Module Handbook for the Master's Degree Programmes
in Mathematics and Technomathematics
at the Faculty of
Computer Science, Electrical Engineering and Mathematics

New version released on 24 June 2014

Note: The following translation of the German "Modulhandbuch" (AM.Uni.Pb.Nr. 144/14) for the Master's degree programmes in Mathematics and Technomathematics is offered for the convenience of our international students. Legally valid is the German version only.

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Based on § 2 Section 4 and § 64 Section 1 of the "Gesetz über die Hochschulen des Landes Nordrhein-Westfalen (Hochschulgesetz – HG)" (State of North Rhine-Westphalia Higher Education Act) released on 31 October 2006 (GV.NRW.2006 page 474), last amended by Article 1 of the law released on 3 December 2013 (GV.NRW.2013 page 723), the University of Paderborn has issued the examination regulations for the Master's degree programme in Mathematics (AM.Uni.Pb.Nr. 47/13), released 31 May 2013, and amended by the statute (AM.Uni.Pb.Nr. 142/14), released on 24 June 2014, and the examination regulations for the Master's degree programme in Technomathematics (AM.Uni.Pb.Nr. 48/13), released 31 May 2013, and amended by the statute (AM.Uni.Pb.Nr. 143/14), released on 24 June 2014. This module handbook is Attachment II of the examination regulations previously mentioned and forms an integral part of these examination regulations.

MASTER

Module name	Code number	Credits	Academic in charge	Area
Algebra I	5.A.1.x	9	Klüners	A
Algebra II	5.A.2.x	9	Klüners	A
Geometry I	5.A.3.x	9	Lau	A
Geometry II	5.A.4.x	9	Lau	A
Special Chapters of Algebra and Geometry	5.A.7.x	9	Wedhorn	A
Selected Chapters of Algebra and Geometry	5.A.8.x	5	Wedhorn	A
Functional Analysis I	5.B.1.x	9	Glöckner	B
Functional Analysis II	5.B.2.x	9	Glöckner	B
Differential Equations I	5.B.3.x	9	Winkler	B
Differential Equations II	5.B.4.x	9	Winkler	B
Stochastic I	5.B.5.x	9	Dietz	B
Stochastic II	5.B.6.x	9	Dietz	B
Special Chapters of Analysis and Stochastic	5.B.7.x	9	Rösler	B
Selected Chapters of Analysis and Stochastic	5.B.8.x	5	Rösler	B
Numerics of Differential Equations I	5.C.1.x	9	Walther	C
Numerics of Differential Equations II	5.C.2.x	9	Walther	C
Computational Dynamics I	5.C.3.x	9	Dellnitz	C
Computational Dynamics II	5.C.4.x	9	Dellnitz	C
Optimisation	5.C.5.x	9	Walther	C
Special Chapters of Scientific Computing	5.C.7.x	9	Dellnitz	C
Selected Chapters of Scientific Computing	5.C.8.x	5	Walther	C
Seminar	6.y.1.x	6	Glöckner	
Project Seminar	6.y.2.x	6	Dellnitz	
"Studium Generale" (General Studies)		6-12	Glöckner	

Every module is uniquely identified by its code number of the form "a.y.b.x", where a, b, x are numbers and y is one of the letters A, B, C, with the following meaning:

- a: type of course:
  5 = lecture course with tutorial, 6 = seminar/project seminar
- y: area:
  A = Algebra and Geometry, B = Analysis and Stochastic, C = Numerical Mathematics
- b: sequential number for a fixed type of course and a fixed area
- x: sequential number for different modules that are described by one common module description with different specialisations

Module name **Algebra I**			Workload **270 h**	Credits **9 Credits**
Classification	**Degree programme** Master in Mathematics Master in Technomathematics	**Curriculum** elective	**Area** Algebra and Geometry	
Courses/hours per week (hpw)/group size		**Semester**	**Workload**	
			Teaching hours	Independent study
Lecture course/4 hpw/20 students + tutorial/2 hpw/20 students		1./2. semester	60+30 h	180 h

Desired learning outcomes

Knowledge:
The students have gained a general knowledge of algebraic problems in one of the topics. They have become acquainted with central terminology and methods.

Skills:
The students are capable of applying methods of the theoretical part to elementary problems.
The students have gained the skills to work on algebraic problems in an autonomous, active way.

Competencies:
The students are able to abstract a problem and to recognise analogies and patterns. They master a safe handling of algebraic algorithms.
The students can work independently with scientific and research literature. The students master the fundamental proof techniques and principles of Algebra.

Course content

This module runs different lecture courses, such as “Commutative Algebra”, “Representation Theory“, “Number Theory“.

“Commutative Algebra”
- module theory, flat and projective modules, localization, completion, primary decomposition, normalisation, Nullstellensatz, dimension, Hilbert polynomials, regular local rings, Ext and Tor.

“Representation Theory“
- representations of algebraic structures (e.g. groups, algebras, Lie-algebras) via endomorphisms of linear spaces, irreducible and indecomposable spaces, classification and decomposition theorems.

“Number Theory“
- valuation theory, local fields, class field theory, zeta functions and L-series

References (examples only)

- Commutative Algebra, David Eisenbud, Springer Verlag
- Representation Theory, Joe Harris, William Fulton, Springer Verlag
- Algebraic Number Theory, Jürgen Neukirch, Springer Verlag

Further literature may possibly be announced by the respective lecturer.

Prerequisites for attending	**Recommended prerequisites**
None	Knowledge, skills and expertise, analogous to the ones taught in “Linear Algebra 1”, “Linear Algebra 2” and “Algebra” of the Bachelor’s degree programme.
Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector, assigned written exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Algebra and Geometry	Prof. Dr. Jürgen Klüners

Module name **Algebra II**			Workload **270 h**	Credits **9 Credits**
Classification	**Degree programme** Master in Mathematics Master in Technomathematics	**Curriculum** elective	**Area** Algebra and Geometry	

Courses/hours per week (hpw)/group size	**Semester**	**Workload**	
		Teaching hours	Independent study
Lecture course/4 hpw/20 students + tutorial/2 hpw/20 students	2./3. semester	60+30 h	180 h

Desired learning outcomes

Knowledge:
The students have gained knowledge of advanced terms and profound methods of Algebra. They have gained a comprehensive understanding of problems.

Skills:
The students are capable of applying methods of the theoretical part to algebraic problems.
The students master theoretical methods of Algebra. Furthermore, they have gained the skills to work on advanced algebraic problems in an autonomous, active way.

Competencies:
The students are able to abstract a problem and to recognize analogies and patterns. They master a safe handling of profound proof techniques and problems.
The students can work independently with selected research literature. They can work with substantial proof techniques and principles.

Course content

Continuation and addition of contents from the module "Algebra I".

References (examples only)

- Algebraic Number Theory, Jürgen Neukirch, Springer Verlag
- Commutative Algebra, David Eisenbud, Springer Verlag
- Representation Theory, Joe Harris, William Fulton, Springer Verlag

Further literature may possibly be announced by the respective lecturer.

Prerequisites for attending	**Recommended prerequisites**
none	Module "Algebra I"
Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector, assigned written exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Algebra and Geometry	Prof. Dr. Jürgen Klüners

<table>
<tr><td colspan="3">Module name
Geometry I</td><td>Workload
270 h</td><td>Credits
9 Credits</td></tr>
<tr><td>Classification</td><td>Degree programme
Master in Mathematics
Master in Technomathematics</td><td>Curriculum
elective</td><td colspan="2">Area
Algebra and Geometry</td></tr>
<tr><td colspan="2" rowspan="2">Courses/hours per week (hpw)/group size

Lecture course/4 hpw/20 students
+ tutorial/2 hpw/20 students</td><td rowspan="2">Semester

1./2. semester</td><td colspan="2">Workload</td></tr>
<tr><td>Teaching hours
60+30 h</td><td>Independent study
180 h</td></tr>
<tr><td colspan="5">Desired learning outcomes
The students have developed an understanding of advanced problems in a subarea of Geometry and have become familiar with the fundamental concepts required for working on such problems. They have become proficient in applying the respective terminology and methods. The students can work independently with scientific literature.</td></tr>
<tr><td colspan="5">Course content
This module runs lecture courses with different specialisations, such as "Basic Algebraic Geometry", "Basic Differential Geometry", "Topology". Exemplary, the topics of "Basic Algebraic Geometry" have been specified:
- sheaf theory
- the category of schemes
- fibered products and separatedness
- projective and proper morphisms
- examples: quadrics, Grassmannians, curves</td></tr>
<tr><td colspan="5">References (examples only)
- Dieudonné, Grothendieck: Éléments de géométrie algébrique
- Görtz, Wedhorn: Algebraic Geometry
- Hartshorne: Algebraic Geometry
- Liu: Algebraic Geometry
- Mumford: The Red Book of Varieties and Schemes
Further literature may be announced by the respective lecturer of the course.</td></tr>
<tr><td colspan="2">Prerequisites for attending
None</td><td colspan="3">Recommended prerequisites
Knowledge, skills and expertise, analogous to the ones taught in the modules "Linear Algebra 1", "Linear Algebra 2" and "Algebra" of the Bachelor's degree programme.</td></tr>
<tr><td colspan="2">Language of instruction
German / English (where required)</td><td colspan="3">Teaching materials and teaching method
Class room lecture with the aid of the black board and possibly a data projector, assigned written exercises.</td></tr>
<tr><td colspan="5">Awarding of credits, mode of assessment, course work and und final examination
Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.</td></tr>
<tr><td colspan="2">Lecturers
The lecturers in the area Algebra and Geometry.</td><td colspan="3">Academic in charge
Prof. Dr. Eike Lau</td></tr>
</table>

Module name **Geometry II**			Workload **270 h**	Credits **9 Credits**
Classification	**Degree programme** Master in Mathematics Master in Technomathematics	**Curriculum** elective	**Area** Algebra and Geometry	
Courses/hours per week (hpw)/group size		**Semester**	**Workload**	
			Teaching hours	Independent study
Lecture course/4 hpw/20 students + tutorial/2 hpw/20 students		2./3. semester	60+30 h	180 h

Desired learning outcomes

The students have a profound understanding of advanced problems in a subarea of Geometry that reach up to current research. They can master a complex mathematical theory. The students can work independently with scientific research literature.

Course content

This module runs lecture courses with different specialisations, such as "Algebraic Geometry", "Differential Geometry", "Lie Groups", "Algebraic Groups", "Algebraic Topology".
Exemplary, the topics of "Algebraic Geometry" have been specified:
- local structure of schemes
- smooth and étale morphisms
- sheaf cohomology and duality
- theorem of Riemann-Roch.

References (examples only)

- Dieudonné, Grothendieck: Éléments de géométrie algébrique
- Görtz, Wedhorn: Algebraic Geometry
- Hartshorne: Algebraic Geometry
- Liu: Algebraic Geometry
- Mumford: The Red Book of Varieties and Schemes

Further literature may be announced by the respective lecturer of the course.

Prerequisites for attending	**Recommended prerequisites**
None	Knowledge, skills and expertise, analogous to the ones taught in the module "Geometry I".
Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector, assigned written exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Algebra and Geometry.	Prof. Dr. Eike Lau

Module name	Workload	Credits
Special Chapters of Algebra and Geometry	**270 h**	**9 Credits**

Classification	**Degree programme**	**Curriculum**	**Area**
	Master in Mathematics Master in Technomathematics	elective	Algebra and Geometry

Courses/hours per week (hpw)/group size	**Semester**	**Workload**	
		Teaching hours	Independent study
Lecture course/4 hpw/20 students + tutorial/2 hpw/20 students	1./2./3. semester	60+30 h	180 h

Desired learning outcomes

The students have developed an understanding of problems in current mathematical research in a subarea of Algebra or Geometry. They can work with advanced notions and methods in Algebra or Geometry. They are able to work independently with mathematical research literature. The students complement and/or advance their knowledge of the contents of the modules “Algebra I and II” and “Geometry I and II”.

Course content

This module runs lecture courses with a current topic in Algebra and Geometry, such as “Non-Archimedean Geometry”, “Shimura Varieties”, “Algorithmic Galois Theory”, or “Geometric Invariant Theory”.

References (examples only)

Literature will be announced by the respective lecturer of the course.

Prerequisites for attending	**Recommended prerequisites**
none	Will be announced by the respective lecturer of the course.

Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector or guided scientific reading, assigned written exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Algebra and Geometry.	Prof. Dr. Torsten Wedhorn

<table>
<tr><td colspan="4">Module name
Selected Chapters of Algebra and Geometry</td><td>Workload
150 h</td><td>Credits
5 Credits</td></tr>
<tr><td>Classification</td><td colspan="2">Degree programme
Master in Mathematics
Master in Technomathematics</td><td>Curriculum
elective</td><td colspan="2">Area
Algebra and Geometry</td></tr>
<tr><td colspan="3" rowspan="2">Courses/hours per week (hpw)/group size

Lecture course/2 hpw/20 students
+ tutorial/1 hpw/20 students</td><td rowspan="2">Semester

1./2./3.
semester</td><td colspan="2">Workload</td></tr>
<tr><td>Teaching hours
30+15 h</td><td>Independent study
105 h</td></tr>
<tr><td colspan="6">Desired learning outcomes
The students have developed an understanding of problems in current mathematical research in a selected subarea of Algebra or Geometry. They can work with advanced notions and methods in a selected subarea of Algebra or Geometry. They are able to work independently with mathematical research literature. The students complement and/or advance their knowledge of the contents of the modules “Algebra I and II” and “Geometry I and II”.</td></tr>
<tr><td colspan="6">Course content
This module runs lecture courses with a current topic in Algebra and Geometry, such as “Algorithmic Class Field Theory”, “Abelian Varieties”, “p-Adic Hodge Theory”, or “Linear Algebraic Groups”.</td></tr>
<tr><td colspan="6">References (examples only)
Literature will be announced by the respective lecturer of the course.</td></tr>
<tr><td colspan="2">Prerequisites for attending
none</td><td colspan="4">Recommended prerequisites
Will be announced by the respective lecturer of the course.</td></tr>
<tr><td colspan="2">Language of instruction
German / English (where required)</td><td colspan="4">Teaching materials and teaching method
Class room lecture with the aid of the black board and possibly a data projector or guided scientific reading, assigned written exercises.</td></tr>
<tr><td colspan="6">Awarding of credits, mode of assessment, course work and und final examination
Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.</td></tr>
<tr><td colspan="3">Lecturers
The lecturers in the area Algebra and Geometry.</td><td colspan="3">Academic in charge
Prof. Dr. Torsten Wedhorn</td></tr>
</table>

Module name **Functional Analysis I**	Workload **270 h**	Credits **9 Credits**

Classification	**Degree programme**	**Curriculum**	**Area**
	Master in Mathematics Master in Technomathematics	elective	Analysis and Stochastic

Courses/hours per week (hpw)/group size	**Semester**	**Workload**	
		Teaching hours	Independent study
Lecture course/4 hpw/20 students + tutorial/2 hpw/20 students	1./2. semester	60+30 h	180 h

Desired learning outcomes

The students have developed an understanding of the fundamentals of Functional Analysis. They have deepened their capability to apply abstract ideas to analytic problems. The students have acquired a foundation for specialising in the area of Analysis.

Course content

Linear functionals and operators on Banach spaces and locally convex spaces. Hahn-Banach theorem and consequences. Weak topology, reflexive spaces. Open mapping theorem and closed graph theorem. Banach-Steinhaus theorem. Compact operators and Fredholm operators. Hilbert spaces and the spectral theorem for compact self-adjoint operators.

References (examples only)

- Bourbaki, N., Topological Vector Spaces, Chapters 1-5, Springer, 2003
- Rudin, W., Functional Analysis, McGraw-Hill, 2006
- Werner, D., Funktionalanalysis, Springer, 2011

Further literature may be announced by the respective lecturer of the course.

Prerequisites for attending	**Recommended prerequisites**
None	Basic modules “Analysis 1” and “Analysis 2” as well as “Linear Algebra 1” and “Linear Algebra 2,” also lecture courses devoted to Topology and Lebesgue Integration.

Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector, assigned written exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.

The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Analysis and Stochastic.	Prof. Dr. Helge Glöckner

Module name **Functional Analysis II**			Workload **270 h**	Credits **9 Credits**
Classification	**Degree programme** Master in Mathematics Master in Technomathematics	**Curriculum** elective	**Area** Analysis and Stochastic	

Courses/hours per week (hpw)/group size	**Semester**	**Workload**	
		Teaching hours	Independent study
Lecture course/4 hpw/20 students + tutorial/2 hpw/20 students	2./3. semester	60+30 h	180 h

Desired learning outcomes

The students have deepened their knowledge of Functional Analysis. They have studied a special area of Functional Analysis and its relations to other areas of mathematics.

Course content

E.g. Banach algebras, Gelfand theory, operator theory, locally convex spaces, distributions, nonlinear functional analysis.

References (examples only)

Literature will be announced by the respective lecturer of the course.

Prerequisites for attending	**Recommended prerequisites**
None	Module “Functional Analysis I”.
Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector, assigned written exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Analysis and Stochastic.	Prof. Dr. Helge Glöckner

Module name			Workload	Credits
Differential Equations I			**270 h**	**9 Credits**
Classification	**Degree programme** Master in Mathematics Master in Technomathematics	**Curriculum** elective	**Area** Analysis and Stochastic	
Courses/hours per week (hpw)/group size		**Semester**	**Workload**	
			Teaching hours	Independent study
Lecture course/4 hpw/25 students + tutorial/2 hpw/25 students		1./2. semester	60+30 h	180 h

Desired learning outcomes

The students have developed an understanding of fundamental aspects in the theory of partial differential equations. They are familiar with important classes of examples and can apply various methods to handle these analytically. They have the ability to work independently and actively on fundamental problems on the basis of both classical and abstract functional analytic techniques.

Course content

Partial Differential Equations: examples and classes of examples, e.g. elliptic, parabolic or hyperbolic differential equations; typical mathematical techniques, such as the method of characteristics, potential theoretical approaches, or Hilbert space methods.

References (examples only)

- Evans, L.C.: Partial Differential Equations (AMS)
- Friedman, A.: Partial Differential Equations (Holt, Rinehart & Winston)
- Gilbarg, D., Trudinger, N.E.: Elliptic Partial Differential Equations of Second Order (Springer)

Further literature may be announced by the respective lecturer of the course.

Prerequisites for attending	**Recommended prerequisites**
None	Module “Functional Analysis I”.
Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector, assigned written exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Analysis and Stochastic.	Prof. Dr. Michael Winkler

Module name **Differential Equations II**			Workload **270 h**	Credits **9 Credits**
Classification	**Degree programme** Master in Mathematics Master in Technomathematics	**Curriculum** elective	**Area** Analysis and Stochastic	
Courses/hours per week (hpw)/group size		**Semester**	**Workload**	
			Teaching hours	Independent study
Lecture course/4 hpw/20 students + tutorial/2 hpw/20 students		2./3. semester	60+30 h	180 h

Desired learning outcomes

The students have obtained a profound knowledge of selected aspects from the analysis of differential equations. They are familiar with functional analytic methods and are able to apply these flexibly to solve both theoretically motivated problems as well as questions stemming from applications. The students are able to work independently and successfully on challenging problems, e.g. from the subareas existence and regularity theory, or also from the qualitative description of solution behaviour.

Course content

Selected chapters from the Theory of Differential Equations, such as concepts of generalized solutions and their construction, regularity theory in Sobolev spaces, long-term behaviour in evolution equations, spontaneous emergence of structures and singularities, scattering theory, semigroups.

References (examples only)

The relevant literature will be announced by the respective lecturer of the course.

Prerequisites for attending	**Recommended prerequisites**
None	Modules “Functional Analysis I” and “Differential Equations I”.
Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector, assigned written exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Analysis and Stochastic.	Prof. Dr. Michael Winkler

Module name **Stochastic I**			Workload **270 h**	Credits **9 Credits**
Classification	**Degree programme** Master in Mathematics Master in Technomathematics	**Curriculum** elective	**Area** Analysis and Stochastic	
Courses/hours per week (hpw)/group size		**Semester**	**Workload**	
			Teaching hours	Independent study
Lecture course/4 hpw/20 students + tutorial/2 hpw/20 students		1./2. semester	60+30 h	180 h

Desired learning outcomes

Knowledge:

The students gain detailed knowledge about ideas, concepts, methods and results in Stochastic to be able to model and analyse complex, in particular, time-dependent stochastic phenomena. In addition, the students have a deep understanding of the theory.

Skills:

The students are able to successfully apply the acquired knowledge of stochastic basic objects from a current research and application area for solving more complex problems of a stochastic nature.

Competencies:

The students have the ability to model and to analyse complex relationships of stochastic structures.

Course content

- Basics of Stochastic
- Introduction to the Wiener process
- Introduction to the Itô-calculus
- Applications of the Itô-calculus: Continuous-time Kalman-filter, stability theory, introduction to the Black-Scholes-theory in Financial Mathematics

References (examples only)

- G.R. Grimmet, D.R. Stirzaker: Probability and Random Processes, Oxford Science Publication, 1994
- Karatzas, S.E. Shreve: Brownian Motion and Stochastic Calculus, 1991

Further literature may be announced by the respective lecturer of the course.

Prerequisites for attending	**Recommended prerequisites**
None	Attending the course “Foundations of Stochastic”.
Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector, assigned written exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, with is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Analysis and Stochastic.	Prof. Dr. Hans-M. Dietz

Module name	Workload	Credits
Stochastic II	**270 h**	**9 Credits**

Classification	Degree programme	Curriculum	Area
	Master in Mathematics Master in Technomathematics	elective	Analysis and Stochastic

Courses/hours per week (hpw)/group size	Semester	Workload: Teaching hours	Workload: Independent study
Lecture course/4 hpw/20 students + tutorial/2 hpw/20 students	2./3. semester	60+30 h	180 h

Desired learning outcomes

Knowledge:

The students have a profound knowledge of topics, problems, methods and results in an area of Stochastic that is of interest for current research.

Skills:

The students master the techniques of the covered relevant topic at an advanced level.

Competencies:

The students have the ability to work independently on new problems and to rate their relevance, and they can also work independently on these problems with the help of current literature.

Course content

One of the following topics will be offered:
- Stochastic Partial Differential Equations
- Statistics of Stochastic Processes
- Random Dynamical Systems

Other topics can be offered in agreement between the students and the lecturer.

References (examples only)

- W.H. Fleming, R.W. Rishel: Deterministic and Stochastic Optimal Control, Springer, 1975

Further literature may be announced by the respective lecturer of the course.

Prerequisites for attending	Recommended prerequisites
None	Attending courses about Stochastic as well as Differential Equations and Dynamical Systems.

Language of instruction	Teaching materials and teaching method
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector, assigned written exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, with is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	Academic in charge
The lecturers in the area Analysis and Stochastic.	Prof. Dr. Hans-M. Dietz

<table>
<tr><td colspan="3">Module name
Special Chapters of Analysis and Stochastic</td><td>Workload
270 h</td><td>Credits
9 Credits</td></tr>
<tr><td>Classification</td><td>Degree programme
Master in Mathematics
Master in Technomathematics</td><td>Curriculum
elective</td><td colspan="2">Area
Analysis and Stochastic</td></tr>
<tr><td colspan="2" rowspan="2">Courses/hours per week (hpw)/group size

Lecture course/4 hpw/20 students
+ tutorial/2 hpw/20 students</td><td rowspan="2">Semester

1./2./3.
semester</td><td colspan="2">Workload</td></tr>
<tr><td>Teaching hours
60+30 h</td><td>Independent study
180 h</td></tr>
</table>

Desired learning outcomes

- The students have a profound and detailed knowledge in a subject within the area Analysis and Stochastic.
- They have gained the ability to work independently and in an active way on more advanced problems within the respective subject, which also qualifies them to take up a Master's thesis within this subject.
- They have learned to use modern techniques of scientific work.

Course content

This module runs lecture courses with advanced and more specialised topics from the areas of Functional Analysis, Differential Equations and Stochastic, as well as topics from connected areas such as harmonic analysis, representation theory, infinite dimensional analysis, nonlinear and global analysis, mathematical physics, special functions, complex analysis, and statistics.

References (examples only)

Literature will be announced by the respective lecturer of the course.

Prerequisites for attending	**Recommended prerequisites**
None	Knowledge, skills and expertise in the respective area that the course is based on. These will be announced by the respective lecturer.
Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of blackboard and possibly a data projector or guided scientific reading; assigned written exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the course.

Lecturers	**Academic in charge**
The lecturers in the area Analysis and Stochastic.	Prof. Dr. Margit Rösler

Module name **Selected Chapters of Analysis and Stochastic**			Workload **150 h**	Credits **5 Credits**
Classification	**Degree programme** Master in Mathematics Master in Technomathematics	**Curriculum** elective	**Area** Analysis and Stochastic	

Courses/hours per week (hpw)/group size	**Semester**	**Workload**	
		Teaching hours	Independent study
Lecture course/2 hpw/20 students + tutorial/1 hpw/20 students	1./2./3. semester	30+15 h	105 h

Desired learning outcomes

- Depending on the intention of the specific course, the students have either obtained a profound knowledge in an advanced topic within the area of Analysis and Stochastic, or have gained fundamental insights into an advanced topic within this area.
- They are able to consider and classify problems within the studied area in the wider mathematical context and to make useful interconnections with other areas.
- They have the ability to work independently on challenging problems connected to the respective area.

Course content

This module runs lecture courses with advanced and additional topics in the area Analysis and Stochastic. This may include advanced and specialised topics that build on the content of preceding modules. However, the module may also offer additional insight into topics not covered otherwise. Examples: Topics from harmonic analysis, Banach algebras, operator semigroups, calculus of variations, distributions, differential equations from mathematical biology, financial mathematics.

References (examples only)

Literature will be announced by the respective lecturer of the course.

Prerequisites for attending	**Recommended prerequisites**
None	Knowledge, skills and expertise in the respective area that the course is based on. These will be announced by the respective lecturer.
Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of blackboard and possibly a data projector or guided scientific reading; assigned written exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the course.

Lecturers	**Academic in charge**
The lecturers in the area Analysis and Stochastic.	Prof. Dr. Margit Rösler

<table>
<tr><td colspan="3">Module name
Numerics of Differential Equations I</td><td>Workload
270 h</td><td>Credits
9 Credits</td></tr>
<tr><td>**Classification**</td><td>**Degree programme**
Master in Mathematics
Master in Technomathematics</td><td>**Curriculum**
elective</td><td colspan="2">**Area**
Numerical Mathematics</td></tr>
<tr><td colspan="2" rowspan="2">**Courses/hours per week (hpw)/group size**

Lecture course/4 hpw/20 students
+ tutorial/2 hpw/20 students</td><td rowspan="2">**Semester**

1./2. semester</td><td colspan="2">**Workload**</td></tr>
<tr><td>Teaching hours
60+30 h</td><td>Independent study
180 h</td></tr>
<tr><td colspan="5">**Desired learning outcomes**
The students have developed a profound understanding of central problems and techniques for the numerical solution of differential equations. They have learned how to assess the conditioning and the stability of a method. The students have become familiar with the development and analysis of numerical algorithms and the use of numerical software.</td></tr>
<tr><td colspan="5">**Course content**
The course covers numerical methods for the solution of initial and boundary value problems for ordinary and/or partial differential equations, such as difference methods, Galerkin schemes for weak formulations and finite elements.</td></tr>
<tr><td colspan="5">**References (examples only)**
- Braess, Finite Elements, 3rd ed., Springer 2007
- Dahmen, Reusken, Numerik fuer Ingenieure und Naturwissenschaftler, Springer, 2005
- Hanke-Bourgeois, Grundlagen der numerischen Mathematik und das wissenschaftlichen Rechnens, Vieweg+Teubner Verlag, 2009
Further literature may be announced by the respective lecturer of the course.</td></tr>
<tr><td colspan="2">**Prerequisites for attending**
None</td><td colspan="3">**Recommended prerequisites**
Modules “Numerics 1” and/or “Numerics 2”.</td></tr>
<tr><td colspan="2">**Language of instruction**
German / English (where required)</td><td colspan="3">**Teaching materials and teaching method**
Class room lecture with the aid of the black board and possibly a data projector, assigned course work, written and computer-based exercises.</td></tr>
<tr><td colspan="5">**Awarding of credits, mode of assessment, course work and und final examination**
Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.</td></tr>
<tr><td colspan="2">**Lecturers**
The lecturers in the area Numerical Mathematics.</td><td colspan="3">**Academic in charge**
Prof. Dr. Andrea Walther</td></tr>
</table>

Module name **Numerics of Differential Equations II**			Workload **270 h**	Credits **9 Credits**
Classification	**Degree programme** Master in Mathematics Master in Technomathematics	**Curriculum** elective	**Area** Numerical Mathematics	
Courses/hours per week (hpw)/group size		**Semester**	**Workload**	
			Teaching hours	Independent study
Lecture course/4 hpw/20 students + tutorial/2 hpw/20 students		2./3. semester	60+30 h	180 h

Desired learning outcomes

Expertise in Numerics of Partial Differential Equations.

Course content

Weak formulations of partial differential equations, regularity in Sobolev spaces, Galerkin methods, finite elements, error estimates, multigrid methods.

References (examples only)

- Braess, Finite Elements, 3rd ed., Springer 2007
- Dahmen, Reusken, Numerik für Ingenieure und Naturwissenschaftler, Springer, 2005
- Hanke-Bourgeois, Grundlagen der numerischen Mathematik und das wissenschaftlichen Rechnens, Vieweg+Teubner Verlag, 2009

Further literature may be announced by the respective lecturer of the course.

Prerequisites for attending	**Recommended prerequisites**
None	Modules “Numerics of Differential Equations I” and “Functional Analysis I”.
Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector, written and computer-based exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Numerical Mathematics.	Prof. Dr. Andrea Walther

<table>
<tr><td colspan="3">Module name
Computational Dynamics I</td><td>Workload
270 h</td><td>Credits
9 Credits</td></tr>
<tr><td>**Classification**</td><td>**Degree programme**
Master in Mathematics
Master in Technomathematics</td><td>**Curriculum**
elective</td><td colspan="2">**Area**
Numerical Mathematics</td></tr>
<tr><td colspan="2" rowspan="2">**Courses/hours per week (hpw)/group size**

Lecture course/4 hpw/20 students
+ tutorial/2 hpw/20 students</td><td rowspan="2">**Semester**

1./2. semester</td><td colspan="2">**Workload**</td></tr>
<tr><td>Teaching hours
60+30 h</td><td>Independent study
180 h</td></tr>
</table>

Desired learning outcomes

The students have a broad knowledge of phenomena arising in the context of Dynamical Systems. They know various methods of analysis and are familiar with specific results from the Theory of Dynamical Systems.

Course content

In this module a broad overview of the Theory of Dynamical Systems is provided. On the one hand, topics that may already have been presented before in a module of Numerical Mathematics are reconsidered and are dealt with more deeply in the lecture course. On the other hand, new aspects (e.g. bifurcation theory including its numerical treatment) are presented.

References (examples only)

- M. Denker: Einführung in die Analysis Dynamischer Systeme. Springer, Berlin Heidelberg (2004)
- M. W. Hirsch and S. Smale: Differential Equations, Dynamical Systems, and Linear Algebra. Academic Press, New York (1974)

Further literature may be announced by the respective lecturer of the course.

Prerequisites for attending	**Recommended prerequisites**
none	Taking the Bachelor’s module “Numerics 2” beforehand is recommended, but not mandatory.

Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture making use of a black board and possibly a data projector, written or computer-based exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually assigned course work accompanying the lectures is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Numerial Mathematics.	Prof. Dr. Michael Dellnitz

<table>
<tr><td colspan="3">Module name
Computational Dynamics II</td><td>Workload
270 h</td><td>Credits
9 Credits</td></tr>
<tr><td>**Classification**</td><td>**Degree programme**
Master in Mathematics
Master in Technomathematics</td><td>**Curriculum**
elective</td><td colspan="2">**Area**
Numerical Mathematics</td></tr>
<tr><td colspan="2" rowspan="2">**Courses/hours per week (hpw)/group size**

Lecture course/4 hpw/20 students
+ tutorial/2 hpw/20 students</td><td rowspan="2">**Semester**

2./3. semester</td><td colspan="2">**Workload**</td></tr>
<tr><td>Teaching hours
60+30 h</td><td>Independent study
180 h</td></tr>
</table>

Desired learning outcomes

The students know specific results and methods from the theory of dynamical systems and are able to apply these. They are prepared for writing a Master's thesis on a topic in the area Dynamical Systems Theory.

Course content

The lecture course looks deeper into a specific subarea of the Theory of Dynamical Systems. Possible topics are, for instance,

- dynamical systems in mechanics
- geometric mechanics
- symbolic dynamics

In addition to theoretical aspects, numerical aspects are also addressed.

References (examples only)

Will be announced by the respective lecturer of the course.

Prerequisites for attending

none

Recommended prerequisites

Taking the module "Computational Dynamics I" beforehand is recommended.

Language of instruction

German / English (where required)

Teaching materials and teaching method

Class room lecture making use of a black board and possibly a data projector, written or computer-based exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually assigned course work accompanying the lectures is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers

The lecturers in the area Numerical Mathematics.

Academic in charge

Prof. Dr. Michael Dellnitz

Module name **Optimisation**			Workload **270 h**	Credits **9 Credits**
Classification	**Degree programme** Master in Mathematics Master in Technomathematics	**Curriculum** elective	**Area** Numerical Mathematics	
Courses/hours per week (hpw)/group size		**Semester**	**Workload**	
			Teaching hours	Independent study
Lecture course/4 hpw/20 students + tutorial/2 hpw/20 students		1./2. semester	60+30 h	180 h

Desired learning outcomes

The students have a profound knowledge of the theory of continuous optimisation problems. Furthermore, the students are familiar with the theory and application of advanced methods of local and global optimisation.

Course content

Theory and practice of advanced local optimisation methods such as SQP, trust-region and interior-point methods, as well as basics of multi-objective optimisation based on the KKT conditions. Building on the previous topics: methods of multi-objective optimisation.

References (examples only)

- Jorge Nocedal, Stephen Wright: Numerical Optimization;
- Walter Alt: Nichtlineare Optimierung;
- Florian Jarre, Josef Stoer: Optimierung;

Further references will possibly be announced by the respective lecturers.

Prerequisites for attending	**Recommended prerequisites**
none	Participation in the Bachelor’s module “Nonlinear Optimisation” is recommended.
Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector, assigned written or computer-based exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually study-related course work is also required.

The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Numerical Mathematics.	Prof. Dr. Andrea Walther

Module name **Special Chapters of Scientific Computing**			Workload **270 h**	Credits **9 Credits**
Classification	**Degree programme** Master in Mathematics Master in Technomathematics	**Curriculum** elective	**Area** Numerical Mathematics	

Courses/hours per week (hpw)/group size	**Semester**	**Workload**	
		Teaching hours	Independent study
Lecture course/4 hpw/20 students + tutorial/2 hpw/20 students	1./2./3. semester	60+30 h	180 h

Desired learning outcomes

The students have developed a profound understanding for central problems of scientific computing in the covered areas, such as efficiency, parallelisation, problem-oriented modelling of algorithms, their convergence behaviour and error-proneness.

Course content

Exemplary: Modelling and numerics of problems in mathematical finance, fluid mechanics, hyperbolic conservation laws, error estimators, adaptive methods.

References (examples only)

Literature will be announced by the respective lecturer of the course.

Prerequisites for attending	**Recommended prerequisites**
None	Modules of Numerics and Scientific Computing.

Language of instruction	**Teaching materials and teaching method**
German / English (where required)	Class room lecture with the aid of the black board and possibly a data projector or guided scientific reading, assigned written or computer-based exercises.

Awarding of credits, mode of assessment, course work and und final examination

Passing of a final examination, which is usually an oral examination; usually some accompanying assigned course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.

Lecturers	**Academic in charge**
The lecturers in the area Numerical Mathematics.	Prof. Dr. Michael Dellnitz

<table>
<tr><td colspan="3">Module name
Selected Chapters of Scientific Computing</td><td>Workload
150 h</td><td>Credits
5 Credits</td></tr>
<tr><td>Classification</td><td>Degree programme
Master in Mathematics
Master in Technomathematics</td><td>Curriculum
elective</td><td colspan="2">Area
Numerical Mathematics</td></tr>
<tr><td colspan="2" rowspan="2">Courses/hours per week (hpw)/group size</td><td rowspan="2">Semester</td><td colspan="2">Workload</td></tr>
<tr><td>Teaching hours</td><td>Independent study</td></tr>
<tr><td colspan="2">Lecture course/2 hpw/20 students
+ tutorial/1 hpw/20 students</td><td>1./2./3.
semester</td><td>30+15 h</td><td>105 h</td></tr>
<tr><td colspan="5">Desired learning outcomes
The students have obtained a deeper understanding of advanced problems in Scientific Computing, such as efficiency, parallelisation, problem-oriented modelling of algorithms, their convergence behaviour and error-proneness. Furthermore, the students will be familiar with the implementation of algorithms taking into account the problems mentioned above.</td></tr>
<tr><td colspan="5">Course content
Exemplary: modelling and numerical analysis of problems of financial mathematics, fluid mechanics, hyperbolic conservation equations, error estimators, adaptive methods.</td></tr>
<tr><td colspan="5">References (examples only)
Will be announced by the respective lecturer.</td></tr>
<tr><td colspan="2">Prerequisites for attending
none</td><td colspan="3">Recommended prerequisites
Modules of Numerics.</td></tr>
<tr><td colspan="2">Language of instruction
German / English (where required)</td><td colspan="3">Teaching materials and teaching method
Class room lecture with the aid of the black board and possibly a data projector or guided scientific reading, assigned written or computer-based course work.</td></tr>
<tr><td colspan="5">Awarding of credits, mode of assessment, course work and und final examination
Passing of a final examination, usually in the form of an oral examination; usually study-related course work is also required.
The respective lecturer will announce the mode of assessment and the course work component at the beginning of the lecture course.</td></tr>
<tr><td colspan="2">Lecturers
The lecturers in the area Numerical Mathematics.</td><td colspan="3">Academic in charge
Prof. Dr. Andrea Walther</td></tr>
</table>

<table>
<tr><td colspan="3">Module name
Seminar</td><td>Workload
180 h</td><td>Credits
6 Credits</td></tr>
<tr><td>**Classification**</td><td>**Degree programme**
Master in Mathematics
Master in Technomathematics</td><td>**Curriculum**
compulsory</td><td colspan="2">**Area**
Depends on the specification of the Seminar</td></tr>
<tr><td colspan="2" rowspan="2">**Courses/hours per week (hpw)/group size**

Seminar/2 hpw/20 students</td><td rowspan="2">**Semester**

1./2./3. semester</td><td colspan="2">**Workload**</td></tr>
<tr><td>Teaching hours
30 h</td><td>Independent study
150 h</td></tr>
<tr><td colspan="5">**Desired learning outcomes**
The students are able to independently study and present mathematical results from recent research. They are able to search, find and process information in the relevant mathematical literature.
Based on joint work on topics in small groups, the students have acquired some experience in team work. They can communicate mathematical content.</td></tr>
<tr><td colspan="5">**Course content**
Will be specified in the Seminar announcement by the respective lecturer.</td></tr>
<tr><td colspan="5">**References (examples only)**
Will be announced by the respective lecturer.</td></tr>
<tr><td colspan="2">**Prerequisites for attending**
none</td><td colspan="3">**Recommended prerequisites**
Will be announced by the responsible lecturer.</td></tr>
<tr><td colspan="2">**Language of instruction**
German / English (where required)</td><td colspan="3">**Teaching materials and teaching method**
Students work with literature and give a presentation with the aid of a black board or possibly a data projector.</td></tr>
<tr><td colspan="5">**Awarding of credits, mode of assessment, course work and und final examination**
The credit points will be awarded after a successful presentation and possibly a written report of the talk. The requirements will be announced by the respective lecturer at the beginning of the course.</td></tr>
<tr><td colspan="2">**Lecturers**
Faculty in Mathematics.</td><td colspan="3">**Academic in charge**
Prof. Dr. Helge Glöckner</td></tr>
</table>

<table>
<tr><td colspan="3">Module name
Project Seminar</td><td>Workload
180 h</td><td>Credits
6 Credits</td></tr>
<tr><td>Classification</td><td>Degree programme
Master in Mathematics
Master in Technomathematics</td><td>Curriculum
elective</td><td colspan="2">Area
Numerical Mathematics</td></tr>
<tr><td colspan="2" rowspan="2">Courses/hours per week (hpw)/group size

Seminar/2 hpw/20 students
+ tutorial/2 hpw/20 students</td><td rowspan="2">Semester

2./3. Semester</td><td colspan="2">Workload</td></tr>
<tr><td>Teaching hours
30+30 h</td><td>Independent study
120 h</td></tr>
<tr><td colspan="5">Desired Learning outcomes
The students have a deep understanding of algorithmic methods in mathematics. They have acquired the ability to present complex (mathematical-)technical content. They possess the key qualifications conveyed by promoting the “competence in presenting and communicating contents” and possibly “teamwork”.</td></tr>
<tr><td colspan="5">Course content
Development and practical application of algorithms for the solution of given problem statements, including programming and professional presentation at the end of the Project Seminar.</td></tr>
<tr><td colspan="5">References (examples only)
Will be announced by the respective lecturer.</td></tr>
<tr><td colspan="2">Prerequisites for attending
None</td><td colspan="3">Recommended prerequisites
Successful participation in at least one module from the corresponding area.</td></tr>
<tr><td colspan="2">Language of instruction
German / English (where required)</td><td colspan="3">Teaching materials and teaching method
Working on praxis-related projects with a final presentation.</td></tr>
<tr><td colspan="5">Awarding of credits, mode of assessment, course work and und final examination
The credits are awarded on the basis of an oral presentation and a written report on the results of the project work. Thereby, the solution of the given problem with the help of self-written computer programs is expected. The respective lecturer will announce the requirements at the beginning of the course.</td></tr>
<tr><td colspan="2">Lecturers
The lecturers in the area Numerical Mathematics.</td><td colspan="3">Academic in charge
Prof. Dr. Michael Dellnitz</td></tr>
</table>

<table>
<tr><td colspan="3">Module name
„Studium Generale“ (General Studies)</td><td>Workload
180-360 h</td><td>Credits
6-12 Credits</td></tr>
<tr><td>**Classification**</td><td>**Degree programme**
Master in Mathematics
Master in Technomathematics</td><td>**Curriculum**
compulsory</td><td colspan="2">**Area**
arbitrary (outside Mathematics)</td></tr>
<tr><td colspan="2" rowspan="2">**Courses/hours per week (hpw)/group size**</td><td rowspan="2">**Semester**</td><td colspan="2">**Workload**</td></tr>
<tr><td>Teaching hours</td><td>Independent study</td></tr>
<tr><td colspan="5">**Desired learning outcomes**
The students expand their scientific horizon beyond Mathematics.
Depending on the chosen courses of study, they have acquired competencies in the areas of communication skills, team work and scientific presentation techniques.</td></tr>
<tr><td colspan="5">**Course content**
Will be announced by the lecturer in charge.</td></tr>
<tr><td colspan="5">**References (examples only)**
Will be announced by the respective lecturer.</td></tr>
<tr><td colspan="2">**Prerequisites for attending**
none</td><td colspan="3">**Recommended prerequisites**
Will be announced by the respective lecturer.</td></tr>
<tr><td colspan="2">**Language of instruction**
Will be announced by the respective lecturer.</td><td colspan="3">**Teaching materials and teaching method**
Will be announced by the respective lecturer.</td></tr>
<tr><td colspan="5">**Awarding of credits, mode of assessment, course work and und final examination**
Will be announced by the respective lecturer.</td></tr>
<tr><td colspan="2">**Lecturers**
Faculty of the University of Paderborn.</td><td colspan="3">**Academic in charge**
Prof. Dr. Helge Glöckner.</td></tr>
</table>

Issued based on the decision of the Faculty Council of the Faculty of Computer Science, Electrical Engineering and Mathematics on 22 April 2013 and based on the verification of lawfulness by the Steering Committee on 22 May 2013.

Paderborn, 31 May 2013

President

of the University of Paderborn

Professor Dr. Nikolaus Risch

Appendix 1: Objectives and Learning Outcomes of the Master's Degree Programme in Mathematics

The course of studies in the Master's degree programme in Mathematics gives the students the required mathematical knowledge, skills, expertise and methods, while taking into account the requirements and changes in the professional world, such that the students are enabled to do independent scientific work, to apply mathematical methods in research and praxis and to develop these further, to critically classify scientific findings and to act with responsibility.

The examination for the Master's degree forms the second (and postgraduate) degree in tertiary education in the subject Mathematics, and this degree qualifies for the primary labour market. The examination for the Master's degree assesses that the students

- have expanded their mathematical knowledge from the Bachelor's degree programme and have deepened this mathematical knowledge in selected areas.
- are able to independently apply mathematical methods and scientific findings and to advance these in an area of specialisation.

Learning Outcomes	**Possible Curricular Contents**
The graduates in the Master's degree programme in Mathematics …	
• are able to work independently using Mathematics at the university, in the education sector, in the economy and in administration.	In tutorials and seminars the students learn and train to communicate and convey their ideas and knowledge, as well as to independently work on problems as a team. In the Master's thesis the self-reliance is trained, in particular, by working with research literature and doing one's own independent scientific investigation.
• possess deepened and cross-linked mathematical knowledge and are aware of the state of the current research in selected areas.	In the Master's modules in Mathematics the existing knowledge is deepened. The modules for specialising in one area prepare for the Master's thesis and introduce the student to the state of the current research.
• are able to familiarise themselves with new mathematical areas and, where appropriate, to actively contribute to developments in these areas.	The ability to do an independent literature study, which has already been obtained in the Bachelor's degree programme, is further developed in seminars. In the Master's thesis, which takes up a quarter of the Master's degree programme, this ability is advanced to include the study of research literature. This enhances the capacity to familiarise oneself with new mathematical areas up to the state of the current research.
• have the ability to independently find their own solutions to problems, based on studying current research literature.	This is trained while writing the Master's thesis.
• have intensively and actively studied mathematical theorems and proofs.	In all lecture courses in Mathematics, the contents are always connected via proofs and logical arguments to previous knowledge. The active participation in these lecture courses (by reading up on the lecture contents and particularly by working on the related problems in the homework) provides these competencies.
• given a very good Master's degree result, are able to write a subsequent innovative scientific thesis with the aim to obtain a doctoral degree.	While writing the Master's thesis, students can work on problems that are directly connected to current developments in the research literature. Therefore, a higher-than-the-average Master's degree result can provide a direct entrance to starting the doctoral studies.

Appendix 2: Objectives and Learning Outcomes of the Master's Degree Programme in Technomathematics

The course of studies in the Master's degree programme in Technomathematics gives the students the required mathematical and engineering-specific knowledge, skills, expertise and methods, while taking into account the requirements and changes in the professional world and in the context of engineering, such that the students are enabled to do independent scientific work, to apply mathematical methods in research and technical professions and to develop these further, to critically classify scientific findings and to act with responsibility.

The examination for the Master's degree forms the second (and postgraduate) degree in tertiary education in the subject Technomathematics, and this degree qualifies for the primary labour market. The examination for the Master's degree assesses that the students

- have expanded their mathematical knowledge and the skills and expertise in the specialised subject, obtained in the Bachelor's degree programme, and have deepened these in selected areas.
- are able to independently apply mathematical methods, methods from the specialised subject and scientific findings and to advance these in an area of specialisation.

Learning Outcomes	**Possible Curricular Contents**
The graduates in the Master's degree programme in Technomathematics …	
• are able to work independently using Mathematics at the university, in the education sector, in the economy and in administration.	In tutorials and seminars the students learn and train to communicate and convey their ideas and knowledge, as well as to independently work on problems as a team. In the Master's thesis the self-reliance is trained, in particular, by working with research literature and doing one's own independent scientific investigation.
• have profound knowledge in an engineering discipline and in several mathematical areas that are relevant for technical applications.	By attending individually selected modules in the specialised subject and in Mathematics, the existing knowledge is advanced.
• are aware of the state of the current research in selected areas from Applied Mathematics and the technical application area.	In the Master's modules in Mathematics the existing knowledge is deepened. The modules for specialising in one area prepare for the Master's thesis and introduce the student to the state of the current research.
• are able to familiarise themselves with new areas and problems in Mathematics and the technical application area and, where appropriate, to actively contribute to developments in these areas.	The ability to do an independent literature study, which has already been obtained in the Bachelor's degree programme, is further developed in seminars and project seminars in Mathematics and in Engineering. In the Master's thesis, which takes up a quarter of the Master's degree programme and which can also be written in the specialised subjects if it interlinks with mathematical topics, this ability is advanced to include the study of research literature. This enhances the capacity to familiarise oneself with new mathematical and technical areas up to the state of the current research.
• have the ability to independently find their own solutions to problems, based on studying current research literature, and are able to conduct their own research and development in mathematical projects that are related to application problems.	This skill is trained during the project seminar and while writing the Master's thesis.
• have intensively and actively studied mathematical methods and algorithms.	In all lecture courses in the area of Applied Mathematics, particularly in Numerical Mathematics, methods and algorithms are taught and are connected to previous knowledge. The active participation in these lecture courses (by reading up on the lecture contents and particularly by working on the related problems in the

	homework) provides these competencies.
• given a very good Master’s degree result, are able to write a subsequent innovative scientific thesis with the aim to obtain a doctoral degree.	While writing the Master’s thesis, students can work on problems that are directly connected to current developments in the research literature. Therefore, a higher-than-the-average Master’s degree result can provide a direct entrance to starting the doctoral stud-ies.