15 CP)			Geometry (9 CP)	Subject Didactics Computer Science II (6 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

<table>
<tr><th colspan="8">Degree B.Sc. Computer Science, 2. Subject Mathematics (with Stochastics as prerequisite)</th></tr>
<tr><th colspan="8">Possible Study Plan for Students Starting in the Winter Semester</th></tr>
<tr><th>FS</th><th>CP</th><th colspan="6">Module Achievements</th></tr>
<tr><td>1</td><td>35</td><td colspan="2">Consolidation of the Foundations of Ma (6 CP)</td><td>Numerical Mathematics (9 CP)</td><td>Geometry (9 CP)</td><td>Subject Didactics Computer Science II* (6 CP)</td><td>Education Science 1 (MEd-IPM) (5 CP)</td></tr>
<tr><td>2</td><td>28</td><td>Algebra (9 CP)</td><td>Subject Didactics Mathematics 1 (3 CP)</td><td>Subject Didactics Mathematics 2: Algebra (3 CP)</td><td>Subject Didactics Computer Science I* (3 CP)</td><td>Empirical Educational Research and Educational Psychology (6 CP)</td><td rowspan="2">School Pedagogy 1 (4+2=6 CP)</td></tr>
<tr><td>3</td><td>24</td><td colspan="3">School Practise Semester (16 CP)</td><td>Subject Didactics Mathematics 3: Professional Knowledge (3 CP)</td><td>Subject Didactics Computer Science III (3 CP)</td></tr>
<tr><td>4</td><td>33</td><td colspan="3">Master thesis (15 CP)</td><td>Consolidation of Special Areas of Mathematics (9 CP)</td><td>Proseminar Mathematical Presentations (3 CP)</td><td>Inclusion, Diversity and Heterogeneity (6 CP)</td></tr>
</table>

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:
*It is strongly recommended that the Subject Didactics Computer Science I module is taken before the Subject Didactics Computer Science II and Subject Didactics Computer Science III modules. Should a different constellation appear necessary due to the course of study, the possible options should be discussed with the Faculty Course Advisor beforehand.

<table>
<tr><th colspan="8">Degree B.Sc. Computer Science, second Subject Mathematics (with Stochastics as prerequisite)</th></tr>
<tr><th colspan="8">Possible Study Plan for Students Starting in the Winter Semester – Alternative</th></tr>
<tr><th>FS</th><th>CP</th><th colspan="6">Module Achievements</th></tr>
<tr><td>1</td><td>29</td><td colspan="2">Consolidation of the Foundations of Ma (6 CP)</td><td>Geometry (9 CP)</td><td>Subject Didactics Mathematics 2: Geometry (3 CP)</td><td>Subject Didactics Computer Science II* (6 CP)</td><td>Education Science 1 (MEd-IPM) (5 CP)</td></tr>
<tr><td>2</td><td>31</td><td>Algebra (9 CP)</td><td>Mathematics for Computer Sience 4: Numerical Methods** (6 CP)</td><td>Subject Didactics Mathematics 1 (3 CP)</td><td>Subject Didactics Computer Science I* (3 CP)</td><td>Empirical Educational Research and Educational Psychology (6 CP)</td><td rowspan="2">School Pedagogy 1 (4+2=6 CP)</td></tr>
<tr><td>3</td><td>24</td><td colspan="2">School Practise Semester (16 CP)</td><td colspan="2">Subject Didactics Mathematics 3: Profe (3 CP)</td><td>Subject Didactics Computer Science III (3 CP)</td></tr>
<tr><td>4</td><td>36</td><td>Master thesis (15 CP)</td><td colspan="2">Introduction to Complex Analysis and C (9 CP)</td><td>Module from the M.Sc. Mathematics** (3 CP)</td><td>Proseminar Mathematical Presentations (3 CP)</td><td>Inclusion, Diversity and Heterogeneity (6 CP)</td></tr>
</table>

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:

*It is strongly recommended that the Subject Didactics Computer Science I module is taken before the Subject Didactics Computer Science II and Subject Didactics Computer Science III modules. Should a different constellation appear necessary due to the course of study, the possible options should be discussed with the Faculty Course Advisor beforehand.

** Replacing the module “Numerical Mathematics’ with the module “Mathematics for Computer Sience 4: Numerical Methods’ and a module from the Master of Science - Mathematics programme requires the approval of the examination board.

Degree B.Sc. Computer Science, second Subject Mathematics (with Stochastics as prerequisite)

Possible Study Plan for Students Starting in the Summer Semester

FS	CP	Module Achievements					
1	29	Consolidation of the Foundations of Mathematics (6 CP)	Introduction to Complex Analysis and Ordinary Differential Equations (9 CP)	Proseminar Mathematical Presentations (3 CP)	Subject Didactics Mathematics 1 (3 CP)	Subject Didactics Computer Science I (3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	24	School Practise Semester (16 CP)			Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	Subject Didactics Computer Science III (3 CP)	School Pedagogy 1 (2+4=6 CP)
3	28	Algebra (9 CP)	Subject Didactics Mathematics 2: Algebra (3 CP)	Empirical Educational Research and Ed (6 CP)		Inclusion, Diversity and Heterogeneity (6 CP)	
4	39	Master thesis (15 CP)			Geometry (9 CP)	Numerical Mathematics (9 CP)	Subject Didactics Computer Science II (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Degree B.Sc. Computer Science, second Subject Mathematics (with Stochastics as prerequisite)

Possible Study Plan for Students Starting in the Summer Semester – Alternative

FS	CP	Module Achievements					
1	29	Consolidation of the Foundations of Mathematics (6 CP)	Introduction to Complex Analysis and Ordinary Differential Equations (9 CP)	Proseminar Mathematical Presentations (3 CP)	Subject Didactics Mathematics 1 (3 CP)	Subject Didactics Computer Science I (3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	24	School Practise Semester (16 CP)			Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	Subject Didactics Computer Science III (3 CP)	School Pedagogy 1 (2+4=6 CP)
3	31	Algebra (9 CP)	Mathematics for Computer Science 4: Numerical Methods* (6 CP)	Module from the M.Sc. Mathematics (3 CP)	Subject Didactics Mathematics 2: Algebra (3 CP)	Empirical Educational Research and Educational Psychology (6 CP)	

4	36	Master thesis (15 CP)		Geometry (9 CP)	Subject Didactics Computer Science II (6 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:
* Replacing the module “Numerical Mathematics’ with the module “Mathematics for Computer Science 4: Numerical Methods’ and a module from the Master of Science - Mathematics programme requires the approval of the examination board.

2.6.2 Degree B.Sc. Computer Science, second Subject Physics

Degree B.Sc. Computer Science, second Subject Physics

Possible Study Plan for Students Starting in the Winter Semester

FS	**CP**	**Module Achievements**					
1	38	Physics Basic Course 3 (12 CP)		Modern Physics A (12 CP)	Subject Didactics Physics 1 (3 CP)	Subject Didactics Computer Science II* (6 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	28	Practical Course in Physics 1 (6 CP)	Practical Course in Physics 2 (6 CP)	Subject Didactics Physics 2 (MEd-IPM) (3 CP)	Subject Didactics Computer Science I* (3 CP)	Empirical Educational Research and Educational Psychology (6 CP)	School Pedagogy 1 (4+2=6 CP)
3	24	School Practise Semester (16 CP)			Subject Didactics Computer Science III (3 CP)	Subject Didactics Physics 4 (3 CP)	
4	30	Master thesis (15 CP)			Modern Physics D (9 CP)		Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:
*It is strongly recommended that the Subject Didactics Computer Science I module is taken before the Subject Didactics Computer Science II and Subject Didactics Computer Science III modules. Should a different constellation appear necessary due to the course of study, the possible options should be discussed with the Faculty Course Advisor beforehand.

Degree B.Sc. Computer Science, second Subject Physics

Possible Study Plan for Students Starting in the Winter Semester – Alternative

FS	**CP**	**Module Achievements**					
1	35	Physics Basic Course 3 (12 CP)	Practical Course in Physics 1 (6 CP)	Modern Physics A (Part: Molecules, Atom, Light)* (3 CP)	Subject Didactics Physics 1 (3 CP)	Subject Didactics Computer Science II** (6 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	31	Basic Module Quantum Mechanics* (9 CP)	Practical Course in Physics 2 (6 CP)	Subject Didactics Physics 3 (MEd-IPM) (3 CP)	Subject Didactics Computer Science I** (3 CP)	Empirical Educational Research and Educational Psychology (6 CP)	

3	24	School Practise Semester (16 CP)			Subject Didactics Computer Science III (3 CP)	Subject Didactics Physics 4 (3 CP)	School Pedagogy 1 (4+2=6 CP)
4	30	Master thesis (15 CP)			Modern Physics D (9 CP)		Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:

*The Modern Physics A module can also be replaced, in consultation with the Faculty Course Advisor, by successful participation in the Basic Module Quantum Mechanics from the B.Sc. Physics together with the section "Molecules, Atom, Light" from the module Modern Physics A.

**It is strongly recommended that the Subject Didactics Computer Science I module is taken before the Subject Didactics Computer Science II and Subject Didactics Computer Science III modules. Should a different constellation appear necessary due to the course of study, the possible options should be discussed with the Faculty Course Advisor beforehand.

Degree B.Sc. Computer Science, second Subject Physics

Possible Study Plan for Students Starting in the Summer Semester

FS	CP	Module Achievements					
1	32	Modern Physics D (9 CP)	Practical Course in Physics 1 (6 CP)	Subject Didactics Physics 2 (MEd-IPM) (3 CP)	Subject Didactics Computer Science I (3 CP)	Education Science 1 (MEd-IPM) (5 CP)	Inclusion, Diversity and Heterogeneity (6 CP)
2	33	Physics Basic Course 3 (12 CP)		Modern Physics A (12 CP)		Subject Didactics Physics 1 (3 CP)	Subject Didactics Computer Science II (6 CP)
3	31	Master thesis (15 CP)			Practical Course in Physics 2 (6 CP)	Empirical Educational Research and Educational Psychology (6 CP)	School Pedagogy 1 (4+2=6 CP)
4	24	School Practise Semester (16 CP)			Subject Didactics Computer Science III (3 CP)	Subject Didactics Physics 4 (3 CP)	

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Degree B.Sc. Computer Science, second Subject Physics

Possible Study Plan for Students Starting in the Summer Semester - Alternative 1

FS	CP	Module Achievements				
1	26	Modern Physics D (9 CP)		Practical Course in Physics 1 (6 CP)	Subject Didactics Physics 2 (MEd-IPM) (3 CP)	Subject Didactics Computer Science I (3 CP)	Education Science 1 (MEd-IPM) (5 CP)

2	24	School Practise Semester (16 CP)			Subject Didactics Computer Science III (3 CP)	Subject Didactics Physics 4 (3 CP)	School Pedagogy 1 (2+4=6 CP)
3	31	Master thesis* (15 CP)			Practical Course in Physics 2 (6 CP)	Empirical Educational Research and Educational Psychology (6 CP)	
4	36	Physics Basic Course 3 (12 CP)		Modern Physics A (12 CP)	Subject Didactics Physics 1 (3 CP)	Subject Didactics Computer Science II (6 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:
*In this case, the Master's thesis cannot be written in Physics but must be written in Computer Science.

Degree B.Sc. Computer Science, second Subject Physics

Possible Study Plan for Students Starting in the Summer Semester - Alternative 2

FS	CP	Module Achievements					
1	32	Modern Physics D (9 CP)	Practical Course in Physics 1 (6 CP)	Subject Didactics Physics 2 (MEd-IPM) (3 CP)	Subject Didactics Computer Science I (3 CP)	Education Science 1 (MEd-IPM) (5 CP)	Inclusion, Diversity and Heterogeneity (6 CP)
2	24	School Practise Semester (16 CP)			Subject Didactics Computer Science III (3 CP)	Subject Didactics Physics 4 (3 CP)	School Pedagogy 1 (2+4=6 CP)
3	31	Master thesis* (15 CP)			Practical Course in Physics 2 (6 CP)	Empirical Educational Research and Educational Psychology (6 CP)	
4	33	Physics Basic Course 3 (12 CP)		Modern Physics A (12 CP)		Subject Didactics Physics 1 (3 CP)	Subject Didactics Computer Science II (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:

2.6.3 Degree B.Sc. Mathematics, second Subject Computer Science

Degree B.Sc. Mathematics, second Subject Computer Science

Possible Study Plan for Students Starting in the Winter Semester

FS	CP	Module Achievements					
1	29	Theoretical Computer Science 1: Algorithms and Data Structures (9 CP)		Compulsory Elective Module I (6 CP)	Subject Didactics Computer Science II* (6 CP)	Subject Didactics Mathematics 2: Geometry (3 CP)	Education Science 1 (MEd-IPM) (5 CP)

2	34	Theoretical Computer Science 2: Formal Languages, Computability and Complexity (9 CP)	Practical Computer Science 3: Software Engeneering (6 CP)	Subject Didactics Computer Science I* (3 CP)	Subject Didactics Mathematics 1 (3 CP)	Empirical Educational Research and Educational Psychology (6 CP)	School Pedagogy 1 (4+2=6 CP)
3	24	School Practise Semester (16 CP)			Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	Subject Didactics Computer Science III (3 CP)	
4	33	Master thesis (15 CP)			Computer Engeneering 2: Computer Science of Systems (9 CP)	Elective subject Theoretical or Practical Computer Science or Computer Engineering (6 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:
*It is strongly recommended that the Subject Didactics Computer Science I module is taken before the Subject Didactics Computer Science II and Subject Didactics Computer Science III modules. Should a different constellation appear necessary due to the course of study, the possible options should be discussed with the Faculty Course Advisor beforehand.

Degree B.Sc. Mathematics, second Subject Computer Science

Possible Study Plan for Students Starting in the Summer Semester

FS	**CP**	**Module Achievements**					
1	29	Theoretical Computer Science Formal Languages, Computability and (9 CP)		Practical Computer Science 3: Software Engeneering (6 CP)	Subject Didactics Computer Science I (3 CP)	Subject Didactics Mathematics 1 (3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	24	School Practise Semester (16 CP)			Subject Didactics Computer Science III (3 CP)	Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	School Pedagogy 1 (2+4=6 CP)
3	31	Computer Engeneering 2: Computer Science of Systems (9 CP)	Compulsory Elective Module I (6 CP)	Elective subject Theoretical or Practical Computer Science or Computer Engineering (6 CP)	Subject Didactics Mathematics 2: Algebra (3 CP)	Empirical Educational Research and Educational Psychology (6 CP)	
4	36	Master thesis (15 CP)			Theoretical Computer Science 1: Algorithms and Data Structures (9 CP)	Subject Didactics Computer Science II (6 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

2.6.4 Degree B.Sc. Mathematics, second Subject Physics

Degree B.Sc. Mathematics, second Subject Physics

Possible Study Plan for Students Starting in the Winter Semester

FS	**CP**	**Module Achievements**					
1	32	Physics Basic Course 3 (12 CP)		Modern Physics A (12 CP)		Subject Didactics Physics 1 (3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	31	Practical Course in Physics 1 (6 CP)	Practical Course in Physics 2 (6 CP)	Subject Didactics Physics 2 + 3 (MEd-IPM) (3+3 CP)	Subject Didactics Mathematics 1 (3 CP)	Empirical Educational Research and Educational Psychology (6 CP)	School Pedagogy 1 (4+2=6 CP)
3	24	School Practise Semester (16 CP)			Subject Didactics Physics 4 (3 CP)	Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	
4	31	Master thesis (15 CP)			Modern Physics D (9 CP)	Subject Didactics Mathematics 2: Algebra (3 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Degree B.Sc. Mathematics, second Subject Physics

Possible Study Plan for Students Starting in the Winter Semester - Alternative

FS	**CP**	**Module Achievements**					
1	29	Physics Basic Course 3 (12 CP)		Practical Course in Physics 1 (6 CP)	Modern Physics A (Teil: Moleküle, Atom, Licht)* (3 CP)	Subject Didactics Physics 1 (3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	34	Basic Module Quantum Mechanics* (9 CP)	Practical Course in Physics 2 (6 CP)	Subject Didactics Physics 2 + 3 (MEd-IPM) (3+3 CP)	Subject Didactics Mathematics 1 (3 CP)	Empirical Educational Research and Educational Psychology (6 CP)	School Pedagogy 1 (4+2=6 CP)
3	24	School Practise Semester (16 CP)			Subject Didactics Physics 4 (3 CP)	Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	
4	33	Master thesis (15 CP)			Modern Physics D (9 CP)	Subject Didactics Mathematics 2: Algebra (3 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:
*The Modern Physics A module can also be replaced, in consultation with the Faculty Course Advisor, by successful participation in the Basic Module Quantum Mechanics from the B.Sc. Physics together with the section "Molecules, Atom, Light" from the module Modern Physics A.

Degree B.Sc. Mathematics, second Subject Physics

Possible Study Plan for Students Starting in the Summer Semester

FS	**CP**	**Module Achievements**					
1	32	Modern Physics D (9 CP)	Practical Course in Physics 1 (6 CP)	Subject Didactics Physics 2 + 3 (MEd-IPM) (3+3 CP)	Subject Didactics Mathematics 1 (3 CP)	Subject Didactics Mathematics 2: Algebra (3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	33	Physics Basic Course 3 (12 CP)		Modern Physics A (12 CP)		Subject Didactics Physics 1 (3 CP)	Inclusion, Diversity and Heterogeneity (6 CP)
3	31	Master thesis (15 CP)			Practical Course in Physics 2 (6 CP)	Empirical Educational Research and Educational Psychology (6 CP)	School Pedagogy 1 (2+4=6 CP)
4	24	School Practise Semester (16 CP)			Subject Didactics Physics 4 (3 CP)	Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Degree B.Sc. Mathematics, second Subject Physics

Possible Study Plan for Students Starting in the Summer Semester - Alternative

FS	**CP**	**Module Achievements**					
1	32	Modern Physics D (9 CP)	Practical Course in Physics 1 (6 CP)	Subject Didactics Physics 2 + 3 (MEd-IPM) (3+3 CP)	Subject Didactics Mathematics 1 (3 CP)	Subject Didactics Mathematics 2: Algebra (3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	24	School Practise Semester (16 CP)			Subject Didactics Physics 4 (3 CP)	Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	School Pedagogy 1 (2+4=6 CP)
3	31	Master thesis* (15 CP)			Practical Course in Physics 2 (6 CP)	Empirical Educational Research and Educational Psychology (6 CP)	
4	33	Physics Basic Course 3 (12 CP)		Modern Physics A (12 CP)		Subject Didactics Physics 1 (3 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:
*In this case, the Master's thesis cannot be written in Physics but must be written in the subject Mathematics.

2.6.5 Degree B.Sc. Physics, second Subject Computer Science

Degree B.Sc. Physics, second Subject Computer Science

Possible Study Plan for Students Starting in the Winter Semester

FS	**CP**	**Module Achievements**					
1	29	Theoretical Computer Science 1: Algorithms and Data Structures (9 CP)		Compulsory Elective Module I (6 CP)	Subject Didactics Computer Science II* (6 CP)	Subject Didactics Physics 1 (3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	34	Theoretical Computer Science 2: Formal Languages, Computability and Complexity (9 CP)	Practical Computer Science 3: Software Engeneering (6 CP)	Subject Didactics Computer Science I* (3 CP)	Subject Didactics Physics 2 (MEd-IPM) (3 CP)	Empirical Educational Research and Educational Psychology (6 CP)	School Pedagogy 1 (4+2=6 CP)
3	24	School Practise Semester (16 CP)			Subject Didactics Computer Science III (3 CP)	Subject Didactics Physics 4 (3 CP)	
4	33	Master thesis (15 CP)			Computer Engeneering 2: Computer Science of Systems (9 CP)	Elective subject Theoretical or Practical Computer Science or Computer Engineering (6 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:
*It is strongly recommended that the Subject Didactics Computer Science I module is taken before the Subject Didactics Computer Science II and Subject Didactics Computer Science III modules. Should a different constellation appear necessary due to the course of study, the possible options should be discussed with the Faculty Course Advisor beforehand.

Degree B.Sc. Physics, second Subject Computer Science

Possible Study Plan for Students Starting in the Summer Semester

FS	CP	Module Achievements					
1	32	Theoretical Computer Science Formal Languages, Computability and ((9 CP)		Practical Computer Science 3: Software Engeneering (6 CP)	Subject Didactics Computer Science I (3 CP)	Subject Didactics Physics 2 + 3 (MEd-IPM) (3+3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	24	School Practise Semester (16 CP)			Subject Didactics Computer Science III (3 CP)	Subject Didactics Physics 4 (3 CP)	School Pedagogy 1 (2+4=6 CP)
3	28	Computer Engeneering 2: Computer Science of Systems (9 CP)	Compulsory Elective Module I (6 CP)	Elective subject Theoretical or Practica ering		Empirical Educational Research and Educational Psychology (6 CP)	
4	36	Master thesis (15 CP)			Theoretical Computer Science 1: Algorithms and Data Structures (9 CP)	Subject Didactics Computer Science II (6 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Degree B.Sc. Physics, second Subject Computer Science

Possible Study Plan for Students Starting in the Summer Semester - Alternative 1

FS	CP	Module Achievements					
1	29	Theoretical Computer Science Formal Languages, Computability and ((9 CP)		Practical Computer Science 3: Software Engeneering (6 CP)	Subject Didactics Computer Science I (3 CP)	Subject Didactics Physics 2 (MEd-IPM) (3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	24	School Practise Semester (16 CP)			Subject Didactics Computer Science III (3 CP)	Subject Didactics Physics 4 (3 CP)	School Pedagogy 1 (2+4=6 CP)
3	31	Master thesis* (15 CP)			Computer Engeneering 2: Computer Science of Systems (9 CP)	Empirical Educational Research and Educational Psychology (6 CP)	

4	36	Compulsory Elective Module I (6 CP)	Elective subject Theoretical or Practical Computer Science or Computer Engineering (6 CP)	Theoretical Computer Science 1: Algorithms and Data Structures (9 CP)	Subject Didactics Computer Science II (6 CP)	Subject Didactics Physics 1 (3 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:
*In this case, the Master's thesis cannot be written in Computer Science but must be written in the subject Physics.

Degree B.Sc. Physics, second Subject Computer Science

Possible Study Plan for Students Starting in the Summer Semester - Alternative 2

FS	**CP**	**Module Achievements**					
1	29	Theoretical Computer Science Formal Languages, Computability and ((9 CP)		Practical Computer Science 3: Software Engeneering (6 CP)	Subject Didactics Computer Science I (3 CP)	Subject Didactics Physics 2 (MEd-IPM) (3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	36	Compulsory Elective Module I (6 CP)	Elective subject Theoretical or Practical Computer Science or Computer Engineering (6 CP)	Theoretical Computer Science 1: Algorithms and Data Structures (9 CP)	Subject Didactics Computer Science II (6 CP)	Subject Didactics Physics 1 (3 CP)	Inclusion, Diversity and Heterogeneity (6 CP)
3	31	Master thesis (15 CP)			Computer Engeneering 2: Computer Science of Systems (9 CP)	Empirical Educational Research and Educational Psychology (6 CP)	School Pedagogy 1 (4+2=6 CP)
4	24	School Practise Semester (16 CP)			Subject Didactics Computer Science III (3 CP)	Subject Didactics Physics 4 (3 CP)	

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

2.6.6 Degree B.Sc. Physics, second Subject Mathematics

Degree B.Sc. Physics, second Subject Mathematics

Possible Study Plan for Students Starting in the Winter Semester

FS	**CP**	**Module Achievements**					
1	32	Consolidation of the Foundations of Ma (6 CP)		Numerical Mathematics (9 CP)	Geometry (9 CP)	Subject Didactics Physics 1 (3 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	31	Algebra (9 CP)	Subject Didactics Mathematics 2: Algebra (3 CP)	Subject Didactics Mathematics 1 (3 CP)	Subject Didactics Physics 2 (6 CP)	Empirical Educational Research and Educational Psychology (6 CP)	School Pedagogy 1 (4+2=6 CP)
3	24	School Practise Semester (16 CP)			Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	Subject Didactics Physics 4 (3 CP)	
4	33	Master thesis (15 CP)			Stochastics (9 CP)	Proseminar Mathematical Presentations (3 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Degree B.Sc. Physics, second Subject Mathematics

Possible Study Plan for Students Starting in the Summer Semester

FS	**CP**	**Module Achievements**					
1	32	Consolidation of the Foundations of Mathematics (6 CP)	Stochastics (9 CP)	Proseminar Mathematical Presentations (3 CP)	Subject Didactics Mathematics 1 (3 CP)	Subject Didactics Physics 2 (6 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	24	School Practise Semester (16 CP)			Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	Subject Didactics Physics 4 (3 CP)	School Pedagogy 1 (2+4=6 CP)
3	28	Algebra (9 CP)	Subject Didactics Mathematics 2: Algebra (3 CP)	Empirical Educational Research and Ed (6 CP)		Inclusion, Diversity and Heterogeneity (6 CP)	
4	36	Master thesis (15 CP)			Numerical Mathematics (9 CP)	Geometry (9 CP)	Subject Didactics Physics 1 (3 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Degree B.Sc. Physics, second Subject Mathematics

Possible Study Plan for Students Starting in the Summer Semester – Alternative

FS	**CP**	**Module Achievements**					
1	32	Consolidation of the Foundations of Mathematics (6 CP)	Stochastics (9 CP)	Proseminar Mathematical Presentations (3 CP)	Subject Didactics Mathematics 1 (3 CP)	Subject Didactics Physics 2 (6 CP)	Education Science 1 (MEd-IPM) (5 CP)
2	24	School Practise Semester (16 CP)			Subject Didactics Mathematics 3: Professional Knowledge (3 CP)	Subject Didactics Physics 4 (3 CP)	School Pedagogy 1 (2+4=6 CP)
3	34	Master thesis* (15 CP)			Algebra (9 CP)	Empirical Educational Research and Educational Psychology (6 CP)	
4	30	Numerical Mathematics (9 CP)		Geometry (9 CP)	Subject Didactics Mathematics 2: Geometry (3 CP)	Subject Didactics Physics 1 (3 CP)	Inclusion, Diversity and Heterogeneity (6 CP)

Explanation of the Abbreviations:
FS=semester, CP=credit points (ECTS points)

Notes:
*In this case, the Master's thesis cannot be written in the subject Mathematics but must be written in the subject Physics.

3 Module Descriptions

Section 1: 2nd Subject Computer Science

<table>
<tr><td>Module Number:
INFL20</td><td colspan="2">Module Title:
Elective Module I</td><td>Type of Module:
Compulsory Module with Choice</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">6</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
180 h</td><td>Time in Class:
60 h</td><td>Self-Study:
120 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">every Semester</td></tr>
<tr><td>Term</td><td colspan="3">3-4</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture, excercise class</td></tr>
<tr><td>Comment</td><td colspan="3">Instead of a lecture with exercise classes, a lecture without exercise classes totalling 4 SWS can also be included.</td></tr>
<tr><td>Content</td><td colspan="3">The module imparts advanced knowledge of computer science. These are acquired in selected courses from the compulsory elective subjects Practical Computer Science, Computer Engineering, Theoretical Computer Science, as well as other compulsory elective subjects in Bioinformatics and Medical Informatics.
Students can also take courses from the corresponding compulsory elective subjects of the Master’s degree programmes in Computer Science (compulsory elective subject Practical Computer Science, Computer Engineering, Theoretical Computer Science), Bioinformatics or Medical Informatics.</td></tr>
<tr><td>Objectives</td><td colspan="3">Students are familiar with current issues and fields of research in computer science, have in-depth theoretical, practical and technical knowledge in relation to selected topics, have different analytical and methodological approaches to computer science, had the opportunity to improve their communication skills and their ability to work in small groups.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td rowspan="2">Selected course</td><td>L</td><td>o</td><td>3</td><td>4,5</td><td rowspan="2">-</td><td rowspan="2">wr. o. or.</td><td rowspan="2">60</td><td rowspan="2">g</td><td rowspan="2">100</td></tr>
<tr><td>P</td><td>o</td><td>1</td><td>1,5</td></tr>
</table>
</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
</table>

Prerequisites	There ae no prerequisites.
Responsible Persons	Professors from the Computer Science Department

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number:	**Module Title:**	**Type of Module:**
INFM2111	Practical Computer Science 3: Software Engineering	Compulsory Module with Choice

ECTS-Points	6		
Workload - Time in Class - Self-Study	Workload: 180 h	Time in Class: 60 h	Self-Study: 120 h
Duration	1 Semester		
Frequency	every Semester		
Term	1-4		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, excercise class		
Content	The module covers the topics of introduction to software engineering, Software project management, software process models, requirements management, large-scale programming, API and library design, distributed and concurrent software systems software systems, module concept, version control, software quality (in particular test processes and software metrics as well as programme analyses), design by contract, design patterns, code reviews, SCRUM.		
Objectives	Competences: Students can name the essential areas of software engineering and categorise them in the context of a software development project; they can use established software development tools in a targeted manner; they are able to carry out basic quality assurance such as automated tests; they can design and implement software systems using basic object-oriented and functional design patterns.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Practical Computer Science 3: Software Engineering	L	o	2	4	yes	wr.	-	g	100
	E	o	2	2					

Transfer	-
Prerequisites	Knowledge of the Practical Computer Science 1 and Practical Computer Science 2 modules is required.
Responsible Persons	Klaus Ostermann

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **INFM2310**	**Module Title:** Computer Engineering 2: Computer Science of Systems		**Type of Module:** Compulsory Module
ECTS-Points	9		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Duration	1 Semester		
Frequency	regularly in Summer Semester		
Term	1-3		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, excercise class		
Content	The basic lecture provides an overview of the following five areas: Internet, coding, assembler programming, computer architecture, operating systems and power supply. In all 5 areas a basic system view is conveyed. The content of the 5 areas covers the following topics are covered: • Internet: Number representations and character encoding; protocol layers and basic structure of the Internet; • Coding: source coding, channel coding, line coding; • Assembler programming: basics, calling subroutines in assembler, use of the stack assembler, use of the stack, programme translation and execution, (effect of) compiler optimisation; • Computer architecture: Instruction set architecture, application binary interface, structure of computers, Moore's Law, basic performance considerations; Von Neumann architecture, CISC/RISC architectures; • operating systems: Structure of the processor, pipelining, hazards, exceptions; Memory technologies and hierarchy, locality principles, caches, processes and process management, structure and functionality of virtual memory, Translation-Lookaside Buffer (TLB), cache cohesion with multiple processors, user/kernel mode processors, user/kernel mode; structure of storage media, reliability, RAID; virtual machines, advantages of virtualisation, virtualisation methods, Virtual LAN (VLAN); I/O devices, handshaking protocols for buses, parallel and serial buses, PCI and serial buses, PCI, USB, control of I/O devices by the processor processor, data exchange between I/O devices and main memory, Direct Memory Access (DMA), further topics in the area of operating systems; • Energy supply: electricity grids, energy markets, electricity mix, combined heat and power, demand-side management, quantitative comparison of CO of CO 2 emissions, climate change and energy transition.		
Objectives	Students know the basics of the internet, coding, assembler programming, computer architecture, operating systems and energy supply. They are able to explain important terms, correlations, advantages and disadvantages. They understand the basic structure and functionality of the systems covered at various levels. Students are able to outline and interpret their structures and functions. They are able to recognise the theoretical concepts in practice and apply what they have learned.		

<table>
<tr><td rowspan="3">Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td>Title</td><td>Type of Course</td><td>Status</td><td>SWS</td><td>ECTS</td><td>Coursework</td><td>Type of Exam</td><td>Dur. of Exam (min)</td><td>Grading</td><td>Weight for Grade</td></tr>
<tr><td rowspan="2">Computer Engineering 2: Computer Science of Systems</td><td>L</td><td>o</td><td>4</td><td>6</td><td rowspan="2">yes</td><td rowspan="2">wr.</td><td rowspan="2">60</td><td rowspan="2">g</td><td rowspan="2">100</td></tr>
<tr><td>E</td><td>o</td><td>2</td><td>3</td></tr>
<tr><td>Transfer</td><td colspan="10">-</td></tr>
<tr><td>Prerequisites</td><td colspan="10">There are no prerequisites</td></tr>
<tr><td>Responsible Persons</td><td colspan="10">Michael Menth</td></tr>
</table>

Abbreviations:

Grading System : g=graded, ng=not graded
Examination Type : MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status : o=obligatory, f=facultative
Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **INFM2410**	**Module Title:** Theoretical Computer Science 2: Formal Languages, Computability, and Complexity		**Type of Module:** Compulsory Module
ECTS-Points	9		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Duration	1 Semester		
Frequency	regularly in Summer Semester		
Term	1-3		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise class		
Content	Topics include formal languages, Chomsky grammars and automata, computability, decidability and recursive decidability, existence of undecidable problems, Rice’s first theorem, complexity theory, time and space requirements and space requirements and NP-completeness.		
Objectives	Students have the ability to carry out standard constructions from the area of finite automata and regular expressions. They have an understanding of the phenomenon of non-computability and the frequency of its occurrence as well as a basic understanding of the concept of NP-completeness and its motivation.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Theoretical Computer Science 2: Formal Languages, Computability and Complexity	L	o	4	6	yes	wr.	90	g	100
	E	o	2	3					

Transfer	-
Prerequisites	There are no prerequisites
Responsible Persons	Ulrike von Luxburg, Philipp Hennig

Abbreviations:

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Examination Type : MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **INFM2420**	**Module Title:** Theoretical Computer Science 1: Algorithms and Data Structures		**Type of Module:** Compulsory Module
ECTS-Points	9		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Duration	1 Semester		
Frequency	regularly in Winter Semester		
Term	1-3		
Language of Instruction	German		
Forms of Teaching and Learning	lecture, excercise class		
Content	Introduction: computational models, efficiency measures; sorting methods: yuicksort, heapsort, mergesort; elementary data structures: lists, trees, graphs, dynamic search structures, hashing; graph algorithms: patterning, shortest paths, spanning trees; algorithms on strings: pattern search; programming: learnt algorithms and data structures.		
Objectives	Students have a basic knowledge of fundamental data structures in computer science and of algorithms for fundamental problems. Within this framework, they are familiar with the independent creative development of algorithms and data structures. Students know the interactions between data structures and algorithms and can apply these to concrete examples. Based on the analysis techniques they have learnt, they can evaluate simple algorithmic approaches according to their quality, efficiency and complexity. In addition, students are able to apply the implement the algorithms and data structures they have learnt.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Theoretical Computer Science 1: Algorithms and Data Structures	L	o	4	6	yes	wr.	90	g	100
	E	o	2	3					

Transfer	-
Prerequisites	Knowledge from the Practical Computer Science 1 module and basic knowledge of mathematics are required.
Responsible Persons	Michael Kaufmann

Abbreviations:

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Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **INFM3110**	**Module Title:** Elective Subject in Practical Computer Science		**Type of Module:** Compulsory Module with Choice
ECTS-Points	6		
Workload **- Time in Class** **- Self-Study**	Workload: 180 h	Time in Class: 60 h	Self-Study: 120 h
Duration	1 Semester		
Frequency	every Semester		
Term	3-4		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, excercise class		
Comment	Instead of a lecture with exercise classes, a lecture without exercise classes totalling 4 SWS can also be included.		
Content	The module imparts basic knowledge of practical computer science. This knowledge is acquired in selected courses from the subject areas of practical computer science. These areas include, for example, image communication, database systems, graphical data processing, machine learning and artificial intelligence, human-computer interaction, web development and multimedia, programming languages and compiler construction, software engineering and cognitive modelling.		
Objectives	Students know the foundations of practical computer science and are able to apply these in a suitable context. They are able to communicate in an understandable way about the technical content of this area of computer science. They can model simple problems in an appropriate way and solve them.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Selected course	L	o	3	4,5	-	wr. o. or.	60	g	100
	P	o	1	1,5					

Transfer	-
Prerequisites	There are no prerequisites
Responsible Persons	Torsten Grust

Abbreviations:

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Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status : o=obligatory, f=facultative
Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **INFM3310**	**Module Title:** Elective Subject in Computer Engineering		**Type of Module:** Compulsory Module with Choice
ECTS-Points	6		
Workload **- Time in Class** **- Self-Study**	Workload: 180 h	Time in Class: 60 h	Self-Study: 120 h
Duration	1 Semester		
Frequency	every Semester		
Term	3-4		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise class		
Comment	Instead of a lecture with exercise classes, a lecture without exercise classes totalling 4 SWS can also be included.		
Content	The module imparts basic knowledge of computer engineering. These are acquired in selected courses from the subject areas of computer engineering. These areas include, for example, chip design, media technology, communication networks, computer architecture, robotics and other special chapters of computer engineering.		
Objectives	Students know the basics of computer engineering and are able to apply these in a suitable context. They are able to communicate in an understandable way about the technical content of this area of computer science. They can model simple problems in a suitable way and solve them.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Selected course	L	o	3	4,5	-	wr. o. or.	60	g	100
	P	o	1	1,5					

Transfer	-
Prerequisites	There are no prerequisites
Responsible Persons	Michael Menth

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **INFM3410**	**Module Title:** Elective Subject in Theoretical Computer Science		**Type of Module:** Compulsory Module with Choice
ECTS-Points	6		
Workload **- Time in Class** **- Self-Study**	Workload: 180 h	Time in Class: 60 h	Self-Study: 120 h
Duration	1 Semester		
Frequency	every Semester		
Term	3-4		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise class		
Comment	Instead of a lecture with exercise classes, a lecture without exercise classes totalling 4 SWS can also be included.		
Content	The module imparts basic knowledge of theoretical computer science. These are acquired in selected courses from the subject areas of Theoretical Computer Science. These areas include, for example, algorithmics, computability and complexity, discrete mathematics, formal languages, cryptology and information theory and logic.		
Objectives	Students know the basics of theoretical computer science and are able to apply these in a suitable context. They are able to communicate in an understandable way about the technical content of this area of computer science. They can model simple problems in a suitable way and solve them.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Selected course	L	o	3	4,5	-	wr. o. or.	60	g	100
	P	o	1	1,5					

Transfer	-
Prerequisites	The module Theoretical Computer Science is a prerequisite.
Responsible Persons	Klaus-Jörn Lange

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Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Section 2: 2nd Subject Mathematics

Module Number: **MAT-10-11**	**Module Title:** Consolidation of the Foundations of Mathematics		**Type of Module:** Compulsory Module
ECTS-Points	6		
Workload **- Time in Class** **- Self-Study**	Workload: 180 h	Time in Class: 60 h	Self-Study: 120 h
Duration	1 Semester		
Frequency	every Semester		
Term	1		
Language of Instruction	German		
Forms of Teaching and Learning	• Algebraic Structures, Lecture 2 SWS + Ex.cl. 1 SWS • Mathematical Software, Practical course 1 SWS		
Comment	The coursework and the examination in the module part algebraic structures can be replaced by the module Linear Algebra from the study programme Bachelor of Science Mathematics. The Mathematical Software sub-module is usually provided to students in the Bachelor of Education Lehramt Gymnasium by participating in the practical exercises in the module Numerical Mathematics. Further courses which could be taken instead will be listed in the course catalogue.		
Content	• Algebraic structures: – Groups, subgroups, group homomorphisms, normal subgroups, quotient group. – Cyclic groups and the symmetric group. – Commutative rings with one, divisibility. – Euclidean rings, principal ideal domains, factorial rings. – The ring of integers and the polynomial ring. • Mathematical software: – Getting to know one or more subject-specific software packages. – Implementation of simple algorithms, e.g. of linear algebra, in subject-typical software.		
Objectives	Students have learnt and understood essential aspects of linear algebra based on the Foundations of Mathematics module: the algebraic structures group and ring, which are essential for all areas of mathematics. They have deepened their structural skills acquired in the Foundations of Mathematics module. They are familiar with the most fundamental statements and methods in the field. Their capacity for abstraction has been enhanced, they have been trained in analytical thinking and their mathematical imagination has been stimulated. Using a proof- and structure-orientated approach, they have learnt to understand mathematical proofs of algebra and to independently prove or disprove mathematical statements using simple examples. They are able to place the structures they have learnt in linear algebra in a larger context and understand them better. In the exercise classes they have acquired a confident, precise and independent handling of the terms, statements and methods of the lecture. In addition, the students' presentation and communication skills were trained through written work and presenting their own solutions. The students are able to acquire knowledge through self-study and at the same time their ability to work in a team has been promoted by working in smaller groups. In the practical course on mathematical software, students have familiarised themselves with one or more subject-specific software packages or computer algebra systems. They are trained to work out selected problems, e.g. linear algebra, algorithmically and to implement the developed algorithms in a subject-specific software package. In doing so, they have expanded and deepened the algorithmic skills they acquired in the Foundations of Mathematics.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Algebraic Structures	L	o	2	3	yes	wr. o. or.	90-180 o. 20-30	g	100
	E	o	1	1,5					
Mathematical Software	P	o	1	1,5	yes	-	-	nb	0

In the sub-module Algebraic Structures an exercise certificate is to be acquired as coursework. For participation in the examination the coursework must have been acquired. Whether the examination is written or oral is decided by the instructor with approval by the head of the examination board.

Literature

Possible References :

- Serge Lang: Algebraische Strukturen. Vandenhoek & Ruprecht 1979.
- Gerd Fischer: Lineare Algebra und Analytische Geometrie. Springer 2010.

Transfer

-

Prerequisites

There are no prerequisites.

Responsible Persons

Jürgen Hausen, Hannah Markwig, Thomas Markwig, Walther Paravicini

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Status : o=obligatory, f=facultative
Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
MAT-20-02</td><td colspan="2">Module Title:
Introduction to Complex Analysis and Ordinary Differential Equations</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">9</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
270 h</td><td>Time in Class:
90 h</td><td>Self-Study:
180 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">regularly in Summer Semester</td></tr>
<tr><td>Term</td><td colspan="3">1-4</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture 4 SWS + Ex.cl. 2 SWS</td></tr>
<tr><td>Content</td><td colspan="3">• Complex Analysis:
– Holomorphic functions, Cauchy-Riemann equations.
– Antiderivatives, Cauchy’s integral formula, Cauchy’s integral theorem.
– Compact convergence of families of functions, formal and convergent power series, complex-analytical functions, identity theorem.
– Liouville’s theorem, inverse function theorem for holomorphic functions, open mapping theorem, maximum principle.
– Laurent series, holomorphic functions with isolated singularities, Casorati-Weierstrass theorem.
– Residue theorem and applications.
• Ordinary differential equations, a choice of the following:
– Picard-Lindelöf existence and uniqueness theorem.
– Linear ordinary differential equations, Gronwall’s lemma.
– Continous dependence on initial conditions, differential dependence on initial conditions.
– Basics of dynamical systems, stability of equilibrium positions, characteristic exponents, first integrals, Liapunov-functions.
– Ordinary differential equations over the complex numbers.
– Regularity, the criterion of Fuchs.
– The method of Frobenius.</td></tr>
<tr><td>Objectives</td><td colspan="3">The students know the foundations of the theory of complex analysis and ordinary differential equations. The are acquainted to essential calculation techniques and can calculate line integrals as well as explicitly solve simple differential equations. They know fundamental applications of the theory like e.g. the fundamental theorem of algebra and the Newtonian equations of motion. They also have the ability to transfer abstract questions into concrete problems of complex analysis or respectively of ordinary differential equations and solve them this way.
In the exercise classes they have acquired a confident, precise and independent handling of the terms, statements and methods of the lecture. Furthermore the presentation and communication skills of the students was trained by written assignments and presenting their own solutions. The students are capable of adopting knowledge by self-study and at the same time their capacity for teamwork was enhanced by working in small groups.</td></tr>
</table>

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Introduction to Complex Analysis and ODEs.	L	o	4	6	yes	wr. o. or.	90-180 o. 20-30	g	100
	E	o	2	3					

In this module an exercise certificate is to be acquired as coursework. For participation in the examination the coursework must have been acquired. Whether the examination is written or oral is decided by the instructor with approval by the head of the examination board.

Literature

Possible References :

- Lars Valerian Ahlfors: Complex analysis. McGraw-Hill 1979.
- John B. Conway: Functions of one complex variable. Springer 1996.
- Wolfgang Fischer, Ingo Lieb: Einführung in die Komplexe Analysis. Springer 2010.
- Walter Rudin: Reelle und komplexe Analysis. Oldenbourg 2009.
- Earl A. Coddington, Norman Levinson: Theory of ordinary differential equations. McGraw-Hill 1955.
- William T. Reid: Ordinary differential equations. John Wiley & Sons 1971.
- Hille, Einar: Ordinary differential equations in the complex domain. Dover Publications 1997.
- Wasow, Wolfgang: Asymptotic expansions for ordinary differential equations. John Wiley 1965.

Transfer

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Prerequisites

There are no prerequisites.

Responsible Persons

Anton Deitmar, Reiner Schätzle

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Status : o=obligatory, f=facultative
Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
MAT-20-11</td><td colspan="2">Module Title:
Numerical Mathematics</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">9</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
270 h</td><td>Time in Class:
90 h</td><td>Self-Study:
180 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">regularly in Winter Semester</td></tr>
<tr><td>Term</td><td colspan="3">1-4</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture 4 SWS + Ex.cl. 2 SWS</td></tr>
<tr><td>Content</td><td colspan="3">Interpolation and approximation of functions.
Numeric integration and differentiation.
Systems of linear equations and linear curve fitting.
Systems of non-linear equations and non-linear curve fitting.
Initial value problems for ordinary differential equations.</td></tr>
<tr><td>Objectives</td><td colspan="3">The students know the foundations of numerical mathematics and are capable of performing basic calculation techniques. They understand to bring the knowledge gathered in the modules Analysis and Linear Algbra in the analysis of numerical methods and to use the methods for specific problems. Their algorithmic thinking was enhanced and they are acquainted to the analysis of algorithms with a view to questions of efficiency and complexity.
In the exercise classes they have acquired a confident, precise and independent handling of the terms, statements and methods of the lecture. Furthermore the presentation and communication skills of the students were trained by written assignments and presenting their own solutions. The students are capable of adopting knowledge by self-study and at the same time their capacity for teamwork was enhanced by working in small groups.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td rowspan="2">Numerical Mathematics</td><td>L</td><td>o</td><td>4</td><td>6</td><td rowspan="2">yes</td><td rowspan="2">wr. o. or.</td><td rowspan="2">90-180 o. 20-30</td><td rowspan="2">g</td><td rowspan="2">100</td></tr>
<tr><td>E</td><td>o</td><td>2</td><td>3</td></tr>
</table>
In this module an exercise certificate is to be acquired as coursework. For participation in the examination the coursework must have been acquired. Whether the examination is written or oral is decided by the instructor with approval by the head of the examination board.</td></tr>
<tr><td>Literature</td><td colspan="3">Possible References :
Peter Deuflhard, Andreas Hohmann: Numerische Mathematik 1. De Gruyter 2008.
Martin Hanke-Bourgeois: Grundlagen der Numerischen Mathematik und des Wissenschaftlichen Rechnens. Vieweg+Teubner 2009.</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
</table>

Prerequisites	There are no prerequisites.
Responsible Persons	Christian Lubich, Andreas Prohl

Abbreviations:

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Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
MAT-20-12</td><td colspan="2">Module Title:
Stochastics</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">9</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
270 h</td><td>Time in Class:
90 h</td><td>Self-Study:
180 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">regularly in Summer Semester</td></tr>
<tr><td>Term</td><td colspan="3">1-4</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture 4 SWS + Ex.cl. 2 SWS</td></tr>
<tr><td>Content</td><td colspan="3">• Introduction to probability theory and statistics.
• Topics from probability theory: Probability spaces, simple conditional probabilities, urn models, random variables, distribution functions, discret and continous distributions, expectation and variance, inequalities, independence, joint probability distribution, notions of convergence, laws of lagre numbers, central limit theorem.
• Topics from statistics: Point estimators, hypothesis testing, standard testing methods.</td></tr>
<tr><td>Objectives</td><td colspan="3">The students know the basic principles of stochastics. They have the ability to abstract stochastic questions and are capable of using their knowledge on specific problems.
In the exercise classes they have acquired a confident, precise and independent handling of the terms, statements and methods of the lecture. Furthermore the presentation and communication skills of the students were trained by written assignments and presenting their own solutions. The students are capable of adopting knowledge by self-study and at the same time their capacity for teamwork was enhanced by working in small groups.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td rowspan="2">Stochastics</td><td>L</td><td>o</td><td>4</td><td>6</td><td rowspan="2">yes</td><td rowspan="2">wr. o.
or.</td><td rowspan="2">90-180
o. 20-30</td><td rowspan="2">g</td><td rowspan="2">100</td></tr>
<tr><td>E</td><td>o</td><td>2</td><td>3</td></tr>
</table>
In this module an exercise certificate is to be acquired as coursework. For participation in the examination the coursework must have been acquired. Whether the examination is written or oral is decided by the instructor with approval by the head of the examination board.</td></tr>
<tr><td>Literature</td><td colspan="3">Possible References :
• Hans-Otto Georgii: Stochastik. De Gruyter 2015.
• Ulrich Krengel: Einführung in die Wahrscheinlichkeitstheorie und Statistik. Vieweg 2005.</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">There are no prerequisites.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">Martin Möhle, Martin Zerner</td></tr>
</table>

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MAT-20-03**	**Module Title:** Algebra		**Type of Module:** Compulsory Module
ECTS-Points	9		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Duration	1 Semester		
Frequency	regularly in Summer Semester		
Term	2-4		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 4 SWS + Ex.cl. 2 SWS		
Content	• Groups and structure theory of finite groups. • Rings, ideals, polynomial rings, divisibility theory. • Fields and field extensions. • Geometric and algebraic applications of field theory.		
Objectives	The students deepen their structural thinking, know basic algebraic concepts and can apply them on other mathematical disciplines. They understand, in particular, through the example of field theory, how the interaction of different branches of algebra leads to new insights, e.g. answers to classical problems from antiquity. In the process they have experienced, that the coaction of different areas of mathematics can be essential for solving concrete problems. In the exercise classes they have acquired a confident, precise and independent handling of the terms, statements and methods of the lecture. Furthermore the presentation and communication skills of the students was trained by written assignments and presenting their own solutions. The students are capable of adopting knowledge by self-study and at the same time their capacity for teamwork was enhanced by working in small groups.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Algebra	L	o	4	6	yes	wr. o. or.	90-180 o. 20-30	g	100
	E	o	2	3					

In this module an exercise certificate is to be acquired as coursework. For participation in the examination the coursework must have been acquired. Whether the examination is written or oral is decided by the instructor with approval by the head of the examination board.

Literature	**Possible References :** • Siegfried Bosch: Algebra. Springer 2009. • Gerd Fischer, Reinhard Sacher: Einführung in die Algebra. Teubner 1983. • Christian Karpfinger, Kurt Meyberg: Algebra: Gruppen-Ringe-Körper. Springer Spektrum 2010. • Kurt Meyberg: Algebra 1. Hanser 1980. • Kurt Meyberg: Algebra 2. Hanser 1976. • Hans-Jörg Reiffen, Günter Scheja, Udo Vetter: Algebra. Bibliographisches Institut 1984.
Transfer	-
Prerequisites	Knowledge from the module Consolidation of the Foundations of Mathematics is required.
Responsible Persons	Jürgen Hausen, Hannah Markwig, Thomas Markwig

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
MAT-20-20</td><td colspan="2">Module Title:
Proseminar: Presentations in Mathematics</td><td>Type of Module:
Compulsory Module with Choice</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">3</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
90 h</td><td>Time in Class:
30 h</td><td>Self-Study:
60 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">every Semester</td></tr>
<tr><td>Term</td><td colspan="3">2-4</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Proseminar, talk, presentation, e-learning, blended learning</td></tr>
<tr><td>Content</td><td colspan="3">Various topics from the foundations of mathematics.</td></tr>
<tr><td>Objectives</td><td colspan="3">The students independently work on a coherent mathematical topic and prepare it in a didactical appealing form. They learn how to present their work to a group, how to be responsive to questions regarding the content and how to lead a professional discussion.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td>Proseminar</td><td>PS</td><td>o</td><td>2</td><td>3</td><td>yes</td><td>Pr</td><td>60-90</td><td>g</td><td>100</td></tr>
</table>
The acquisition of the credit points requires alongside with a successfull presentation the regular active participation in the course, like by asking questions, contributing to a discussion or working on problem tasks. Additionally a written elaboration of the own talk or the issue of a handout for the participants may be required. This further work constitutes the coursework of the module.</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">There are no prerequisites.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">The dean of studies at the Department of Mathematics</td></tr>
</table>

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MAT-50-01**	**Module Title:** Geometry		**Type of Module:** Compulsory Module
ECTS-Points	9		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Duration	1 Semester		
Frequency	regularly in Winter Semester		
Term	2-4		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 4 SWS + Ex.cl. 2 SWS		
Content	• Axiomatic foundation of planar geometry. • Euclidean and non-Euclidean geometry. • Parametrised curves and surfaces.		
Objectives	The students deepen their axiomatic way of thinking and are capable of giving correct proofs. They know the basic principles of geometry, are able to solve concrete problems and know the fundamental links between geometry and topology. The students are capable of naming and proving the essential results of the lecture as well as assessing and explaining the presented connections. In the exercise classes they have acquired a confident, precise and independent handling of the terms, statements and methods of the lecture. They have learned to transfer the methods to new problems, to analyse them and to work on solution strategies on their own or in a team. They are able to present their solutions and, if necessary, defend them in critical discourse.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Geometry	L	f	4	6	yes	wr. o. or.	90-180 o. 20-30	g	100
	E	f	2	3					

In this module an exercise certificate is to be acquired as coursework. For participation in the examination the coursework must have been acquired. Whether the examination is written or oral is decided by the instructor with approval by the head of the examination board.

Literature	**Possible References :** • Michele Audin: Geometry. Springer 2003. • Marcel Berger: Geometry Revealed: A Jacob’s Ladder to Modern Higher Geometry. Springer 2010. • David A. Brannan, Matthew F. Esplen, Jeremy J. Gray: Geometry. Cambridge University Press 2012. • John Stillwell: The four pillars of geometry. Springer 2005.
Transfer	-

Prerequisites	Knowledge from the module Consolidation of the Foundations of Mathematics is assumed.
Responsible Persons	Christoph Bohle, Carla Cederbaum, Hannah Markwig, Ivo Radloff

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
MAT-40-51</td><td colspan="2">Module Title:
Specialisation</td><td>Type of Module:
Compulsory Module with Choice</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">9</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
270 h</td><td>Time in Class:
90 h</td><td>Self-Study:
180 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">every Semester</td></tr>
<tr><td>Term</td><td colspan="3">3-4</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German or English</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture 4 SWS + Ex.cl. 2 SWS</td></tr>
<tr><td>Comment</td><td colspan="3">A course must be selected from the catalogue of courses in Section 4.1 of the module handbook, comprising 4 hours of lectures and 2 hours of exercises per week. The approval of additional courses or alternative course formats (e.g., two courses with 2 hours of lectures and 1 hour of exercises each) is at the discretion of the head of the examination board, upon a written request by the student.</td></tr>
<tr><td>Content</td><td colspan="3">The content is determined by the choice of a course.</td></tr>
<tr><td>Objectives</td><td colspan="3">The students have acquired in-depth knowledge in a specific area of mathematics and gained further experience in presenting and communicating mathematical topics. They are capable of identifying the key statements of the lecture, reproducing the techniques used for their derivation and proof, and critically evaluating them. Additionally, they can integrate the methodological and theoretical foundations of the chosen mathematical subfield and place them within the broader mathematical context.
In the exercise classes they have acquired a confident, precise and independent handling of the terms, statements and methods of the lecture. They have learned to transfer the methods onto new problems, to analyse them and to work on solution strategies on their own or in a team.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td rowspan="2">see Comment</td><td>L</td><td>o</td><td>4</td><td>6</td><td rowspan="2">yes</td><td rowspan="2">wr. o. or.</td><td rowspan="2">90-180
o. 20-30</td><td rowspan="2">g</td><td rowspan="2">100</td></tr>
<tr><td>E</td><td>o</td><td>2</td><td>3</td></tr>
</table>
In this module an exercise certificate is to be acquired as coursework. For participation in the examination the coursework must have been acquired. Whether the examination is written or oral is decided by the instructor with approval by the head of the examination board.</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">There are no formal prerequisites, however, depending on the choice of the lecture knowledge from other modules may be needed.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">The dean of studies at the Department of Mathematics</td></tr>
</table>

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Section 3: 2nd Subject Physics

<table>
<tr><td>Module Number:
BLP03</td><td colspan="2">Module Title:
Physics Basic Course 3</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">12</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
360 h</td><td>Time in Class:
90 h</td><td>Self-Study:
270 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">regularly in Winter Semester</td></tr>
<tr><td>Term</td><td colspan="3">1-2</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture, exercise classes, independent study, group work</td></tr>
<tr><td>Content</td><td colspan="3">Optics
Electromagnetic theory of light, phase and group velocities, dispersion of light in a medium, refractive index, geometric optics (Fermat's principle), instruments of geometric optics, diffraction at a slit, gratings, coherence of light waves, interference, polarisation, X-rays.
Analytical mechanics
Constraints, D'Alembert's principle, variational principle, Lagrangian and Hamiltonian formalisms, symmetries and conservation laws, phase space, canonical transformations.</td></tr>
<tr><td>Objectives</td><td colspan="3">Students understand the fundamental methods and concepts of optics and analytical mechanics. They recognise the relationship between physical experiments and the corresponding mathematical formulations. Students are able to reproduce the content of optics and analytical mechanics covered in the lectures. They can formulate and approximately solve simple physical problems mathematically. For all topics, they use appropriate technical language and mathematical methods. They are able to communicate in a generally understandable way about physical facts of classical physics and compare their models.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3"><table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td rowspan="3">Physics Basic Course 3</td><td>L</td><td>o</td><td>4</td><td>6</td><td rowspan="3">yes</td><td rowspan="3">wr.</td><td rowspan="3">-</td><td rowspan="3">g</td><td rowspan="3">100</td></tr>
<tr><td>E</td><td>o</td><td>2</td><td>3</td></tr>
<tr><td>or.</td><td>o</td><td>0</td><td>3</td></tr>
</table>
Credits are earned through the participation in two written exams on the two parts of the course. To be admitted to the exams, attendance in the exercise classes and submission of more than 50% of the assignments are required.</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">Knowledge from the modules Physics Basic Course 1, Physics Basic Course 2, Mathematics for Natural Scientists 1, and Mathematics for Natural Scientists 2 is required.</td></tr>
</table>

Responsible Persons	Lecturers from the Department of Physics

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
BLP04</td><td colspan="2">Module Title:
Modern Physics A</td><td>Type of Module:
Compulsory Module with Choice</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">12</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
360 h</td><td>Time in Class:
120 h</td><td>Self-Study:
240 h</td></tr>
<tr><td>Duration</td><td colspan="3">2 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">regularly in Winter Semester</td></tr>
<tr><td>Term</td><td colspan="3">2-3</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture, exercise classes, independent study, group work</td></tr>
<tr><td>Content</td><td colspan="3">Quantum Mechanics, Atomic Physics, and Quantum Optics:
• Postulates of quantum mechanics, single-particle potential models, Schrödinger and Heisenberg equations, particle-wave duality, spin, measurement process, quantum mechanical states, spectra and selection rules of atoms and atomic nuclei, non-locality, many-body problem, lasers, quantum optics.</td></tr>
<tr><td>Objectives</td><td colspan="3">Students are familiar with concepts of modern quantum and atomic physics. They can formulate simple physical problems mathematically and use appropriate technical language in doing so.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td rowspan="2">Modern Physics A (Quantum Mechanics and Atomic Physics)</td><td>L</td><td>o</td><td>6</td><td>9</td><td rowspan="2">yes</td><td rowspan="2">wr.</td><td rowspan="2">-</td><td rowspan="2">g</td><td rowspan="2">100</td></tr>
<tr><td>E</td><td>o</td><td>2</td><td>3</td></tr>
</table>
Credits are earned through an exam. To be admitted to the exam, attendance in the exercise classes and submission of more than 50% of the assignments are required.</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">Knowledge from the modules Physics Basic Course 1-2 and Mathematics for Scientists 1-2, as well as the modules Physics Basic Course 3 and Experimental Physics 1, is required.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">Lecturers from the Department of Physics</td></tr>
</table>

Abbreviations:

Grading System : g=graded, ng=not graded
Examination Type : MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status : o=obligatory, f=facultative
Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **BLP05PP1**	**Module Title:** Physics Laboratory 1		**Type of Module:** Compulsory Module
ECTS-Points	6		
Workload **- Time in Class** **- Self-Study**	Workload: 180 h	Time in Class: 60 h	Self-Study: 120 h
Duration	1 Semester		
Frequency	every Semester		
Term	1-2		
Language of Instruction	German		
Forms of Teaching and Learning	Practical work, independent study, group work		
Content	Conducting physical experiments in optics, mechanics, and electrical engineering.		
Objectives	Students • know the basics of conducting experiments; • are able to follow instructions; • can present results both in writing and orally.		

Requirements for obtaining Credits / Grading (Weighting if applicable)	Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
	Physics Laboratory 1	P	o	4	6	-	-	-	ng	-

Transfer	-
Prerequisites	Knowledge from the modules Physics Basic Course 1 and Mathematics for Natural Scientists 1 is required.
Responsible Persons	Lecturers from the Department of Physics

Abbreviations:
Grading System : g=graded, ng=not graded
Examination Type : MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status : o=obligatory, f=facultative
Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **BLP06PP2**	**Module Title:** Physics Laboratory 2		**Type of Module:** Compulsory Module
ECTS-Points	6		
Workload **- Time in Class** **- Self-Study**	Workload: 180 h	Time in Class: 60 h	Self-Study: 120 h
Duration	1 Semester		
Frequency	every Semester		
Term	2-3		
Language of Instruction	German		
Forms of Teaching and Learning	Practical work, independent study, group work		
Content	Conducting physical experiments in optics, mechanics, and electrical engineering.		
Objectives	Students • know the basics of conducting experiments; • are able to follow instructions; • can present results both in writing and orally; • develop advanced software skills for data collection and analysis; • are familiar with statistical methods for determining measurement uncertainties.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Physics Laboratory 2	P	o	4	6	-	-	-	ng	-

Transfer	-
Prerequisites	Knowledge from the modules Physics Basic Course 1 and Mathematics for Scientists 1, as well as the module Experimental Physics 1, is required.
Responsible Persons	Lecturers from the Department of Physics

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MLP14**	**Module Title:** Modern Physics D		**Type of Module:** Compulsory Module with Choice
ECTS-Points	9		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Duration	1 Semester		
Frequency	every year		
Term	3-4		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise classes, independent study, group work		

Content

Depending on the choice of course, content may include the following topics:

- Statistical physics
  - Temperature and energy, entropy, thermodynamic processes and machines, classical gases and quantum gases, Bose condensation, black-body radiation.
- Solid state physics
  - Crystals, diffraction methods, electron conduction, phonons, magnetism, semiconductors, nanostructures.
- Nuclear and particle physics
  - Building blocks of matter, reactions, nuclear models, Standard Model of particle physics.
- Astronomy and astrophysics
  - Optical devices and instruments, star formation and evolution, Big Bang, black holes, messengers, cosmology.

Objectives

Students master the technical language; they can relate theoretical foundations, experimental evidence, and practical applications. They can summarise and present issues and relationships in a structured manner. They can interpret results from current research. They can apply learned technical methods to their field of work. They can establish connections between various subfields of modern physics and explain their correspondences with classical physics clearly.

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Modern Physics D	L	o	4	6	yes	wr.	-	g	100
	L	o	2	3					

To be admitted to the written exam, attendance in the exercise classes and submission of more than 50% of the assignments are required.

Transfer	-
Prerequisites	There are no formal prerequisites. However, prior participation in the module Modern Physics A is advisable.

Responsible Persons	Lecturers from the Department of Physics

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
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Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Section 4: Didactics

<table>
<tr><td>Module Number:
INFL01</td><td colspan="2">Module Title:
Subject Didactics in Computer Science I</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">3</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
90 h</td><td>Time in Class:
30 h</td><td>Self-Study:
60 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">regularly in Summer Semester</td></tr>
<tr><td>Term</td><td colspan="3">1-2</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Seminar</td></tr>
<tr><td>Content</td><td colspan="3">Basic planning, organisation and implementation of computer science lessons, knowledge, initial analysis and didactic preparation of suitable practical fields, individual teaching test.</td></tr>
<tr><td>Objectives</td><td colspan="3">The students have specialised didactic knowledge, in particular for determining, selection and justification of objectives, content, methods and media of computer science education.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td>Subject Didactics in Computer Science I</td><td>S</td><td>o</td><td>2</td><td>3</td><td>-</td><td>K o. mP o. R o. H</td><td>-</td><td>g</td><td>100</td></tr>
</table>
</td></tr>
<tr><td>Transfer</td><td colspan="3">The module is a prerequisite for the modules Subject Didactics in Computer Science II and III.</td></tr>
<tr><td>Prerequisites</td><td colspan="3">There are no prerequisites</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">Klaus Ostermann</td></tr>
</table>

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
INFL02</td><td colspan="2">Module Title:
Subject Didactics in Computer Science II</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">6</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
180 h</td><td>Time in Class:
60 h</td><td>Self-Study:
120 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">regularly in Summer Semester</td></tr>
<tr><td>Term</td><td colspan="3">2-3</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture, seminar</td></tr>
<tr><td>Content</td><td colspan="3">Methods and media for teaching computer science content, individual teaching test, use of software packages for teaching selected computer science content, such as Filius.</td></tr>
<tr><td>Objectives</td><td colspan="3">Students are familiar with subject-specific didactic concepts and can effectively use educational software as well as computer-assisted learning and teaching methods.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td rowspan="2">Subject Didactics II</td><td>L</td><td>o</td><td>2</td><td>4,5</td><td rowspan="2">-</td><td rowspan="2">K o. mP o. R o. H</td><td rowspan="2">-</td><td rowspan="2">g</td><td rowspan="2">100</td></tr>
<tr><td>E</td><td>o</td><td>1</td><td>1,5</td></tr>
</table>
</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">Knowledge from the module Subject Didactics in Computer Science I is assumed.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">Klaus Ostermann</td></tr>
</table>

Abbreviations:

Grading System : g=graded, ng=not graded
Examination Type : MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status : o=obligatory, f=facultative
Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **INFL03a**	**Module Title:** Subject Didactics in Computer Science IIIa (MEd IPM)		**Type of Module:** Compulsory Module
ECTS-Points	3		
Workload **- Time in Class** **- Self-Study**	Workload: 90 h	Time in Class: 30 h	Self-Study: 60 h
Duration	1 Semester		
Frequency	every year		
Term	3-4		
Language of Instruction	German		
Forms of Teaching and Learning	Intensive course		
Content	Didactic (re-)construction of subject knowledge, analysis and evaluation of teaching and learning processes in computer science education, interdisciplinary aspects related to the subject of computer science, project work: development of a teaching unit and implementation through individual presentations.		
Objectives	Students have initial reflective experience in the planning, implementation, and analysis of competence-oriented computer science teaching.		

Requirements for obtaining Credits / Grading (Weighting if applicable)	Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
	Subject Didactics IIIa	S	o	2	3	-	K o. mP o. R o. H	-	g	100

Transfer	-
Prerequisites	Knowledge from the modules Subject Didactics in Computer Science I and Subject Didactics in Computer Science II is assumed.
Responsible Persons	Klaus Ostermann, Andreas Koch

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MAT-80-01**	**Module Title:** Subject Didactics Mathematics 1		**Type of Module:** Compulsory Module
ECTS-Points	3		
Workload **- Time in Class** **- Self-Study**	Workload: 90 h	Time in Class: 30 h	Self-Study: 60 h
Duration	1 Semester		
Frequency	regularly in Summer Semester		
Term	1-2		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise class, proseminar, talk, presentation, e-learning, blended learning, project work, case studies		
Content	**Didactics of Algebra and Arithmetic:** This course deals with the foundations of the didactics of mathematics in the educational plans and in particular the didactic reduction of important basic concepts of algebra and arithmetic to school level, various ways of introducing important concepts of algebra and arithmetic at school and ways of motivating basic algebraic and arithmetic ideas.		
Objectives	Students know the basic didactic principles of teaching concepts and can orientate themselves in the educational plans. They are able to compare and evaluate subject-specific approaches to central concepts in algebra and arithmetic. They have the ability to convey algebraic and arithmetic content in a way that is both student- and subject-orientated.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Subject Didactics Mathematics 1	LIC	o	2	3	no	K o. mP o. P	90-180 o. 20-30	g	100

Whether the examination is written or oral is decided by the instructor with approval by the head of the examination board.

Transfer	-
Prerequisites	There are no prerequisites.
Responsible Persons	Frank Loose, Walther Paravicini

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MAT-80-04**	**Module Title:** Subject Didactics Mathematics 2 (MEd-IPM)		**Type of Module:** Compulsory Module
ECTS-Points	3		
Workload **- Time in Class** **- Self-Study**	Workload: 90 h	Time in Class: 30 h	Self-Study: 60 h
Duration	1 Semester		
Frequency	every Semester		
Term	2-3		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise, proseminar, talk, presentation, e-learning, blended learning, project work, case studies		
Content	The module deals with the didactic reduction of important basic concepts of analysis, linear algebra, geometry or stochastics at school level, various options for introducing important terms in analysis, linear algebra, geometry or stochastics at school as well as motivational options for analytical, geometric or stochastic basic ideas.		
Objectives	The students know the didactic basic principles of teaching concepts. They are able to compare and assess technical approaches to central terms in analysis, linear algebra or stochastics. They have the ability to convey analytic, algebraic or stochastic content		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Subject Didactics Mathematics 2 – Part 1 or 2	SV	o	2	3	yes	K o. mP o. R o. H	90-180 o. 20-30	g	100

Transfer	-
Prerequisites	If a course on didactics of geometry and linear algebra is chosen, the module Geometry should be taken parallel or prior to this course as knowledge from the module Geometry will be required.
Responsible Persons	Frank Loose, Walther Paravicini

Abbreviations:

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Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
MAT-80-05</td><td colspan="2">Module Title:
Subject Didactics Mathematics 3: Professional Knowledge</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">3</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
90 h</td><td>Time in Class:
30 h</td><td>Self-Study:
60 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">regularly in Winter Semester</td></tr>
<tr><td>Term</td><td colspan="3">3-4</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture, exercise, proseminar, talk, presentation, e-learning, blended learning, project work, case studies</td></tr>
<tr><td>Content</td><td colspan="3">Varying topics are covered, who are especially related to the teaching profession and are also suited for a didactical refurbishment of the school internship semester.</td></tr>
<tr><td>Objectives</td><td colspan="3">The students

know subject didactical principles and education concepts and can evaluate and scrutinize them,
can compare and evaluate subject related approaches to central terms and theorems of the treated fields,
can plan, execute, analyse and evaluate competence oriented mathematical education on the basis of subject didactical concepts,
can motivate the general educating value of mathematical contents and methods and the social importance of mathematics and put it in context with the goals and contents of mathematical education,
can specifically use subject specific media,
can create a portfolio ans document important experiences, findings and insights in a tructured manner.
</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td>Subject Didactics Mathematics 3: Professional Knowledge</td><td>S</td><td>o</td><td>2</td><td>3</td><td>yes</td><td>K o. mP o. R o. H</td><td>90-180 o. 20-30</td><td>g</td><td>100</td></tr>
</table>
</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">There are no prerequisits.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">Frank Loose, Walther Paravicini</td></tr>
</table>

Abbreviations:

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Examination Type : MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MAT-80-06**	**Module Title:** Subject Didactics Mathematics 3: Elective Specialisation		**Type of Module:** Compulsory Module with Choice
ECTS-Points	3		
Workload **- Time in Class** **- Self-Study**	Workload: 90 h	Time in Class: 30 h	Self-Study: 60 h
Duration	1 Semester		
Frequency	regularly in Summer Semester		
Term	3-4		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise class, proseminar, lecture, presentation, e-learning, blended learning, project work, case studies		
Content	Changing topics in the didactics of mathematics are dealt with, which can lead to current research in the didactics of mathematics.		
Objectives	The students • can compare and assess technical approaches to central concepts and sentences in the areas covered, • can explain the general educational content of mathematical content and methods and the social significance of mathematics and place it in the context of the objectives and content of mathematics lessons, • can use subject-specific media in a targeted manner, • can create a portfolio and document significant experiences, and insights in a structured manner.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Subject Didactics Mathematics 3: Elective Specialisation	S	o	2	3	yes	K o. mP o. R o. H	90-180 o. 20-30	g	100

Transfer	-
Prerequisites	The modules Didactics of Mathematics 1 and Didactics of Mathematics 2 (ME-IPM) are a prerequisite.
Responsible Persons	Frank Loose, Walther Paravicini

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
BLP05F</td><td colspan="2">Module Title:
Subject Didactics in Physics 1</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">3</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
90 h</td><td>Time in Class:
30 h</td><td>Self-Study:
60 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">every year</td></tr>
<tr><td>Term</td><td colspan="3">1-2</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture, exercise classes, presentation, independent study, group work</td></tr>
<tr><td>Content</td><td colspan="3">Basics of subject didactics, subject-specific working and thinking methods, students' preconceptions and learning difficulties, subject-specific reduction.</td></tr>
<tr><td>Objectives</td><td colspan="3">Students
are familiar with the subject-specific didactic content;
understand concepts of subject-specific education;
recognise the importance of experimentation.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td>Subject Didactics 1</td><td>S</td><td>o</td><td>2</td><td>3</td><td>-</td><td>wr. o. or.</td><td>-</td><td>g</td><td>100</td></tr>
</table>
</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">Knowledge from the modules Physics Basic Course 1 and Mathematics for Scientists 1 is required.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">Lecturers from the Department of Physics</td></tr>
</table>

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **BLP06F**	**Module Title:** Subject Didactics Physics 2		**Type of Module:** Compulsory Module
ECTS-Points	3		
Workload **- Time in Class** **- Self-Study**	Workload: 90 h	Time in Class: 30 h	Self-Study: 60 h
Duration	1 Semester		
Frequency	every year		
Term	2-3		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise classes, presentation, practical work, independent study, group work		
Content	Planning and analysing physics lessons with special consideration of competence orientation, heterogeneity and gender aspects, task culture in physics lessons.		
Objectives	Students • can link the didactic learning content and apply it appropriately to the situation; • know the importance of experimentation; • are familiar with lesson planning; • know concepts for designing a lesson (preparation for School Internship Semester).		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Subject Didactics 2	S	o	2	3	-	wr. o. or.	-	g	100

Transfer	-
Prerequisites	Previous participation in the module Didactics of Physics 1 is desirable, but not mandatory. Knowledge from the modules Physics Basic Course 1 and Mathematics for Scientists 1 is required.
Responsible Persons	Lecturers from the Department of Physics

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
BLP06S</td><td colspan="2">Module Title:
Subject Didactics in Physics 3 (MEd-IPM)</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">3</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
90 h</td><td>Time in Class:
30 h</td><td>Self-Study:
60 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">every year</td></tr>
<tr><td>Term</td><td colspan="3">2-3</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture, exercise classes, presentation, practical work, independent study, group work</td></tr>
<tr><td>Content</td><td colspan="3">Planning and analysing physics lessons with special consideration of competence orientation, heterogeneity and gender aspects, task culture in physics lessons, carrying out student experiments.</td></tr>
<tr><td>Objectives</td><td colspan="3">Students
• can link the didactic learning content and apply it appropriately to the situation;
• recognise the importance of experimentation;
• are familiar with lesson planning;
• know concepts for structuring a lesson (preparation for the practical semester).</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td>Subject Didactics 3</td><td>S,P</td><td>o</td><td>2</td><td>3</td><td>-</td><td>wr. o. or.</td><td>-</td><td>g</td><td>100</td></tr>
</table>
</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">Prior participation in the modules Didactics of Physics 1 and Didactics of Physics 2 (MEd-IPM) is desirable but not mandatory. Knowledge from the modules Physics Basic Course 1 and Mathematics for Scientists 1 is required.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">Lecturers from the Department of Physics</td></tr>
</table>

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MLP10F**	**Module Title:** Subject Didactics in Physics 4		**Type of Module:** Compulsory Module
ECTS-Points	3		
Workload **- Time in Class** **- Self-Study**	Workload: 90 h	Time in Class: 30 h	Self-Study: 60 h
Duration	1 Semester		
Frequency	every year		
Term	3-4		
Language of Instruction	German		
Forms of Teaching and Learning	Seminar, exercise classes, portfolio		
Content	Reflection on the School Internship Semester, documentation of the portfolio.		
Objectives	Students evaluate the didactic concepts of experimentation at school and reflect on communication methods and active participation in scientific opinion formation. They can create a structured portfolio and document their findings.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Subject Didactics 4	Sü	o	2	3	-	-	-	ng	-

Transfer	-
Prerequisites	Prior participation in the modules Didactics of Physics 1 and Didactics of Physics 2 (MEd-IPM) is desirable but not mandatory.
Responsible Persons	Lecturers from the Department of Physics

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
MLP12F</td><td colspan="2">Module Title:
Subject Didactics in Physics 5</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">3</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
90 h</td><td>Time in Class:
30 h</td><td>Self-Study:
60 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">every year</td></tr>
<tr><td>Term</td><td colspan="3">3-4</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Seminar, exercise classes, independent study, group work, portfolio</td></tr>
<tr><td>Content</td><td colspan="3">Experimentation in student-oriented teaching.</td></tr>
<tr><td>Objectives</td><td colspan="3">Students can plan a coordinated lesson. They are able to use modern media in teaching.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td>Subject Didactics 5</td><td>ü</td><td>o</td><td>2</td><td>3</td><td>-</td><td>wr. o. or.</td><td>-</td><td>g</td><td>100</td></tr>
</table>
</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">Prior participation in the modules Didactics of Physics 1 and Didactics of Physics 2 (MEd-IPM) is desirable but not mandatory.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">Lecturers from the Department of Physics</td></tr>
</table>

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master’s thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Section 5: Education

Module Number: **BWS-ME0**	**Module Title:** Educational Sciences 1 (MEd-IPM)		**Type of Module:** Compulsory Module
ECTS-Points	5		
Workload **- Time in Class** **- Self-Study**	Workload: 150 h	Time in Class: 60 h	Self-Study: 90 h
Duration	2 Semester		
Frequency	every Semester		
Term	1-2		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture, seminar		
Content	The lecture introduces the Tübingen teacher training programme (topics and organisation) and the study of educational science. Selected topics and tasks of the teaching profession (e.g. school as a workplace, tasks of the teaching profession, professionalisation theories) as well as central topics of the micro, meso and macro level (teaching, school, school system) are examined in depth. The introduction includes basic concepts and theories (e.g. teaching theory/didactics, education, educational inequality, upbringing, socialisation, anthropology). The lecture provides an introduction to the school internship semester (e.g. criteria and methods of observation and documentation) as well as to theory-based, empirical and development-related work in the educational sciences. The compulsory portfolio is introduced on the basis of specific objectives, functions and methods of documentation. The compulsory seminar Profession and Professionalism II introduces students to the academic discourse on the teaching profession, the theory and empirical research on professionalism in the teaching profession and also to teaching research. Contents include, for example, lesson planning and teaching concepts, characteristics and framework conditions of the teaching profession, professional biographies of teachers, research on teacher behaviour, stress and strain in the teaching profession, teaching quality, classroom management and communication and interaction in the classroom. The school internship semester is initiated.		

Objectives

The students

- are familiar with the concept of the Tübingen teacher training programme;
- are able to reproduce and differentiate between basic educational science terms and theories;
- recognise the levels of the education system relevant to educational processes and quality development in schools based on selected topics;
- are able to distinguish between theoretical and empirical research work and practical challenges based on selected topics and tasks in the teaching profession;
- know the objectives, subject areas and organisation of the orientation internship as well as their tasks during the internship;
- can create their portfolio and document significant experiences, findings and insights in a structured manner;
- know models of lesson planning, lesson concepts and didactic principles;
- know selected findings of empirical professional research;
- know analysis categories of teaching research and are able to use them to reflect on observed lessons;
- reflect on their career choice against the background of practical experiences and their contextualisation in academic discourse;
- are able to use their portfolio as a medium for reflecting on their professional biographical development and career choice.

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Introduction to the Study of Educational Sciences	L	o	2	3	-	wr. o. or.	je nach Art	g	100
Profession and Professionalism II	S	o	2	2	-	-	-	nb	-

Transfer -

Prerequisites There are no prerequisites

Responsible Persons -

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Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **BWS-ME1**	**Module Title:** School Pedagogy I		**Type of Module:** Compulsory Module
ECTS-Points	6		
Workload **- Time in Class** **- Self-Study**	Workload: 180 h	Time in Class: 60 h	Self-Study: 120 h
Duration	2 Semester		
Frequency	every Semester		
Term	1-2		
Language of Instruction	German or English		
Forms of Teaching and Learning	Seminar / portfolio work, case work		
Content	In the seminar School Practice in Theory and Research, students prepare for the school practise semester and research one aspect of the school practice semester on the basis of theory and empirical research. In the seminar Micro Level: Teaching in Theory and Research, the subject area of teaching is dealt with, deepened using exemplary theories and empirical approaches and reflected on in the portfolio. The courses are coordinated with the seminars in sub-module 1b and serve the cumulative acquisition of skills following on from the the acquired orientation knowledge.		
Objectives	The students • know the general didactic foundations of lesson planning; • know methods of lesson observation and diagnostics; • know the foundations of pedagogical diagnostics, support and learning guidance; • are able to prepare a case description of their own teaching (school internship semester), document it in the portfolio and reflect on this case against the background of scientific theories and models in a criteria-led (research-based) manner; • are familiar with selected didactic models and teaching concepts; • are able to reflect on their own subjective theories in the portfolio; • know central aspects of research on teaching quality; • know central aspects of classroom management; • are familiar with the discourse on tasks and task culture (e.g. learning tasks, examination tasks, homework); • are able to reflect on appropriate ways of dealing with heterogeneity in schools and lessons; • know the advantages and disadvantages of more open and more closed forms of teaching; • know central aspects of performance assessment and are able to understand these using examples.		

Requirements for obtaining Credits / Grading (Weighting if applicable)	Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
	School Practice in Theory and Research	S	o	2	2	-	-	-	nb	-
	Micro Level: Teaching in Theory and Research	S	o	2	4	-	mP o. K	je nach Art	g	100
Transfer	-									
Prerequisites	Knowledge of the BWS-ME0 module is assumed.									
Responsible Persons	-									

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Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **BWS-ME3**	**Module Title:** Inclusion, Diversity, and Heterogeneity		**Type of Module:** Compulsory Module with Choice
ECTS-Points	6		
Workload **- Time in Class** **- Self-Study**	Workload: 150 h	Time in Class: 60 h	Self-Study: 90 h
Duration	2 Semester		
Frequency	every Semester		
Term	2-3		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture, seminar		
Content	The module prepares students for the challenges of difference- and inclusion-oriented school education under the conditions of social differentiation and social inequality. In the introductory lecture, phenomena of diversity, heterogeneity and inequality are examined from a social, cultural and educational science perspective in terms of basic theory as well as empirically, and examples are analysed in depth. Subsequently, processes of inclusion and exclusion in a social and institutional context are analysed. In the compulsory elective lecture or the compulsory elective seminar *Inclusion, Diversity and Heterogeneity in the School Context*, the institutional framework conditions for inclusion in the school system are reflected upon in depth and perspectives on inclusive school and teaching development are developed. In the compulsory elective course *Linguistic Heterogeneity*, students specialise in the area of language. The focus is on the professional handling of linguistic heterogeneity in schools and specialised teaching. On the one hand, students learn about the educational language requirements of schools and, on the other hand, about the acquisition of the language skills necessary for success at school and about possible impairments in the acquisition process (e.g. due to dyslexia). In addition, students gain insights into various language acquisition scenarios and learn which factors influence the development of multilingualism and how, in order to be able to derive recommendations for action in schools. Taking various subjects into account, students are introduced to methods of language-sensitive and language-promoting lesson planning using practical examples.		

Objectives

The students

- know the basics of theoretical and empirical approaches to diversity, heterogeneity and social inequality in their interdisciplinary breadth;
- deal with the relationship between inclusion and exclusion in society and the education system;
- are able to reflect on inclusion against the background of social and educational phenomena of diversity and heterogeneity;
- can relate questions of educational inequality and educational equity to their future actions as a teacher;
- deal with aspects of migration, flight and interculturality;
- deal with different concepts of sex and gender and concepts of sexual identity;
- deepen or expand their knowledge and skills in an area of their choice by
  - developing a complex and reflective understanding of processes of inclusion and exclusion in the school context and of concepts of inclusive school and lesson development, thereby gaining diversity- and heterogeneity-sensitive pedagogical orientation knowledge
  - **or** get to know the manifestations of linguistic heterogeneity that can be found in everyday life at grammar school in order to acquire a repertoire of methods that will enable them to analyse teaching materials for potential linguistic difficulties and to design language-sensitive subject lessons that are able to respond adequately to the needs of a linguistically heterogeneous student body.

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Introduction to the Topics of Inclusion, Diversity and Heterogeneity	L	o	2	3	-	wr.	60 min	g	100
Linguistic Heterogeneity *or* Inclusion, Diversity and Heterogeneity in the School Context	L	f	2	3	-	-	-	nb	-

Transfer

-

Prerequisites

Knowledge of the BWS-ME0 module is assumed.

Responsible Persons

-

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Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **BWS-ME4**	**Module Title:** Empirical Educational Research and Educational Psychology		**Type of Module:** Compulsory Module
ECTS-Points	6		
Workload **- Time in Class** **- Self-Study**	Workload: 180 h	Time in Class: 60 h	Self-Study: 120 h
Duration	2 Semester		
Frequency	every Semester		
Term	3-4		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture, seminar		
Content	The module provides an overview of the concepts and findings of empirical educational research and educational psychology. The focus is on psychological aspects of teaching and learning. These include, among others: classical and modern learning theories; intelligence concepts and giftedness; psychology of personality; self-regulated learning and learning strategies; motivation and emotion in educational contexts; school-related self-concepts; interest and expectancy-value model(s); psychological aspects of teaching quality; professional competence of teachers; social disparities and gender differences in the school context; effectiveness in the education system; fundamentals of educational-psychological diagnostics; experimental planning and designs of empirical studies in educational research and educational psychology.		
Objectives	The students • have practical knowledge of central fields of pedagogical-psychological research and empirical educational research on the basis of this module; • are able to reflect on and apply what they have learnt with regard to educational fields of practice; • are familiar with the basic methodological concepts of empirical research and are able to interpret the results of empirical studies.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Introduction to educational psychology	L	o	2	2	-	wr.	120 min	g	100
Core Topics of Empirical Educational Research and Educational Psychology	SV	o	2	2	-				
Module Exam	-	o	-	2	-				

Transfer	-
Prerequisites	Knowledge of the BWS-ME0 module is assumed.
Responsible Persons	-

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Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Section 6: School Practise Semester

The School Practise Semester can only be completed in a winter semester, and prior to that, students should have completed coursework in subject didactics in both subjects as part of their Master's studies. If starting in the winter semester, it is recommended to complete the School Practise Semester in the third semester; if starting in the summer semester, it is recommended to complete it in the second or in the fourth semester. The School Practise Semester begins each September with the start of the new school year and lasts for 12 weeks. During this time, students are supervised by a State Seminar for Didactics and Teacher Education (Gymnasium) affiliated with the school, and they attend accompanying events at the seminar throughout the entire practise period. Students are informed about the application procedure for the School Practise Semester at the beginning of their studies. Further information about the School Practise Semester can be found in the publications of the Ministry of Education under the following link:

`https://lehrer-online-bw.de/schulpraktika`.

<table>
<tr><td>Module Number:
SP</td><td colspan="2">Module Title:
School Practice Semester</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">16</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
480 h</td><td>Time in Class:
120 h</td><td>Self-Study:
360 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">regularly in Winter Semester</td></tr>
<tr><td>Term</td><td colspan="3">2-3</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">School Internship</td></tr>
<tr><td>Content</td><td colspan="3">School Internship</td></tr>
<tr><td>Objectives</td><td colspan="3">School Internship</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td>School Practice Semester</td><td>-</td><td>o</td><td>-</td><td>16</td><td>-</td><td>-</td><td>-</td><td>-</td><td>100</td></tr>
</table>
</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">One subject didactics module in each subject, as well as the module BWS-ME0, is required.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">-</td></tr>
</table>

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Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Section 7: Master Thesis

The Master's thesis is the final part of the Master's programme and can be completed in one of the two subjects (including subject didactics), but not in the educational sciences. If the Master's thesis is on a subject didactics topic, it will be completed in the subject whose didactics is the main focus of the thesis.

<table>
<tr><td>Module Number:
INFL31</td><td colspan="2">Module Title:
Master Thesis Computer Science</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">15</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
450 h</td><td>Time in Class:
0 h</td><td>Self-Study:
450 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">every Semester</td></tr>
<tr><td>Term</td><td colspan="3">4</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Master thesis, Independent study</td></tr>
<tr><td>Content</td><td colspan="3">The Master's thesis can be written in Computer Science in the case of a subject combination with Computer Science.</td></tr>
<tr><td>Objectives</td><td colspan="3">In the master's thesis, students demonstrate that they have mastered the fundamentals of academic research in computer science and can independently, comprehensively, and problem-orientedly address an academic question within a limited time frame and present it appropriately.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td>Master Thesis</td><td>MT</td><td>o</td><td>-</td><td>15</td><td>no</td><td>MT</td><td>-</td><td>g</td><td>100</td></tr>
</table>
</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">A subject-specific requirement for admission to the master thesis module, in addition to the general conditions stated in the study and examination regulations, is the attainment of at least 36 credits from the second subject area and at least 15 credits from the subject didactics area.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">The dean of studies</td></tr>
</table>

Abbreviations:

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Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MAT-40-53**	**Module Title:** Master Thesis		**Type of Module:** Compulsory Module
ECTS-Points	15		
Workload **- Time in Class** **- Self-Study**	Workload: 450 h	Time in Class: 0 h	Self-Study: 450 h
Duration	1 Semester		
Frequency	every Semester		
Term	4		
Language of Instruction	German		
Forms of Teaching and Learning	Master thesis		
Content	The master's thesis represents the culmination of the master's degree programme. Under the guidance of a supervisor, students are required to work on a well-defined problem in mathematics (including mathematics education), which may extend to the frontiers of current research. This involves using scientific methods and presenting the results in written form. Specifically, this includes: • formulating a scientific research question in consultation with the supervisor; • independently searching for and studying relevant scientific literature; • formulating appropriate research questions and methodological approaches for their solution; • independently carrying out the project, as well as presenting the project and its results in writing and, if applicable, orally, within the context of the current state of research. The results should contribute to scientific knowledge.		
Objectives	The students: • are capable of familiarising themselves with a problem, which may extend to the frontiers of current research, within a given timeframe and independently developing a solution approach, • can increasingly apply appropriate scientific methods independently and present the results in a scientifically appropriate manner, • are able to independently work on a scientific topic while applying their mathematical methodological knowledge, • deepen their problem-solving skills and can transfer their methodological knowledge, • are able to present the results of their project to a professional audience.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Master Thesis	MT	o	-	15	no	MT	-	g	100

Transfer	-

Prerequisites	In addition to the requirements mentioned in the general part of the study and examination regulations, the technical admission requirement for admission to the master's thesis module is the acquisition of at least 36 credit points from the second subject area and at least 15 credit points from the subject didactics area.
Responsible Persons	The dean of studies at the Department of Mathematics

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Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MLP13**	**Module Title:** Master Thesis (Physics)	**Type of Module:** Compulsory Module

ECTS-Points	15
Workload **- Time in Class** **- Self-Study**	Workload: 450 h Time in Class: 50 h Self-Study: 400 h
Duration	1 Semester
Frequency	every Semester
Term	4
Language of Instruction	German
Forms of Teaching and Learning	Master thesis, independent study, discussion with the supervisor, presentation
Content	Preparation of a scientific paper (master's thesis, processing time 16 weeks). The master's thesis can be written in physics in the case of a subject combination with physics. It may also include subject-related didactic elements.
Objectives	Students grasp the fundamentals of scientific research and acquire an understanding of science. They are able to independently, comprehensively, and problem-orientedly address an academic question within a limited time frame and can appropriately formulate and present their findings in a written report.

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Master Thesis	MT	o	-	15	no	MT	-	g	100

The results of the master's thesis are presented in the research group.

Transfer	-
Prerequisites	A subject-specific requirement for admission to the Master thesis module, in addition to the general requirements stated in the study and examination regulations, is the attainment of at least 36 credits from the second subject area and at least 15 credits from the subject didactics area.
Responsible Persons	The dean of studies

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Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Section 8: Requirements

Depending on the combination of subjects, certain requirements must have already been fulfiled in the chosen second subject as part of the Bachelor of Science programme that qualifies for admission to this programme. These are listed in Section 2.3 for each subject combination. For completeness, we list the module descriptions of the modules of the second subjects listed as admission requirements in Section 2.3. These or equivalent requirements may also be imposed if necessary.

Module Number: **BLP01**	**Module Title:** Physics Basic Course 1		**Type of Module:** Compulsory Module
ECTS-Points	12		
Workload **- Time in Class** **- Self-Study**	Workload: 360 h	Time in Class: 135 h	Self-Study: 225 h
Duration	1 Semester		
Frequency	regularly in Winter Semester		
Term	-		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise classes, independent study, group work		
Content	• Mechanics – Space, time, measurement, coordinate systems, vectors, Newton's equations of motion, force, conservative force fields, work (line integrals, gradient), solution of equations of motion (differential equations), harmonic oscillator, with damping, driven oscillator (complex numbers), law of gravitation, Kepler's laws, angular momentum, many-body systems, centre of mass, rigid body (volume integrals), moment of inertia tensor, rotations (orthogonal transformations), fictitious forces, gyroscopes, vibrations and waves, acoustics, Fourier decomposition. • Thermodynamics – Temperature, heat capacity, Boltzmann distribution, ideal gas, barometric height formula, entropy, heat engines, phase transitions.		
Objectives	Students understand the fundamental methods and concepts of mechanics and thermodynamics. They recognise the relationship between physical experiments in mechanics/thermodynamics and mathematical formulations. Students are able to reproduce and explain the content covered in the lectures using examples. They can formulate and solve simple physical problems mathematically, either exactly or approximately. For all topics, they use appropriate technical language and mathematical methods.		
Requirements for obtaining Credits / Grading (Weighting if applicable)			

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Physics Basic Course 1	L	o	6	9	yes	wr.	-	g	100
	E	o	3	3					

Admission requirement for the module exam (two exams) is successful participation in the exercise classes. Details such as the weighting of the exams will be announced at the start of the course.

Transfer	Physics Basic Courses in the Bachelor's programme and in the teaching programmes for physics and astronomy.
Prerequisites	none
Responsible Persons	Lecturers from the Department of Physics

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Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **BLP02**	**Module Title:** Physics Basic Course 2		**Type of Module:** Compulsory Module
ECTS-Points	12		
Workload **- Time in Class** **- Self-Study**	Workload: 360 h	Time in Class: 135 h	Self-Study: 225 h
Duration	1 Semester		
Frequency	regularly in Summer Semester		
Term	-		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise classes, independent study, group work		
Content	Electrostatics (surface integrals, rotation, divergence; Stokes' and Gauss' theorems), boundary value problems, multipole expansion, electrostatics in a medium, Ohm's law, magnetostatics, Maxwell's equations, alternating current, inductances, capacitances, complex resistances, simple circuits, electromagnetic waves, special relativity.		
Objectives	Students understand the fundamental methods and concepts of electrodynamics. They have grasped the basic concepts of special relativity. They recognise the relationship between physical experiments in electrodynamics and the corresponding mathematical formulations. Students are able to reproduce and explain the content of electrodynamics and special relativity covered in the lectures using examples. They can formulate and solve simple physical problems mathematically, either exactly or approximately. For all topics, they use appropriate technical language and mathematical methods.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Physics Basic Course 2	L	o	6	9	yes	wr.	-	g	100
	E	o	3	3					

Admission requirement for the module exam (two exams) is successful participation in the exercise classes. Details, such as the weighting of the exams, will be announced at the start of the course.

Transfer	Physics Basic Courses in the Bachelor's programme and in the teaching programmes for physics and astronomy
Prerequisites	none
Responsible Persons	Lecturers from the Department of Physics

Abbreviations:

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Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **INFM1010**	**Module Title:** Mathematics for Computer Science 1: Analysis		**Type of Module:** Compulsory Module
ECTS-Points	9		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Duration	1 Semester		
Frequency	regularly in Winter Semester		
Term	-		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, excercise class		
Content	Topics include the basics (mathematical reasoning; sets; mappings and relations; natural numbers), real numbers, sequences and series, limits and growth of functions, differential and integral calculus, Taylor expansion.		
Objectives	Students know the basics of analysis, which is an important prerequisite in all areas of computer science. They have the ability to formally correct (mathematical) argumentation and representation. Through working in small exercise groups, students have the ability to to work on problems together and to critically assess solutions of other students. By dealing with strictly formal content and tools, argumentative precision is developed and perseverance is strengthened.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Mathematics for Computer Science 1: Analysis	L	o	4	6	yes	wr.	120	g	100
	E	o	2	3					

Transfer	-
Prerequisites	There are no prerequisites
Responsible Persons	Britta Dorn, Stephan Eckstein

Abbreviations:

Grading System : g=graded, ng=not graded
Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status : o=obligatory, f=facultative
Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **INFM1020**	**Module Title:** Mathematics for Computer Science 2: Linear Algebra		**Type of Module:** Compulsory Module
ECTS-Points	9		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Duration	1 Semester		
Frequency	regularly in Summer Semester		
Term	-		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise classes		
Content	Topics include algebra (groups, rings, bodies, polynomial rings, secondary classes and Lagrange's theorem) and linear algebra (vector spaces, linear mappings and their matrix representation, rank of a matrix, change of basis, orthonormal bases, linear systems of equations and their solution using the Gauß algorithm, determinants, eigenvectors and eigenvalues, orthogonal and symmetrical matrices).		
Objectives	Students acquire knowledge of algebraic structures and linear algebra and their applications in computer science. They are able to argue about abstract algebraic structures and can correctly apply the methods and algorithms of linear algebra to solve linear systems of equations and describe geometric situations. After completing this module, students are confident in formally correct mathematical argumentation and its presentation.		
Requirements for obtaining Credits / Grading (Weighting if applicable)			

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Mathematics for Computer Science 2: Linear Algebra	L	o	4	6	yes	wr.	120	g	100
	E	o	2	3					

Transfer	-
Prerequisites	INF1010 Mathematics for Computer Science 1 recommended
Responsible Persons	Britta Dorn, Stephan Eckstein

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **INFM1110**	**Module Title:** Practical Computer Science 1: Declarative Programming		**Type of Module:** Compulsory Module
ECTS-Points	9		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Duration	1 Semester		
Frequency	regularly in Winter Semester		
Term	-		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise classes, presence exercise		
Content	Elements of programming, case distinctions and branching, composite and mixed data, programming with accumulators, higher-order functions, interactive programmes, recursive data structures and recursive functions, pattern matching, designing programmes, design recipes, reduction semantics and programme equivalence.		
Objectives	Students are familiar with design instructions for the systematic design of computer programmes and are able to use them appropriately. They know the characteristics of the functional paradigm and can assess its strengths and limitations. They can structure problems, describe them abstractly and then develop programmes in a disciplined process. They can present their results clearly and explain the details of their solution using specialised terminology.		
Requirements for obtaining Credits / Grading (Weighting if applicable)			

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Practical Computer Science 1: Declarative Programming	L	o	4	6	yes	wr.	90	g	100
	E	o	2	3					

Transfer	-		
Prerequisites	There are no prerequisites		
Responsible Persons	Klaus Ostermann, Torsten Grust		

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **INFM1120**	**Module Title:** Practical Computer Science 2: Imperative and Object-Oriented Programming		**Type of Module:** Compulsory Module
ECTS-Points	9		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Duration	1 Semester		
Frequency	regularly in Winter Semester		
Term	-		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture, exercise classes		
Content	Modelling of data, class concept, composition and union of class references, class hierarchies, object-oriented modelling and programming, methods and parameter-passing, encapsulation of data, abstract classes, visibility and access rights, imperative methods, GUI programming, debugging		
Objectives	Students know methods and tools of object-oriented modelling and programming and can use them appropriately. They know the characteristics of stateful programming and understand the necessity of encapsulating the state of objects. Students are able to implement and test basic computer science algorithms and data structures using imperative and object-orientated programming methods. In addition, students can effectively localise and eliminate errors in programs. They are prepared to use their programming skills effectively in subsequent larger projects.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Practical Computer Science 2: Imperative and Object-Oriented Progr.	L	o	4	6	yes	wr.	90	g	100
	E	o	2	3					

Transfer	-
Prerequisites	There are no participation requirements.
Responsible Persons	Torsten Grust

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **INFM2010**	**Module Title:** Mathematics for Computer Science 3: Advanced Topics	**Type of Module:** Compulsory Module
ECTS-Points	9	
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h Self-Study: 180 h
Duration	1 Semester	
Frequency	regularly in Winter Semester	
Term	-	
Language of Instruction	German	
Forms of Teaching and Learning	Lecture, exercise classes	
Content	Topics include multidimensional analysis, Fourier series, optimisation (extreme value problems under constraints, Lagrange multipliers, algorithms in discrete and continuous optimisation), topics from discrete mathematics such as number theory with applications in cryptology.	
Objectives	Students acquire knowledge of multidimensional analysis, number theory and their application in cryptology and optimisation. After completing this module, students are able to establish links between different mathematical sub-areas and name their significance for computer science.	

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Mathematics for Computer Science 3: Advanced Topics	L	o	4	6	yes	wr.	120	g	100
	E	o	2	3					

Transfer	-
Prerequisites	INFM1010 Mathematics for Computer Science 1 and INFM1020 Mathematics for Computer Science 2 are recommended
Responsible Persons	Britta Dorn, Stephan Eckstein

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
INFM2020</td><td colspan="2">Module Title:
Mathematics for Computer Science 4: Numerical Methods or Stochastics</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">6</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
180 h</td><td>Time in Class:
60 h</td><td>Self-Study:
120 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">regularly in Summer Semester</td></tr>
<tr><td>Term</td><td colspan="3">-</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture, exercise classes</td></tr>
<tr><td>Content</td><td colspan="3">The module provides in-depth knowledge of mathematics and is acquired in one of the of the following lectures:
• INF2021 Stochastics,
• INF2022 Numerics.</td></tr>
<tr><td>Objectives</td><td colspan="3">The students know the basic principles of a sub-area of mathematics – here: numerics or stochastics – and can apply these in a suitable context. For stochastics, they have the ability to abstract stochastic problems and are able to apply their knowledge to concrete problems.
For the sub-area of numerics, students know the basic principles of numerical mathematics and are proficient in basic calculation techniques. They understand how to apply the knowledge acquired in the basic lectures in mathematics for computer science to analyse numerical methods and apply the methods to specific problems. Their algorithmic thinking has been sharpened and they are familiar with analysing algorithms in terms of efficiency and complexity. In the exercise classes, they developed a confident, precise and independent approach to the concepts, statements and methods from the lectures. In addition, the students' presentation and communication skills were trained through written work and presenting their own solutions. The students are able to acquire knowledge through self-study and at the same time their ability to work in a team was promoted by working in smaller groups.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td rowspan="2">INF2021 Stochastics or INF2022 Numerics</td><td>L</td><td>o</td><td>3</td><td>4,5</td><td rowspan="2">yes</td><td rowspan="2">wr.</td><td rowspan="2">120</td><td rowspan="2">g</td><td rowspan="2">100</td></tr>
<tr><td>E</td><td>o</td><td>1</td><td>1,5</td></tr>
</table>
</td></tr>
<tr><td>Transfer</td><td colspan="3">-</td></tr>
<tr><td>Prerequisites</td><td colspan="3">Mathematics for Computer Science 1-3 (INFM1010, INFM1020, INFM2010)</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">Britta Dorn</td></tr>
</table>

Abbreviations:

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Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MAT-10-01**	**Module Title:** Analysis		**Type of Module:** Compulsory Module
ECTS-Points	18		
Workload **- Time in Class** **- Self-Study**	Workload: 540 h	Time in Class: 180 h	Self-Study: 360 h
Duration	2 Semester		
Frequency	every Semester		
Term	-		
Language of Instruction	German		
Forms of Teaching and Learning	1. Semester: Analysis 1, Lecture 4 SWS + Ex.cl. 2 SWS + Rev.c. 2 SWS 2. Semester: Analysis 2, Lecture 4 SWS + Ex.cl. 2 SWS + Rev.c. 2 SWS		
Higher Objectives	In the Analysis module, students learn the essential content-related and methodological foundations of single-variable and multivariable calculus in their interconnected context. Particular emphasis is placed on the similarities and differences in approach. In the oral examination, students demonstrate that they have recognised these connections and are capable of integrating the central results of the lectures into these frameworks. The duration of the module not only supports these objectives but also facilitates the acquisition of a new language - the language of mathematics - and the development of a precise, strictly logical approach to problem-solving. This allows students the necessary time to make the significant transition from school-level mathematics to university-level mathematics. With the deeper and integrated understanding demonstrated in the oral examinations, the foundation is laid for successful participation in all advanced modules throughout their studies.		
Content	• Basic logic and sets. • Structure of real and complex numbers. • Sequences, convergence and series; criteria for convergence; power series, sequences of functions; pointwise and uniform covergence. • Continous functions in one dimension and between metric spaces and their properties. • One- and multidimensional differential calculus (especially: intermediate value theorem, Taylor expansion, implicit function theorem, inverse function theorem, extrema under constraints). • One- and multidimensional Riemann integral (especially Fubini's theorem, transformation formula). • Basic concepts of topology in metric and normed spaces. • Basic concepts of the theory of ordinary differential equations (Picard-Lindelöf theorem, linear ordinary differential equations, flows). • The lecture Analysis 1 focuses predominately on contents from one-dimensional analysis, the lecture Analysis 2 on multidimensional analysis.		

Objectives

The students know and understand the fundamental concepts, principles, and methods of single-variable and multivariable calculus. They have also developed a basic awareness of problems related to ordinary differential equations and initial value problems.
Their capacity for abstraction has been enhanced, they have been trained in analytical thinking, and their mathematical creativity has been stimulated. Through a proof- and structure-oriented approach, they have learned to follow mathematical proofs in calculus and independently prove or disprove mathematical statements in simple examples. They have recognised the essential connections within the theory of single-variable and multivariable calculus, understanding their similarities and differences, and are able to situate the central statements of the lectures within these contexts.
In the exercises, they have acquired a confident, precise, and independent handling of the concepts, principles, and methods introduced in the lectures. Furthermore, their presentation and communication skills have been developed through written assignments and presenting their own solutions. The students are capable of acquiring knowledge through self-study, and their teamwork skills have been strengthened through collaborative work in small groups.

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Analysis 1	L	o	4	6	yes	or.	20-30	g	100
	E	o	2	3					
	T	o	2	0					
Analysis 2	L	o	4	6	yes				
	E	o	2	3					
	T	o	2	0					

In both parts of the module an exercise certificate is to be acquired as coursework. The exercise certificate is acquired after regular participation in the exercise classes by taking part in a written test. Both partial assessments must be completed in the same semester.

For taking the oral exam at least one of the two exercise certificates has to be acquired. The module is finished only if both exercise certificates have been acquired and the oral exam is passed.

Literature

Possible References :

- T. Apostol: Mathematical Analysis, Addison Wesely Publishing Company 1971.
- Anton Deitmar: Analysis. Springer Spektrum 2017.
- Otto Forster: Analysis 1. Springer Spektrum 2013.
- Otto Forster: Analysis 2. Vieweg+Teubner 2011.
- Harro Heuser: Lehrbuch der Analysis Teil 1. Vieweg+Teubner 2009.
- Harro Heuser: Lehrbuch der Analysis Teil 2. Teubner 2004.
- Konrad Königsberger: Analysis 1. Springer 2004.
- Konrad Königsberger: Analysis 2. Springer 2004.
- Wolfgang Walter: Analysis 1. Springer 2004.
- Wolfgang Walter: Analysis 2. Springer 1995.

Transfer

Depending on the combination of subjects, this is an admission requirement that can be issued as a condition if necessary.

Prerequisites

There are no prerequisites for participation in the module.

Responsible Persons	Anton Deitmar, Frank Loose, Reiner Schätzle, Stefan Teufel

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Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MAT-10-02**	**Module Title:** Linear Algebra		**Type of Module:** Compulsory Module
ECTS-Points	18		
Workload **- Time in Class** **- Self-Study**	Workload: 540 h	Time in Class: 180 h	Self-Study: 360 h
Duration	2 Semester		
Frequency	every Semester		
Term	-		
Language of Instruction	German		
Forms of Teaching and Learning	1. Semester: Linear Algebra 1, Lecture 4 SWS + Ex.cl. 2 SWS + Rev.c. 2 SWS 2. Semester: Linear Algebra 2, Lecture 4 SWS + Ex.cl. 2 SWS + Rev.c. 2 SWS		
Higher Objectives	In the Linear Algebra module, students learn the essential conceptual and methodological foundations of Linear and Multilinear Algebra, with a particular focus on their interconnections, similarities, and synergies. In the oral examination, students demonstrate that they have recognised these relationships and are capable of situating the core results of the lectures within these contexts. The duration of the module not only supports these objectives but also accounts for the acquisition of a new language - the language of mathematics - and the development of a precise and rigorously logical working methodology. This allows students the necessary time to make the significant transition from school-level mathematics to university-level mathematics. By showcasing deeper and integrated understanding during the oral examinations, students lay the foundation for successful participation in all subsequent modules of their academic programme.		
Content	• Basic algebraic concepts (groups, rings, fields, symmetric group, polynomial ring). • Vector spaces and linear maps. • Matrices and systems of linear equations. • Determinants, eigenvalues and diagonalizability. • Jordan canonical form. • Euclidean and unitary vector spaces, spectral theorems. • Bilinear forms and multilinear algebra (tensor product, exterior product). • Additionally a selection of the following topics will be covered: – Rational normal form and elementary divisors. – Beginning of divisibility theory in rings (euclidean rings, principle ideal rings, factorial rings). – Basic concepts of modules (torsion module, finitely generated modules, abelian groups). – Modules over euclidean rings (Hermite normal form, Smith normal form, structure theorems). – Finitely generated modules over principle ideal rings. – Normal divisors, factor group, Lagrange's theorem, group homomorphisms. – Analytical geometry, classification of conic sections.		

<table>
<tr><td>Objectives</td><td>The students are familiar with and understand the fundamental concepts, statements, and methods of Linear Algebra. Their capacity for abstraction has been enhanced, they have developed analytical thinking skills, and their mathematical imagination has been stimulated. Through a proof- and structure-oriented approach, they have learned to comprehend mathematical proofs in Linear Algebra and independently prove or disprove mathematical statements in simple examples. They have recognised the essential interrelations in the theory of Linear and Multilinear Algebra, particularly their structural similarities, and are able to contextualise the core content of the lectures within these frameworks.
In the exercises, they have developed a confident, precise, and independent approach to the concepts, statements, and methods covered in the lectures. Additionally, their presentation and communication skills have been cultivated through written work and presenting their own solutions. The students are capable of acquiring knowledge through self-study, while their teamwork abilities have been fostered through collaboration in small groups.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td>
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td rowspan="3">Linear Algebra 1</td><td>L</td><td>o</td><td>4</td><td>6</td><td rowspan="3">yes</td><td rowspan="6">or.</td><td rowspan="6">20-30</td><td rowspan="6">g</td><td rowspan="6">100</td></tr>
<tr><td>E</td><td>o</td><td>2</td><td>3</td></tr>
<tr><td>T</td><td>o</td><td>2</td><td>0</td></tr>
<tr><td rowspan="3">Linear Algebra 2</td><td>L</td><td>o</td><td>4</td><td>6</td><td rowspan="3">yes</td></tr>
<tr><td>E</td><td>o</td><td>2</td><td>3</td></tr>
<tr><td>T</td><td>f</td><td>2</td><td>0</td></tr>
</table>
In both parts of the module an exercise certificate is to be acquired as coursework. The exercise certificate is acquired after regular participation in the exercise classes by taking part in a written test. Both partial assessments must be completed in the same semester.
For taking the oral exam at least one of the two exercise certificates has to be acquired. The module is finished only if both exercise certificates have been acquired and the oral exam is passed.
The revision course for Linear Algebra 2 is only offered when there is a specific need.</td></tr>
<tr><td>Literature</td><td>Possible References :
• Siegfried Bosch: Lineare Algebra. Springer 2008.
• Egbert Brieskorn: Lineare Algebra und analytische Geometrie 1. Vieweg 1985.
• Theodor Bröcker: Lineare Algebra und analytische Geometrie. Birkhäuser 2013.
• Gerd Fischer: Lineare Algebra. Springer Spektrum 2014.
• Peter Lax: Linear Algebra. Wiley 2007.
• Max Koecher: Lineare Algebra und analytische Geometrie. Springer 2003.</td></tr>
<tr><td>Transfer</td><td>Depending on the combination of subjects, this is an admission requirement that can be issued as a condition if necessary.</td></tr>
<tr><td>Prerequisites</td><td>There are no prerequisites for participation in the module.</td></tr>
<tr><td>Responsible Persons</td><td>Victor Batyrev, Jürgen Hausen, Hannah Markwig, Thomas Markwig</td></tr>
</table>

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MP1**	**Module Title:** Mathematics for Physicists 1		**Type of Module:** Compulsory Module
ECTS-Points	9		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Duration	1 Semester		
Frequency	every Semester		
Term	-		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 4 SWS + Ex.cl. 2 SWS		
Content	• Simple logic and sets. • Structure of real and complex numbers. • Sequences, convergence and series; convergence criteria; power series, function sequences; pointwise and uniform convergence. • Continuous functions in one dimension and their properties. • Differential calculus in one dimension (in particular the Mean Value Theorem, Taylor expansion). • Riemann integral in one dimension.		
Objectives	Students know and understand the basic concepts, statements and methods of one-dimensional analysis that are relevant to the study of physics. Their ability to abstract has been promoted and they have been trained in analytical thinking. Using a structure-orientated approach, they have learned to classify physically relevant mathematical statements, to understand mathematical proofs of analysis and to independently prove or disprove mathematical statements using simple examples. They have recognised the essential connections of the theory of one-dimensional analysis and are able to classify the central statements of the lectures in these connections. In the exercises, they have developed a confident, precise and independent handling of the concepts, statements and methods from the lectures. In addition, the students' presentation and communication skills were trained through written work and presenting their own solutions. The students are able to acquire knowledge through self-study and at the same time their ability to work in a team was promoted by working in smaller groups.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Mathematics for Physicists 1	L	o	4	6	yes	wr. o. or.	90-180 o. 20-30	g	100
	E	o	2	3					

In this module an exercise certificate is to be acquired as coursework. For participation in the examination the coursework must have been acquired. Whether the examination is written or oral is decided by the instructor with approval by the head of the examination board.

Transfer	Mathematics for physicists on the Bachelor's degree programme in Physics
Prerequisites	none

Responsible Persons	The dean of studies at the Department of Mathematics

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
MP2</td><td colspan="2">Module Title:
Mathematics for Physicists 2</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">9</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
270 h</td><td>Time in Class:
90 h</td><td>Self-Study:
180 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">every Semester</td></tr>
<tr><td>Term</td><td colspan="3">-</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture 4 SWS + Ex.cl. 2 SWS</td></tr>
<tr><td>Content</td><td colspan="3">• Vector spaces and linear mappings.
• Matrix calculus and linear systems of equations.
• Determinants, eigenvalues, diagonalisability and Jordan normal form.
• Euclidean and unitary vector spaces, spectral theorems, principles of analytic geometry.</td></tr>
<tr><td>Objectives</td><td colspan="3">Students know and understand the basic concepts, statements and methods of linear algebra. Their ability to think abstractly has been promoted, they have been trained in analytical thinking and their mathematical imagination has been stimulated. Using a structure-orientated approach, they have learned to classify physically relevant mathematical statements, to understand mathematical proofs of linear algebra and to independently prove or disprove mathematical statements using simple examples. They have recognised the essential connections of the theory of linear algebra and are able to classify the central statements of the lectures in these connections.
In the exercises, they have developed a confident, precise and independent handling of the concepts, statements and methods from the lectures. In addition, the students' presentation and communication skills were trained through written work and presenting their own solutions. The students are able to acquire knowledge through self-study and at the same time their ability to work in a team was promoted by working in smaller groups.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td rowspan="2">Mathematics for Physicists 2</td><td>L</td><td>o</td><td>4</td><td>6</td><td rowspan="2">yes</td><td rowspan="2">wr. o. or.</td><td rowspan="2">90-180 o. 20-30</td><td rowspan="2">g</td><td rowspan="2">100</td></tr>
<tr><td>E</td><td>o</td><td>2</td><td>3</td></tr>
</table>
In this module an exercise certificate is to be acquired as coursework. For participation in the examination the coursework must have been acquired. Whether the examination is written or oral is decided by the instructor with approval by the head of the examination board.</td></tr>
<tr><td>Transfer</td><td colspan="3">Mathematics for physicists on the Bachelor's degree programme in Physics</td></tr>
<tr><td>Prerequisites</td><td colspan="3">none</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">The dean of studies at the Department of Mathematics</td></tr>
</table>

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

Module Number: **MP3**	**Module Title:** Mathematics for Physicists 3		**Type of Module:** Compulsory Module
ECTS-Points	9		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Duration	1 Semester		
Frequency	every Semester		
Term	-		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 4 SWS + Ex.cl. 2 SWS		
Content	• Basic topological concepts in metric and normalised spaces. • Sequences, convergence and series; convergence criteria; power series, function sequences; pointwise and uniform convergence. • Continuous functions between metric spaces and their properties. • Differential calculus in multidimensions (in particular Mean Value Theorem, Taylor expansion, Theorem on Implicit Functions, Theorem of the Inverse Function, extrema under constraints). • Riemann integral in multidimensions (in particular Fubini's Theorem, transformation formula). • Basic concepts from the theory of ordinary differential equations (Theorem of Picard-Lindelöf, linear ordinary differential equations, flows).		
Objectives	Students know and understand the basic concepts, statements and methods of multidimensional analysis that are relevant to the study of physics. Their capacity for abstraction has been developed and they are trained in analytical thinking. Students can apply the algorithmic methods they have learnt confidently and purposefully. They have recognised the essential interrelations of the theory of multidimensional analysis and are capable of situating the physically relevant statements from the lectures within these interrelations. In the exercises, they have developed a confident, precise and independent handling of the concepts, statements and methods from the lectures. In addition, the students' presentation and communication skills were trained through written work and presenting their own solutions. The students are able to acquire knowledge through self-study and at the same time their ability to work in a team was promoted by working in smaller groups.		

Requirements for obtaining Credits / Grading (Weighting if applicable)

Title	Type of Course	Status	SWS	ECTS	Coursework	Type of Exam	Dur. of Exam (min)	Grading	Weight for Grade
Mathematics for Physicists 3	L	o	4	6	yes	wr. o. or.	90-180 o. 20-30	g	100
	E	o	2	3					

In this module an exercise certificate is to be acquired as coursework. For participation in the examination the coursework must have been acquired. Whether the examination is written or oral is decided by the instructor with approval by the head of the examination board.

Transfer	Mathematics for physicists on the Bachelor's degree programme in Physics

Prerequisites	Knowledge of Mathematics for Physicists 1 and 2 is expected.
Responsible Persons	The dean of studies at the Department of Mathematics

Abbreviations:

Grading System	: g=graded, ng=not graded
Examination Type	: MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format	: L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom
Status	: o=obligatory, f=facultative
Other	: h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

<table>
<tr><td>Module Number:
MP4</td><td colspan="2">Module Title:
Mathematics for Physicists 4</td><td>Type of Module:
Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">6</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
180 h</td><td>Time in Class:
60 h</td><td>Self-Study:
180 h</td></tr>
<tr><td>Duration</td><td colspan="3">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">regularly in Summer Semester</td></tr>
<tr><td>Term</td><td colspan="3">-</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture 3 SWS + Ex.cl. 1 SWS</td></tr>
<tr><td>Content</td><td colspan="3">• Holomorphic functions, Cauchy-Riemann Differential equations.
• Antiderivatives, Cauchy’s integral formula, Cauchy’s integral theorem.
• Formal and convergent power series, complex-analytical functions, Identity Theorem.
• Laurent series, holomorphic functions with isolated singularities singularities, Casorati-Weierstraß Theorem.
• Residue Theorem and applications.
• Curve and surface integrals.
• Integrals Theorems by Green, Gauß and Stokes.</td></tr>
<tr><td>Objectives</td><td colspan="3">Students know the basics of function theory and are familiar with the integral theorems. They are proficient in the essential calculation techniques and can explicitly solve path integrals as well as curve and surface integrals. They are familiar with central applications of the theory in mathematics and physics and have the ability to transfer abstract questions to concrete problems in function theory and solve them there.
In the exercises, they have developed a confident, precise and independent handling of the concepts, statements and methods from the lectures. In addition, the students’ presentation and communication skills were trained through written work and presenting their own solutions. The students are able to acquire knowledge through self-study and at the same time their ability to work in a team was promoted by working in smaller groups.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="3">
<table>
<tr><th>Title</th><th>Type of Course</th><th>Status</th><th>SWS</th><th>ECTS</th><th>Coursework</th><th>Type of Exam</th><th>Dur. of Exam (min)</th><th>Grading</th><th>Weight for Grade</th></tr>
<tr><td rowspan="2">Mathematics for Physicists 4</td><td>L</td><td>o</td><td>3</td><td>4,5</td><td rowspan="2">yes</td><td rowspan="2">wr. o. or.</td><td rowspan="2">90-180 o. 20-30</td><td rowspan="2">g</td><td rowspan="2">100</td></tr>
<tr><td>E</td><td>o</td><td>1</td><td>1,5</td></tr>
</table>
In this module an exercise certificate is to be acquired as coursework. For participation in the examination the coursework must have been acquired. Whether the examination is written or oral is decided by the instructor with approval by the head of the examination board.</td></tr>
<tr><td>Transfer</td><td colspan="3">Mathematics for physicists on the Bachelor’s degree programme in Physics</td></tr>
<tr><td>Prerequisites</td><td colspan="3">Knowledge of Mathematics for Physicists 1 to 3 is expected.</td></tr>
</table>

Responsible Persons	The dean of studies at the Department of Mathematics

Abbreviations:

Grading System : g=graded, ng=not graded

Examination Type : MT=master's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests

Teaching Format : L=lecture, LE=lecture with integrated exercises, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, PS=proseminar, IC=inverted classroom

Status : o=obligatory, f=facultative

Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week

4 Courses for the Module Specialisation

4.1 Catalogue of Courses

The following is a list of courses that can be included in the module Specialisation. Additional courses may be authorised upon written application to the head of the examination board.

Course Title:	Algebraic Topology 1		
Specialisation	Geometry		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	not regularly		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS		
Content	• Set theoretical topology. • Basic concepts of category theory. • The fundamental group of a punctured topological space. • Theory of covering spaces. • Basic concepts of singular homology theory. • Applications.		
Special Objectives	The students learn how to realise ideas in topology, e.g. the detection of holes in topological spaces, into a precise theory, even with a sophisticated technique. In particular, they recognise how abstract concepts, e.g. from category theory and homological algebra, provide effective ways of speaking that enable the formation of ideas to be adequately implemented.		
Literature	**Possible References :** • Allen Hatcher: Algebraic topology. Cambridge University Press 2009. • Horst Schubert: Topologie. Teubner 1971. • Edwin H. Spanier: Algebraic topology. McGraw-Hill 1966. • Ralph Stöcker, Heiner Zieschang: Algebraische Topologie. Teubner 1994.		
Responsible Persons	Anton Deitmar, Frank Loose		

Course Title:	Algorithms of Numerical Mathematics		
Specialisation	Scientific Computing		
Workload **- Time in Class** **- Self-Study**	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	regularly		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS		

Content	Advanced, important algorithms of numerics (without differential equations) such as: • Fast Fourier transformation; • QR algorithms for the calulation of eigenvalues; • Method of conjugated gradients and more general Krylov space methods as iterative methods in numeric linear algebra and in non-linear optimisation; • Simplex method and interior point methods in linear optimisation.
Special Objectives	The students have learned the key concepts, results, and methods of algorithmic numerical mathematics.
Literature	**Possible References :** • Peter Deuflhard, Andreas Hohmann: Numerische Mathematik 1. De Gruyter 2008. • Martin Hanke-Bourgeois: Grundlagen der Numerischen Mathematik und des Wissenschaftlichen Rechnens. Vieweg 2009.
Responsible Persons	Christian Lubich, Andreas Prohl

Course Title:	Introduction to K-Theory		
Specialisation	Geometry		
Workload - Time in Class - Self-Study	Workload: 90 h	Time in Class: 30 h	Self-Study: 60 h
Frequency	not regularly		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 2 SWS		
Content	• Vector bundles. • Topological K-theory. • Künneth formula and Bott periodicity. • Characteristic classes. • Chern character. • Algebraic K-theory • Plus construction.		
Special Objectives	The students have learnt an important mathematical field that combines analysis, geometry, algebra and number theory. They have learnt to recognise and use the connections between different areas. They can understand and use terms such as vector or fibre bundles or categorical K-groups and apply them. They have learnt to think in large contexts.		

Literature	**Possible References :** • Michael Atiyah: K-theory. Addison-Wesley 1989. • Max Karoubi: K-theory. Springer 2008. • Emilio Lluis-Puebla, Jean-Louis Loday, Henri Gillet, Christophe Soule, Victor Snaith: Higher algebraic K-theory: an overview. Springer 1992.
Responsible Persons	Anton Deitmar

Course Title:	Introduction to Mathematical Logic		
Specialisation	Analysis		
Workload - Time in Class - Self-Study	Workload: 90 h	Time in Class: 30 h	Self-Study: 60 h
Frequency	not regularly		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 2 SWS		
Content	• Propositional logic. • Languages of the first order: – Completeness and compactness. • Theory of computations: – Register machines; – Gödelisation. • Incompleteness of arithmetic: – First and second incompleteness theorem. • Set theory: – Ordinal- and cardinal numbers; – Incompleteness of set theory.		
Special Objectives	Students are able to understand mathematical theorems and theories in the context of mathematical logic. They understand the limits of possible mathematical knowledge, recognise the difference between truth and provability and can apply basic theoretical model thinking to mathematical content.		
Literature	**Possible References :** • Rautenberg, Wolfgang: Einführung in die Mathematische Logik. Vieweg+Teubner 2008. • Ziegler, Martin: Mathematische Logik. Birkhäuser 2016.		
Responsible Persons	Anton Deitmar		

Course Title:	Introduction to set theory		
Specialisation	Analysis		
Workload - Time in Class - Self-Study	Workload: 90 h	Time in Class: 30 h	Self-Study: 60 h
Frequency	not regularly		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 2 SWS		
Content	**Content:** •		
Special Objectives	-		
Literature	**Possible References :** •		
Responsible Persons	Frank Loose		

Course Title:	Introduction to Optimisation		
Specialisation	Scientific Computing		
Workload - Time in Class - Self-Study	Workload: 180 h	Time in Class: 60 h	Self-Study: 120 h
Frequency	not regularly		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 3 SWS + Exercise class 1 SWS		
Content	• Optimality theory for smooth, convex and linear optimisation problems optimisation problems with constraints. • Foundations of the theory of convex sets and functions. • Duality theory for convex and linear optimisation problems. • Solution methods for linear optimisation problems.		
Special Objectives	Students know and understand methods and algorithms for solving convex and linear optimisation problems. They have learnt to apply the methods to simple problems related to economics, technology or physics. They will be able to critically assess the possibilities and limitations of using the methods.		

Literature	**Possible References :** • Florian Jarre, Joseph Stoer: Optimierung: Einführung in mathematische Theorie und Methoden. Springer 2019. • Jorge Nocedal, Stephen J. Wright: Numerical optimization. Springer 2006.
Responsible Persons	Christian Lubich

Course Title:	Introduction to Dynamical Systems		
Specialisation	Analysis		
Workload **- Time in Class** **- Self-Study**	Workload: 90 h	Time in Class: 30 h	Self-Study: 60 h
Frequency	not regularly		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture 2 SWS		
Content	• Kepler’s laws. • Equilibrium positions. • Stability. • Predator-prey model. • Poincaré-Bendixson theorem. • Limit sets. • Periodic orbits. • Celestial mechanics.		
Special Objectives	The students can ask and examine qualitative questions about the solutions of ordinary differential equations, like e.g.: How long do mathematical solutions exist? Are there equilibrium states or periodic orbits? When are trajectories stable?		
Literature	**Possible References :** • Morris W. Hirsch, Stephen Smale: Differential equations, dynamical systems, and linear algebra. Academic Press 1974. • Vladimir I. Arnold: Mathematical methods of classical mechanics. Springer 2010. • Carl Ludwig Siegel, Jürgen Moser: Lectures on celestial mechanics. Springer 1995.		
Responsible Persons	Frank Loose		

Course Title:	Introduction to Geometric Measure Theory
Specialisation	Analysis

Workload - Time in Class - Self-Study	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	not regularly		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS		
Content	• Measures, covering theorems, differentiation of measures, Hausdorff measures and densities. • Isodiametric inequality. • Rademacher's theorem and Whitney's embedding theorem. • Surface- and cosurface formula. • Countable rectifiable sets, rectifiable varifolds.		
Special Objectives	Students have familiarised themselves with an important mathematical field that combines analysis and geometry and whose concepts and methods can be successfully applied to various problems. They have familiarised themselves with the basic concepts, results and methods of geometric measure theory and can successfully apply these methods in further courses.		
Literature	**Possible References :** • Lawrence C. Evans, Ronald F. Gariepy: Measure theory and fine properties of functions. CRC Press 1992. • Herbert Federer: Geometric measure theory. Springer 1969. • Leon Simon: Lectures on geometric measure theory. Australian National University 1984.		
Responsible Persons	Reiner Schätzle		

Course Title:	Introduction to Geometric Measure Theory – Measure Theoretic Methods		
Specialisation	Analysis		
Workload - Time in Class - Self-Study	Workload: 150 h	Time in Class: 45 h	Self-Study: 105 h
Frequency	not regularly		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture 2 SWS + Exercise class 1 SWS		
Content	• Measures, covering theorems, differentiation of measures, Hausdorff measures and densities. • Isodiametric inequality. • Rademacher's theorem and Whitney's embedding theorem.		

Special Objectives	Students have familiarised themselves with an important mathematical field that combines analysis and geometry and whose concepts and methods can be successfully applied to various problems. They have familiarised themselves with the basic concepts, results and methods of geometric measure theory and can successfully apply these methods in further courses.
Literature	**Possible References :** • Lawrence C. Evans, Ronald F. Gariepy: Measure theory and fine properties of functions. CRC Press 1992. • Herbert Federer: Geometric measure theory. Springer 1969. • Leon Simon: Lectures on geometric measure theory. Australian National University 1984.
Responsible Persons	Reiner Schätzle

Course Title:	Introduction to Geometric Measure Theory – Varifolds		
Specialisation	Analysis		
Workload - Time in Class - Self-Study	Workload: 150 h	Time in Class: 45 h	Self-Study: 105 h
Frequency	not regularly		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture 2 SWS + Exercise class 1 SWS		
Content	• Surface- and cosurface formula. • Countable rectifiable sets, rectifiable varifolds.		
Special Objectives	Students have familiarised themselves with an important mathematical field that combines analysis and geometry and whose concepts and methods can be successfully applied to various problems. They have familiarised themselves with basic concepts, results and methods of geometric measure theory and can successfully apply these methods in further courses.		
Literature	**Possible References :** • Lawrence C. Evans, Ronald F. Gariepy: Measure theory and fine properties of functions. CRC Press 1992. • Herbert Federer: Geometric measure theory. Springer 1969. • Leon Simon: Lectures on geometric measure theory. Australian National University 1984.		
Responsible Persons	Reiner Schätzle		

Course Title:	Introduction to Commutative Algebra and Algebraic Geometry
Specialisation	Algebra

Workload - Time in Class - Self-Study	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	regularly in Winter Semester		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS		
Content	• Rings and ideals. • Gröbner bases. • Localization. • Noetherian rings and modules. • Integral ring extensions. • Krull's principal ideal theorem and dimension theory. • Hilbert's Nullstellensatz and Noether normalisation. • Affine varieties, Zariski topology, morphisms.		
Special Objectives	The students have become familiar with the central concepts, results, and methods of commutative algebra and affine algebraic geometry. They have experienced the profound interplay between algebra and geometry through the example of affine varieties. Furthermore, the students understand how adopting a higher perspective - namely, abstracting the problem - enables the simultaneous treatment and resolution of seemingly unrelated questions.		
Literature	**Possible References :** • Michael Francis Atiyah, Ian G. Macdonald: Introduction to commutative algebra. Addison Wesley 1969. • David A. Cox, John B. Little, Donal O'Shea: Ideals, varieties, and algorithms. Springer 2008. • David Eisenbud: Commutative algebra with a view toward algebraic geometry. Springer 1995. • Ernst Kunz: Einführung in die kommutative Algebra und algebraische Geometrie. Vieweg 1980. • Miles Reid: Undergraduate Commutative Algebra. Cambridge University Press 1997.		
Responsible Persons	Jürgen Hausen		

Course Title:	Introduction to Partial Differential Equations		
Specialisation	Analysis		
Workload - Time in Class - Self-Study	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	regularly		
Language of Instruction	English		

Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS
Content	• Harmonic functions. • Maximum principles. • Sobolev spaces. • L^2 theory. • Important examples (Laplace equation, wave equation, heat equation). • Fundamental solutions (elliptic situation). • Weak solutions of elliptic equations.
Special Objectives	The students got to know a central branch of analysis, whose terms and methods are fundamental for many fields, like numerics or stochastics. Also evolutionary equations, who have strong connections to geometry, are issue of the lecture. The students are acquainted with central terms, results and methods of linear partial differential equations and are able to use these methods in advanced courses.
Literature	**Possible References :** • Lawrence C. Evans: Partial differential equations. American Mathematical Society 2010. • David Gilbarg, Neil S. Trudinger: Elliptic partial differential equations of second order. Springer 2001. • Olga A. Ladyzenskaja, Vsevolod A. Solonnikov, Nina N. Uralceva: Linear and quasilinear equations of parabolic type. AMS 1968.
Responsible Persons	Gerhard Huisken, Reiner Schätzle

Course Title:	Introduction to Partial Differential Equations – Part 1		
Specialisation	Analysis		
Workload **- Time in Class** **- Self-Study**	Workload: 150 h	Time in Class: 45 h	Self-Study: 105 h
Frequency	not regularly		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture 2 SWS + Exercise class 1 SWS		
Content	• Harmonic functions. • Maximum principles. • Sobolev spaces.		
Special Objectives	The students have familiarised themselves with the first basic features of a central area of analysis, the concepts and methods of which are fundamental for many other areas, such as numerics and stochastics. Students are familiar with the central concepts, results and methods of linear partial differential equations and can successfully apply these methods in the more advanced courses.		

Literature	**Possible References :** • Lawrence C. Evans: Partial differential equations. American Mathematical Society 2010. • David Gilbarg, Neil S. Trudinger: Elliptic partial differential equations of second order. Springer 2001. • Olga A. Ladyzenskaja, Vsevolod A. Solonnikov, Nina N. Uralceva: Linear and quasilinear equations of parabolic type. AMS 1968.
Responsible Persons	Gerhard Huisken, Reiner Schätzle

Course Title:	Elementary Number Theory		
Specialisation	Algebra		
Workload - Time in Class - Self-Study	Workload: 180 h	Time in Class: 60 h	Self-Study: 120 h
Frequency	not regularly		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 2 SWS + Exercise class 2 SWS		
Content	• Divisibility in the integers. • Prime numbers. • Congruences. • Quadratic residues. • Arithmetic functions. • Multiplicative functions. • Classical theorems. • Applications.		
Special Objectives	Students deepen their basic knowledge of integers and experience applying this knowledge to mathematical problems of various kinds.		
Literature	**Possible References :** • Friedhelm Padberg: Elementare Zahlentheorie. Spektrum Akademischer Verlag 2001. • Stefan Mueller-Stach, J. Piontkowski: Elementare und algebraische Zahlentheorie. Vieweg 2006.		
Responsible Persons	Victor Batyrev, Thomas Markwig		

Course Title:	Functional Analysis
Specialisation	Analysis

Workload - Time in Class - Self-Study	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	regularly		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS		
Content	• Normed spaces, Banach spaces, dual spaces. • Hahn-Banach theorem, uniform boundedness principle. • Closed graph theorem, open mapping theorem, Banach-Alaoglu theorem. • Compact operators, normal operators, spectral theorems.		
Special Objectives	The students are aquainted with the basic principles and techniques of the theory of infinte dimensional spaces and can apply them to problems in analysis and geometry. They understand the complexity of problems of spectral theory and can use its results for the solution of analytical problems.		
Literature	**Possible References :** • Nicolas Bourbaki: Topological vector spaces. Springer 1987. • Adam Bowers, Nigel Dalton: An introductory course in functional analysis. Springer 2014. • Harro Heuser: Funktionalanalysis. Teubner 2006. • Markus Haase: Functional analysis. American Mathematical Society 2014. • Peter D. Lax: Functional analysis. Wiley 2002. • Gert Kjaergaard Pedersen: Analysis now. Springer 1995. • Walter Rudin: Functional analysis. McGraw-Hill 1991. • Dirk Werner: Funktionalanalysis. Springer 2011. • Kosaku Yosida: Functional analysis. Springer 1995. • Hans Wilhelm Alt: Lineare Funktionalanalysis. Springer 2012.		
Responsible Persons	Carla Cederbaum, Anton Deitmar, Gerhard Huisken, Reiner Schätzle		

Course Title:	Geometry of Manifolds 1		
Specialisation	Geometry		
Workload - Time in Class - Self-Study	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	not regularly		
Language of Instruction	German or English		

Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS
Content	• Manifolds and submanifolds. • Vector fields and flows. • Metrics, foundations of Riemannian geometry. • Complex structures. • Theorem of Gauß-Bonnet on surfaces.
Special Objectives	The students know and understand the fundamental concepts of real and complex differential geometry and the basic techniques for handling them. Especially they have deepened their understanding of differential and integral calculus and have exemplarily experienced how mathematical concepts are used in a natural way in geometry.
Literature	**Possible References :** • Sylvestre Gallot, Dominique Hulin, Jacques Lafontaine: Riemannian Geometry. Springer 2004. • John M. Lee: Introduction to Smooth Manifolds. Springer 2012. • Liviu I. Nicolaescu: Lectures On The Geometry Of Manifolds. World Scientific 1996. • Clifford Henry Taubes: Differential Geometry: Bundles, Connections, Metrics and Curvature. Oxford University Press 2011.
Responsible Persons	Christoph Bohle, Frank Loose

Course Title:	Foundations of Discrete Mathematics		
Specialisation	Stochastics		
Workload - Time in Class - Self-Study	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	not regularly		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS		
Content	• Logic. • Sets, relations, functions. • Partial orders. • Combinatorics. • Number theory. • Graph theory. • Algorithms and formal languages. • Discrete optimization.		

Special Objectives	Students have learned how to use basic methods of discrete mathematics. They can analyze discrete structures and identify discrete structures in different contexts.
Literature	**Possible References :** • Ronald Graham, Donald Knuth, Oren Patashnik: Concrete Mathematics. Addison-Wesley 1994. • Kenneth H. Rosen: Discrete Mathematics and Its Application. McGraw-Hill 2019. • Ralph P. Grimaldi: Discrete and Combinatorial Mathematics. Addison-Wesley 2004. • Norman L. Biggs: Discrete Mathematics. Oxford University Press 2002.
Responsible Persons	Martin Möhle, Martin Zerner, Elmar Teufl

Course Title:	Hyperbolic Geometry: Axiomatic, Reflection Geometric, Algebraic		
Specialisation	Geometry		
Workload - Time in Class - Self-Study	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	not regularly		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS		
Content	Starting from a system of axioms for plane absolute geometry with the basic concepts of incidence and congruence, the associated Bachmann reflection geometry is developed. After the introduction of the hyperbolic axiom, this is continued with reflection-geometric end theory. A Euclidean field is created from the rotations around an end and the translations along a straight line, with the help of which the hyperbolic plane under consideration is described algebraically.		
Special Objectives	The students have learnt to look at one and the same mathematical object (in this case absolute and hyperbolic planes) from completely different perspectives and to link them together. In particular, they have learnt about Bachmann's group-theoretically oriented reflection geometry, which rarely appears in the curriculum, and thus deepen their knowledge of groups. They also deepened their knowledge about the interweaving of geometry and algebra.		
Literature	**Possible References :** • Friedrich Bachmann: Aufbau der Geometrie aus dem Spiegelungsbegriff. Springer 1959. • Robin Hartshorne: Geometry: Euclid and beyond. Springer 2000. • Helmut Karzel, Kay Sörensen, Dirk Windelberg: Einführung in die Geometrie. Vandenhoeck und Ruprecht 1973.		
Responsible Persons	Hermann Hähl, Hannah Markwig		

Course Title:	Commutative Algebra
Specialisation	Algebra

Workload - Time in Class - Self-Study	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	regularly in Winter Semester		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS		
Content	• Rings and Ideals. • Localisation and local rings. • Noetherian and Artinian rings and modules. • Integral ring extensions and Cohen-Seidenberg theorems. • Krull's principal ideal theorem and dimension theory. • Primary decomposition. • Normality, regularity and discrete valuation rings. • Hilbert's Nullstellensatz and Noether normalisation.		
Special Objectives	The students are familiar with and understand the language and methods of commutative algebra, which are essential for studying the fields of algebra, geometry, and number theory. They recognise how adopting a higher perspective - namely, abstracting the problem - enables the simultaneous treatment and resolution of seemingly unrelated questions.		
Literature	**Possible References :** • Michael Francis Atiyah, Ian G. Macdonald: Introduction to commutative algebra. Addison Wesley 1969. • David A. Cox, John B. Little, Donal O'Shea: Ideals, varieties, and algorithms. Springer 2008. • David Eisenbud: Commutative algebra with a view toward algebraic geometry. Springer 1995. • Ernst Kunz: Einführung in die kommutative Algebra und algebraische Geometrie. Vieweg 1980. • Miles Reid: Undergraduate Commutative Algebra. Cambridge University Press 1997.		
Responsible Persons	Victor Batyrev, Thomas Markwig		

Course Title:	Convex Geometry		
Specialisation	Geometry		
Workload - Time in Class - Self-Study	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	not regularly		
Language of Instruction	German or English		

Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS
Content	• Cones, polytopes, polyhedra, fans, polyedral complexes. • Normal fans of polygons. • Triangulations, subdivisions, secondary fans, discriminants.
Special Objectives	In the lecture the students learn basic terms, results and methods of convex geometry. They develope a deepened understanding for the concept of duality of mathematical objects on the example of polytopes and fans. Furthermore they enhance their geometric view and their spatial sense.
Literature	**Possible References :** • Günter M. Ziegler: Lectures on Polytopes. Springer 1998.
Responsible Persons	Hannah Markwig

Course Title:	Cryptography		
Specialisation	Algebra		
Workload - Time in Class - Self-Study	Workload: 150 h	Time in Class: 45 h	Self-Study: 105 h
Frequency	not regularly		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture 2 SWS + Exercise class 1 SWS		
Content	• Brief review of key concepts and results from algebra and number theory. • Historical ciphers and their cryptanalysis (Caesar, Vigenere, substitution); encryption schemes. • Diffie-Hellman protocol and fast exponentiation. • Discrete logarithms: Shanks' algorithm and Pollard's rho method. • RSA: correctness, security, and attacks. • Signature schemes.		
Special Objectives	Students are familiar with the fundamental concepts and results of elementary number theory and algebra, as well as their application in cryptography. They can implement the methods covered in Python or SageMath in an exemplary manner and know what to pay attention to. Using classical ciphers, they understand typical strengths and weaknesses; they master the Diffie-Hellman protocol and are familiar with the man-in-the-middle attack. They can compute discrete logarithms in cyclic groups, understand the RSA scheme, and are able to interpret the recommendations of the Federal Office for Information Security (BSI). In various attack scenarios, they can identify weaknesses of RSA when the requisite conditions are not met. By engaging with numerous open problems in cryptography – whose solution approaches can, perhaps surprisingly, stem from very different areas of mathematics – students practise critical thinking. The exercises are central and support students in working independently and in a practice-oriented way, especially with CAS systems such as SageMath.		

Literature	**Possible References :** • Jeffrey Hoffstein, Jill Pipher, Joseph H. Silverman: An introduction to mathematical cryptography. Springer 2008. • Christian Karpfinger, Hubert Kiechle: Kryptologie, Algebraische Methoden und Algorithmen, Vieweg 2010. • Dan Boneh, Victor Shoup: A Graduate Course in Applied Cryptography. 2023 (online Version: https://toc.cryptobook.us/). • Jonathan Katz, Yehuda Lindell: Introduction to Modern Cryptography. Chapman and Hall/CRC 2020.
Responsible Persons	Thomas Markwig

Course Title:	Lie Groups		
Specialisation	Analysis		
Workload - Time in Class - Self-Study	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	not regularly		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS		
Content	• Manifolds and Lie groups, • Lie algebras and exponential map, • Covering spaces and classification of Lie groups by their Lie algebras, • Classical Lie groups, • Operations of Lie groups and homogeneous spaces.		
Special Objectives	Lie groups lie at the interface between geometry, algebra and analysis. They are suitable for describing the symmetries of geometric objects, but also algebraic equations or solutions of differential equations, in particular if these symmetries form a continuous set. The students learn from a prominent example how different disciplines of mathematics can work together very successfully and how a convincing formalism is developed that can precisely describe a variety of symmetry phenomena.		
Literature	**Possible References :** • Joachim Hilgert, Karl-Hermann Neeb: Liegruppen und Lie-Algebren. Vieweg 1991. • Gerhard P. Hochschild: The structure of Lie groups. Holden-Day 1965. • Frank W. Warner: Foundations of differentiable manifolds and Lie groups. Springer 1983.		
Responsible Persons	Anton Deitmar, Frank Loose		

<table>
<tr><td>Course Title:</td><td colspan="3">Linear Control Theory</td></tr>
<tr><td>Specialisation</td><td colspan="3">Analysis</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
180 h</td><td>Time in Class:
60 h</td><td>Self-Study:
120 h</td></tr>
<tr><td>Frequency</td><td colspan="3">not regularly</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture 2 SWS + Exercise class 2 SWS</td></tr>
<tr><td>Content</td><td colspan="3">Mathematical methods are indispensable for the management and control of complex systems and processes. The underlying theory is not only fascinating due to its diverse applications, but also, in its abstract form, due to the clarity and elegance of its methods and results. In this lecture, finite-dimensional systems are dealt with first, for which a good knowledge of analysis and linear algebra is sufficient. The aims are Kalman's controllability criterion and the resulting criteria for stabilisability. If there is enough time, we will extend the theory to infinite-dimensional systems. In the exercise classes we will apply the theory to concrete examples.</td></tr>
<tr><td>Special Objectives</td><td colspan="3">Students have learnt basic methods of linear control theory. At the same time, they have experienced and understood the interaction of various theoretical concepts from linear algebra and analysis and their benefits for specific applications.</td></tr>
<tr><td>Literature</td><td colspan="3">Possible References :
• Hans Wilhelm Knobloch, Huibert Kwakernaak: Lineare Kontrolltheorie. Springer 1985.
• Jerzy Zabczyk: Mathematical Control Theory. Birkhäuser 1992.
• Ruth F. Curtain, Hans Zwart: An Introduction to Infinite-Dimensional Systems Theory. Springer 1995.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">Rainer Nagel</td></tr>
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<table>
<tr><td>Course Title:</td><td colspan="3">Non-Linear Optimisation</td></tr>
<tr><td>Specialisation</td><td colspan="3">Scientific Computing</td></tr>
<tr><td>Workload
- Time in Class
- Self-Study</td><td>Workload:
270 h</td><td>Time in Class:
90 h</td><td>Self-Study:
180 h</td></tr>
<tr><td>Frequency</td><td colspan="3">regularly</td></tr>
<tr><td>Language of Instruction</td><td colspan="3">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="3">Lecture 4 SWS</td></tr>
</table>

Content	• Finite-dimensional optimisation, gradient method with Armijo's rule, globalised Newton method. • Restricted optimisation, Farkas' lemma, tangent cone. • Abadie CQ, KKT conditions, Slater conditions. • Linear programme, duality, simplex method. • Penalty and barrier methods, interior point method. • Nonlinear programs, SQP methods, non-smooth optimisation.
Special Objectives	Students master the basic principles and techniques of analysis and numerics of constrained optimisation problems.
Literature	**Possible References :** • Carl Geiger, Christian Kanzow: Theorie und Numerik restringierter Optimierungsaufgaben. Springer 2002.
Responsible Persons	Andreas Prohl

Course Title:	Topology		
Specialisation	Geometry		
Workload - Time in Class - Self-Study	Workload: 180 h	Time in Class: 60 h	Self-Study: 120 h
Frequency	not regularly		
Language of Instruction	German		
Forms of Teaching and Learning	Lecture 2 SWS + Exercise class 2 SWS		
Content	• Review of metric spaces: closed sets, environment, continuity, complete metric spaces, compactness in metric spaces metric spaces. • Set-theoretic topology: topological spaces, continuity convergence, compactness, separation axioms. • Spaces of continuous functions: Urysohn's lemma and applications, Stone-Cech compactification, the theorem of Stone-Weierstraß, notions of convergence in functions, compactness in spaces of functions. • Baire's spaces and application of Baire's theory: Baire's function classes, existence theorems. • Outlook on algebraic topology.		
Special Objectives	Students have familiarised themselves with the central concepts, results and methods of set-theoretical topology and have understood that this theory can be used to describe many phenomena in different areas of mathematics. In this way, they link their knowledge of very different areas of mathematics.		

Literature	**Possible References :** • Felix Hausdorff: Grundzüge der Mengenlehre. Von Veit & Comp. 1914. • Boto von Querenburg: Mengentheoretische Topologie. Springer 2001. • Volker Runde: A Taste of Topology. Springer 2005.
Responsible Persons	Rainer Nagel

Course Title:	Calculus of Variations		
Specialisation	Analysis		
Workload - Time in Class - Self-Study	Workload: 150 h	Time in Class: 45 h	Self-Study: 105 h
Frequency	not regularly		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture 2 SWS + Exercise class 1 SWS		
Content	• Direct method of calculus of variations. • Euler-Lagrange equations. • Palais-Smale condition. • Mountain-Pass Lemma according to Ambrosetti-Rabinowitz.		
Special Objectives	In the first part of the course, students have learnt the direct method of calculus of variations, which is primarily used to prove the existence of weak solutions of partial differential equations, but also has applications in e.g. differential geometry. They have also acquired the necessary basics from functional analysis and partial differential equations and can also use these in a different context, e.g. geometric analysis. In the second part of the course, students learnt about a so-called mountain-pass lemma. With its help, they can analyse non-uniqueness in the existence of solutions of partial differential equations.		
Literature	**Possible References :** • Michael Struwe: Variational Methods, Springer 2008. • David Gilbarg, Neil S. Trudinger: Elliptic Partial Differential Equations of Second Order, Springer 1998. • Walter Rudin: Functional Analysis, Mc Graw Hill Education 1991.		
Responsible Persons	Reiner Schätzle		

Course Title:	Probability Theory		
Specialisation	Stochastics		
Workload - Time in Class - Self-Study	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h

Frequency	regularly in Winter Semester
Language of Instruction	German
Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS
Content	• Characteristic functions and additions to the central limit theorem. • Conditional expectations and further measure-theoretic foundations. • Markov chains and martingales in discrete time, classification, asymptotic behaviour, stopping times, stationarity, ergodicity. • Introduction to processes in contiuous time like Poisson processes and Brownian motion.
Special Objectives	The students got to know the central terms results and methods of probability theory. They can model, analyse and interprete stochastic dependency structures of random quantities in a measure theoretically founded manner. The students are capable of naming and proving the central results of the lecture as well as assessing and explaining the presented connections.
Literature	**Possible References :** • Heinz Bauer: Wahrscheinlichkeitstheorie und Grundzüge der Maßtheorie. De Gruyter 2010. • Richard Durrett: Probability, Theory and Examples. Cambridge University Press 2010. • Hans-Otto Georgii: Stochastik. De Gruyter 2009. • Jean Jacod, Philip E. Protter: Probability essentials. Springer 2004. • Olav Kallenberg. Foundations of Modern Probability. Springer 2002. • Achim Klenke: Wahrscheinlichkeitstheorie. Springer 2013. • David Meintrup, Stefan Schäffler: Stochastik. Springer 2005. • Albert N. Shiryaev: Probability-1. Springer 2016.
Responsible Persons	Martin Möhle, Martin Zerner

Course Title:	Number Theory and Cryptography		
Specialisation	Algebra		
Workload - Time in Class - Self-Study	Workload: 270 h	Time in Class: 90 h	Self-Study: 180 h
Frequency	not regularly		
Language of Instruction	German or English		
Forms of Teaching and Learning	Lecture 4 SWS + Exercise class 2 SWS		

Content	• RSA cryptosystem, primality tests, AKS algorithm. • Factorisation methods, number field sieve. • Quadratic reciprocity in cryptography. • Evaluation of the discrete logarithm. • Dynamical systems and Pollard's rho algorithm. • Elliptic curve cryptography. • Lattices and post-quantum cryptography. • Zero-knowledge proofs, digital signatures and hash functions.
Special Objectives	The students know the basic concepts of elementary number theory and their applications in cryptography. They have deepened and extended their knowledge about neighbouring disciplines: They encounter methods of the theory of dynamical systems and become acquainted with elliptic curves over finite fields. They understand how fundamental cryptographic protocolls are working. Through studying many open problems of crytography, whose solutions may suprisingly come from most distinct branches of mathematics, the students learn to think critically.
Literature	**Possible References :** • Jeffrey Hoffstein, Jill Pipher, Joseph H. Silverman: An introduction to mathematical cryptography. Springer 2008. • Stefan Müller-Stach, Jens Piontkowski: Elementare und algebraische Zahlentheorie. Vieweg+Teubner 2011. • Joseph H. Silverman, John T. Tate: Rational points on elliptic curves. Springer 1992. • Nigel Smart: Cryptography: An introduction. McGraw-Hill 2003. (online version: https://www.cs.bris.ac.uk/~nigel/Crypto_Book/). • Lawrence C. Washington: Elliptic curves: Number theory and cryptography. Chaman & Hall/CRC 2008.
Responsible Persons	Elena Klimenko, Thomas Markwig