Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG

# Module Catalogue

for the Module studies (Master)

# Mathematics

Examination regulations version: 2019
Responsible: Faculty of Mathematics and Computer Science
Responsible: Institute of Mathematics

# Contents

# The subject is divided into

# Abbreviations used

Course types: **E** = field trip, **K** = colloquium, **O** = conversatorium, **P** = placement/lab course, **R** = project, **S** = seminar, **T** = tutorial, **Ü** = exercise, **V** = lecture

Term: **SS** = summer semester, **WS** = winter semester

Methods of grading: **NUM** = numerical grade, **B/NB** = (not) successfully completed

Regulations: **(L)ASPO** = general academic and examination regulations (for teaching-degree programmes), **FSB** = subject-specific provisions, **SFB** = list of modules

Other: **A** = thesis, **LV** = course(s), **PL** = assessment(s), **TN** = participants, **VL** = prerequisite(s)

# Conventions

Unless otherwise stated, courses and assessments will be held in German, assessments will be offered every semester and modules are not creditable for bonus.

# Notes

Should there be the option to choose between several methods of assessment, the lecturer will agree with the module coordinator on the method of assessment to be used in the current semester by two weeks after the start of the course at the latest and will communicate this in the customary manner.

Should the module comprise more than one graded assessment, all assessments will be equally weighted, unless otherwise stated below.

Should the assessment comprise several individual assessments, successful completion of the module will require successful completion of all individual assessments.

# In accordance with

the general regulations governing the degree subject described in this module catalogue:

associated official publications (FSB (subject-specific provisions)/SFB (list of modules)):

**15-May-2019 (2019-36)**

**27-Jun-2019 (2019-41)**

**14-Nov-2019 (2019-52)**

**22-Jan-2020 (2020-13)**

**06-May-2020 (2020-39)**

**22-Jul-2020 (2020-57)**

**17-Dec-2020 (2020-110)**

**10-Mar-2021 (2021-17)**

**09-Jun-2021 (2021-58)**

**22-Dec-2021 (2021-85)**

**05-Jul-2022 (2022-52)**

**31-Jan-2023 (2022-86)**

**15-Jun-2023 (2023-58)**

**13-Dec-2023 (2023-107)**

**07-Aug-2024 (2024-82)**

**22-Jan-2025 (2025-1)**

**09-Jul-2025 (2025-75)**

This module handbook seeks to render, as accurately as possible, the data that is of statutory relevance according to the examination regulations of the degree subject. However, only the FSB (subject-specific provisions) and SFB (list of modules) in their officially published versions shall be legally binding. In the case of doubt, the provisions on, in particular, module assessments specified in the FSB/SFB shall prevail.

## Winter Term 2019

(0 ECTS credits)

| Module title | | | Abbreviation |
|---|---|---|---|
| **Research in Groups - Deformation Quantization** | | | 10-M=GDFQ-161-m01 |
| **Module coordinator** | | **Module offered by** | |
| Dean of Studies Mathematik (Mathematics) | | Institute of Mathematics | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 10 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

Selected modern topics in deformation quantization.

Recommended previous knowledge:
Knowledge of the contents of the modules "Differential Geometry" and "Geometric Mechanics" is recommended.

**Intended learning outcomes**

The student gains insight into contemporary research problems in Deformation Quantization. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

talk (60 to 120 minutes)
Language of assessment: German or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester

**Allocation of places**

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**Additional information**

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**Workload**

300 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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| Module title | | | Abbreviation |
|---|---|---|---|
| **Seminar in Non-linear Analysis** | | | 10-M=SNLA-161-m01 |
| **Module coordinator** | | **Module offered by** | |
| Dean of Studies Mathematik (Mathematics) | | Institute of Mathematics | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 5 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

A modern topic in non-linear analysis.

Recommended previous knowledge:
Depending on the content, basic and advanced knowledge from different areas of analysis is required. In case of doubt, it is recommended to consult the lecturer.

**Intended learning outcomes**

The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

talk (60 to 120 minutes)
Language of assessment: German or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester

**Allocation of places**

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**Additional information**

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**Workload**

150 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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## Summer Term 2021

(0 ECTS credits)

| Module title | | | Abbreviation |
|---|---|---|---|
| **Algorithmic Number Theory** | | | 10-M=VAZT-192-m01 |
| **Module coordinator** | | **Module offered by** | |
| Dean of Studies Mathematik (Mathematics) | | Institute of Mathematics | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 10 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

Binary numbers, computation of the greatest common divisor, pseudoprime tests, computation of primitive roots. Primality tests for Fermat and Mersenne numbers, factorisation methods (Pollard-Rho, (p-1)-method, elliptic curve method, quadratic sieve method), discrete logarithm.

Recommended previous knowledge:
Basic knowledge of algebra and number theory is assumed, such as can be acquired in the modules "Introduction to Algebra", „Introduction to Number Theory“ and "Applied Algebra".

**Intended learning outcomes**

The student knows about the theoretical foundations and the possible applications of several methods in algorithmic number theory.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or
b) oral examination of one candidate each (approx. 20 minutes) or
c) oral examination in groups (groups of 2, 15 minutes per candidate)
Language of assessment: German or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester
creditable for bonus

**Allocation of places**

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**Additional information**

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**Workload**

300 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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## Winter Term 2021

(0 ECTS credits)

| Module title | | | Abbreviation |
|---|---|---|---|
| **Algorithmic Number Theory** | | | 10-M=VAZT-192-m01 |
| **Module coordinator** | | **Module offered by** | |
| Dean of Studies Mathematik (Mathematics) | | Institute of Mathematics | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 10 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

Binary numbers, computation of the greatest common divisor, pseudoprime tests, computation of primitive roots. Primality tests for Fermat and Mersenne numbers, factorisation methods (Pollard-Rho, (p-1)-method, elliptic curve method, quadratic sieve method), discrete logarithm.

Recommended previous knowledge:
Basic knowledge of algebra and number theory is assumed, such as can be acquired in the modules "Introduction to Algebra", „Introduction to Number Theory“ and "Applied Algebra".

**Intended learning outcomes**

The student knows about the theoretical foundations and the possible applications of several methods in algorithmic number theory.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or
b) oral examination of one candidate each (approx. 20 minutes) or
c) oral examination in groups (groups of 2, 15 minutes per candidate)
Language of assessment: German or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester
creditable for bonus

**Allocation of places**

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**Additional information**

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**Workload**

300 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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| Module title | | | Abbreviation |
|---|---|---|---|
| **Applied Analysis** | | | 10-M=AAAN-161-m01 |
| **Module coordinator** | | **Module offered by** | |
| Dean of Studies Mathematik (Mathematics) | | Institute of Mathematics | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 10 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

In-depth study of functional analysis and operator theory, Sobolev spaces and partial differential equations, theory of Hilbert spaces and Fourier analysis, spectral theory and quantum mechanics, numerical methods (in particular FEM methods), principles of functional analysis, function spaces, embedding theorems, compactness, theory of elliptic, parabolic and hyperbolic partial differential equations with methods from functional analysis.

Recommended previous knowledge:
Familiarity with the contents of the module "Functional Analysis" is strongly recommended.

**Intended learning outcomes**

The student is acquainted with the fundamental notions, methods and results of higher analysis. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and questions in physics and other natural and engineering sciences.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or
b) oral examination of one candidate each (approx. 20 minutes) or
c) oral examination in groups (groups of 2, 15 minutes per candidate)
Language of assessment: German or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester
creditable for bonus

**Allocation of places**

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**Additional information**

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**Workload**

300 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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| Module title | | | Abbreviation |
|---|---|---|---|
| **Research in Groups - Algebra** | | | 10-M=GALG-161-m01 |
| **Module coordinator** | | **Module offered by** | |
| Dean of Studies Mathematik (Mathematics) | | Institute of Mathematics | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 10 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

Selected modern topics in algebra (e. g. ring theory, commutative algebra, differential algebra, local fields, computer algebra, algebras, division rings, quadratic forms).

Recommended previous knowledge:
Basic knowledge of algebra is assumed, such as can be acquired in the modules "Introduction to Algebra" and "Applied Algebra".

**Intended learning outcomes**

The student gains insight into contemporary research problems in algebra. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

talk (60 to 120 minutes)
Language of assessment: German or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester

**Allocation of places**

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**Additional information**

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**Workload**

300 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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| Module title | | | Abbreviation |
|---|---|---|---|
| **Research in Groups - Deformation Quantization** | | | 10-M=GDFQ-161-m01 |
| **Module coordinator** | | **Module offered by** | |
| Dean of Studies Mathematik (Mathematics) | | Institute of Mathematics | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 10 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

Selected modern topics in deformation quantization.

Recommended previous knowledge:
Knowledge of the contents of the modules "Differential Geometry" and "Geometric Mechanics" is recommended.

**Intended learning outcomes**

The student gains insight into contemporary research problems in Deformation Quantization. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

talk (60 to 120 minutes)
Language of assessment: German or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester

**Allocation of places**

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**Additional information**

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**Workload**

300 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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| Module title | | | Abbreviation |
|---|---|---|---|
| **Research in Groups - Differential Geometry** | | | 10-M=GDGE-161-m01 |
| **Module coordinator** | | **Module offered by** | |
| Dean of Studies Mathematik (Mathematics) | | Institute of Mathematics | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 10 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

Selected modern topics in differential geometry.

Recommended previous knowledge:
Advanced knowledge of differential geometry is required, such as can be acquired in the module "Differential Geometry". Knowledge of the contents of the modules "Applied Differential Geometry", "Geometric Mechanics", "Pseudo-Riemannian and Riemannian Geometry" and "Lie Theory" is also recommended.

**Intended learning outcomes**

The student gains insight into contemporary research problems in Differential Geometry. He/She masters advanced techniques in this field and can apply them to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (2) + S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

talk (60 to 120 minutes)
Language of assessment: German or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester

**Allocation of places**

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**Additional information**

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**Workload**

300 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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| Module title | | | Abbreviation |
|---|---|---|---|
| **Selected Topics in Analysis** | | | 10-M=VANA-161-m01 |
| **Module coordinator** | | **Module offered by** | |
| Dean of Studies Mathematik (Mathematics) | | Institute of Mathematics | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 10 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

In-depth discussion of a specialised topic in analysis taking into account recent developments and interrelations with other mathematical concepts.

Recommended previous knowledge:
Depending on the content, basic and advanced knowledge from different areas of analysis is required. In case of doubt, it is recommended to consult the lecturer.

**Intended learning outcomes**

The student is acquainted with advanced results in a selected topic in analysis, and is able to apply these to complex problems.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or
b) oral examination of one candidate each (approx. 20 minutes) or
c) oral examination in groups (groups of 2, 15 minutes per candidate)
Language of assessment: German or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester creditable for bonus

**Allocation of places**

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**Additional information**

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**Workload**

300 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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| Module title | | | Abbreviation |
|---|---|---|---|
| **Geometric Complex Analysis** | | | 10-M=VGFT-192-m01 |
| **Module coordinator** | | **Module offered by** | |
| Dean of Studies Mathematik (Mathematics) | | Institute of Mathematics | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 10 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

Advanced methods and results in geometric complex analysis (e.g. conformal maps, conformal Riemannian metrics, quasiconformal maps, harmonic functions, biholomorphic maps).

Recommended previous knowledge:
Basic knowledge of the contents of the module "Introduction to Complex Analysis" is recommended.

**Intended learning outcomes**

The student is acquainted with fundamental concepts, methods and results in geometric complex analysis, is able classify these results within more general theories and knows about the connections of geometric complex analysis with other fields of mathematics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or
b) oral examination of one candidate each (approx. 20 minutes) or
c) oral examination in groups (groups of 2, 15 minutes per candidate)
Language of assessment: German or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester creditable for bonus

**Allocation of places**

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**Additional information**

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**Workload**

300 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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| Module title | | | Abbreviation |
|---|---|---|---|
| **Partial Differential Equations of Mathematical Physics** | | | 10-M=VPDP-161-m01 |
| **Module coordinator** | | **Module offered by** | |
| Dean of Studies Mathematik (Mathematics) | | Institute of Mathematics | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 10 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

Elliptic, parabolic, and hyperbolic equations; Laplace equation, heat equation and wave equation as standard examples; initial and boundary value problems; well-posed and ill-posed problems; solution methods; extensions and generalisations; Hilbert space methods; Sobolev spaces and Fourier transforms.

Recommended previous knowledge:
Basic knowledge from the modules "Ordinary Differential Equations" and "Introduction to Partial Differential Equations" is recommended, as well as basic knowledge of functional analysis.

**Intended learning outcomes**

The student is acquainted with fundamental concepts and solution methods in the theory of partial differential equations, as well as standard examples from mathematical physics. He/She is able to establish a connection between his/her acquired skills and other branches of mathematics and questions in physics.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + Ü (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

a) written examination (approx. 90 to 120 minutes, usually chosen) or
b) oral examination of one candidate each (approx. 20 minutes) or
c) oral examination in groups (groups of 2, 15 minutes per candidate)
Language of assessment: German or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester
creditable for bonus

**Allocation of places**

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**Additional information**

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**Workload**

300 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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| Module title | | | Abbreviation |
|---|---|---|---|
| **Seminar Mathematics in the Sciences** | | | 10-M=SMSC-161-m01 |
| **Module coordinator** | | **Module offered by** | |
| Dean of Studies Mathematik (Mathematics) | | Institute of Mathematics | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 5 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

A modern topic in mathematics in the sciences.

Recommended previous knowledge:
Basic knowledge from the modules "Ordinary Differential Equations" and "Introduction to Partial Differential Equations" is recommended, as well as basic knowledge of functional analysis.

**Intended learning outcomes**

The student is able to elaborate a contemporary research topic. This includes comprehending and structuring of the topic and the available literature, preparing a talk and the ability to participate in a scientific discussion.

**Courses** (type, number of weekly contact hours, language — if other than German)

S (2)
Module taught in: German and/or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

talk (60 to 120 minutes)
Language of assessment: German or English
Assessment offered: In the semester in which the course is offered and in the subsequent semester

**Allocation of places**

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**Additional information**

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**Workload**

150 h

**Teaching cycle**

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**Referred to in LPO I** (examination regulations for teaching-degree programmes)

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