EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Mathematisch-
Naturwissenschaftliche
Fakultät

Department of Mathematics

# Module Handbook

## Mathematics

## Bachelor of Education

## im Höheren Lehramt an beruflichen Schulen*

Winter Semester 2025

Last updated on 29th October 2025

*This is a teaching degree for professional schools with a minor in mathematics. The modul handbook is valid for the 2018 study and examination regulations.

# Contents

# 1 Description of the Study Programme

## 1.1 Qualification Objectives

Within the teacher training Study Programme Bachelor of Education für das höhere Lehramt an beruflichen Schulen (B.Ed.) with the general education minor in Mathematics, graduates acquire basic and initial in-depth subject-specific and subject-didactic knowledge and skills necessary for a scientifically based teaching in higher education at professional schools.

Graduates are familiar with the fundamental questions in Linear Algebra, Analysis, Geometry and Stochastics as well as Algebraic Structures and master the central techniques for solving them. In doing so, they acquire basic mathematical thought patterns such as structuring problems, creating chains of argumentation and finally the proof of mathematical theorems. Graduates are able to communicate mathematical facts, use suitable media and establish links to school mathematics. They are able to justify the educational value of mathematical content and convey the societal significance of mathematics. With the Bachelor's degree, graduates are able to apply their knowledge and skills in a teaching-related Master's study programme or, with credit for the work completed, in a science-related Bachelor's degree programme in mathematics.

## 1.2 Structure of the Study Programme

In Mathematics, the first year of study is filled with the large compulsory module Foundations of Mathematics, which covers the subject-specific fundamentals of Analysis and Linear Algebra from an academic point of view. The corresponding lectures are accompanied by exercise classes, where students are intensively supervised and taught basic mathematical thinking and working methods as well as the ability to present solutions. In addition, the department provides students with revision sessions as question times.

In the second and third years of the programme, students deepen their theoretical knowledge. They expand their knowledge in the areas of Algebra, Geometry and Stochastics. The content in the compulsory mathematics modules is taught through lectures and accompanying exercise classes. For each lecture there are weekly tasks, which students have to complete in paper form. In the exercise classes, the students present their solutions or create them under the supervision. Through this system, which is common in mathematical study programmes, students learn to systematically work on the tasks set for them and to practise analytical and structural thinking. Furthermore, they should be able to explain complex mathematical matters and present them verbally. This requires students to be able to organise themselves and to do a lot of self-study, which is provided for and credited in the course of study. At the same time, intensive supervision and individual support options are provided.

In addition to the subject modules, students in the third year of study take modules in the field of subject didactic. These are designed so that the subject-didactic courses in the areas of Geometry and Statistics are closely linked to the corresponding subject modules, while the subject-didactic

course for Algebra is linked to the subject courses for Algebraic Structures. In the subject modules, the subject-specific prerequisites for the subject-didactic courses are conveyed.

In the third year of study, students also complete a bachelor's thesis. This can be written in the professional subject or in the general education secondary subject (including their subject didactics).

Integrating a study component at a foreign university into teacher training studies is challenging, as it involves coordinating two subjects and Educational Sciences. Whether attempting to fulfil components in all areas during the stay at the other university or adjusting the study plan at the University of Tübingen to allocate parts of the curriculum to different semesters to create flexibility, ensuring not all three areas need to be covered at the foreign university presents a challenge. Complicating matters is the fact that in the field of Mathematics, all modules are mandatory, leaving little room for content customisation. Therefore, it is essential to plan a suitable timeframe for a study component at a foreign university through a personal consultation with the Faculty Course Advisor. Essentially, from the Mathematics perspective, any academic semester is suitable for this purpose. The decision will depend on the student's previous achievements and the courses offered at the chosen foreign university.

## 1.3 Examination Regulations

Oral examinations are conducted in the presence of at least two examiners or one examiner, along with an observer (see also Exam Regulations General Part §12 (2).

# 2 Study Plans

## 2.1 Overview by Modules

Here we provide an overview of the study plan as a table showing the modules to be taken.

| ST | Module Number | Module Title | Type of Course | Type of Module | Course-work | Type of Exam | ECTS-Points |
|---|---|---|---|---|---|---|---|
| **Section 1: Foundations of Mathematics** | | | | | | | |
| 1+2 | MAT-10-10 | Foundations of Mathematics | | PM | | or. | 27 |
| | | - Linear Algebra 1 | L+E+T | | EC | | |
| | | - Analysis 1 | L+E+T | | EC | | |
| | | - Analysis 2 | L+E+T | | EC | | |
| 3-4 | MAT-10-11 | Consolidation of the Foundations of Mathematics | | PM | | wr. o. or. | 6 |
| | | - Algebraic Structures | L+E | | EC | | |
| | | - Mathematical Software | P | | PC | | |
| **Section 2: Compulsory Intermediate Modules** | | | | | | | |
| 5-6 | MAT-20-12 | Stochastics | L+E | PM | EC | wr. o. or. | 9 |
| 3-4 | MAT-50-01 | Geometry | L+E | PM | EC | wr. o. or. | 9 |
| **Section 3: Didactics of Mathematics** | | | | | | | |
| 5-6 | MAT-80-01 | Subject Didactics Mathematics 1 | LIC | PM | s.M. | K o. mP o. P | 3 |
| 5-6 | MAT-80-02 | Subject Didactics Mathematics 2 | SLIC+SLIC | PM | - | K o. mP o. R o. H o. P. | 6 |
| **Section 4: Bachelor Thesis** | | | | | | | |
| 6 | MAT-30-40 | Bachelor Thesis | BT | PM | s.M. | BA+mP | 6 |
| **Section 5: Transferable Credits for the Master Degree** | | | | | | | |
| - | MAT-20-02 | Introduction to Complex Analysis and Ordinary Differential Equations | L+E | WM | EC | wr. o. or. | 9 |
| - | MAT-20-03 | Algebra | L+E | WM | EC | wr. o. or. | 9 |
| - | MAT-20-11 | Numerical Mathematics | L+E | WM | EC | wr. o. or. | 9 |
| - | MAT-40-52 | Seminar: Mathematical Specialisation | S | WM | s.M. | Pr | 4 |
| - | MAT-40-53 | Seminar: Mathematical Specialisation | S | WM | s.M. | Pr | 4 |

**Abbreviations:**

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

## 2.2 Overview by the Course of Studies

Firstly, we provide an overview of the possible course of study in the form of a table both for entry in the winter semester and for entry in the summer semester. The second subject and the area of educational sciences are not broken down in detail.

**Study plan for students starting in the winter semester**

| FS | CPiM | Subject Mathematics | | | Main Subject | ES |
|---|---|---|---|---|---|---|
| 1 | 15 | Foundations of Mathematics (27 CP) | | | Social Pedagoy / Pedagogy (102 CP) | Education Science and Orientation Internship (12 CP) |
| 2 | 12 | | | | | |
| 3 | 15 | Consolidation of the Foundations of Mathematics (6 CP) | Geometry (9 CP) | | | |
| 4 | 0 | | | | | |
| 5 | 3 | | | Subject Didactics Mathematics 2 (6 CP) | | |
| 6 | 15 | Stochastics (9 CP) | Subject Didactics Mathematics 1 (3 CP) | | | |
| | | | | possibly Bachelor Thesis (6 CP) | | |

**Explanation of the Abbreviations**:
FS=semester, CP=credit points (ECTS points), CPiM=credit points in mathematics, ES=educational science

**Study plan for Students Starting in the Summer Semester**

| FS | CPiM | Subject Mathematics | | | Main Subject | ES |
|---|---|---|---|---|---|---|
| 1 | 15 | Foundations of Mathematics (27 CP) | | | Social Pedagoy / Pedagogy (102 CP) | Education Science and Orientation Internship (12 CP) |
| 2 | 12 | | | | | |
| 3 | 0 | | | | | |
| 4 | 15 | Consolidation of the Foundations of Mathematics (6 CP) | Geometry (9 CP) | | | |
| 5 | 15 | Stochastics (9 CP) | Subject Didactics Mathematics 1 (3 CP) | Subject Didactics Mathematics 2 (6 CP) | | |
| 6 | 3 | | | | | |
| | | | | possibly Bachelor Thesis (6 CP) | | |

**Explanation of the Abbreviations**:
FS=semester, CP=credit points (ECTS points), CPiM=credit points in mathematics, ES=educational science

## 2.3 Overview of Programme Structure with Semester Assignment

| Overview of Programme Structure with Semester Assignment for Students Starting in the Winter Semester | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Exam | | | | Teaching | | | | Term | | | | | | | |
| | | Type of Exam | Duration(min) | Grading | Weight in the final grade | Type of Course | Status | SWS | ECTS Points (CP) | The allocation of examinations / ECTS points to semesters is of a recommendatory nature. The allocation of ECTS points to courses are of an informative nature. The crediting of credit points are only after completion of the module. | | | | | | | |
| | | | | | | | | | | 1. CP | 2. CP | 3. CP | 4. CP | 5. CP | 6. CP | | |
| **Section 1: Foundations of Mathematics** | | | | | | | | | **33** | | | | | | | | |
| Foundations of Mathematics | | | | | | | | 24 | 27 | | | | | | | | |
| 1. | Lecture | Or. | 30-40 | g | 27 | L | o | 12 | | 9 | 9 | | | | | | |
| 2. | Exercise class | | | | | E | o | 6 | | 6 | 3 | | | | | | |
| 3. | Revision course | | | | | r | o | 6 | | 0 | 0 | | | | | | |
| Consolidation of the Foundations of Mathematics | | | | | | | | 4 | 6 | | | | | | | | |
| 1. | Lecture | Wr. o. Or. | 90-180 o. 20-30 | g | 6 | L | o | 2 | | | | 3 | | | | | |
| 2. | Exercise class | | | | | E | o | 1 | | | | 1,5 | | | | | |
| 3. | Practical training | - | | ng | | P | o | 1 | | | | 1,5 | | | | | |
| **Section 2: Compulsory Advanced Modules** | | | | | | | | | **18** | | | | | | | | |
| Geometry | | | | | | | | 6 | 9 | | | | | | | | |
| 1. | Lecture | Wr. o. Or. | 90-180 o. 20-30 | g | 9 | V | o | 4 | | | | 6 | | | | | |
| 2. | Exercise class | | | | | E | o | 2 | | | | 3 | | | | | |
| Stochastics | | | | | | | | 6 | 9 | | | | | | | | |
| 1. | Lecture | Wr. o. Or. | 90-180 o. 20-30 | g | 9 | V | o | 4 | | | | | | | | | 6 |
| 2. | Exercise class | | | | | E | o | 2 | | | | | | | | | 3 |
| **Section 3: Subject Didactics Mathematics** | | | | | | | | | **9** | | | | | | | | |
| Subject Didactics Mathematics 1 | | | | | | | | 2 | 3 | | | | | | | | |
| 1. | Subject Didactics Mathematics 1 | Wr. o. Or. | 90-180 o. 20-30 | g | 3 | LS | o | 2 | | | | | | | | | 3 |
| Subject Didactics Mathematics 2 | | | | | | | | 4 | 6 | | | | | | | | |
| 1. | Subject Didactics Mathematics 2 – Part 1 | 1 | 90-180 o. 20-30 | g | 3 | LS | o | 2 | | | | | | 3 | | | |
| 2. | Subject Didactics Mathematics 2 – Part 2 | Wr. o. Or. o. Pres. o. TP | 90-180 o. 20-30 | g | 3 | LS | o | 2 | | | | | | | | | 3 |

| Overview of Programme Structure with Semester Assignment for Students Starting in the Winter Semester | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Exam | | | | Teaching | | | | Term | | | | | | | |
| | | Type of Exam | Duration(min) | Grading | Weight in the final grade | Type of Course | Status | SWS | ECTS Points (CP) | The allocation of examinations / ECTS points to semesters is of a recommendatory nature. The allocation of ECTS points to courses are of an informative nature. The crediting of credit points are only after completion of the module. | | | | | | | |
| | | | | | | | | | | 1. CP | 2. CP | 3. CP | 4. CP | 5. CP | 6. CP | | |
| **Section 4: Bachelor Thesis** | | | | | | | | | **6** | | | | | | | | |
| Bachelor Thesis | | | | | | | | | 6 | | | | | | | | |
| 1. | Bachelor thesis | BA | | g | | BA | o | | | | | | | | 6 | | |

**Explanation of the abbreviations:**
Marking system : g=graded, ng=non graded
Form of examination : BA=bachelor thesis, Or.=oral exam, Wr.=written exam, Pres=presentation, TP=term paper
Form of teaching : L=lecturre, SL=seminar or lecture, E= exercise class, r=revision course, P=practical training
Status : o=obligatory, f=facultative
Other : o.=or, SWS=hours in class per week, CP=credit points=ECTS Points

| Overview of Programme Structure with Semester Assignment for Students Starting in the Summer Semester | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Exam | | | | Teaching | | | | Term | | | | | | | |
| | | Type of Exam | Duration (min) | Grading | Weight in the final grade | Type of course | Status | SWS | ECTS points (CP) | The allocation of examinations / ECTS points to semesters is of a recommendatory nature. The allocation of ECTS points to courses are of an informative nature. The crediting of credit points are only after completion of the module. | | | | | | | |
| | | | | | | | | | | 1. CP | 2. CP | 3. CP | 4. CP | 5. CP | 6. CP | | |
| **Section 1: Foundations of Mathematics** | | | | | | | | | **33** | | | | | | | | |
| Foundations of Mathematics | | | | | | | | 24 | 27 | | | | | | | | |
| 1. | Lecture | Or. | 30-40 | g | 27 | L | o | 12 | | 9 | 9 | | | | | | |
| 2. | Exercise class | | | | | E | o | 6 | | 6 | 3 | | | | | | |
| 3. | Revision course | | | | | r | o | 6 | | 0 | 0 | | | | | | |
| Consolidation of the Foundations of Mathematics | | | | | | | | 4 | 6 | | | | | | | | |
| 1. | Lecture | Or. | 20-30 | g | 6 | L | o | 2 | | | | | 3 | | | | |
| 2. | Exercise class | | | | | E | o | 1 | | | | | 1,5 | | | | |
| 3. | Practical training | - | | ng | | P | o | 1 | | | | | 1,5 | | | | |

| Overview of Programme Structure with Semester Assignment for Students Starting in the Summer Semester | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Exam | | | | Teaching | | | | Term | | | | | | | |
| | | Type of Exam | Duration (min) | Grading | Weight in the final grade | Type of course | Status | SWS | ECTS points (CP) | The allocation of examinations / ECTS points to semesters is of a recommendatory nature. The allocation of ECTS points to courses are of an informative nature. The crediting of credit points are only after completion of the module. | | | | | | | |
| | | | | | | | | | | 1. CP | 2. CP | 3. CP | 4. CP | 5. CP | 6. CP | | |
| **Section 2: Compulsory Advanced Modules** | | | | | | | | | **18** | | | | | | | | |
| Geometry | | | | | | | | 6 | 9 | | | | | | | | |
| 1. | Lecture | Wr. o. Or. | 90-180 o. 20-30 | g | 9 | V | o | 4 | | | | | 6 | | | | |
| 2. | Exercise class | | | | | E | o | 2 | | | | | 3 | | | | |
| Stochastics | | | | | | | | 6 | 9 | | | | | | | | |
| 1. | Lecture | Wr. o. Or. | 90-180 o. 20-30 | g | 9 | L | o | 4 | | | | | | 6 | | | |
| 2. | Exercise class | | | | | E | o | 2 | | | | | | 3 | | | |
| **Section 3: Subject Didactics Mathematics** | | | | | | | | | **9** | | | | | | | | |
| Subject Didactics Mathematics 1 | | | | | | | | 2 | 3 | | | | | | | | |
| 1. | Subject Didactics Mathematics 1 | Wr. o. Or. | 90-180 o. 20-30 | g | 3 | LS | o | 2 | | | | | | 3 | | | |
| Subject Didactics Mathematics 2 | | | | | | | | 4 | 6 | | | | | | | | |
| 1. | Subject Didactics Mathematics 2 – Part 1 | Wr. o. Or. o. Pres. o. TP | 90-180 o. 20-30 | g | 3 | LS | o | 2 | | | | | | 3 | | | |
| 2. | Subject Didactics Mathematics 2 – Part 2 | Wr. o. Or. o. Pres. o. TP | 90-180 o. 20-30 | g | 3 | LS | o | 2 | | | | | | | | | 3 |
| **Section 4: Bachelor Thesis** | | | | | | | | | **6** | | | | | | | | |
| Bachelor Thesis | | | | | | | | | 6 | | | | | | | | |
| 1. | Bachelor thesis | BA | | g | | BA | o | | | | | | | | | | 6 |

**Explanation of the abbreviations:**

Marking system : g=graded, ng=non graded
Form of examination : BA=bachelor thesis, Or.=oral exam, Wr.=written exam, Pres=presentation, TP=term paper
Form of teaching : L=lecturre, SL=seminar or lecture, E=exercise class, r=revision course, P=practical training
Status : o=obligatory, f=facultative
Other : o.=or, SWS=hours in class per week, CP=credit points=ECTS Points

# 3 Module Descriptions

## Section 1: Foundations of Mathematics

| **Module Number:**<br>**MAT-10-10** | **Module Title:**<br>Foundations of Mathematics | | **Type of Module:**<br>Compulsory Module |
|---|---|---|---|
| **ECTS-Points** | 27 | | |
| **Workload**<br>**- Time in Class**<br>**- Self-Study** | Workload:<br>810 h | Time in Class:<br>270 h | Self-Study:<br>540 h |
| **Duration** | 2 Semester | | |
| **Frequency** | every Semester | | |
| **Term** | 1+2 | | |
| **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<br>1. Semester: Analysis 1, Lecture 4 SWS + Ex.cl. 2 SWS + Rev.c. 2 SWS<br>2. Semester: Analysis 2, Lecture 4 SWS + Ex.cl. 2 SWS + Rev.c. 2 SWS | | |
| **Higher Objectives** | In the Foundations of Mathematics module, students learn the essential conceptual and methodological foundations of linear algebra as well as single-variable and multivariable calculus, exploring their interconnections with particular emphasis on the similarities and differences in their approaches. In the oral exam, students demonstrate that they have recognised these relationships and are capable of contextualising the core results of the lectures within these frameworks.<br>The duration of the module supports these objectives while also accounting for the acquisition of a new language - the language of mathematics - and the development of a precise and rigorously logical working methodology. This provides students with the necessary time to make the significant transition from school-level mathematics to university-level mathematics. By demonstrating a deeper and more integrated understanding in the oral exams, students establish a strong foundation for successful participation in all subsequent modules in their academic programme. | | |

| | |
|---|---|
| **Content** | • Basic logic and sets.<br>• Structure of real and complex numbers.<br>• Sequences, convergence and series; criteria for convergence; power series, sequences of functions; pointwise and uniform covergence.<br>• Continous functions in one dimension and between metric spaces and their properties.<br>• One- and multidimensional differential calculus (especially: intermediate value theorem, Taylor expansion, implicit function theorem, inverse function theorem, extrema under constraints).<br>• One- and multidimensional Riemann integral (especially Fubini's theorem, transformation formula).<br>• Basic concepts of topology in metric and normed spaces.<br>• Basic concepts of the theory of ordinary differential equations (Picard-Lindelöf theorem, linear ordinary differential equations, flows).<br>• Vector spaces and linear maps.<br>• Matrices and systems of linear equations.<br>• Determinants, eigenvalues and diagonalisability.<br>• Jordan canonical form.<br>• Euclidean and unitary vector spaces, spectral theorems.<br>• Basics of analytical geometry.<br>• The lecture Analysis 1 focuses predominately on contents from one-dimensional analysis, the lecture Analysis 2 on multidimensional analysis. The lecture Linear Algebra 1 covers the contents of linear algebra. |
| **Objectives** | The students are familiar with and understand the fundamental concepts, statements, and methods of single-variable and multivariable calculus as well as linear algebra. They have also developed a foundational awareness of ordinary differential equations and initial value problems.<br>Their capacity for abstraction has been enhanced, they have been trained in analytical thinking, and their mathematical imagination has been stimulated. Through a proof- and structure-oriented approach, they have learned to comprehend mathematical proofs in calculus and linear algebra and to independently prove or disprove mathematical statements in simple examples. They have recognised the essential relationships within the theory of single-variable and multivariable calculus, their similarities and differences, as well as their connections to linear algebra, and are able to contextualise the core results 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 assignments 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. |

**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 |
|---|---|---|---|---|---|---|---|---|---|
| Linear Algebra 1 | L | o | 4 | 6 | yes | or. | 30-40 | g | 100 |
| | E | o | 2 | 3 | | | | | |
| | T | o | 2 | 0 | | | | | |
| Analysis 1 | L | o | 4 | 6 | yes | | | | |
| | E | o | 2 | 3 | | | | | |
| | T | o | 2 | 0 | | | | | |
| Analysis 2 | L | o | 4 | 6 | yes | | | | |
| | E | o | 2 | 3 | | | | | |
| | T | o | 2 | 0 | | | | | |

In each of the three 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.

The examination of the module consists of an oral exam covering all three parts of the module. To be eligible for the oral exam, students must have obtained at least one of the two exercise certificates for the Analysis 1 and Analysis 2 module parts, as well as the exercise certificate for the Linear Algebra 1 module part. The module is considered complete only when all three exercise certificates have been obtained and the oral exam has been successfully passed.
Of the 27 credit points for the module, 15 are allocated to the first semester and 12 to the second semester. The relatively higher share of credit points in the second semester, compared to the actual teaching hours, is due to the preparation required for the oral exam, which takes place after the second semester.

**Literature**

**Possible References :**

- Anton Deitmar: Analysis. Springer 2016.
- Otto Forster: Analysis 1. Springer Spektrum 2013.
- Otto Forster: Analysis 2. Vieweg+Teubner 2011.
- Theodor Bröcker: Lineare Algebra und analytische Geometrie. Birkhäuser 2013.
- Gerd Fischer: Lineare Algebra. Springer Spektrum 2014.

**Transfer**

The successful participation in the module Foundations of Mathematics is a prerequisite for the participation in the module Bachelor Thesis. The exercise certificates of the module are prerequisite for all modules of the Sections 2-4.

**Prerequisites**

There are no prerequisites for participation in the module.

**Responsible Persons**

Victor Batyrev, Anton Deitmar, Christian Hainzl, Jürgen Hausen, Frank Loose, Hannah Markwig, Thomas Markwig, Reiner Schätzle, Stefan Teufel

**Abbreviations:**

Grading System : g=graded, ng=not graded
Examination Type : BT=bachelor's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests
Teaching Format : L=lecture, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, 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:<br>MAT-10-11</td><td colspan="2">Module Title:<br>Consolidation of the Foundations of Mathematics</td><td>Type of Module:<br>Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">6</td></tr>
<tr><td>Workload<br>- Time in Class<br>- Self-Study</td><td>Workload:<br>180 h</td><td>Time in Class:<br>60 h</td><td>Self-Study:<br>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">• Algebraic Structures, Lecture 2 SWS + Ex.cl. 1 SWS<br>• Mathematical Software, Practical course 1 SWS</td></tr>
<tr><td>Comment</td><td colspan="3">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.</td></tr>
<tr><td>Content</td><td colspan="3">• Algebraic structures:<br>– Groups, subgroups, group homomorphisms, normal subgroups, quotient group.<br>– Cyclic groups and the symmetric group.<br>– Commutative rings with one, divisibility.<br>– Euclidean rings, principal ideal domains, factorial rings.<br>– The ring of integers and the polynomial ring.<br>• Mathematical software:<br>– Getting to know one or more subject-specific software packages.<br>– Implementation of simple algorithms, e.g. of linear algebra, in subject-typical software.</td></tr>
<tr><td>Objectives</td><td colspan="3">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.<br>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.<br>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.</td></tr>
</table>

<table>
<tr><td rowspan="4">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">Algebraic Structures</td><td>L</td><td>o</td><td>2</td><td>3</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>
<tr><td>Mathematical Software</td><td>P</td><td>o</td><td>1</td><td>1,5</td><td>yes</td><td>-</td><td>-</td><td>nb</td><td>0</td></tr>
<tr><td colspan="11">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.</td></tr>
<tr><td>Literature</td><td colspan="11">Possible References :<br>• Serge Lang: Algebraische Strukturen. Vandenhoek & Ruprecht 1979.<br>• Gerd Fischer: Lineare Algebra und Analytische Geometrie. Springer 2010.</td></tr>
<tr><td>Transfer</td><td colspan="11">The module is a prerequisite for the module Bachelor Thesis.</td></tr>
<tr><td>Prerequisites</td><td colspan="11">There are no prerequisites.</td></tr>
<tr><td>Responsible Persons</td><td colspan="11">Jürgen Hausen, Hannah Markwig, Thomas Markwig, Walther Paravicini</td></tr>
<tr><td colspan="12">Abbreviations:<br>Grading System : g=graded, ng=not graded<br>Examination Type : BT=bachelor's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests<br>Teaching Format : L=lecture, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, IC=inverted classroom<br>Status : o=obligatory, f=facultative<br>Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week</td></tr>
</table>

# Section 2: Compulsory Intermediate Modules

<table>
<tr><td>Module Number:<br>MAT-20-12</td><td colspan="2">Module Title:<br>Stochastics</td><td>Type of Module:<br>Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">9</td></tr>
<tr><td>Workload<br>- Time in Class<br>- Self-Study</td><td>Workload:<br>270 h</td><td>Time in Class:<br>90 h</td><td>Self-Study:<br>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">5-6</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.<br>• 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.<br>• 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.<br>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 :<br>• Hans-Otto Georgii: Stochastik. De Gruyter 2015.<br>• Ulrich Krengel: Einführung in die Wahrscheinlichkeitstheorie und Statistik. Vieweg 2005.</td></tr>
<tr><td>Transfer</td><td colspan="3">If applicable, the module is prerequisite for the module Bachelor Thesis.</td></tr>
<tr><td>Prerequisites</td><td colspan="3">At least two of the exercise certificates from the module Foundations in Mathematics must have been acquired. One of these must be the certificate for Linear Algebra 1.</td></tr>
</table>

| **Responsible Persons** | Martin Möhle, Martin Zerner |
|---|---|

**Abbreviations:**

| | |
|---|---|
| Grading System | : g=graded, ng=not graded |
| Examination Type | : BT=bachelor's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests |
| Teaching Format | : L=lecture, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, 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:<br>MAT-50-01</td><td colspan="3">Module Title:<br>Geometry</td><td>Type of Module:<br>Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="4">9</td></tr>
<tr><td>Workload<br>- Time in Class<br>- Self-Study</td><td>Workload:<br>270 h</td><td colspan="2">Time in Class:<br>90 h</td><td>Self-Study:<br>180 h</td></tr>
<tr><td>Duration</td><td colspan="4">1 Semester</td></tr>
<tr><td>Frequency</td><td colspan="4">regularly in Winter Semester</td></tr>
<tr><td>Term</td><td colspan="4">3-4</td></tr>
<tr><td>Language of Instruction</td><td colspan="4">German</td></tr>
<tr><td>Forms of Teaching and Learning</td><td colspan="4">Lecture 4 SWS + Ex.cl. 2 SWS</td></tr>
<tr><td>Content</td><td colspan="4">• Axiomatic foundation of planar geometry.<br>• Euclidean and non-Euclidean geometry.<br>• Parametrised curves and surfaces.</td></tr>
<tr><td>Objectives</td><td colspan="4">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.<br>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.</td></tr>
<tr><td>Requirements for obtaining Credits / Grading (Weighting if applicable)</td><td colspan="4">
<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">Geometry</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="4">Possible References :<br>• Michele Audin: Geometry. Springer 2003.<br>• Marcel Berger: Geometry Revealed: A Jacob’s Ladder to Modern Higher Geometry. Springer 2010.<br>• David A. Brannan, Matthew F. Esplen, Jeremy J. Gray: Geometry. Cambridge University Press 2012.<br>• John Stillwell: The four pillars of geometry. Springer 2005.</td></tr>
<tr><td>Transfer</td><td colspan="4">If applicable, the module is a prerequisite for the module bachelor thesis.</td></tr>
</table>

| | |
|---|---|
| **Prerequisites** | At least two of the exercise certificates from the module Foundations of Mathematics must have been acquired. One of these must be the exercise certificate of Linear Algebra 1. |
| **Responsible Persons** | Christoph Bohle, Carla Cederbaum, Hannah Markwig, Ivo Radloff |

**Abbreviations:**

| | |
|---|---|
| Grading System | : g=graded, ng=not graded |
| Examination Type | : BT=bachelor's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests |
| Teaching Format | : L=lecture, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, 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: Didactics of Mathematics

<table>
<tr><td>Module Number:<br>MAT-80-01</td><td colspan="2">Module Title:<br>Subject Didactics Mathematics 1</td><td>Type of Module:<br>Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">3</td></tr>
<tr><td>Workload<br>- Time in Class<br>- Self-Study</td><td>Workload:<br>90 h</td><td>Time in Class:<br>30 h</td><td>Self-Study:<br>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">5-6</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 class, proseminar, talk, presentation, e-learning, blended learning, project work, case studies</td></tr>
<tr><td>Content</td><td colspan="3">Didactics of Algebra and Arithmetic:<br>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.</td></tr>
<tr><td>Objectives</td><td colspan="3">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.</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 1</td><td>LIC</td><td>o</td><td>2</td><td>3</td><td>no</td><td>K o. mP<br>o. P</td><td>90-180<br>o. 20-30</td><td>g</td><td>100</td></tr>
</table>
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">The module Didactics of Mathematics 1 is compulsory for the module Bachelor Thesis, if the bachelor thesis is written in mathematics.</td></tr>
<tr><td>Prerequisites</td><td colspan="3">At least two of the exercise certificates from the module Foundations of Mathematics must have been acquired. One of these must be the exercise certificate for Linear Algebra 1.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">Frank Loose, Walther Paravicini</td></tr>
<tr><td colspan="4">Abbreviations:<br>Grading System : g=graded, ng=not graded<br>Examination Type : BT=bachelor's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests<br>Teaching Format : L=lecture, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, IC=inverted classroom<br>Status : o=obligatory, f=facultative<br>Other : h=hours, o.=or, s.M.=see module description, SWS=contact hours per week</td></tr>
</table>

<table>
<tr><td>Module Number:<br>MAT-80-02</td><td colspan="2">Module Title:<br>Subject Didactics Mathematics 2</td><td>Type of Module:<br>Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">6</td></tr>
<tr><td>Workload<br>- Time in Class<br>- Self-Study</td><td>Workload:<br>180 h</td><td>Time in Class:<br>60 h</td><td>Self-Study:<br>120 h</td></tr>
<tr><td>Duration</td><td colspan="3">2 Semester</td></tr>
<tr><td>Frequency</td><td colspan="3">every Semester</td></tr>
<tr><td>Term</td><td colspan="3">5-6</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">The module consists of the two parts<br>• didactics of geometry and linear algebra,<br>• didactics of analysis and stochastics.<br>It 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 analytic, geometric and stochastic basic ideas.</td></tr>
<tr><td>Objectives</td><td colspan="3">Students are familiar with the basic didactic principles of teaching concepts. They are able to compare and evaluate subject-specific approaches to central concepts in analysis, linear algebra, geometry and stochastics. They have the ability to convey geometric and algebraic content in a way that is both student- and subject-orientated.</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 2 – Part 1</td><td>SLIC</td><td>o</td><td>2</td><td>3</td><td>yes</td><td>K o. mP o. R o. H o. P.</td><td>90-180 o. 20-30</td><td>g</td><td>50</td></tr>
<tr><td>Subject Didactics Mathematics 2 – Part 2</td><td>SLIC</td><td>o</td><td>2</td><td>3</td><td>yes</td><td>K o. mP o. R o. H o. P.</td><td>90-180 o. 20-30</td><td>g</td><td>50</td></tr>
</table>
The module consists of two parts, for which the teaching learning methods (lecture, exercise class or seminar) as well as the type of examination (written or oral exam, presentation or paper) are usually different. This is taken into account by the fact that, the examination in this module consists of two equally weighted parts.</td></tr>
<tr><td>Transfer</td><td colspan="3">If applicable, part of the he module Subject Didactics of Mathematics 2 is a prerequisite for the module Bachelor Thesis, if the bachelor thesis is written in mathematics.</td></tr>
<tr><td>Prerequisites</td><td colspan="3">The module Foundations of Mathematics must be completed. The module Geometry should be taken parallel to the Didactics of Geometry or should have been taken beforehand, as knowledge from the module Geometry is required in the Didactics of Geometry module.</td></tr>
<tr><td>Responsible Persons</td><td colspan="3">Frank Loose, Walther Paravicini</td></tr>
</table>

**Abbreviations:**

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

# Section 4: Bachelor Thesis

<table>
<tr><td>Module Number:<br>MAT-30-40</td><td colspan="2">Module Title:<br>Bachelor Thesis</td><td>Type of Module:<br>Compulsory Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">6</td></tr>
<tr><td>Workload<br>- Time in Class<br>- Self-Study</td><td>Workload:<br>180 h</td><td>Time in Class:<br>0 h</td><td>Self-Study:<br>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">6</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">Bachelor thesis</td></tr>
<tr><td>Content</td><td colspan="3">The students have to work under instruction of an advisor on a defined task from mathematics or subject didactics mathematics with scientific methods and present the results in written form. In detail this includes:<ul><li>the formulation of a scientific question in accordance with the advisor;</li><li>the independent search for and the study of relevant scientific literature;</li><li>the formulation of suited questions and methodical approaches for their solution;</li><li>the independent realisation of the project, the written presentation of the project and the reults in the context of the current state of research.</li></ul></td></tr>
<tr><td>Objectives</td><td colspan="3">The students<ul><li>can work independently and with scientific methods on an assigned topic,</li><li>operate a literature research for scientific sources,</li><li>choose scientific methods and techniques or develop them further to solve a problem,</li><li>communicate the results in a clearly structured fashion and in academically suited form in their thesis.</li></ul></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>Bachelor Thesis</td><td>BT</td><td>f</td><td>-</td><td>6</td><td>no</td><td>BA+mP</td><td>-</td><td>g</td><td>100</td></tr></table>The oral examination is assessed on a pass/fail basis only. The module grade is the grade of the bachelor thesis. The module is only deemed passed if both assessments have been passed. The oral examination covers the contents of the bachelor thesis.</td></tr>
<tr><td>Transfer</td><td colspan="3">Bachelorarbeit</td></tr>
</table>

| | |
|---|---|
| **Prerequisites** | Subject specific prerequisite for admission to the module Bachelor Thesis is besides the general part of the examination regulations the acquisition of the credit points from the modules of Section 1 Foundations of Mathematics as well as of at least 9 credit points from the modules of the Section 2 and at least 3 credit points from the modules of Section 3. |
| **Responsible Persons** | The dean of studies at the Department of Mathematics |

**Abbreviations:**

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|---|---|
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| Teaching Format | : L=lecture, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, 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: Transferable Credits for the Master Degree

In anticipation of a prospective Master's programme in Master of Education for Secondary Schools at the University of Tübingen, certain credits may be earned during the Bachelor's programme that can be credited towards the Master's programme, provided specific conditions are met. This is intended to provide flexibility in individual study planning when transitioning from the Bachelor to the Master of Education.

### Conditions and Scope

In the Bachelor of Education programme, up to 24 ECTS credits can be earned as pre-study credits for the Master's programme, if all the following conditions are met:

- There is an enrolment (matriculation) in and an examination entitlement in the Bachelor of Education im Höheren Lehramt an beruflichen Schulen;
- A total of at least 150 ECTS credits have already been acquired in the two main subjects and in educational sciences;
- There is an enrolment in and an examination entitlement in the subject in which credits for the Master's programme are to be acquired.

It can be freely chosen how many ECTS credits are earned in which of the studied subjects. For example, all 24 ECTS credits can be earned in one subject if modules are offered in the required extent. Master's modules of a subject taken as a third subject cannot be advanced. Module examinations within the framework of Master's credits can only be repeated once. For further regulations concerning Master's credits, please refer to the study and examination regulations.

Within the Master's programme, **two out of the three** modules listed below must be completed. Accordingly, only **two** of these modules can be advanced.

| **Module Number:**<br>**MAT-20-02** | **Module Title:**<br>Introduction to Complex Analysis and Ordinary Differential Equations | | **Type of Module:**<br>Elective Module |
|---|---|---|---|
| **ECTS-Points** | 9 | | |
| **Workload**<br>**- Time in Class**<br>**- Self-Study** | Workload:<br>270 h | Time in Class:<br>90 h | Self-Study:<br>180 h |
| **Duration** | 1 Semester | | |
| **Frequency** | regularly in Summer Semester | | |
| **Term** | - | | |
| **Language of Instruction** | German | | |
| **Forms of Teaching and Learning** | Lecture 4 SWS + Ex.cl. 2 SWS | | |

**Content**

- 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.

**Objectives**

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.

**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 :**<br>• Lars Valerian Ahlfors: Complex analysis. McGraw-Hill 1979.<br>• John B. Conway: Functions of one complex variable. Springer 1996.<br>• Wolfgang Fischer, Ingo Lieb: Einführung in die Komplexe Analysis. Springer 2010.<br>• Walter Rudin: Reelle und komplexe Analysis. Oldenbourg 2009.<br>• Earl A. Coddington, Norman Levinson: Theory of ordinary differential equations. McGraw-Hill 1955.<br>• William T. Reid: Ordinary differential equations. John Wiley & Sons 1971.<br>• Hille, Einar: Ordinary differential equations in the complex domain. Dover Publications 1997.<br>• Wasow, Wolfgang: Asymptotic expansions for ordinary differential equations. John Wiley 1965. |
| **Transfer** | It is to be transferred to the consecutive master's programme. |
| **Prerequisites** | At least one of the exercise certificates from each of the modules Analysis and Linear Algebra must be acquired |
| **Responsible Persons** | Anton Deitmar, Reiner Schätzle |

**Abbreviations:**

| | |
|---|---|
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| Teaching Format | : L=lecture, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, 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:<br>MAT-20-03</td><td colspan="2">Module Title:<br>Algebra</td><td>Type of Module:<br>Elective Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">9</td></tr>
<tr><td>Workload<br>- Time in Class<br>- Self-Study</td><td>Workload:<br>270 h</td><td>Time in Class:<br>90 h</td><td>Self-Study:<br>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 4 SWS + Ex.cl. 2 SWS</td></tr>
<tr><td>Content</td><td colspan="3">• Groups and structure theory of finite groups.<br>• Rings, ideals, polynomial rings, divisibility theory.<br>• Fields and field extensions.<br>• Geometric and algebraic applications of field theory.</td></tr>
<tr><td>Objectives</td><td colspan="3">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.<br>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>
<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">Algebra</td><td>L</td><td>o</td><td>4</td><td>6</td><td rowspan="2">yes</td><td rowspan="2">wr. o.<br>or.</td><td rowspan="2">90-180<br>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>
<tr><td colspan="10">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>
</table>
</td></tr>
</table>

| | |
|---|---|
| **Literature** | **Possible References :**<br>• Siegfried Bosch: Algebra. Springer 2009.<br>• Gerd Fischer, Reinhard Sacher: Einführung in die Algebra. Teubner 1983.<br>• Christian Karpfinger, Kurt Meyberg: Algebra: Gruppen-Ringe-Körper. Springer Spektrum 2010.<br>• Kurt Meyberg: Algebra 1. Hanser 1980.<br>• Kurt Meyberg: Algebra 2. Hanser 1976.<br>• Hans-Jörg Reiffen, Günter Scheja, Udo Vetter: Algebra. Bibliographisches Institut 1984. |
| **Transfer** | It is to be transferred to the consecutive master's programme. |
| **Prerequisites** | At least two of the exercise certificates from the Foundations of Mathematics module must have been acquired, one of which must be the exercise certificate for Linear Algebra 1. Content-wise, knowledge from the submodule Algebraic Structures is assumed. |
| **Responsible Persons** | Jürgen Hausen, Hannah Markwig, Thomas Markwig |

**Abbreviations:**

| | |
|---|---|
| Grading System | : g=graded, ng=not graded |
| Examination Type | : BT=bachelor's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests |
| Teaching Format | : L=lecture, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, 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:<br>MAT-20-11</td><td colspan="2">Module Title:<br>Numerical Mathematics</td><td>Type of Module:<br>Elective Module</td></tr>
<tr><td>ECTS-Points</td><td colspan="3">9</td></tr>
<tr><td>Workload<br>- Time in Class<br>- Self-Study</td><td>Workload:<br>270 h</td><td>Time in Class:<br>90 h</td><td>Self-Study:<br>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">-</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.<br>• Numeric integration and differentiation.<br>• Systems of linear equations and linear curve fitting.<br>• Systems of non-linear equations and non-linear curve fitting.<br>• 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.<br>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 :<br>• Peter Deuflhard, Andreas Hohmann: Numerische Mathematik 1. De Gruyter 2008.<br>• Martin Hanke-Bourgeois: Grundlagen der Numerischen Mathematik und des Wissenschaftlichen Rechnens. Vieweg+Teubner 2009.</td></tr>
<tr><td>Transfer</td><td colspan="3">It is to be transferred to the consecutive master's programme.</td></tr>
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|---|---|
| **Prerequisites** | At least two of the exercise certificates from the module Foundations in Mathematics must have been acquired. One of these must be the certificate for Linear Algebra 1. Furthermore, before admission to the examination, the practical certificate for the practical course in Numerical Analysis from the module Introduction to Scientific Programming must have been obtained. |
| **Responsible Persons** | Christian Lubich, Andreas Prohl |

**Abbreviations:**

| | |
|---|---|
| Grading System | : g=graded, ng=not graded |
| Examination Type | : BT=bachelor's thesis, or.=oral exam, wr.=written exam, Pr=presentation, E=essay, P=portfolio, T=continous assessment tests |
| Teaching Format | : L=lecture, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, 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-40-52 | **Module Title:** Seminar: Mathematical Specialisation | | **Type of Module:** Elective Module |
|---|---|---|---|
| **ECTS-Points** | 4 | | |
| **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** | - | | |
| **Language of Instruction** | German | | |
| **Forms of Teaching and Learning** | Seminar, talk, presentation, e-learning, blended learning | | |
| **Content** | Various topics from the advanced fields of mathematics. | | |
| **Objectives** | The students independently work on a coherent mathematical topic and prepare it in a didactical appealing fashion. 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. The work and the presentation may be the foundation or a deepened study in the scope of a master thesis. | | |

**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 |
|---|---|---|---|---|---|---|---|---|---|
| Seminar | S | o | 2 | 4 | yes | Pr | 60-90 | g | 100 |

The acquisition of the credit points requires alongside with a successful 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. These further efforts constitute the coursework of the module.

| | |
|---|---|
| **Transfer** | It is to be transferred to the consecutive master's programme. |
| **Prerequisites** | The participation in the module requires the successful completion of at least one of the modules Introduction to Complex Analysis and Ordinary Differential Equations, Algebra or Numerical Mathematics. |
| **Responsible Persons** | The dean of studies at the Department of Mathematics |

**Abbreviations:**

Grading System : g=graded, ng=not graded

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

Teaching Format : L=lecture, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, 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:** Seminar: Mathematical Specialisation | | **Type of Module:** Elective Module |
|---|---|---|---|
| **ECTS-Points** | 4 | | |
| **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** | - | | |
| **Language of Instruction** | German | | |
| **Forms of Teaching and Learning** | Seminar, talk, presentation, e-learning, blended learning | | |
| **Content** | Various topics from the advanced fields of mathematics. | | |
| **Objectives** | The students independently work on a coherent mathematical topic and prepare it in a didactical appealing fashion. 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. The work and the presentation may be the foundation or a deepened study in the scope of a master thesis. | | |

**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 |
|---|---|---|---|---|---|---|---|---|---|
| Seminar | S | o | 2 | 4 | yes | Pr | 60-90 | g | 100 |

The acquisition of the credit points requires alongside with a successful 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. These further efforts constitute the coursework of the module.

| | |
|---|---|
| **Transfer** | It is to be transferred to the consecutive master's programme. |
| **Prerequisites** | The participation in the module requires the successful completion of at least one of the modules Introduction to Complex Analysis and Ordinary Differential Equations or Stochastics. |
| **Responsible Persons** | The dean of studies at the Department of Mathematics |

**Abbreviations:**

Grading System : g=graded, ng=not graded

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

Teaching Format : L=lecture, SL=seminar or lecture, E=exercise class, T=tutorial, P=practical course, IC=inverted classroom

Status : o=obligatory, f=facultative

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