Module title			Abbreviation
Advanced Computational Mathematics			10-M-VTC-122-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)**	
20	numerical grade	--	
Duration	**Module level**	**Other prerequisites**	
2 semester	undergraduate	By way of exception, additional prerequisites are listed in the section on assessments.	

Contents

Two of the following topics in pure or applied mathematics:
Stochastics 1 (Combinatorics, Laplace models, selected discrete distributions, elementary measure and integration theory, continuous distributions: normal distribution, random variable, distribution function, product measures and stochastic independence, elementary conditional probability, characteristics of distributions: expected value and variance, limit theorems: law of large numbers, central limit theorem)
Stochastics 2 (Elements of data analysis, statistics of data in normal and other distributions, elements of multivariate statistics)
Introduction to Algebra (Fundamental algebraic structures: groups, rings, fields; Galois theory)
Introduction to Differential Geometry (Curves in Euclidean spaces, curvature, Frenet equations, local classification, submanifolds in Euclidean spaces, hypersurfaces in particular, curvature of hypersurfaces, geodesics, isometries, main theorem on local surface theory, special classes of surfaces)
Ordinary Differential Equations (Existence and uniqueness theorem; continuous dependence of solutions on initial values, systems of linear differential equations, matrix exponential series, linear differential equations of higher order)
Introduction to Complex Analysis (Complex differentiability and Cauchy-Riemann differential equations, path integrals and Cauchy integral theorems, isolated singularities, meromorphic functions and Laurent series, residue theorem and applications, Weierstraß product theorem and theorem of Mittag-Leffler, conformal maps)
Geometric Analysis (Fundamentals in analysis on manifolds, submanifolds, calculus of differential forms, Stoke's theorem and applications in vector analysis and topology)
Introduction to Projective Geometry (Projective and affine planes, projective and affine spaces, theorem of Desargues, fundamental theorems for projective spaces, dualities and polarities of projective spaces)
Introduction to Discrete Mathematics (Techniques from combinatorics, introduction to graph theory including applications, cryptographic methods, error-correcting codes)
Introduction to Functional Analysis (Banach spaces and Hilbert spaces, bounded operators, principles of functional analysis)
Operations Research (Linear programming, duality theory, transport problems, integral linear programming, graph theoretic problems)
Introduction to Number Theory (Elementary properties of divisibility, prime numbers and prime number factorisation, modular arithmetics, prime tests and methods for factorisation, structure of the residue class rings, theory of quadratic remainder, quadratic forms, diophantine approximation and diophantine equations).

Intended learning outcomes

The student is acquainted with advanced concepts and methods of pure and/or applied mathematics. Based on these fundamental mathematical concepts and methods he/she is able to persue further studies and interrelate these concepts, and realises the advantages of thinking across the borders of different branches in mathematics.

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

This module has 6 components; information on courses listed separately for each component.

- 10-M-STO-1-122, 10-M-DGL-1-122, 10-M-FTH-1-122, 10-M-GAN-1-122, and 10-M-FAN-1-122: V + Ü (no information on language and number of weekly contact hours available)
- 10-M-VTC-P-122: M (no information on language and number of weekly contact hours available)

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

This module has the following 6 assessment components. To pass this module, students must pass two out of the 5 assessment components that are first in the list below and the assessment component that is last in the list below.

Assessment in module component 10-M-STO-1-122: Stochastik 1 (Stochastics 1), **in module component 10-M-DGL-1-122:** Gewöhnliche Differentialgleichungen (Ordinary Differential Equations), **in module component 10-M-FTH-1-122:** Einführung in die Funktionentheorie (Introduction to Complex Analysis), **in module component 10-M-GAN-1-122:** Geometrische Analysis (Geometric Analysis), and **in module component 10-M-FAN-1-122:** Einführung in die Funktionalanalysis (Introduction to Functional Analysis) **:**

- 8 ECTS credits, pass / fail
- written examination (approx. 90 to 180 minutes). If announced by the lecturer, the written examination may be replaced by an oral examination of one candidate each (approx. 20 minutes) or an oral examination in groups of 2 candidates (approx. 30 minutes). The module component will also be considered successfully completed if it is selected as subject of the oral examination covering several modules (separate module component for assessment purposes (Prüfungsteilmodul)) and this examination is passed.
- Language of assessment: German; English if agreed upon with examiner(s)
- Additional prerequisites: To qualify for admission to assessment, students must meet certain prerequisites. The lecturer will inform students about the respective details at the beginning of the course. Registration for the course will be considered a declaration of will to seek admission to assessment. If students have obtained the qualification for admission to assessment over the course of the semester, the lecturer will put their registration for assessment into effect. Students who meet all prerequisites will be admitted to assessment in the current or in the subsequent semester. For assessment at a later date, students will have to obtain the qualification for admission to assessment anew.

Assessment in module component 10-M-VTC-P-122: Prüfung in Vertiefung Computational Mathematics (Assessment in Advanced Computational Mathematics)

- 4 ECTS credits, numerical grading
- oral examination of one candidate each (approx. 30 minutes). Assessment will have reference to the topics covered in the two module components selected by students.
- Language of assessment: German; English if agreed upon with examiner(s)
- Only after successful completion of module components: Module component 10-M-VTC-P can only be taken by students who passed the written examination in one of the other five module components.

Allocation of places

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Additional information

Additional information on module duration: 1 to 2 semesters.

Workload

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Teaching cycle

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

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Module appears in

Bachelor's degree (1 major) Computational Mathematics (2012)
Bachelor's degree (1 major) Computational Mathematics (2013)