Modulhandbuch
für den
Masterstudiengang
Mathematics for Data and Resource Sciences

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Abkürzungen

KA: schriftliche Klausur / written exam
MP: mündliche Prüfung / oral examination
AP: alternative Prüfungsleistung / alternative examination
PVL: Prüfungsvorleistung / prerequisite
MP/KA: mündliche oder schriftliche Prüfungsleistung (abhängig von Teilnehmerzahl) / written or oral examination (dependent on number of students)

SS, SoSe: Sommersemester / sommer semester
WS, WiSe: Wintersemester / winter semester

SX: Lehrveranstaltung in Semester X des Moduls / lecture in module semester x

SWS: Semesterwochenstunden

Data:	ATPF MA. Nr. 3698 / Examination number: 30714	Version: 07.10.2019	Start Year: WiSe 2020
Module Name:	**Advanced Theory of Potential Fields**		
(English):	Advanced Theory of Potential Fields		
Responsible:	Gerhards, Christian / Prof. Dr.		
Lecturer(s):	Gerhards, Christian / Prof. Dr.		
Institute(s):	Institute of Geophysics and Geoinformatics		
Duration:	1 Semester(s)		
Competencies:	The students will be able to understand the mathematical aspects of geophysical potential fields methods as they occur, e.g., in gravimetry and geomagnetism. They will be able to apply and interpret specific approximation and inversion methods for such problems.		
Contents:	- Approximation methods on the sphere; in particular, spherical harmonics and wavelets/multiscale methods - ill-posedness of inverse geophysical potential field problems - specific examples from gravimetry and geomagnetism Depending on the audience, the lecture can also be held in German.		
Literature:	Blakely, R.J., 1995, Potential Theory in Gravity and Magnetic Applications, Cambridge University Press Freeden, W., Schreiner, M., 2009, (Spherical) Functions of Mathematical Geosciences - A Scalar, Vectorial, and Tensorial Setup, Springer Freeden, W., Gerhards, C., 2012, Geomathematically Oriented Potential Theory, Taylor & Francis Michel, V., 2013, Lectures on Constructive Approximation - Fourier, Spline, and Wavelet Methods on the Real Line, the Sphere, and the Ball, Birkhaeuser		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Theory of Potential Fields, introductory lecture on (partial) differential and integral equations		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP		
Credit Points:	4		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 120h. It is the result of 45h attendance and 75h self-studies.		

Data:	ALGRAPH. MA. Nr. 435 / Examination number: 10211	Version: 18.05.2026	Start Year: WiSe 2027
Module Name:	**Algorithmic and Structural Graph Theory**		
(English):			
Responsible:	Carmesin, Johannes / Prof.		
Lecturer(s):	Carmesin, Johannes / Prof.		
Institute(s):	Institute of Discrete Mathematics and Algebra		
Duration:	2 Semester(s)		
Competencies:	The students will study basic concepts and proof techniques of algorithmic graph theory. They should be able to analyse applied examples and to solve them with graph algorithms.		
Contents:	The first part of the module covers essential fundamentals of graph theory, including proof techniques, applications, and numerous algorithms. Key topics include minimum spanning trees, shortest paths, Eulerian tours (Chinese postman problem), Hamiltonian cycles (Traveling Salesperson Problem), random graphs, and matchings. Building on this, the second part of the module introduces the theory of tree decompositions and minors, and discusses applications for FPT (Fixed-Parameter Tractable) algorithms and embedding problems. Furthermore, we introduce matroids as a generalizing perspective on min-max theorems and examine connectivity questions.		
Literature:	Diestel, R.: Graphentheorie, Springer, 2017, 5. Auflage Volkmann, L.: Graphen und Digraphen, Springer, 1991. Clark, J.; Holton, D. A.: Graphentheorie, Spektrum, 1994. West, D.: Introduction to Graph Theory, Prentice Hall, 2001		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): (*) / Exercises (1 SWS) S2 (SS): (*) / Lectures (2 SWS) S2 (SS): (*) / Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Diskrete Strukturen 1: Logik und algebraische Strukturen, 2024-04-22 Algebra, 2021-05-10 Mathematik I für naturwissenschaftliche Studiengänge, 2021-04-21 Lineare Algebra 1, 2021-05-03		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: KA* [120 min] MP* [30 min] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA* [120 min] MP* [30 min] * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.		
Credit Points:	9		
Grade:	The Grade is generated from the examination result(s) with the following weights (w):		

	KA* [w: 1] MP* [w: 1] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
Workload:	The workload is 270h. It is the result of 90h attendance and 180h self-studies.

Data:	ALGEO. MA. Nr. 499 / Examination number: 10212	Version: 18.05.2026	Start Year: WiSe 2026
Module Name:	**Algorithmic Geometry**		
(English):			
Responsible:	Carmesin, Johannes / Prof.		
Lecturer(s):	Carmesin, Johannes / Prof.		
Institute(s):	Institute of Discrete Mathematics and Algebra		
Duration:	1 Semester(s)		
Competencies:	The students will study basic concepts and proof techniques of algorithmic geometry. They should be able to analyse applied examples and to solve them with geometric algorithms.		
Contents:	convex hulls in the plane packings and coverings 3-dimensional combinatorics knot theory Electric flows and Square Tilings colourings of the plane		
Literature:	Quaisser, E.: Diskrete Geometrie, Spektrum, 1994.		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Diskrete Strukturen 1: Logik und algebraische Strukturen, 2024-04-22 Algebra, 2021-05-10 Lineare Algebra 1, 2021-05-03		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies.		

Data:	ALTOP. MA. / Examination number: 10210	Version: 18.05.2026	Start Year: WiSe 2027
Module Name:	**Algorithmic Topology**		
(English):			
Responsible:	Carmesin, Johannes / Prof.		
Lecturer(s):	Carmesin, Johannes / Prof.		
Institute(s):	Institute of Discrete Mathematics and Algebra		
Duration:	1 Semester(s)		
Competencies:	Students will learn basic concepts and essential proof techniques of Algorithmic Topology. They should be able to analyze application-relevant examples and solve them using geometric algorithms.		
Contents:	**Methods:** • Structure theorem for 2-dimensional compact manifolds • Reidemeister moves • Fundamental groups • Homology theory **Algorithmic Problems:** • IKEA Problem • Knot Recognition • various questions from fixed parameter complexity		
Literature:	Quaisser, E.: Diskrete Geometrie, Spektrum, 1994. Hatcher: Algebraic Topology Und Armstrong: Basic Topology Und Livingston: Knotentheorie für Einsteiger		
Types of Teaching:	S1 (WS): in winter semester of odd years / Lectures (2 SWS) S1 (WS): in winter semester of odd years / Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Diskrete Strukturen 1: Logik und algebraische Strukturen, 2024-04-22 Algebra, 2021-05-10 Lineare Algebra 1, 2021-05-03		
Frequency:	every 2 years in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies.		

Data:	ALGORIT. MA. / Examination number: 10213	Version: 28.06.2024	Start Year: SoSe 2027
Module Name:	**Algorithms**		
(English):			
Responsible:	Carmesin, Johannes / Prof.		
Lecturer(s):	Carmesin, Johannes / Prof.		
Institute(s):	Institute of Discrete Mathematics and Algebra		
Duration:	1 Semester(s)		
Competencies:	Students will study concepts and basic techniques for the design of algorithms and their applications in computer science and mathematics. Moreover they will be familiarized with instances for application and their analysis. They will be capable to analyse, evaluate and design such algorithms.		
Contents:	Concepts for algorithms Design techniques for algorithms Design and analysis of algorithms for: - searching and sorting - encryption - planning and strategic action - optimization		
Literature:	Vöcking, B.: Taschenbuch der Algorithmen, Springer, 2008. Schöning, U.: Algorithmik, Spektrum, 2001.		
Types of Teaching:	S1 (SS): Lectures (2 SWS) S1 (SS): Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Diskrete Strukturen 1: Logik und algebraische Strukturen, 2024-04-22 Höhere Mathematik I für naturwissenschaftliche Studiengänge, 2014-06-01 Lineare Algebra 1, 2021-05-03 Basics in Theoretical Comnputer Science		
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP: seminar talk [30 min] KA [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP: Vortrag [30 min] KA [30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: seminar talk [w: 3] KA [w: 1]		
Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies.		

Data:	GEOMOD. MA. Nr. 121 / Examination number: 30715	Version: 27.06.2022	Start Year: WiSe 2022
Module Name:	**Applied Geomodelling**		
(English):	Applied Geomodelling		
Responsible:	Gerhards, Christian / Prof. Dr.		
Lecturer(s):	Gerhards, Christian / Prof. Dr.		
Institute(s):	Institute of Geophysics and Geoinformatics		
Duration:	1 Semester(s)		
Competencies:	The students will be made familiar with the mathematical and computer scientific aspects of 3d geomodelling and are able to use the tools in advanced geoscientific applications. They will be able to use of typical 3d geomodelling software and understand their connectional differences.		
Contents:	- principles of heterogeneous data - spatial geodata models, cellular partitions - interpolation and parametrization - case studies for the modeling of geological structures Depending on the audience, the lecture can be held in German.		
Literature:	Mallet J.-L. 2002, Geomodelling, Oxford University Press Houlding, S.W., 1994, 3D Geoscience Modeling: Computer Techniques for Geological Characterization, Springer		
Types of Teaching:	S1 (WS): Lectures (1 SWS) S1 (WS): Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Grundlagen der Geoinformationssysteme für Nebenhörer, 2023-03-24		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP: Project documentation		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP: Projektdokumentation		
Credit Points:	4		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: Project documentation [w: 1]		
Workload:	The workload is 120h. It is the result of 45h attendance and 75h self-studies.		

Data:	Examination number: 35707	Version: 09.10.2024	Start Year: SoSe 2025
Module Name:	**Applied Machine Learning for Geoscience**		
(English):			
Responsible:	Butscher, Christoph / Prof. Dr.		
Lecturer(s):	Taher Dang Koo, Reza / Dr.		
Institute(s):	Institute of Geotechnics		
Duration:	1 Semester(s)		
Competencies:	Students will be able to establish an environment for implementing, analyzing, and interpreting machine learning models in combination with geological and geotechnical data. They will gain a solid understanding of various machine learning techniques, as well as the common challenges and limitations encountered during the stages of model development, validation, and testing. Moreover, students will develop the ability to create automated workflows that streamline data preprocessing, model building, hyperparameter tuning, and the interpretation of results. The completing students will be able to apply these methods to real-world geological and geotechnical challenges.		
Contents:	Introduction to machine learning concepts and their application in geology and geotechnics. Overview of supervised and unsupervised learning techniques, including decision trees, support vector machines, and clustering methods. Fundamentals of shallow and deep neural networks, with a focus on model architecture, training processes, and hyperparameter optimization. Introduction to data preprocessing, feature engineering, and model evaluation. Hands-on exercises using Python and Jupyter notebooks to implement workflows for data preprocessing, model building, and hyperparameter tuning.		
Literature:	Andrew NG: Machine Learning Yearning, DeepLearning.AI Goodfellow et al. (2106): Deep learning. MIT press Kubat, M (2015): An introduction to machine learning, Springer		
Types of Teaching:	S1 (SS): Lectures (2 SWS) S1 (SS): Exercises (1 SWS)		
Pre-requisites:			
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: KA* [90 min] AP*: Project assignment and report * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA* [90 min] AP*: Projektarbeit mit Bericht * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): KA* [w: 1] AP*: Project assignment and report [w: 1]		

	* In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.

Data:	ANGSTAT. MA. Nr. 991 / Examination number: 11713	Version: 30.04.2026	Start Year: WiSe 2009
Module Name:	**Applied Statistics**		
(English):	Applied Statistics		
Responsible:	van den Boogaart, Gerald / Prof. Dr.		
Lecturer(s):	van den Boogaart, Gerald / Prof. Dr.		
Institute(s):	Institute of Stochastics		
Duration:	1 Semester(s)		
Competencies:	Students can collect, explore, and analyse statistical data with exploratory and confirmatory methods including statistical tests and linear models as long as standard methodology applies to this data. They understand the underlying concepts, can judge the applicability of required assumptions, and can select the appropriate methodology.		
Contents:	The lecture provides a science oriented introduction into applied statistics for Students with a background mathematics and probability theory, including • Representation and Representativity of Statistical Data, • Statistical Scale, • Statistical Graphics, selection, definition, interpretation, • Statistical tests (Parametric, Nonparameteric and Robust, for different scales and tasks) for a wide range of application situations • Application of linear Models including advanced models and methods • Statistical consulting • Outlook to methods for advanced situations (e.g. other scales like compositional data, Bayes methods, generalized linear models) The focus is on pratical application of the methodology in real world situations using statistical software, like e.g. R.		
Literature:	Eric Goh Ming Hui: Learn R for Applied Statistics: With Data Visualizations, Regressions, and Statistics, Springer, 2019. Justin C. Touchon: Applied Statistics With R: A Practical Guide for the Life Sciences and Beyond, Oxford University Press, 2025.		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Statistical Foundations of Data Science, 2026-04-27 Stochastik für Mathematiker, 2026-01-07 An understanding of probablity theory including random variables, mean, variance, distributions, probability density functions, discrete distributions such as binomial, multinomial and Poission distribution, and the concept of stochastic independence is assumed.		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	6		

Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]
Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies.

Data:	PDE1 MA. / Examination number: 10725	Version: 04.05.2021	Start Year: WiSe 2021
Module Name:	**Basics in Partial Differential Equations**		
(English):			
Responsible:	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Waurick, Marcus / Prof. Dr.		
Lecturer(s):	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Waurick, Marcus / Prof. Dr.		
Institute(s):	Institute of Applied Analysis		
Duration:	1 Semester(s)		
Competencies:	Die Studierenden lernen Denkweisen, Methoden und Algorithmen der Theorie partieller Differentialgleichungen. Students learn thought processes, methods and algorithms in the theory of partial differential equations.		
Contents:	Sobolevräume und elementare Existenz- und Eindeutigkeitsresultate, Hilbert- und/oder Banachraummethoden Sobolev spaces and elementary existence and uniqueness theory using Hilbert and/or Banach space methods		
Literature:	Evans: Partial Differential Equations Gilbarg, Trudinger: Elliptic Partial Differential Equations of Second Order Picard, McGhee: Partial Differential Equations – A Hilbert space approach		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Analysis 4 (Funktionalanalysis), 2021-05-04 Analysis 3 (Gewöhnliche Differentialgleichungen), 2021-05-04		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	4		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 120h. It is the result of 45h attendance and 75h self-studies.		

Data:	ATMOSCL. MA. Nr. 3031 / Examination number: 32012	Version: 12.10.2023	Start Year: WiSe 2010
Module Name:	**Climate Change**		
(English):	Klimawandel		
Responsible:	Jackisch, Conrad / Prof.		
Lecturer(s):	Jackisch, Conrad / Prof.		
Institute(s):	Institute of Drilling Engineering and Fluid Mining		
Duration:	1 Semester(s)		
Competencies:	Students know the components of the climate system with physical and chemical principles (energy balance, water cycle, carbon cycle) and climate models. They understand significant driving and regulating forces of climate change on different temporal and spatial scales in order to evaluate historical climate variability and projections of future developments that are subject to uncertainty. On this basis, they can identify specific challenges, design strategies to mitigate climate change and derive options for action to adapt to climate change. In the exercise, they learn how to access climate data and model projections, interpret and visualise these data and evaluate it using statistical methods and indices. They also acquire skills in dealing with uncertainties.		
Contents:	The lecture is combines general foundations of climate change and examples for specific aspects. The lecture spans the range from the earth system to current model calculations for the development of the climate. Starting from palaeoclimatic developments we work towards current trands in the Antropocene and focus on periods of change and their drivers. We will analyse non-linear interactions and feedbacks on different scales, get to know models and model products, deal with uncertainties, and we will shed light on the border areas of physical reality and socio-economic decision-making. The lecture series underpins and extends this basis with specific examples from certain regions and subject areas. In the exercise, current climate data and climate projections will be analysed. Step by step, we will load, visualise, summarise and interpret data. We will apply methods for analysing changes and extremes, as well as climatological indices. All analyses will be carried out directly on your own computer using Python.		
Literature:	IPCC Reports (https://www.ipcc.ch/) Wiegandt (Hrsg., 2023) 3 Grad mehr Rahmstorf & Schellnhuber (2019) Der Klimawandel – Diagnose, Prognose, Therapie Krauss (2021) The Physics of Climate Change		
Types of Teaching:	S1 (WS): Climate System and Climate Change / Lectures (2 SWS) S1 (WS): Climate Data Analysis / Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** The lecture attempts to balance the general applicability for all (natural science) disciplines with subject-specific depth in environmental system sciences - geoecology. For the exercise, the basic handling of data and a scripting language such as R/Python must at least be known.		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains:		

	AP: Own climate data analysis project with report (as preferrably Jupyter notebook)
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP: Projekt zur Klimadatenanalyse mit Bericht (vorzugsweise als Jupyter Notebook)
Credit Points:	5
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: Own climate data analysis project with report (as preferrably Jupyter notebook) [w: 1]
Workload:	The workload is 150h. It is the result of 60h attendance and 90h self-studies.

Data:	MPGEO MA Nr. 3699 / Examination number: 36001	Version: 08.08.2019	Start Year: SoSe 2021
Module Name:	**Continuum Multiphysics in the Geosciences**		
(English):	Continuum Multiphysics in the Geosciences		
Responsible:	Nagel, Thomas / Prof. Dr.		
Lecturer(s):	Nagel, Thomas / Prof. Dr.		
Institute(s):	Institute of Geotechnics		
Duration:	1 Semester(s)		
Competencies:	At the end of this module the student understands the continuum mechanical principles of describing coupled fluid flow, heat transport, deformation and reactive processes in porous, fractured and granular media and can apply them to a wide range of geoscientific and geotechnical topics. Students are capable of deriving simple models themselves and analyse the assumptions underlying existing formulations as well as understand their consequences.		
Contents:	This module introduces a structured approach to modelling coupled multiphysical processes in porous, fractured and granular geomaterials. Such models are the basis for modern numerical simulations of geoscientific and geotechnical applications such as geofluid flow, geothermal systems, geological disposal facilities, the design of geoinfrastructures, etc. The module emphasises differences between general physical principles and system-specific assumptions to train the geoscientist in a critical assessment of model-based analyses. The following aspects will be covered during the course. • Refresher on tensor calculus • Continuum theories for multiphase media • From global to local balance relations • Aspects of constitutive theories • Example 1: Coupled fluid flow and deformation in rocks and soils • Example 2: Non-isothermal effects in geothermal reservoirs Students should have a foundation in mathematics (linear algebra, calculus and PDEs) and physics (basic mechanics).		
Literature:	Kolumban Hutter and Klaus Jöhnk. Continuum methods of physical modeling: continuum mechanics, dimensional analysis, turbulence. Springer, 2004. Gerhard A. Holzapfel. Nonlinear Solid Mechanics: A Continuum Approach for Engineering. John Wiley & Sons Ltd., 2000. Wolfgang Ehlers and Joachim Bluhm. Porous media: theory, experiments and numerical applications. Springer Science & Business Media, 2002. Ray M. Bowen. “Continuum Physics”. In: ed. by A. Cemal Eringen. Academic Press, Inc., 1976. Chap. Part I – Theory of Mixtures, pp. 1–127. Peter Haupt. Continuum mechanics and theory of materials. Springer, 2002.		
Types of Teaching:	S1 (SS): Continuum Multiphysics in the Geosciences / Lectures (2 SWS)		
Pre-requisites:			
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP/KA (KA if 4 students or more) [MP minimum 30 min / KA 120 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP/KA (KA bei 4 und mehr Teilnehmern) [MP mindestens 30 min / KA		

	120 min]
Credit Points:	4
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP/KA [w: 1]
Workload:	The workload is 120h. It is the result of 30h attendance and 90h self-studies.

Data:	NUMAKTU. MA. Nr. 492 / Examination number: 10916	Version: 19.05.2026	Start Year: WiSe 2014
Module Name:	**Current Topics in Numerical Analysis I**		
(English):			
Responsible:	Aland, Sebastian / Prof. Dr.		
Lecturer(s):	Rheinbach, Oliver / Prof. Dr. Aland, Sebastian / Prof. Dr.		
Institute(s):	Institute of Numerical Mathematics and Optimization		
Duration:	1 Semester(s)		
Competencies:	The students will learn details on recent topics in numerical analysis and computational science and should be able to apply this knowledge for the developement and evaluation of numerical methods. (Die Studierenden lernen neue Forschungsergebnisse der numerischen Mathematik kennen. Sie sollen in der Lage sein, diese Ergebnisse zur Weiterentwicklung und Bewertung numerischer Algorithmen einzusetzen.)		
Contents:	Recent topics in numerical analysis are to be elaborated by means of lecture and self-study. Examplary topics are „High Performance Computing using Domain Decomposition“, „Modelling using Partial Differential Equations“, „Scientific Machine Learning“. (Aktuelle Forschungsgebiete der Numerik sollen durch Vorträge und Selbststudium durchdrungen werden. Beispielsweise: „Hochleistungsrechnen mit Gebietszerlegungsverfahren“, „Modellierung mit partiellen Differentialgleichungen“, „Scientific Machine Learning“)		
Literature:	Publications and monographs		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Seminar (1 SWS)		
Pre-requisites:	**Recommendations:** Numerik für Mathematiker, 2021-04-21		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: in examination variant 1: MP [30 min] or in examination variant 2: AP: Talk and discussion [60 min] The examination variant is announced in the first lecture.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: in Prüfungsvariante 1: MP [30 min] oder in Prüfungsvariante 2: AP: Vortrag und Diskussion [60 min] Die Prüfungsvariante wird in der ersten Vorlesung bekannt gegeben.		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): in examination variant 1: MP [w: 1] or		

	in examination variant 2: AP: Talk and discussion [w: 1]
Workload:	The workload is 180h. It is the result of 45h attendance and 135h self-studies.

Data:	NUMAKTU. MA. Nr. 492 / Examination number: 10919	Version: 19.05.2026	Start Year: SoSe 2009
Module Name:	**Current Topics in Numerical Analysis II**		
(English):			
Responsible:	Aland, Sebastian / Prof. Dr.		
Lecturer(s):	Rheinbach, Oliver / Prof. Dr. Aland, Sebastian / Prof. Dr.		
Institute(s):	Institute of Numerical Mathematics and Optimization		
Duration:	1 Semester(s)		
Competencies:	The students will learn details on recent topics in numerical analysis and computational science and should be able to apply this knowledge for the developement and evaluation of numerical methods. (Die Studierenden lernen neue Forschungsergebnisse der numerischen Mathematik kennen. Sie sollen in der Lage sein, diese Ergebnisse zur Weiterentwicklung und Bewertung numerischer Algorithmen einzusetzen.)		
Contents:	Recent topics in numerical analysis are to be elaborated by means of lecture and self-study. Examplary topics are „High Performance Computing using Domain Decomposition“, „Modelling using Partial Differential Equations“, „Scientific Machine Learning“. (Aktuelle Forschungsgebiete der Numerik sollen durch Vorträge und Selbststudium durchdrungen werden. Beispielsweise: „Hochleistungsrechnen mit Gebietszerlegungsverfahren“, „Modellierung mit partiellen Differentialgleichungen“, „Scientific Machine Learning“.)		
Literature:	Publications and monographs		
Types of Teaching:	S1 (SS): Lectures (2 SWS) S1 (SS): Seminar (1 SWS)		
Pre-requisites:	**Recommendations:** Numerik für Mathematiker, 2021-04-21 (The module "Current topics in Numerical Analysis II" is independent of the module "Current topics in Numerical Analysis I")		
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: in examination variant 1: MP [30 min] or in examination variant 2: AP: Talk and discussion [60 min] The examination variant is announced in the first lecture.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: in Prüfungsvariante 1: MP [30 min] oder in Prüfungsvariante 2: AP: Vortrag und Diskussion [60 min] Die Prüfungsvariante wird in der ersten Vorlesung bekannt gegeben.		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): in examination variant 1:		

	MP [w: 1] or in examination variant 2: AP: Talk and discussion [w: 1]
Workload:	The workload is 180h. It is the result of 45h attendance and 135h self-studies.

Daten:	STOAKTU. MA. / Prüfungs-Nr.: 12109	Stand: 28.04.2026	Start: WiSe 2017
Modulname:	**Current Topics in Stochastics**		
(englisch):	Current Topics in Stochastics		
Verantwortlich(e):	Starkloff, Hans-Jörg / Prof. Dr. Sprungk, Björn / Prof. Dr.		
Dozent(en):	van den Boogaart, Gerald / Prof. Dr. Starkloff, Hans-Jörg / Prof. Dr. Sprungk, Björn / Prof. Dr.		
Institut(e):	Institut für Stochastik		
Dauer:	1 Semester		
Qualifikationsziele / Kompetenzen:	Students are familiar with recent research results in stochastics. They are able to use these findings to analyze and further develop stochastic models and to engage critically with current research topics in probability theory and statistics.		
Inhalte:	Current research areas in stochastics, such as those related to uncertainty quantification, random functions and random differential equations, stochastic modeling, computational and high-dimensional statistics, statistical inverse problems, and machine learning.		
Typische Fachliteratur:	Literature recommendations will be provided by the lecturer at the begining of the semester.		
Lehrformen:	S1 (WS): In odd-numbered years. The module can also be taught in German depending on the audience. / Vorlesung (3 SWS)		
Voraussetzungen für die Teilnahme:	**Empfohlen:** Stochastik für Mathematiker, 2021-05-10		
Turnus:	alle 2 Jahre im Wintersemester		
Voraussetzungen für die Vergabe von Leistungspunkten:	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Leistungspunkte:	6		
Note:	Die Note ergibt sich entsprechend der Gewichtung (w) aus folgenden(r) Prüfungsleistung(en): MP [w: 1]		
Arbeitsaufwand:	Der Zeitaufwand beträgt 180h und setzt sich zusammen aus 45h Präsenzzeit und 135h Selbststudium.		

Data:	DAP MA / Examination number: 12305	Version: 03.07.2025	Start Year: WiSe 2025
Module Name:	**Data Analysis Project**		
(English):	Data Analysis Project		
Responsible:	Tolosana-Delgado, Raimon / PD Dr. Sprungk, Björn / Prof. Dr.		
Lecturer(s):	Tolosana-Delgado, Raimon / PD Dr.		
Institute(s):	Institute of Stochastics		
Duration:	1 Semester(s)		
Competencies:	Students are able to analyse a real dataset autonomously: (a) choose the appropriate method to answer the posed question, (b) adapt and reprogramme it to the requirements or specificities of the data, as well as (c) interprete results and present them in different formats and to different audiences. In particular, students can deal with the specific aspects of data analysis relevant to the georesources industries, such as data with uncommon scales, irregularities and error dependence structures.		
Contents:	• data acquisition techniques, error structures, censoring, outliers and robustness • accounting for statistical scales, sample space, data representation, reference probability distributions and loss functions • tools to deal with lack of independence between observations • analysis, development, interpretation and presentation of results for a complex real data set with an actual scientific question		
Literature:	• Efron, Hastie (2016) Computer Age Statistical Inference. Cambridge University Press. ISBN 9781107149892; 475 pages • Goodfellow, Bengio, Courville (2016) Deep Learning. MIT Press. ISBN 9780262337373, 775 pages • Borradaile (2013) Statistics of Earth Science Data. Springer. ISBN 9783662052235, 351 pages		
Types of Teaching:	S1 (WS): Seminar (1 SWS) S1 (WS): project (1 SWS)		
Pre-requisites:	**Recommendations:** Any statistics and data analysis lecture of previous semesters		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP: Data analysis project documentation inlcuding oral presentation		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP: Dokumentation eines Datenanalyseprojekts inkl. mündlicher Präsentation		
Credit Points:	4		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: Data analysis project documentation inlcuding oral presentation [w: 1]		
Workload:	The workload is 120h. It is the result of 30h attendance and 90h self-studies.		

Data:	PFODA. MA. / Examination number: 12307	Version: 28.04.2026	Start Year: SoSe 2028
Module Name:	**Data-driven Forecasting under Uncertainty**		
(English):	Data-driven Forecasting under Uncertainty		
Responsible:	Starkloff, Hans-Jörg / Prof. Dr. Sprungk, Björn / Prof. Dr.		
Lecturer(s):	Sprungk, Björn / Prof. Dr.		
Institute(s):	Institute of Stochastics		
Duration:	1 Semester(s)		
Competencies:	At the end of the course the students are able to to explain stochastic dynamical systems and ensemble forecasting methods for those sytems. They understand the basics of Bayesian inference and filtering and can apply critically common ensemble filtering methods for forecasting of time-discrete dynamical systems.		
Contents:	• Stochastic dynamical systems in discrete time • Ensemble-based forecasting • Bayesian approach to statistics • Data assimilation methods for time-discrete systems (e.g., ensemble Kalman filter)		
Literature:	S. Reich, C. Cotter: Probabilistic Forecasting and Bayesian Data Assimilation, Cambridge University Press, 2015. K. Law, A. Stuart, K. Zygalakis: Data Assimilation - A Mathematical Introduction, Springer, 2015. M. Asch, M. Bocquet, M. Nodet: Data Assimilation - Methods, Algorithms, and Applications, SIAM, 2016.		
Types of Teaching:	S1 (SS): in even-numbered years / Lectures (2 SWS) S1 (SS): in even-numbered years / Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Statistical Foundations of Data Science, 2026-04-27 Stochastik für Mathematiker, 2021-05-10		
Frequency:	every 2 years in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [20 to 30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [20 bis 30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies.		

Daten:	DEU A1/ 1.Sem. BA. Nr. 948 / Prüfungs-Nr.: 71101	Stand: 04.08.2017	Start: WiSe 2016
Modulname:	**Deutsch A1/ 1. Semester**		
(englisch):	German A 1/ 1st Semester		
Verantwortlich(e):	Polanski, Katja		
Dozent(en):			
Institut(e):	Internationales Universitätszentrum/ Sprachen		
Dauer:	1 Semester		
Qualifikationsziele / Kompetenzen:	Im Kurs werden Grundlagen in Phonetik, Orthographie, Grammatik und Lexik vermittelt. Die Teilnehmer erwerben Grundkenntnisse und Grundfertigkeiten im Hören, Sprechen, Lesen und Schreiben auf der Basis der Allgemeinsprache sowie landeskundliche Kenntnisse.		
Inhalte:	Kommunikation im Alltag (Menschen kennen lernen, Einkaufen, Restaurantbesuch, Tagesabläufe, Uhrzeit); Grammatik: zum Beispiel Fragestellungen, Zahlen, Konjugation der Verben, Präsenz und Präteritum, Mengenangaben, Plural der Nomen, Komposita		
Typische Fachliteratur:	Begegnungen A1+, Schubert Verlag		
Lehrformen:	S1 (WS): Übung (4 SWS)		
Voraussetzungen für die Teilnahme:	**Empfohlen:** Keine Vorkenntnisse der deutschen Sprache notwendig		
Turnus:	jährlich im Wintersemester		
Voraussetzungen für die Vergabe von Leistungspunkten:	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA [90 min] PVL: Aktive Teilnahme an mindestens 80% des Unterrichts PVL müssen vor Prüfungsantritt erfüllt sein bzw. nachgewiesen werden.		
Leistungspunkte:	4		
Note:	Die Note ergibt sich entsprechend der Gewichtung (w) aus folgenden(r) Prüfungsleistung(en): KA [w: 1]		
Arbeitsaufwand:	Der Zeitaufwand beträgt 120h und setzt sich zusammen aus 60h Präsenzzeit und 60h Selbststudium.		

Daten:	DEU A1/ 2. Sem. BA. Nr. 949 / Prüfungs-Nr.: 71102	Stand: 04.08.2017	Start: SoSe 2017
Modulname:	**Deutsch A1/ 2. Semester**		
(englisch):	German A1/ 2nd Semester		
Verantwortlich(e):	Polanski, Katja		
Dozent(en):			
Institut(e):	Internationales Universitätszentrum/ Sprachen		
Dauer:	1 Semester		
Qualifikationsziele / Kompetenzen:	Im Kurs werden Grundlagen in Phonetik, Orthographie, Grammatik und Lexik vermittelt. Die Teilnehmer erwerben Grundkenntnisse und Grundfertigkeiten im Hören, Sprechen, Lesen und Schreiben auf der Basis der Allgemeinsprache sowie landeskundliche Kenntnisse.		
Inhalte:	Orientierung in der Stadt beziehungsweise in der Firma, öffentliche Verkehrsmittel, Wegbeschreibung, Berufe und Arbeitsalltag, Körper und Gesundheit, Wohnungssuche und -einrichtung, Lebenslauf, Kleidung; Grammatik: zum Beispiel Präpositionen, Frageartikel, Modalverben, Possessivartikel, Perfekt, Konjunktionen, Demonstrativpronomen, Graduierung und Komparativ		
Typische Fachliteratur:	Begegnungen A1+, Schubert Verlag		
Lehrformen:	S1 (SS): Übung (4 SWS)		
Voraussetzungen für die Teilnahme:	**Obligatorisch:** Deutsch A1/ 1. Semester, 2015-08-26 oder äquivalente Sprachkenntnisse		
Turnus:	jährlich im Sommersemester		
Voraussetzungen für die Vergabe von Leistungspunkten:	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA [90 min] PVL: Aktive Teilnahme an mind. 80% des Unterrichts PVL müssen vor Prüfungsantritt erfüllt sein bzw. nachgewiesen werden.		
Leistungspunkte:	4		
Note:	Die Note ergibt sich entsprechend der Gewichtung (w) aus folgenden(r) Prüfungsleistung(en): KA [w: 1]		
Arbeitsaufwand:	Der Zeitaufwand beträgt 120h und setzt sich zusammen aus 60h Präsenzzeit und 60h Selbststudium. Der Zeitaufwand beträgt 120 Stunden und setzt sich zusammen aus 60 Stunden Präsenzzeit und 60 Stunden Selbststudium.		

Data:	DIFFGEO MA. / Examination number: 10727	Version: 04.05.2021	Start Year: WiSe 2022
Module Name:	**Differential Geometry**		
(English):			
Responsible:	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Semmler, Gunter / Dr. Waurick, Marcus / Prof. Dr.		
Lecturer(s):	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Semmler, Gunter / Dr. Waurick, Marcus / Prof. Dr.		
Institute(s):	Institute of Applied Analysis		
Duration:	1 Semester(s)		
Competencies:	Die Studierenden lernen Denkweisen, Methoden und Techniken der klassischen Differentialgeometrie kennen. Damit sind sie in der Lage, die erworbenen Fähigkeiten und Fertigkeiten in fortgeschrittenen Vorlesungen und bei Qualifikationsarbeiten anzuwenden. The students are acquainted with principles, methods and techniques of differential geometry. The abilities acquired in this course may serve in furthergoing lectures and student theses.		
Contents:	Dieser Kurs bietet eine Einführung in die klassische Differentialgeometrie von Kurven und Flächen im zwei- und dreidimensionalen Raum. Die Grundbegriffe werden mit Hilfe der Differentialrechnung mehrerer Variabler so entwickelt, dass der Hörer gut auf ein Verständnis des Mannigfaltigkeitsbegriffs vorbereitet wird. Zu Kursbeginn wird in Abhängigkeit von der Zuhörerschaft entschieden, ob der Kurs in Deutsch oder Englisch stattfindet. This course offers an introduction to the classical differential geometry of curves and surfaces in two and three dimensions. Building on multivariate calculus, the basic concepts are presented in a manner that prepares the participant for the concept of a differentiable manifold. At the beginning of the course, it will be decided (dependending on the audience) whether the course will be held in English or German.		
Literature:	W. Kühnel: Differentialgeomtrie, Vieweg 2008; Montiel S.: Curves and surfaces, AMS 2009		
Types of Teaching:	S1 (WS): In even-numbered years. / Lectures (2 SWS) S1 (WS): In even-numbered years. / Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Analysis 1, 2021-04-21 Analysis 2, 2021-04-21		
Frequency:	every 2 years in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.		

Daten:	EMLBD MA. / Prüfungs-Nr.: 11310	Stand: 22.11.2021	Start: SoSe 2022
Modulname:	**Einführung Machine Learning und Big Data**		
(englisch):	Introduction to Machine Learning and Big Data		
Verantwortlich(e):	Groppe, Sven / Prof. Dr.		
Dozent(en):	Groppe, Sven / Prof. Dr.		
Institut(e):	Institut für Informatik		
Dauer:	1 Semester		
Qualifikationsziele / Kompetenzen:	Die Studierenden werden befähigt, Prozesse des maschinellen Lernens im Zusammenhang mit der Verwaltung großer Datenbestände zu analysieren, zu entwerfen und zu realisieren. Sie kennen die Grundlagen und die wichtigsten Verfahren für das maschinelle Lernen. Sie sind in der Lage, Systeme für das Datenmanagement für große Datenmengen aufzusetzen und in Kombination mit Lernverfahren einzusetzen. Completing students will be able to analyze, design and implement complete workflows for machine learning in combination with the management of big data. They have a good understanding of the fundamental issues and most relevant methods and procedures for machine learning. They will be able to install systems for the management of big data and combine these with machine learning algorithms and their implementation.		
Inhalte:	Grundlagen und Verfahren für das maschinelle Lernen, Künstliche Neuronale Netze, Deep Learning Architekturen, Big Data Infrastrukturen. Prozesse für Datenaufbereitung, Datenanalyse und Data Mining sowie für das maschinelle Lernen. Fundamentals of and procedures for machine learning, Artificial Neural Nets, architectures for Deep Learning, infrastructures for Big Data, workflows for data preprocessing, for data analysis, for data mining, and for machine learning.		
Typische Fachliteratur:	Künstliche Intelligenz; Russel, Norvig; Pearson Studium; 2012. Mining of Massive Datasets; Leskovec, Rajaraman, Ullman; Cambridge University Press, 2014 Machine Learning Yearning; Andrew Ng; to appear Deep Learning. Das umfassende Handbuch; Goodfellow, Bengio, Courville; MITP Verlags GmbH, 2018		
Lehrformen:	S1 (SS): [(*) Das Modul kann auch in englischer Sprache abgehalten werden. Die Bekanntgabe erfolgt zu Semesterbeginn.] / Vorlesung (2 SWS) S1 (SS): (*) / Übung (2 SWS)		
Voraussetzungen für die Teilnahme:	**Empfohlen:** Grundlagen der Informatik, 2015-05-19 Künstliche Intelligenz, 2009-05-28		
Turnus:	jährlich im Sommersemester		
Voraussetzungen für die Vergabe von Leistungspunkten:	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP/KA (KA bei 15 und mehr Teilnehmern) [MP mindestens 30 min / KA 120 min]		
Leistungspunkte:	6		
Note:	Die Note ergibt sich entsprechend der Gewichtung (w) aus folgenden(r) Prüfungsleistung(en): MP/KA [w: 1]		
Arbeitsaufwand:	Der Zeitaufwand beträgt 180h und setzt sich zusammen aus 60h Präsenzzeit und 120h Selbststudium.		

Data:	NUMFEM. MA. Nr. 493 / Examination number: 11005	Version: 18.05.2026	Start Year: SoSe 2026
Module Name:	**Finite Element Methods (FEM) for Mathematicians**		
(English):			
Responsible:	Rheinbach, Oliver / Prof. Dr.		
Lecturer(s):	Rheinbach, Oliver / Prof. Dr.		
Institute(s):	Institute of Numerical Mathematics and Optimization		
Duration:	1 Semester(s)		
Competencies:	The students should know, understand and be able to apply the finite element method for the numerical solution of partial differential and as well as its theory. This includes weak formulations, existence and uniqueness, convergence, regularity but also practical aspects such as adaptivity, fast solvers, and the implementation in a modern programming language. (Ziel ist das Verständnis der Methode der finiten Elemente (FE) als Verfahren zur Approximation der Lösung partieller Differentialgleichungen. Hierzu gehören sowohl theoretische Aspekte wie die Umformung in eine schwache Formulierung, Anwendung der Existenzsätze der Variationstheorie und die Konvergenztheorie für FE-Approximationen als auch praktische Aspekte wir Adaptivität und schnelle Löser.)		
Contents:	The lecture will cover variational formulations, existence and uniqueness, stability, construction of finite element spaces. We may cover also applications,e.g., in continuum mechanics, a-posterior error control, mixed finite element methods, and iterative multilevel methods for the solution of finite element problems. (Themen der Vorlesung sind Variationsformulierungen von Randwertaufgaben und damit verbundene Existenz-, Eindeutigkeits- und Stabilitätsaussagen, die Konstruktion von FE-Räumen. Weiter können Anwendungen der FE-Methode auf spezielle Problemtypen (z. B. aus der Strukturmechanik, Strömungsmechanik, Akustik oder Elektromagnetik) betrachtet werden, sowie a posteriori Fehlerschätzer, gemischte FE-Ansätze und Multilevel-Verfahren zur Lösung von FE-Gleichungssystemen.)		
Literature:	Braess, Dietrich, Finite Elemente, Springer Spektrum; Auflage: 5. Aufl. 2013. Ciarlet, P. G.: The finite Element Method for Elliptic Problems, North-Holland 1978. Ern, A.; Guermon, J.-L.: Theory and Practice of Finite Elements, Springer 2004. Brenner, S. C.; Scott, R. L.: The Mathematical Theory of Finite Element Methods, Springer 2002.		
Types of Teaching:	S1 (SS): [(*) The module can also be held in German. The announcement will be made at the beginning of the semester. - In the summer semester of odd-numbered years. / Lectures (4 SWS) S1 (SS): (*) - In the summer semester of odd-numbered years. / Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Analysis 1, 2021-04-21 Analysis 2, 2021-04-21 Lineare Algebra 1, 2021-05-03 Lineare Algebra 2, 2021-05-03		

	Basic knowledge in functional analysis and the theory of partial differential equations.
Frequency:	every 2 years in the summer semester
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]
Credit Points:	9
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]
Workload:	The workload is 270h. It is the result of 90h attendance and 180h self-studies.

Data:	FOURANA MA. / Examination number: 10710	Version: 05.05.2021	Start Year: WiSe 2023
Module Name:	**Fourier Analysis**		
(English):			
Responsible:	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Waurick, Marcus / Prof. Dr.		
Lecturer(s):	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Waurick, Marcus / Prof. Dr.		
Institute(s):	Institute of Applied Analysis		
Duration:	1 Semester(s)		
Competencies:	Die Studierenden sollen Fourierreihen und die Fouriertransformation kennen und zur Lösung von Problemen innerhalb und außerhalb der Mathematik einsetzen können. Students know the concepts of Fourier series and Fourier transformation. They apply these concepts to problems within and outwith mathematical theory.		
Contents:	- Theorie und Anwendungen der Fourier-Transformation - Konvergenz von Fourierreihen - Fourier-Transformation in verschiedenen Funktionenräumen - Theory and application of the Fourier transformation - Convergence of Fourier series - Fourier transformation in different spaces		
Literature:	Pinsky: Introduction to Fourier Analysis and Wavelets Brigola: Fourier-Analysis und Distributionen, Eine Einführung mit Anwendungen Plonka, Potts, Steidl, Tasche: Numerical Fourier Analysis		
Types of Teaching:	S1 (WS): In odd-numbered years. / Lectures (2 SWS) S1 (WS): In odd-numbered years. / Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Analysis 4 (Funktionalanalysis), 2021-05-04 Analysis 3 (Gewöhnliche Differentialgleichungen), 2021-05-04		
Frequency:	every 2 years in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.		

Data:	GEOTOP MA / Examination number: 10110	Version: 02.07.2024	Start Year: WiSe 2022
Module Name:	**Geometry and Topology**		
(English):			
Responsible:	Schneider, Friedrich Martin / Prof. Dr.		
Lecturer(s):	Schneider, Friedrich Martin / Prof. Dr.		
Institute(s):	Institute of Discrete Mathematics and Algebra		
Duration:	1 Semester(s)		
Competencies:	Die Studierenden verstehen grundlegende und weiterführende Methoden der Geometrie und Topologie. Sie verfügen über ein Grundverständnis der Zusammenhänge mit anderen Gebieten der Mathematik und besitzen die Fähigkeit, diese Zusammenhänge zur Problemlösung zu nutzen. Students understand basic and advanced methods of geometry and topology. They apprehend connections to other fields of mathematics and acquire the ability to use those connections for problem solving.		
Contents:	Das Modul bietet eine Einführung in Themen der Geometrie und Topologie und behandelt dabei Verknüpfungen mit und Anwendungen in Dynamik, mathematischer Datenanalyse und theoretischer Informatik. The module provides an introduction to a topic within geometry and topology, comprising links to and applications in dynamics, mathematical data analysis, and theoretical computer science.		
Literature:	Burago, D., Burago, Y., Ivanov, S.: A Course in Metric Geometry, American Mathematical Society, 2001. Pestov, V.: Dynamics of Infinite-Dimensional Groups: The Ramsey-Dvoretzky-Milman Phenomenon, AMS Press, 2006. Roe, J.: Lectures on Coarse Geometry, AMS Press, 2003. Shioya, T.: Metric Measure Geometry, European Mathematical Society, 2016. Todorčević, S.: Topics in Topology, Springer, 1997.		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Grundlagen der Diskreten Mathematik und Algebra 1, 2021-05-03 Grundlagen der Diskreten Mathematik und Algebra 2, 2021-05-03 Lineare Algebra 1, 2021-05-03 Lineare Algebra 2, 2021-05-03		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 180h. It is the result of 45h attendance and 135h self-studies.		

Data:	GM MA. / Examination number: 30114	Version: 24.11.2022	Start Year: SoSe 2026
Module Name:	**Geomodelling – Geostatistics for Natural Resource Modelling**		
(English):			
Responsible:	Benndorf, Jörg / Prof. Dr.-Ing.		
Lecturer(s):	Benndorf, Jörg / Prof. Dr.-Ing.		
Institute(s):	Institute for Mine Surveying and Geodesy		
Duration:	1 Semester(s)		
Competencies:	After successful completion of the course, students are able to: • explain the theoretical foundation of spatial data analysis, • geostatistical model building and estimation, • apply geostatistical methods in the context of estimating natural resources/reserves, • critically evaluate model assumptions of different estimation and simulation method and choose suitable methods for specific applications, • discuss the critical character of the SMU-size to recoverable reserves, • conduct a resource/reserve estimation in a simple case study.		
Contents:	Importance of Resource Modelling and Estimation in the Value Chain of Mining, Uni-variate and Multi-variate Explorative Data Analysis, Analysis of Spatial Continuity, the Spatial Random Function Model, Model Assumptions of Stationarity and Ergodicity, Inference of a Spatial Random Function using unbiased Estimators, Dealing with Preferential Sampling, Variography and Variogram Modeling, Simple Methods for Spatial Estimation including the Polygon Method, Triangulation, Inverse Distance Power and Polynomial Regression, Geostatistical Methods for Spatial Estimation including Simple Kriging, Ordinary Kriging and Universal Kriging, Integrating Secondary Information into Spatial Modeling using Techniques of Co-Kriging, other methods including Indicator Kriging and Block Kriging, Introduction in Modeling spatial Uncertainty using Conditional Simulation, the Method of Sequential, Gaussian Simulation, Geostatistical Considerations in Estimating Reserves in Terms of Volume-Variance Relationship for defining Smallest Minable Units and Grade Tonnage Curves, Applications in Mining Cases, Introduction to CRIRSCO-based International Reporting standards (example JORC Code).		
Literature:	M. Armstrong: “Basic Linear Geostatistics”, Springer Verlag; J. Benndorf: „Angewandte Geodatenanalyse und –Modellierung: Eine Einführung in die Geostatistik für Geowissenschaftler und Geoingenieure“, Springer Verlag; A. G. Journel, and C.J. Huijbregts: Mining Geostatistics, Academic Press; P. Goovaerts: “Geostatistics for Natural Resource Evaluation“, Oxford University Press; T. Schafmeister: “Geostatistik für die hydrogeologische Praxis“, Springer Verlag		
Types of Teaching:	S1 (SS): Lecture Geomodelling / Lectures (2 SWS) S1 (SS): Practical Geomodelling / Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Angewandte Statistik, 2021-11-22		
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: KA [90 min]		

	AP: Assignments and Practical Report
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA [90 min] AP: Belege und Praktikumsbericht
Credit Points:	5
Grade:	The Grade is generated from the examination result(s) with the following weights (w): KA [w: 2] AP: Assignments and Practical Report [w: 1]
Workload:	The workload is 150h. It is the result of 60h attendance and 90h self-studies.

Data:	GLOBA MA. / Examination number: 10723	Version: 04.05.2021	Start Year: SoSe 2023
Module Name:	**Global Analysis**		
(English):			
Responsible:	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Semmler, Gunter / Dr. Waurick, Marcus / Prof. Dr.		
Lecturer(s):	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Semmler, Gunter / Dr. Waurick, Marcus / Prof. Dr.		
Institute(s):	Institute of Applied Analysis		
Duration:	1 Semester(s)		
Competencies:	Die Studierenden lernen Denkweisen, Methoden und Techniken der Analysis auf Mannigfaltigkeiten kennen. Damit sind sie in der Lage, die erworbenen Fähigkeiten und Fertigkeiten in fortgeschrittenen Vorlesungen und bei Qualifikationsarbeiten anzuwenden. The students are acquainted with principles, methods and techniques of analysis on manifolds. The abilities acquired in this course may serve in furthergoing lectures and student theses.		
Contents:	Der Kurs bietet eine Einführung in den Begriff der differenzierbaren Mannigfaltigkeit. Notwendige Hilfsmittel der multilinearen Algebra werden in der Vorlesung entwickelt. Zu Kursbeginn wird in Abhängigkeit von der Zuhörerschaft entschieden, ob der Kurs in Deutsch oder Englisch stattfindet. This course offers an introduction to the notion of a differentiable manifold. Necessary prerequisites of multilinear algebra are provided during the lectures. At the beginning of the course, it will be decided (dependending on the audience) whether the course will be held in English or German.		
Literature:	Barden, D. and Thomas, C.: An introduction to differential manifolds, Imperial College Press 2003 Lee, J. M.: Manifolds and differential geometry, AMS 2009		
Types of Teaching:	S1 (SS): In odd-numbered years. / Lectures (2 SWS) S1 (SS): In odd-numbered years. / Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Differential Geometry, 2021-05-04		
Frequency:	every 2 years in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.		

Data:	MA. / Examination number: 12601	Version: 04.02.2026	Start Year: SoSe 2026
Module Name:	**Introduction to Bayesian Data Analysis**		
(English):	Introduction to Bayesian Data Analysis		
Responsible:	Tolosana-Delgado, Raimon / PD Dr. Sprungk, Björn / Prof. Dr.		
Lecturer(s):	Tolosana-Delgado, Raimon / PD Dr.		
Institute(s):	Institute of Stochastics		
Duration:	1 Semester(s)		
Competencies:	Students will learn to analyse situations where data need to be merged with preexisting knowledge. Key competences are: (a) the expression of such knowledge in a prior distribution, (b) the selection of an appropriate solution strategy, (c) the programming of the chosen strategy for simple situations and (d) the analysis and interpretation of results in terms of the problem at hand.		
Contents:	• review of probability theory: conditional probability, Bayes theorem, prior and posterior • reference probability distributions, Binomial, Poisson, Normal, and their relatives • discretization and conjugate prior methods • sampling methods: Monte Carlo, importance sampling, acceptance/rejection • Markov Chain Monte Carlo methods: Gibbs sampler, Metropolis-Hastings sampler		
Literature:	Leonard, Hsu (2001) Bayesian Methods: an analysis for statisticians and interdisciplinary researchers. Cambridge University Press, 333 pages, ISBN 9780521004145 Diggle, Ribeiro (2007) Chapter 7: Bayesian inference. In: Model-based geostatistics, pp 157-198. Springer, ISBN: 9780387329079 Johnson, Ott, Dogucu (2021) Bayes Rules! An Introduction to Applied Bayesian Modeling. CRC Press, 544 pages. ISBN 9780367255398. Available online: https://www.bayesrulesbook.com/		
Types of Teaching:	S1 (SS): Lectures (1 SWS) S1 (SS): Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** a previous probability theory course is helpful; some programming knowledge is also convenient		
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP*: Practical exercises MP/KA*: MP or KA to be discussed in the course (KA if 15 students or more) * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP*: Praktische Übungen MP/KA*: MP oder KA wird im Kurs entschieden. (KA bei 15 und mehr Teilnehmern) * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0)		

	bewertet sein.
Credit Points:	4
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP*: Practical exercises [w: 3] MP/KA*: MP or KA to be discussed in the course [w: 2] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
Workload:	The workload is 120h. It is the result of 30h attendance and 90h self-studies.

Data:	IHPC. MA. Nr. 3210 / Examination number: 11110	Version: 05.03.2015	Start Year: WiSe 2012
Module Name:	**Introduction to High Performance Computing and Optimization**		
(English):			
Responsible:	Rheinbach, Oliver / Prof. Dr.		
Lecturer(s):	Rheinbach, Oliver / Prof. Dr.		
Institute(s):	Institute of Numerical Mathematics and Optimization		
Duration:	1 Semester(s)		
Competencies:	The students shall have an understanding of and ability to apply: • parallel computing on shared and distributed memory multiprocessor systems • parallel algorithms The students know relevant terms in English.		
Contents:	Ingredients can be: • Portable parallel programming with OpenMP and MPI (Message Passing Interface); hybrid parallelization; accelerators • Code profiling, tracing and optimization methods using tools (profiler, VAMPIRE, etc.); • Relevant software libraries (e.g., BLAS, LAPACK, SCALAPACK, etc.) • Design and analysis of algorithms • Parallel solution of linear systems (dense/sparse systems) • International literature and relevant terms in English		
Literature:	Georg Hager, Gerhard Wellein, Introduction to High Performance Computing for Scientists and Engineers, Chapman & Hall, 2010 OpenMP Standard, www.openmp.org Barbara Chapman, Gabriele Jost, Ruud van der Pas, Using OpenMP: portable shared memory parallel programming, MIT Press, 2008 William Gropp, Ewing Lusk, Anthony Skjellum, Using MPI: Portable Parallel Programming with the Message-Passing Interface, MIT press, 2000 Michael Quinn, Parallel Programming in C with MPI and OpenMP, McGraw-Hill, 2003 Anne Greenbaum, Iterative Methods for Solving Linear Systems, SIAM, 1997		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Basics knowledge in scientific programming and algorithms.		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP/KA: MP = individual examination (KA if 30 students or more) [MP minimum 30 min / KA 120 min] PVL: Programming Project PVL have to be satisfied before the examination.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP/KA: MP = individuelle Prüfung (KA bei 30 und mehr Teilnehmern) [MP mindestens 30 min / KA 120 min] PVL: Programmierprojekt		

	PVL müssen vor Prüfungsantritt erfüllt sein bzw. nachgewiesen werden.
Credit Points:	4
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP/KA: MP = individual examination [w: 1]
Workload:	The workload is 120h. It is the result of 45h attendance and 75h self-studies.

Data:	ISP. MA. Nr. 3211 / Examination number: 11609	Version: 18.05.2017	Start Year: WiSe 2017
Module Name:	**Introduction to Scientific Programming**		
(English):			
Responsible:	Rheinbach, Oliver / Prof. Dr.		
Lecturer(s):	Prüfert, Uwe / Dr. rer. nat. Rheinbach, Oliver / Prof. Dr.		
Institute(s):	Institute of Numerical Mathematics and Optimization		
Duration:	1 Semester(s)		
Competencies:	Students will get familiar with the syntax and semantic of multi paradigm programming languages. Construction of suitable data structures and the choice of adequate algorithms are further skills to learn. Based on this, the students should be able to implement interactive programs having a graphical user interface.		
Contents:	Part programming language: Data types and variables, pointer and arrays, expressions, statements, operators, control structures, functions, objects and classes, encapsulation, access rights, inheritance, polymorphism, overloading of functions an operators, type casting, templates; Part algorithms: Iteration, recursion, special functions; Part GUI programming: User—software interaction, use of standard class libraries for programming graphical user interfaces.		
Literature:	Stroustrup, Bjarne . The C++ programming language Register, Andrew. A guide to MATLAB object oriented programming		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Practical Application (2 SWS)		
Pre-requisites:	**Recommendations:** Höhere Mathematik für Ingenieure 1, 2015-03-12 Höhere Mathematik für Ingenieure 2, 2015-03-12		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: KA [120 min] PVL: Programming Project PVL have to be satisfied before the examination.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA [120 min] PVL: Programmierprojekt PVL müssen vor Prüfungsantritt erfüllt sein bzw. nachgewiesen werden.		
Credit Points:	4		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): KA [w: 1]		
Workload:	The workload is 120h. It is the result of 60h attendance and 60h self-studies.		

Data:	INVPROB MA. / Examination number: 10726	Version: 04.05.2021	Start Year: WiSe 2022
Module Name:	**Inverse Problems**		
(English):			
Responsible:	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Waurick, Marcus / Prof. Dr.		
Lecturer(s):	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Waurick, Marcus / Prof. Dr.		
Institute(s):	Institute of Applied Analysis		
Duration:	1 Semester(s)		
Competencies:	Die Studierenden lernen Denkweisen, Methoden und Techniken inverser Probleme. Damit sind sie in der Lage, die erworbenen Fähigkeiten und Fertigkeiten bei Qualifikationsarbeiten anzuwenden. Students learn ways of thinking, methods and techniques of inverse problems. These enable them to apply the acquired skills and abilities to qualification thesis.		
Contents:	Lineare und nicht lineare inverse Probleme, Regularisierungsmethoden für lineare und nichtlineare Probleme, numerische Verfahren zur stabilen Lösung inverser Probleme, Diskretisierungs- und Iterationsverfahren. Linear and non-linear inverse problems, regularisation methods for linear and non-linear problems, numerical methods for the stable solution of inverse problems, discretisation and iteration methods.		
Literature:	M. Richter, Inverse Probleme, Springer Spektrum, 2015, M. Richter, Inverse Problems, Birkhäuser, 2020, P.C. Hansen, Discrete Inverse Problems: Insight and Algorithms, SIAM, 2010, B. Hofman: Mathematik inverser Probleme, Teubner-Verlag, Stuttgart, Leipzig, 1999.		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Analysis 4 (Funktionalanalysis), 2021-05-04		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.		

Data:	NUMINVGPY. MA Nr. 2988 / Examination number: 31515	Version: 12.02.2021	Start Year: SoSe 2020
Module Name:	**Inverse Problems in Geophysics**		
(English):			
Responsible:	Günther, Thomas / Prof. Dr.		
Lecturer(s):	Günther, Thomas / Prof. Dr.		
Institute(s):	Institute of Geophysics and Geoinformatics		
Duration:	1 Semester(s)		
Competencies:	The students are introduced to fundamental problem-solving strategies in geophysics based on solving the forward and inverse problem. In this course we focus on the inverse problem. The students will understand how inverse problems are formulated and acquire the ability to develop and program them independently.		
Contents:	Inversion techniques are of fundamental importance in geophysics because they aim at reconstructing material parameter models from observed field data. Linear (e.g., magnetics, gravimetry) and nonlinear inverse problems (e.g., geoelectrics, electromagnetics) are addressed as well as regularization strategies and the influence of the eigenvalue spectrum on the solution. Resolution and error analyses, Gauss-Newton, Newton, and Quasi-Newton approaches are presented. The subject is deepend by computer exercises and programming simple problems in Matlab.		
Literature:	Menke: Discrete Inverse Theory, Borchers: Parameter Estimation and Inverse Problems, articles from geophysical journals		
Types of Teaching:	S1 (SS): Lectures (2 SWS) S1 (SS): Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Knowledge in Experimental and Theoretical Physics, Mathematics, Numerics, Partial Differential Equations, and Geophysics		
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP: Solution of Exercises		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP: Lösung von Übungsaufgaben		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: Solution of Exercises [w: 1]		
Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies.		

Data:	MT MA. / Examination number: 9900	Version: 15.07.2021	Start Year: SoSe
Module Name:	**Master Thesis (Mathematics for Data and Resource Sciences)**		
(English):			
Responsible:	Waurick, Marcus / Prof. Dr.		
Lecturer(s):			
Institute(s):	Institute of Applied Analysis		
Duration:	12 Month(s)		
Competencies:	The objective of the master thesis is to give the students the opportunity to apply the knowledge aquired during the studies on a resaerch project. The students are able, within a prescribed period, to independently process a defined complex problem from their field with appropriate scientific methods and to present both the problem and their own work in writing and orally. They are able to manage complex projects, taking responsibility for decision-making in unpredictable study contexts. In the case Students will chose opportunity of an industry internship related with the master thesis, they will apply their gained knowledge in practical tasks during an industry internship in an enterprise, consultant company, public authority or similar institutions. Students will deepen their understanding of the business context of their subject, and develop cross-disciplinary and interpersonal skills.		
Contents:	In the case of an industry internship, it contains of: • 4 months practical work in a company or related institution, • regular consultations with the university supervisor, • a short and consistent internship report, • an evaluation talk with the supervisor. The organization of an internship is in the responsibility of the student. The supervisor has to agree upfront, of the organized internship is suitable for this module.		
Literature:			
Types of Teaching:	S1: Internship (4 moth) with related with Master Thesis (6 months) or Master Thesis withour industry internship (9 months) / Thesis (9 Mon)		
Pre-requisites:	**Mandatory:** Module im Umfang von mind. 50 Leistungspunkten (außer Master Thesis (Mathematics for Data and Resource Sciences))		
Frequency:	constantly		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: in examination variant 1: AP*: Thesis without Internship AP*: Defense [30 to 90 min] or in examination variant 2: AP*: Thesis with Internship AP*: Defense [30 to 90 min] AP*: Written report and evaluation discussion * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst:		

	in Prüfungsvariante 1: AP*: Masterarbeit ohne Berufspraktikum AP*: Kolloquium [30 bis 90 min] oder in Prüfungsvariante 2: AP*: Masterarbeit mit Berufspraktikum AP*: Kolloquium [30 bis 90 min] AP*: Praktikumsbericht und Praktikumsdiskussion * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.
Credit Points:	30
Grade:	The Grade is generated from the examination result(s) with the following weights (w): in examination variant 1: AP*: Thesis without Internship [w: 2] AP*: Defense [w: 1] or in examination variant 2: AP*: Thesis with Internship [w: 2] AP*: Defense [w: 1] AP*: Written report and evaluation discussion [w: 0] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
Workload:	The workload is 900h.

Data:	MABV MA. / Examination number: 10730	Version: 13.12.2022	Start Year: SoSe 2022
Module Name:	**Mathematical Image Processing**		
(English):			
Responsible:	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Waurick, Marcus / Prof. Dr.		
Lecturer(s):	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Waurick, Marcus / Prof. Dr. Hielscher, Ralf / Prof.		
Institute(s):	Institute of Applied Analysis		
Duration:	1 Semester(s)		
Competencies:	Kennenlernen grundlegender Fragestellungen, Begriffe und Methoden der mathematischen Bildverarbeitung, Verstehen der mathematischen Hintergründe, Anwendung von Konzepten der Analysis und der Funktionalanalysis Know basic questions, notions and methods in mathematical image processing. Understanding mathematical background and application of concepts of mathematical analysis and functional analysis		
Contents:	Elementare Methoden der Bildverarbeitung, Glättungsfilter,Variationsformulierungen in der Bildverarbeitung, Kantenerkennung, Entfaltung, Inpainting Segmentierung, Registrierung Elementary methods in image processing, smoothing filters, variational formulations in image processing, edge detection, deconvolution, inpainting, segmentation, registration		
Literature:	Bredies, Lorenz: Mathematische Bildverarbeitung Scherzer, Grasmair, Grossauer, Haltmeier, Lenzen: Variational Methods in Imaging Chan, Shen: Image processing and analysis		
Types of Teaching:	S1 (SS): In odd-numbered years. / Lectures (3 SWS) S1 (SS): In odd-numbered years. / Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Analysis 1, 2021-04-21 Analysis 2, 2021-04-21		
Frequency:	every 2 years in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies.		

Data:	TEXTUR MA. / Examination number: 12401	Version: 04.06.2025	Start Year: WiSe 2025
Module Name:	**Mathematics of Crystallographic Texture Analysis**		
(English):			
Responsible:	Hielscher, Ralf / Prof.		
Lecturer(s):			
Institute(s):	Institute of Applied Analysis		
Duration:	1 Semester(s)		
Competencies:	The module provides the students with a wide variety of mathematical methods for the analysis of the microstructure of polycrystalline materials and its anisotropic physical properties.		
Contents:	- mathematical description of crystal symmetries - quantitative description of polycrystalline materials and its anisotropic properties - determination of the orientation distribution function from EBSD and XRD data - methods of mathematical image analysis for EBSD data - analysis of orientation relationships		
Literature:	Bunge: Mathematische Methoden der Texturanalyse Moraviec: Orientations and Rotations: Computations in Crystallographic Textures Suwas, Ray: Crystallographic Texture of Materials Engler, Randle: Introduction to Texture Analysis		
Types of Teaching:	S1 (WS): Block course / Lectures (2 SWS) S1 (WS): Block course / Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Höhere Mathematik für Ingenieure 1, 2015-03-12 Analysis 1, 2021-04-21 Analysis 2, 2021-04-21 Höhere Mathematik für Ingenieure 2, 2015-03-12		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.		

Data:	MAETH. MA. / Examination number: 11712	Version: 11.01.2025	Start Year: SoSe 2025
Module Name:	**Mathematics of Ethics**		
(English):			
Responsible:	van den Boogaart, Gerald / Prof. Dr. Starkloff, Hans-Jörg / Prof. Dr.		
Lecturer(s):	van den Boogaart, Gerald / Prof. Dr.		
Institute(s):	Institute of Stochastics		
Duration:	1 Semester(s)		
Competencies:	Die Studierenden werden befähigt, Fragestellungen der Ethik mit mathematischen und statistischen Modellen und Methoden zu beschreiben und zu lösen. Students are able to describe and solve ethical problems using mathematical and statistical models and methods.		
Contents:	Die Vorlesung entwickelt die Ethik als eine moderne, durchmathematisierte empirische Wissenschaft und zeigt, wie moderne Werkzeuge der angewandten Mathematik wie Wahrscheinlichkeitstheorie, Kausalitätstheorie, Entscheidungstheorie, Spieltheorie, Statistik und Ausgleichsrechnung zur Beantwortung ethischer Fragestellungen eingesetzt werden können. Die Vorlesung legt dabei besonderen Wert auf das mathematische Verständnis der genannten Gebiete der angewandten Mathematik und ihrer Einsatzmöglichkeiten im Bereich der Ethik. Die Vorlesung bietet zudem einen Einblick in die mathematische Modellierung nichtdeterministischer Prozesse. This course explores ethics as a modern, mathematically grounded empirical science and demonstrates how modern tools of applied mathematics such as probability theory, causality theory, decision theory, game theory, statistics, and utility calculus can be used to address ethical questions. The course places particular emphasis on the mathematical understanding of these areas of applied mathematics and their potential applications in the field of ethics. The course also provides an insight into the mathematical modeling of non-deterministic processes.		
Literature:	Michael Brand (2009) The Mathematics of Justice: How Utilarianism Bridges Game Theory and Ethics, LAP Lambert Academic Publishing Judea Pearl, Dana Mackenzie (2018) The Book of Why: The New Science of Cause and Effect, Basic Books Mindia E. Salukvadze, Vlasislav I Zhukovskiy (2020) The Berge Equilibrium: A Game-Theoretic Framework for the Golden Rule of Ethics, Birkhäuser Erich H. Rast (2022) Theory of Value Structure, From Values to Decisions, Lexington Books		
Types of Teaching:	S1 (SS): in odd-numbered years / Lectures (2 SWS) S1 (SS): Block seminar at the end of the semester term / Seminar (1 SWS) The order of the module semesters is flexible.		
Pre-requisites:	**Recommendations:** Stochastik für Mathematiker, 2021-05-10		
Frequency:	every 2 years in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains:		

	MP* [20 min] AP*: Participation in the seminar, including a presentation * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP* [20 min] AP*: Beteiligung am Seminar incl. eines Vortrags * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.
Credit Points:	5
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP* [w: 1] AP*: Participation in the seminar, including a presentation [w: 1] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.

Data:	MAML MA Nr. 3694 / Examination number: 12309	Version: 28.04.2026	Start Year: SoSe 2027
Module Name:	**Mathematics of Machine Learning**		
(English):	Mathematics of Machine Learning		
Responsible:	Sprungk, Björn / Prof. Dr.		
Lecturer(s):	Sprungk, Björn / Prof. Dr.		
Institute(s):	Institute of Stochastics		
Duration:	1 Semester(s)		
Competencies:	Students are able to explain the basic mathematical concepts of supervised learning and statistical learning theory. They know important algorithms for classification and (nonlinear) regression, can choose an appropriate classification method for a specific problem and implement or apply it using common software. Furthermore, the can critically evaluate the results of these maching learning procedures and identify possible sources of error.		
Contents:	• statistical learning theory for classification and regression (PAC model, empirical risk minimization, Vapnik-Chervonenkis theory) • linear approaches for classification (perceptron, logistic regression, support vector machines, kernel trick) • feedforward neural networks • training via stochastic optimization, regularization, validation and testing Depending on the audience the course may be given either in English or German. / Abhängig von den Teilnehmer*innen wird der Kurs in Deutsch oder Englisch gehalten.		
Literature:	Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006; Gareth James, Daniela Witten, Trevor Hastie, und Robert Tibshirani, An Introduction to Statistical Learning, Springer, 2013; Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012; Shai Shalev-Shwartz und Shai Ben-David, Understanding Machine Learning, Cambridge University Press 2014		
Types of Teaching:	S1 (SS): Lectures (3 SWS) S1 (SS): Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Optimierung für Mathematiker, 2015-03-10 Numerik für Mathematiker, 2021-04-21 Stochastik für Mathematiker, 2021-05-10		
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [20 to 30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [20 bis 30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies. Das Selbststudium umfasst die Vor- und Nachbereitung der Lehrveranstaltungen und die Vorbereitung auf die Modulprüfung.		

Data:	MEML MA / Examination number: 12304	Version: 28.04.2026	Start Year: WiSe 2026
Module Name:	**Methods in Machine Learning**		
(English):			
Responsible:	Sprungk, Björn / Prof. Dr.		
Lecturer(s):	Sprungk, Björn / Prof. Dr.		
Institute(s):	Institute of Stochastics		
Duration:	1 Semester(s)		
Competencies:	Students can explain and apply common methods for several learning tasks such as supervised, unsupervised, generative, and reinforcement learning. In particular, they understand the basic theoretical background of these methods and can choose a suitable algorithms for specific machine learning problems at hand.		
Contents:	• Classification and regression methods (k-nearest neighbors, decision trees, random forests) • Clustering methods (linkage-based, k-means, spectral clustering) • Dimensionality reduction (PCA, compressed sensing) • Elements of generative learning (e.g., GAN) • Basics of reinforcement learning Depending on the audience the course may be given either in English or German. / Abhängig von den Teilnehmer*innen wird der Kurs in Deutsch oder Englisch gehalten.		
Literature:	Daniela Calvetti and Erkki Sommersalo, Mathematics of Data Science: A Computational Approach to Clustering and Classification, SIAM, 2020; Trevor Hastie, Robert Tibshirani, and Jerome Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Springer 2009; Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar, Foundations of Machine Learning, MIT Press, 2018; Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012; Shai Shalev-Shwartz and Shai Ben-David, Understanding Machine Learning, Cambridge University Press 2014; Richard S. Sutton and Andrew M. Barto, Reinforcement Learning: An Introduction, MIT Press, 2014		
Types of Teaching:	S1 (WS): Methods in Machine Learning / Lectures (3 SWS) S1 (WS): Methods in Machine Learning / Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Mathematics of Machine Learning, 2026-04-28		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [20 to 30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [20 bis 30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies.		

Data:	MANGA. MA. Nr. 477 / Examination number: 10109	Version: 02.07.2024	Start Year: SoSe 2023
Module Name:	**Methods of Applied Algebra**		
(English):			
Responsible:	Schneider, Friedrich Martin / Prof. Dr.		
Lecturer(s):	Schneider, Friedrich Martin / Prof. Dr.		
Institute(s):	Institute of Discrete Mathematics and Algebra		
Duration:	1 Semester(s)		
Competencies:	Die Studierenden verstehen fortgeschrittene Methoden der Algebra. Sie verfügen über ein Grundverständnis der Zusammenhänge mit anderen Gebieten der Mathematik und besitzen die Fähigkeit, diese Zusammenhänge zur Problemlösung zu nutzen. Students understand advanced methods of algebra. They apprehend connections to other fields of mathematics and acquire the ability to use those connections for problem solving.		
Contents:	Das Modul bietet eine Einführung in fortgeschrittene Themen der Algebra und behandelt dabei Verknüpfungen mit und Anwendungen in Geometrie, mathematischer Datenanalyse und theoretischer Informatik. The module provides an introduction to an advanced topic of algebra, comprising links to and applications in geometry, mathematical data analysis, and theoretical computer science.		
Literature:	Ceccherini-Silberstein, T., Coornaert, M.: Cellular Automata and Groups, Springer, 2010. Cohn, P. M.: Further Algebra and Applications, Springer, 2003. Goodearl, K.R: Von Neumann Regular Rings, Monographs and Studies in Mathematics, No. 4, Pitman, 1979. Hindman, N., Strauss, D.: Algebra in the Stone-Čech Compactification: Theory and Applications, De Gruyter, 2010. Woess, W.: Random Walks on Infinite Graphs and Groups, Cambridge University Press, 2000.		
Types of Teaching:	S1 (SS): Lectures (2 SWS) S1 (SS): Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Grundlagen der Diskreten Mathematik und Algebra 1, 2021-05-03 Grundlagen der Diskreten Mathematik und Algebra 2, 2021-05-03 Lineare Algebra 1, 2021-05-03 Lineare Algebra 2, 2021-05-03		
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 180h. It is the result of 45h attendance and 135h self-studies.		

Data:	MODSI MA. / Examination number: 10917	Version: 13.12.2024	Start Year: WiSe 2022
Module Name:	**Modelling and Simulation**		
(English):			
Responsible:	Aland, Sebastian / Prof. Dr.		
Lecturer(s):	Aland, Sebastian / Prof. Dr.		
Institute(s):	Institute of Numerical Mathematics and Optimization		
Duration:	1 Semester(s)		
Competencies:	Most problems in nature, technology and everyday life can be described (modeled) by partial differential equations to be simulated on a computer. In this course students learn some fundamental skills of mathematical modeling with a focus on numerical solution of the resulting systems. The students can transfer a variety of problems into mathematical equations, program simple simulation codes and analyze the results. Fast alle Probleme aus Alltag, Natur und Technik lassen sich mathematisch beschreiben (modellieren) und dadurch am Computer simulieren. In diesem Kurs lernen die Studierenden grundlegende Fähigkeiten und Fertigkeiten zur Modellierung unter dem Aspekt der numerischen Simulation. Die Studierenden können danach eine Vielzahl realer Probleme in Gleichungen überführen, numerisch simulieren, und Ergebnisse interpretieren.		
Contents:	Derivation of mathematical models of problems in nature, technology and everyday life, for example by means of conservation laws, energy variation or phase field modeling. Treatment of complex dynamics such as movement, flow, growth and pattern formation. Exemplary systems from computer science, biology, chemistry and physics. Herleitung mathematischer Modelle für Probleme aus Alltag, Natur und Technik, z.B. aus Erhaltungssätzen, Energievariation oder Phasenfeldmodellierung. Behandlung von komplexen Dynamiken wie z.B. Bewegung, Strömung, Wachstum oder Musterbildung. Beispielhafte Systeme aus Informatik, Biologie, Chemie oder Physik.		
Literature:	Garcke, H., Eck, C., & Knabner, P. Mathematische Modellierung. (Springer Verlag) Originalarbeiten		
Types of Teaching:	S1 (WS): in even-numbered years / Lectures (4 SWS) S1 (WS): in even-numbered years / Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Numerik für Mathematiker, 2024-05-27		
Frequency:	every 2 years in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	9		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 270h. It is the result of 90h attendance and 180h self-studies.		

Data:	NUMANWA. BA. Nr. 496 / Examination number: 10918	Version: 19.05.2026	Start Year: WiSe 2027
Module Name:	**Numerical Methods for Initial Value Problems**		
(English):			
Responsible:	Aland, Sebastian / Prof. Dr.		
Lecturer(s):	Aland, Sebastian / Prof. Dr.		
Institute(s):	Institute of Numerical Mathematics and Optimization		
Duration:	1 Semester(s)		
Competencies:	Students will learn how to model the world around us by initial value problems. They understand how to discretize and solve such problems and can apply the learned techniques to new problems. They can evaluate discretization methods in terms of discretization error and stability. They can efficiently solve initial value problems on a computer. (Studierende erwerben grundlegende Kenntnisse zur Modellierung der Welt um uns herum durch Anfangswertprobleme. Sie verstehen, wie solche Probleme diskretisiert und gelöst werden und können die dazu nötigen Techniken auf neue Probleme anwenden. Sie können numerische Methoden dazu bewerten anhand von Diskretisierungsfehlern und Stabilität. Sie können Anfangswertaufgaben effizient auf dem Computer lösen.)		
Contents:	Topics include stiffness, consistency, stability and convergence of linear multistep methods and one-step methods for ordinary differential equations. For partial differential equations, finite difference methods will be discussed. (Gegenstand ist die Beschreibung vielfältiger Systeme und Prozesse durch Anfangswertprobleme gewöhnlicher sowie partieller Differentialgleichungen und deren Lösung durch numerische Verfahren. Für die gewöhnlichen Differentialgleichungen werden folgende Themen behandelt: Konsistenz, Stabilität, Konvergenz, lineare Mehrschrittverfahren, Runge-Kutta-Verfahren, Steifheit. Bei partiellen Differentialgleichungen werden vor allem Differenzenverfahren behandelt.)		
Literature:	R. LeVeque: Finite Difference Methods for Ordinary and Partial Differential Equations, SIAM 2007		
Types of Teaching:	S1 (WS): [(*) The module can also be held in German. The announcement will be made at the beginning of the semester.] In the winter semester of odd-numbered years / Lectures (4 SWS) S1 (WS): (*) In the winter semester of odd-numbered years / Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Knowledge of the content of the basic study modules in Applied Mathematics		
Frequency:	every 2 years in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	9		
Grade:	The Grade is generated from the examination result(s) with the following weights (w):		

	MP [w: 1]
Workload:	The workload is 270h. It is the result of 90h attendance and 180h self-studies.

Data:	NUMNLO. MA. Nr. 478 / Examination number: 11006	Version: 19.05.2026	Start Year: SoSe 2015
Module Name:	**Numerical Methods for Nonlinear Optimization and Nonlinear Systems**		
(English):			
Responsible:	Rheinbach, Oliver / Prof. Dr.		
Lecturer(s):	Rheinbach, Oliver / Prof. Dr.		
Institute(s):	Institute of Numerical Mathematics and Optimization		
Duration:	1 Semester(s)		
Competencies:	The students should know and be able to apply basic concepts in the numerical solution of nonlinear optimization and nonlinear systems of equations. The students should also be able to solve corresponding problems efficiently in Matlab or Python. (Ziel der Lehrveranstaltung ist die Vermittlung grundlegender Konzepte zur numerischen Lösung von Aufgaben der nichtlinearen Optimierung und zur Lösung von nichtlinearen Gleichungssystemen. Insbesondere sollen die Studenten auch in der Lage sein, numerische Probleme aus diesem Bereich effizient unter Verwendung von MATLAB auf dem Computer lösen zu können.)		
Contents:	We will discuss numerical methods for the solution of unconstrained and constrained optimization problems and method for the solution of nonlinear systems of equations. (Behandelt werden numerische Verfahren zur Lösung unrestringierter und restringierter Minimierungsprobleme sowie Verfahren für nicht-lineare Gleichungssysteme und nichtlineare Quadratmittelprobleme.)		
Literature:	Geiger, C.; Kanzow, C.: Numerische Verfahren zur Lösung unrestringierter Optimierungsaufgaben, Springer-Verlag, 1999; Geiger, C.; Kanzow, C.: Theorie und Numerik restringierter Optimierungsaufgaben, Springer-Verlag, 2002; Dennis, J. E. and R. B. Schnabel: Numerical Methods for Unconstrained Optimization and Nonlinear Equations, SIAM Books, Philadelphia, 1996.		
Types of Teaching:	S1 (SS): "[(*) The module can also be held in German. The announcement will be made at the beginning of the semester.] In the summer semester of even-numbered years" / Lectures (4 SWS) S1 (SS): (*) - Im Sommersemester gerader Jahre / Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Basic knowledge in numerical analysis and programming		
Frequency:	every 2 years in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	9		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 270h. It is the result of 90h attendance and 180h self-studies.		

Data:	NUMSIMGPY. MA Nr. 2988 / Examination number: 31516	Version: 12.02.2021	Start Year: WiSe 2019
Module Name:	**Numerical Simulation Methods in Geophysics**		
(English):			
Responsible:	Günther, Thomas / Prof. Dr.		
Lecturer(s):	Günther, Thomas / Prof. Dr.		
Institute(s):	Institute of Geophysics and Geoinformatics		
Duration:	1 Semester(s)		
Competencies:	The students are introduced to fundamental problem-solving strategies in geophysics based on numerical simulation and the solution of the inverse problem. In this course they will understand how computer simulation methods work and acquire the ability to develop and program them independently.		
Contents:	The lecture Numerical Simulation Methods in Geophysics deals with the development of numerical computer simulation techniques on the basis of finite differences. The discretization is mainly discussed using a simple elliptic partial differential equation (PDE) valid for DC geoelectrics. Parabolic PDEs (transient electromagnetics and magnetotellurics) are also treated to address a wider range of geophysical applications. The subject is deepened by computer exercises and programming simple problems in Matlab.		
Literature:	Mostly articles from geophysical journals		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Knowledge in Experimental Physics, Theoretical Physics, Mathematics, Numerics, Partial Differential Equations, and Geophysics		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP: Solution of Exercises		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP: Lösung von Übungsaufgaben		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: Solution of Exercises [w: 1]		
Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies.		

Data:	PARCOMP. MA. Nr. 502 / Examination number: 11002	Version: 10.05.2021	Start Year: SoSe 2015
Module Name:	**Parallel Computing**		
(English):			
Responsible:	Rheinbach, Oliver / Prof. Dr. Aland, Sebastian / Prof. Dr.		
Lecturer(s):	Rheinbach, Oliver / Prof. Dr.		
Institute(s):	Institute of Numerical Mathematics and Optimization		
Duration:	1 Semester(s)		
Competencies:	Students understand basic concepts in parallel scientific computing to distribute work on shared and distributed memory systems. They can apply these concepts to develop and implement efficient parallel algorithms for a given problem. They can evaluate the parallel efficiency and performance. The students know relevant terms in English.		
Contents:	The fastest supercomputers today are massively parallel systems with distributed memory and millions of cores. Small parallel computers from standard components are successfully being used even by companies of small or medium size. The explosion of the number of cores has also further increased the significance of shared memory computing. This course covers theoretical and practical knowledge of parallel scientific programming and computing. Topics may cover architectures, parallel algorithms, standards such as MPI and OpenMP, software libraries, and the solution of sparse linear systems. Such systems, e.g., arise from the application of the finite elements method for partial differential equations. International literature and relevant terms in English.		
Literature:	William Gropp, Ewing Lusk, Anthony Skjellum, Using MPI: Portable Parallel Programming with the Message-Passing Interface, MIT press, 2000 Anne Greenbaum, Iterative Methods for Solving Linear Systems, SIAM, 1997 Michael Quinn, Parallel Programming in C with MPI and OpenMP, McGraw-Hill, 2003 Ananth Grama, Anshul Gupta, George Karypis, Introduction to Parallel Computing: Design and Analysis of Algorithms, Addison-Wesley, 2nd ed. 2003		
Types of Teaching:	S1 (SS): In the summer semester in odd-numbered years / Lectures (3 SWS) S1 (SS): In the summer semester in odd-numbered years / Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Solid knowledge in numerical mathematics and computer programming (loops, functions/methods, pointers, object orientation)		
Frequency:	every 2 years in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		

Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies. The self-studies consist of 45 h individual computer project and preparation and repetition for/of lectures and tutorials as well as the preparation for the exam.

Data:	RANGRA. MA. Nr. / Examination number: 12502	Version: 28.04.2025	Start Year: SoSe 2027
Module Name:	**Random Graphs**		
(English):	Random Graphs		
Responsible:	Brause, Christoph / Dr. Sprungk, Björn / Prof. Dr.		
Lecturer(s):	Brause, Christoph / Dr.		
Institute(s):	Institute of Stochastics		
Duration:	1 Semester(s)		
Competencies:	At the end of the module students are able • to describe important models and methods for random graphs, • to explain how probabilistic local rules in such random graph models influence their global properties, and • to understand the connections and implications to graph theory as well as to real-world networks.		
Contents:	• Real-world network examples • Probabilistic methods • Branching processes • Erdös-Rényi random graph • Configuration model • Preferential attachment model		
Literature:	R. van der Hofstad: Random Graphs and Complex Networks, Volume 1, Cambridge University Press, 2016 A. Frieze, M. Karonski: Introduction to Random Graphs, Cambridge University Press, 2015.		
Types of Teaching:	S1 (SS): Random Graphs - in odd-numbered years / Lectures (2 SWS) S1 (SS): Random Graphs - in odd-numbered years / Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Stochastik für Mathematiker, 2021-05-10 Intermediate knowledge of stochastics and basic knowledge of combinatorics and graph theory.		
Frequency:	every 2 years in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.		

Data:	SCP MA. / Examination number: 10915	Version: 14.10.2021	Start Year: WiSe 2022
Module Name:	**Scientific Computing Project**		
(English):			
Responsible:	Rheinbach, Oliver / Prof. Dr. Aland, Sebastian / Prof. Dr.		
Lecturer(s):	Rheinbach, Oliver / Prof. Dr. Aland, Sebastian / Prof. Dr.		
Institute(s):	Institute of Numerical Mathematics and Optimization		
Duration:	1 Semester(s)		
Competencies:	The students will be able to • understand an algorithm from Scientific Computing in all details, • implement this algorithm efficiently and test the implementation for correctness and efficiency, • present the algorithm, its implementation and its properties, • organize the team work in the project.		
Contents:	The problem and methods will be provided at the beginning of the course.		
Literature:	Will depend on the problem and method.		
Types of Teaching:	S1 (WS): Seminar (3 SWS)		
Pre-requisites:	**Recommendations:** Programming experience.		
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP: Presentation of the algorithm and implementation [45 min] PVL: Notes of the presentation as PDF or in paper PVL have to be satisfied before the examination.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP: Präsentation des Algorithmus und Umsetzung [45 min] PVL: Präsentationsunterlagen mit Erläuterungen PVL müssen vor Prüfungsantritt erfüllt sein bzw. nachgewiesen werden.		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: Presentation of the algorithm and implementation [w: 1]		
Workload:	The workload is 180h. It is the result of 45h attendance and 135h self-studies. The self-study inclus the implementation of the algotithm, the preparing fot the presentation including the notes.		

Data:	AOT2 MA. / Examination number: 10728	Version: 04.05.2021	Start Year: SoSe 2023
Module Name:	**Selected Topics in Applied Operator Theory**		
(English):			
Responsible:	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Waurick, Marcus / Prof. Dr.		
Lecturer(s):	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Waurick, Marcus / Prof. Dr.		
Institute(s):	Institute of Applied Analysis		
Duration:	1 Semester(s)		
Competencies:	Die Studierenden beherrschen das sichere Anwenden der Grundlagen der Analysis und Beweisen tiefer Resultate im operatortheoretischen Kontext. Students are able to apply basic results of analysis and to prove deep results in operator theoretic contexts.		
Contents:	Ein Anwendungsthema aus der Operatortheorie, wie zum Beispiel C_0-Halbgruppen, von Neumann algebren, Stabilitätstheorie partieller Differentialgleichungen. An applied topic from operator theory such as C_0-semigroups, von Neumann algebras, stability theory for partial differential equations.		
Literature:	Reed, Simon: Methods of modern mathematical Physics Dunford, Schwartz: Linear Operators Kato: Perturbation Theory for Linear Operators Engel, Nagel: One-Parameter Semigroups for Linear Evolution Equations Werner: Funktionalanalysis		
Types of Teaching:	S1 (SS): In odd-numbered years. / Lectures (2 SWS) S1 (SS): In odd-numbered years. / Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Analysis 4 (Funktionalanalysis), 2021-05-04 Funktionentheorie, 2021-05-04		
Frequency:	every 2 years in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.		

Data:	PDE2 MA. / Examination number: 10729	Version: 04.05.2021	Start Year: SoSe 2022
Module Name:	**Selected Topics in Partial Differential Equations**		
(English):			
Responsible:	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Waurick, Marcus / Prof. Dr.		
Lecturer(s):	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. Dr. Waurick, Marcus / Prof. Dr.		
Institute(s):	Institute of Applied Analysis		
Duration:	1 Semester(s)		
Competencies:	Die Studierenden lernen und verstehen Denkweisen, Methoden und Algorithmen der Theorie partieller Differentialgleichungen. Sie können die Methoden und Algorithmen selbstständig auf komplexe Aufgabenstellungen und Forschungsthemen anwenden und weiterentwickeln. Students learn and understand thought processes, methods and algorthims in the theory of partial differential equations. They are able to apply the methods and algorithms to complex tasks and research topics independently and they are able to develop them further.		
Contents:	Speziellen Themen wie elliptische, parabolische und/oder hyperbolische Differentialgleichungen, evolutionäre Gleichungen oder Halbgruppenmethoden. Particular Topics as for instance elliptic, paraboilc and/or hyperbolic differential equations, evolutionary equations or semigroup methods		
Literature:	Evans: Partial Differential Equations Gilbarg, Trudinger: Elliptic Partial Differential Equations of Second Order Picard, McGhee: Partial Differential Equations – A Hilbert space approach		
Types of Teaching:	S1 (SS): Lectures (2 SWS) S1 (SS): Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Basics in Partial Differential Equations, 2021-05-04		
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.		

Data:	SMFDRS / Examination number: 12308	Version: 28.04.2026	Start Year: WiSe 2026
Module Name:	**Seminar Mathematical Fundamentals for Data and Resource Science**		
(English):	Seminar Mathematical Fundamentals for Data and Resource Science		
Responsible:	Sprungk, Björn / Prof. Dr.		
Lecturer(s):	Bernstein, Swanhild / Prof. Dr. Rheinbach, Oliver / Prof. Dr. Starkloff, Hans-Jörg / Prof. Dr. Sprungk, Björn / Prof. Dr. Schneider, Friedrich Martin / Prof. Dr. Waurick, Marcus / Prof. Dr. Aland, Sebastian / Prof. Dr. Hielscher, Ralf / Prof. Carmesin, Johannes / Prof.		
Institute(s):	Institute of Applied Analysis Institute of Numerical Mathematics and Optimization Institute of Stochastics Institute of Discrete Mathematics and Algebra		
Duration:	1 Semester(s)		
Competencies:	Students are able to familiarize themselves with advanced abstract concepts of the mathematical foundations of data and resoure science. They are able to gain understanding of the topic and deliver a seminar presentation in a clearly structured way with mathematical precision and rigour. They can argue convincingly during a discussion of the topic.		
Contents:	The topics for the presentations will be assigned by the advisors in the fields of algebra, analysis, stochastics and numerical mathematics. In terms of content, the topics should be designed to broaden and deepen students’ knowledge in the mathematical fundamentals required in data and resource science		
Literature:	This is determined by the advisors; examples include monographs or journal articles.		
Types of Teaching:	S1 (WS): Seminar (3 SWS)		
Pre-requisites:			
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP: Seminar presentation [30 to 45 min] PVL: Active discussion of the presentations PVL have to be satisfied before the examination.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: AP: Seminarvortrag [30 bis 45 min] PVL: Diskussionsbeiträge zu den Vorträgen PVL müssen vor Prüfungsantritt erfüllt sein bzw. nachgewiesen werden.		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: Seminar presentation [w: 1]		
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.		

Data:	SMD MA. / Examination number: 12402	Version: 06.08.2021	Start Year: WiSe
Module Name:	**Seminar Mathematics for Data and Resource Sciences**		
(English):	Seminar Mathematics for Data and Resource Sciences		
Responsible:	Waurick, Marcus / Prof. Dr.		
Lecturer(s):			
Institute(s):	Institute of Applied Analysis		
Duration:	1 Semester(s)		
Competencies:	The students should be able to identify relevant literature for a given mathematical topic. They learn methods and apply techniques to present and argue with high mathematical precission. They provide a clearly structured talk and discuss its mathematical contents with others. The student provide a script for their talk outlining the mathematical details showing their argumentation skills in logically sound mathematical writing.		
Contents:	The students choose one of the proposed mathematical subjects at an appropriate level. It is possible to use the research as a basis for their master's thesis.		
Literature:	Literature recommendations will be provided by the supervisor.		
Types of Teaching:	S1 (WS): Seminar (2 SWS)		
Pre-requisites:			
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP*: Scientific Talk [30 min] AP*: Seminararbeit * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP*: Wissenschaftlicher Vortrag [30 min] AP*: Seminar Thesis * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP*: Scientific Talk [w: 1] AP*: Seminararbeit [w: 1] * In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.		
Workload:	The workload is 180h.		

Data:	STADS MA. 3221 / Examination number: 12306	Version: 27.04.2026	Start Year: WiSe 2026
Module Name:	**Statistical Foundations of Data Science**		
(English):	Statistical Foundations of Data Science		
Responsible:	Sprungk, Björn / Prof. Dr.		
Lecturer(s):	Sprungk, Björn / Prof. Dr.		
Institute(s):	Institute of Stochastics		
Duration:	1 Semester(s)		
Competencies:	Students understand fundamental concepts of probability, can translate real-world problems into probabilistic models, and make probabilistic predictions. They are able to describe and interpret key statistical quantities and apply core statistical methods to analyze data. Furthermore, they understand statistical models and can critically apply methods of statistical inference using scientific software.		
Contents:	• Fundamentals of probability theory (e.g., random variables, conditioning, distributions, limit theorems) • Descriptive statistics (empirical characteristics and statistical graphics) • Statistical inference (parameter estimation, hypothesis testing) • Linear models and regression analysis		
Literature:	• D. Montgomery, G. C. Runger: *Introduction to Probability and Statistics for Data Science*. Cambridge University Press, 2025. • S. Ross: *A First Course in Probability*, Pearson, 2019. • M. Kaptein , E. van den Heuvel: *Statistics for Data Scientists*, Springer, 2022		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Exercises (1 SWS)		
Pre-requisites:			
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: KA: Written exam [120 min] PVL: Programming Project PVL have to be satisfied before the examination.		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: KA: Klausur [120 min] PVL: Programmierprojekt PVL müssen vor Prüfungsantritt erfüllt sein bzw. nachgewiesen werden.		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): KA: Written exam [w: 1]		
Workload:	The workload is 150h. It is the result of 45h attendance and 105h self-studies.		

Daten:	STATANS. MA. Nr. 3040 / Prüfungs-Nr.: 11708	Stand: 22.11.2021	Start: SoSe 2010
Modulname:	**Statistische Analyse von Systemen**		
(englisch):	Statistical Analysis of Systems		
Verantwortlich(e):	van den Boogaart, Gerald / Prof. Dr.		
Dozent(en):	van den Boogaart, Gerald / Prof. Dr.		
Institut(e):	Institut für Stochastik		
Dauer:	1 Semester		
Qualifikationsziele / Kompetenzen:	Die Studenten sollen stochastische Grundmodelle für räumlich und zeitlich erstreckte Systeme kennen lernen und in die Lage versetzt werden, entsprechende Modelle aufzubauen, im Computer zu simulieren und entsprechende reale Daten am Computer im Hinblick auf solche Modelle statistisch zu analysieren. The students learn basic models for spatial, temporal and spatiotemporal systems. They gain the ability to identify applicable models for real situations, to simulated such models in a computer and to analyse observational data from such models statistically.		
Inhalte:	Stochastische Prozesse als Modelle für natürliche Vorgänge und Landschaften, Grundbegriffe der Zeitreihenanalyse, periodische Trends, Grundlagen der stochastischen Differentialgleichungen, Modelle für zufällige dynamische Systeme, stochastische Simulation, Sensitivitätsanalyse, zusammenfassende Statistiken und Fehlerrechnung mit abhängigen Daten, Parameterschätzung in dynamischen Systemen, statistische Tests bei abhängigen Daten und in Prozessmodellen, Beispiele für stochastische Ökosystemmodelle. Die entsprechenden Methoden werden in der Übung praktisch am Computer mit R geübt. The lecture introduces stochastic processes models for natural processes and objects: Dynamic Systems (Ordinary and stochastic differential equations), point process models, geostatistical models, models of random movements, Models for temporal and spatiotemporal dynamic Systems. For these models the lecture introduces application relevant methods including stochastic simulation, Sensitivity Analysis, Estimation procedures (like KQ and RML), model identification methods, and relevant graphics. The methods are trained practically in the exercises with the statistical software R.		
Typische Fachliteratur:	Robert H. Shumway, David S. Stoffer (2006) Time Series Analysis and Its Applications: With R Examples Stefano M. Iacus (2008) Simulation and Inference for Stochastic Differential Equations: With R Examples, Noel Cressie (1993) Spatial Statistics, Teil I		
Lehrformen:	S1 (SS): [(*) Das Modul kann auch in englischer Sprache abgehalten werden. Die Bekanntgabe erfolgt zu Semesterbeginn.] / Vorlesung (2 SWS) S1 (SS): Computerübung - (*) / Übung (2 SWS)		
Voraussetzungen für die Teilnahme:	**Empfohlen:** Kenntnisse in der angewandten Statistik (z.B. aus Datenanalyse und Statistik), Umgang mit Geodaten (z.B. aus Modul Geodatenanalyse), Kenntnisse der höheren Mathematik, insbesondere mehrdimensionale Funktionen und Differentialgleichungen (z.B. aus Höhere Mathematik 2), Grundkenntnisse R (z.B. aus Datenanalyse und Statistik)		
Turnus:	jährlich im Sommersemester		
Voraussetzungen für die Vergabe von	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst:		

Leistungspunkten:	MP [25 min]
Leistungspunkte:	6
Note:	Die Note ergibt sich entsprechend der Gewichtung (w) aus folgenden(r) Prüfungsleistung(en): MP [w: 1]
Arbeitsaufwand:	Der Zeitaufwand beträgt 180h und setzt sich zusammen aus 60h Präsenzzeit und 120h Selbststudium.

Daten:	STOPR. BA. Nr. 463 / Prüfungs-Nr.: 12110	Stand: 10.03.2026	Start: WiSe 2026
Modulname:	**Stochastic Processes**		
(englisch):	Stochastic Processes		
Verantwortlich(e):	Starkloff, Hans-Jörg / Prof. Dr.		
Dozent(en):	Starkloff, Hans-Jörg / Prof. Dr.		
Institut(e):	Institut für Stochastik		
Dauer:	1 Semester		
Qualifikationsziele / Kompetenzen:	Die Studierenden verstehen grundlegende Konzepte der Theorie der stochastischen Prozesse. Sie besitzen die Fähigkeit, für die betrachteten Klassen von stochastischen Prozessen Probleme zu analysieren und zu lösen oder Kenngrößen zu berechnen. Students understand the fundamental concepts of stochastic process theory. They are able to analyze and solve problems or calculate parameters for the classes of stochastic processes under consideration.		
Inhalte:	Es werden Grundlagen der Theorie der stochastischen Prozesse vermittelt. Dazu gehören: grundlegende Definitionen, Beispiele, Elemente der Analysis für Zufallsfunktionen, Zufallsfunktionen zweiter Ordnung, stationäre Prozesse und Markow-Ketten. This course covers the fundamentals of the theory of stochastic processes. Topics include: basic definitions, examples, elements of analysis for random functions, second-order random functions, stationary processes, and Markov chains.		
Typische Fachliteratur:	Wentzell: Theorie zufälliger Prozesse, Akademie-Verlag 1979 Mürmann: Wahrscheinlichkeitstheorie und stochastische Prozesse, Springer 2014 Klenke: Wahrscheinlichkeitstheorie, Springer 2020		
Lehrformen:	S1 (WS): In even-numbered years / Vorlesung (3 SWS) S1 (WS): In even-numbered years / Übung (1 SWS)		
Voraussetzungen für die Teilnahme:	**Empfohlen:** Stochastik für Mathematiker, 2009-05-25		
Turnus:	alle 2 Jahre im Wintersemester		
Voraussetzungen für die Vergabe von Leistungspunkten:	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Leistungspunkte:	6		
Note:	Die Note ergibt sich entsprechend der Gewichtung (w) aus folgenden(r) Prüfungsleistung(en): MP [w: 1]		
Arbeitsaufwand:	Der Zeitaufwand beträgt 180h und setzt sich zusammen aus 60h Präsenzzeit und 120h Selbststudium.		

Data:	UnOP. MA. Nr. 459 / Examination number: 12204	Version: 18.03.2022	Start Year: SoSe 2018
Module Name:	**Stochastic Programming**		
(English):	Stochastic Programming		
Responsible:	Heyde, Frank / PD Dr.		
Lecturer(s):	Heyde, Frank / PD Dr.		
Institute(s):	Institute of Numerical Mathematics and Optimization		
Duration:	1 Semester(s)		
Competencies:	The students get to know basic concepts and methods of stochastic optimization. Moreover, the students are empowerd to formulate analytical models with quantified uncertainties as stochastic optimization problems and to apply suitable solution techniques to these problems. (Die Studierenden lernen grundlegende Konzepte und Methoden der stochastischen Optimierung kennen. Ferner werden die Studierenden befähigt, analytische Modelle mit quantifizierten Unsicherheiten als stochastische Optimierungsaufgaben zu formulieren und geeignete Lösungstechniken auf diese Aufgaben anzuwenden.)		
Contents:	The following topics, among others, are covered (Es werden unter anderem folgende Themen behandelt): - modeling uncertainty (Modellierung von Unsicherheit) - optimization problems with probabilistic constraints (Optimierung mit probabilistischen Nebenbedingungen) - two-stage and multi-stage problems with recourse (Zwei- und mehrstufige Probleme mit Rückgriff) - decomposition methods for stochastic optimization problems (Dekompositionsmethoden für stochastische Optimierungsaufgaben) - risk-averse stochastic optimization models (Risikoaverse stochastische Optimierungssmodelle)		
Literature:	A. Shapiro, D. Dentcheva, A. Ruszczynski: Lectures on Stochastic Programming: Modeling and Theory. SIAM, 2009 J. R. Birge, F. Louveaux: Introduction to Stochastic Programming. Springer, 2011 P. Kall, J: Mayer: Stochastic Linear Programming. Springer, 2011		
Types of Teaching:	S1 (SS): every 2 years in the summer semester / Lectures (3 SWS) S1 (SS): every 2 years in the summer semester / Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Optimierung für Mathematiker, 2015-03-10 Stochastik für Mathematiker, 2021-05-10		
Frequency:	every 2 years in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies.		

Daten:	TÖP MA. / Prüfungs-Nr.: 11616	Stand: 03.06.2026	Start: SoSe 2022
Modulname:	**Techno-Ökologisches Projekt**		
(englisch):	Techno-Ecological Project		
Verantwortlich(e):	Zug, Sebastian / Prof. Dr. Sprungk, Björn / Prof. Dr. Lau, Maximilian / Prof. Jackisch, Conrad / Prof. Kupsch, Christian / Jun.-Prof. Dr.-Ing.		
Dozent(en):	Zug, Sebastian / Prof. Dr. Sprungk, Björn / Prof. Dr. Lau, Maximilian / Prof. Jackisch, Conrad / Prof. Kupsch, Christian / Jun.-Prof. Dr.-Ing.		
Institut(e):	Institut für Informatik Institut für Stochastik Institut für Mineralogie Institut für Bohrtechnik und Fluidbergbau Institut für Maschinenbau		
Dauer:	1 Semester		
Qualifikationsziele / Kompetenzen:	Durch ganzheitliche Bearbeitung einer realistischen techno-ökologischen Fragestellung erlernen Studierende interdisziplinäres Arbeiten und Kommunizieren. Sie sind in der Lage, komplexe Aufgaben sinnvoll zu gliedern, aufzuteilen, eigene Teilbereiche zu bearbeiten, Ergebnisse zu präsentieren und im interdisziplinären Kontext zu begründen. Studierende entwickeln die Kreativität und (Daten-)kompetenz um Lösungswege für komplexe Probleme zu finden. Nach Abschluss des Moduls sind Studierende in der Lage, durch Einnehmen einer forschenden Haltung zukünftige Projekte fragend-entwickelnd und kritisch-reflektierend durchzuführen. By taking a holistic approach to a realistic techno-ecological problem, students learn to work and communicate across disciplines. They are able to structure and divide complex tasks effectively, work on their own specific areas, present their findings, and justify their conclusions within an interdisciplinary context. Students develop the creativity and (data) literacy needed to find solutions to complex problems. Upon completion of the module, students will be able to carry out future projects in an inquiring, developmental, and critically reflective manner by adopting a research-oriented approach.		
Inhalte:	Das Modul richtet sich an alle Studierende im Hauptstudium/Master der Natur- und Ingenieurwissenschaften. Das Praktikum setzt eine realitätsnahe Aufgabenstellung an der Schnittstelle von (Mess-)technik, Informationsverarbeitung, Umwelt und Gesellschaft. Die Aufgabe wird von interdisziplinären Teams bearbeitet. Es wird ein Einstieg in interdisziplinärer Kommunikation und Projektmanagement gegeben. Fachliche Hintergründe werden entsprechend der Aufgabenstellung erklärt und in Kontext gesetzt. Praktische Arbeiten werden im Sinne eines „forschenden Lernens“ („open inquiry“) durch die Studierenden strukturiert und organisiert. Eine fachliche Begleitung erfolgt dabei nach Bedarf (um das Aktivitätsniveau der Studierenden mehr aktiv als rezeptiv zu gestalten). Das Modul kann auch in englischer Sprache abgehalten werden. Die Bekanntgabe erfolgt zu Semesterbeginn.		

	This module is intended for all students in the advanced/master’s phase of their studies in the natural and engineering sciences. The practicum involves a real-world problem at the intersection of (measurement) technology, information processing, environment, and society. The problem is addressed by interdisciplinary teams. An introduction to interdisciplinary communication and project management is provided. Technical background information is explained and contextualized in accordance with the problem at hand. Practical work is structured and organized by the students in the spirit of “inquiry-based learning” (“open inquiry”). Faculty guidance is provided as needed (to ensure that students’ engagement is more active than receptive).
Typische Fachliteratur:	Wird jeweils zum Thema zu Semesterbeginn von den Betreuenden festgelegt. / The topic is determined by the instructors at the start of each semester.
Lehrformen:	S1 (SS): [(*) Das Modul kann auch in englischer Sprache abgehalten werden. Die Bekanntgabe erfolgt zu Semesterbeginn.] / Vorlesung (1 SWS) S1 (SS): (*) / Seminar (1 SWS) S1 (SS): (*) / Praktikum (1 SWS)
Voraussetzungen für die Teilnahme:	**Empfohlen:** Die grundlegenden Bereiche der ingenieurtechnischen, informatischen oder geoökologischen Ausbildung sollten bereits absolviert sein.
Turnus:	jährlich im Sommersemester
Voraussetzungen für die Vergabe von Leistungspunkten:	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP*: Individuelle Vorstellung des Projektarbeitsstandes mit einem Vortrag AP*: Gemeinsamer schriftlicher Bericht zum Projekt (Beleg, max. 20 Seiten) * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.
Leistungspunkte:	5
Note:	Die Note ergibt sich entsprechend der Gewichtung (w) aus folgenden(r) Prüfungsleistung(en): MP*: Individuelle Vorstellung des Projektarbeitsstandes mit einem Vortrag [w: 2] AP*: Gemeinsamer schriftlicher Bericht zum Projekt (Beleg, max. 20 Seiten) [w: 3] * Bei Modulen mit mehreren Prüfungsleistungen muss diese Prüfungsleistung bestanden bzw. mit mindestens "ausreichend" (4,0) bewertet sein.
Arbeitsaufwand:	Der Zeitaufwand beträgt 150h. Er setzt sich aus 45h Präsenzzeit und 105h eigenständiger Projektarbeit nach vorheriger Anleitung im Seminar bzw. im begleiteten Praktikum zusammen.

Data:	THEM. Ma. / Examination number: 35602	Version: 05.02.2021	Start Year: SoSe
Module Name:	**Theory of Electromagnetic Methods**		
(English):			
Responsible:	Börner, Ralph-Uwe / Dr.		
Lecturer(s):	Börner, Ralph-Uwe / Dr.		
Institute(s):	Institute of Geophysics and Geoinformatics		
Duration:	1 Semester(s)		
Competencies:	The students get an introduction to the theory of electromagnetic methods with the emphasis on geophysical applications. They acquire the skills and capabilities to understand the theoretical principles of geoelectromagnetic applications and are able to establish the link between theory and practice.		
Contents:	The lecture on the theory of electromagnetic methods provides the necessary expertise which enables the students to interpret data obtained by geoelectromagnetic applications operating in the frequency and time domain. On the basis of Maxwell's equations, the students first learn to formulate the mathematical problem of the electromagnetic plane-wave and dipole induction in full-space and over a stratified ground using a vector potential approach. Further, the students acquire the basic knowledge of integral transforms and their numerical implementation to evaluate Hankel integrals typically arising in dipole induction applications. During the practical exercises the students implement numerical routines in Julia or MATLAB to solve simple simulation problems.		
Literature:	Nabighian: Electromagnetic Methods in Applied Geophysics, Vol. 1		
Types of Teaching:	S1 (SS): Lectures (2 SWS) S1 (SS): Exercises (1 SWS)		
Pre-requisites:			
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	4		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 120h. It is the result of 45h attendance and 75h self-studies.		

Data:	POTTH MA Nr. 3695 / Examination number: 32903	Version: 05.02.2021	Start Year: WiSe 2020
Module Name:	**Theory of Potential Methods**		
(English):			
Responsible:	Börner, Ralph-Uwe / Dr.		
Lecturer(s):			
Institute(s):	Institute of Geophysics and Geoinformatics		
Duration:	1 Semester(s)		
Competencies:	The students understand the fundamental theory of potential methods, implement gravity and geomagnetic applications, and are able to establish the link between theory and practice.		
Contents:	The lecture on potential theory provides an introduction to potential fields arising, e.g., in gravity, magnetics and resistivity methods. Departing from a basic understanding of the potential of a point source, elaborated density distributions are introduced. Potential distributions caused by non-trivial two- and three-dimensional sources are studied. An extensive introduction to spherical harmonics will be provided with a focus on Earth's magnetic field. The theory of boundary value problems will be studied on the basis of the Poisson problem arising in DC resistivity applications. During the exercises the students are instructed to implement Julia and MATLAB routines to solve numerical simulation problems.		
Literature:	Blakely: Potential Theory in Gravity & Magnetic Applications		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Exercises (1 SWS)		
Pre-requisites:			
Frequency:	yearly in the winter semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	4		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 120h. It is the result of 45h attendance and 75h self-studies.		

Data:	TOPDATA. MA. Nr. 471 / Examination number: 10108	Version: 02.07.2024	Start Year: SoSe 2021
Module Name:	**Topological Data Analysis**		
(English):			
Responsible:	Schneider, Friedrich Martin / Prof. Dr.		
Lecturer(s):	Schneider, Friedrich Martin / Prof. Dr.		
Institute(s):	Institute of Discrete Mathematics and Algebra		
Duration:	1 Semester(s)		
Competencies:	Die Studierenden verstehen grundlegende Konzepte der algebraischen Topologie und der homologischen Algebra. Sie besitzen die Fähigkeit, topologische und algebraische Methoden in der Datenanalyse anzuwenden. Students understand fundamental concepts of algebraic topology and homological algebra and acquire the ability to use topological and algebraic methods for data analysis.		
Contents:	Das Modul bietet eine Einführung in das Gebiet der Topologischen Datenanalyse und behandelt dabei insbesondere Filtrationen simplizialer Komplexe (zur Abbildung von Daten), Persistenzmoduln, persistente Homologie, Barcodes und Persistenzdiagramme, sowie die Stabilität dieser Objekte (gegen Störungen der Input-Daten). The module provides an introduction to Topological Data Analysis, comprising filtrations of simplicial complexes, persistence modules, persistent homology, barcodes and persistent diagrams, as well as stability criteria.		
Literature:	Carlsson G.: Topology and Data, Bulletin of the American Mathematical Society 46 (2009), no. 2, pp. 255–308. Chazal, F., de Silva, V., Glisse, M., Oudot, S.: The Structure and Stability of Persistence Modules, Springer, 2016. Ghrist, R.W.: Elementary Applied Topology, ed. 1.0, CreateSpace, 2014. Edelsbrunner, H., Harer, J. L.: Computational Topology: An Introduction, AMS Press, 2010. Oudot, S. Y.: Persistence Theory: From Quiver Representations to Data Analysis, AMS Press, 2015.		
Types of Teaching:	S1 (SS): Lectures (2 SWS) S1 (SS): Exercises (1 SWS)		
Pre-requisites:	**Recommendations:** Grundlagen der Diskreten Mathematik und Algebra 1, 2021-05-03 Grundlagen der Diskreten Mathematik und Algebra 2, 2021-05-03 Lineare Algebra 1, 2021-05-03 Lineare Algebra 2, 2021-05-03		
Frequency:	yearly in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 180h. It is the result of 45h attendance and 135h self-studies.		

Data:	VEOPT. MA. Nr. 3655 / Examination number: 12203	Version: 22.11.2021	Start Year: SoSe 2019
Module Name:	**Vector Optimization**		
(English):	Vector Optimization		
Responsible:	Heyde, Frank / PD Dr.		
Lecturer(s):	Heyde, Frank / PD Dr.		
Institute(s):	Institute of Numerical Mathematics and Optimization		
Duration:	1 Semester(s)		
Competencies:	The students grasp the basic principles and techniques of vector optimization. Moreover, the students are able to model relevant problems from practice as vector optimization problems and apply suitable methods to solve them. (Die Studierenden beherrschen grundlegende Prinzipien und Techniken der Vektoroptimierung. Außerdem sind die Studierenden nach Abschluss des Moduls in der Lage, Anwendungsprobleme als Vektoroptimierungsprobleme zu modellieren sowie geeignete Methoden zur Lösung dieser Probleme anzuwenden.)		
Contents:	The following topics are covered, among others (Es werden unter anderem folgende Themen behandelt): - partial orders and cones (Halbordnungen und Kegel) - optimality notions in partially ordered sets (Optimalitätsbegriffe in halbgeordneten Räumen) - concepts of scalarization (Skalarisierungskonzepte) - optimality conditions for vector optimization problems (Optimalitätsbedingungen für Vektoroptimierungsprobleme) - relations between vector- and set-valued optimization (Zusammenhang zwischen Vektor- und Mengenoptimierung)		
Literature:	J. Jahn; Vector Optimization: Theory, Applications, and Extensions; Springer, 2004 M. Ehrgott; Multicriteria Optimization; Springer, 2005 A. Löhne: Vector Optimization with Infimum and Supremum; Springer, 2011		
Types of Teaching:	S1 (SS): [(*) The module can also be held in German. The announcement will be made at the beginning of the semester.] In the summer semester of odd-numbered years / Lectures (2 SWS) S1 (SS): (*) - In the summer semester of odd-numbered years / Exercises (2 SWS)		
Pre-requisites:	**Recommendations:** Optimierung für Mathematiker, 2015-03-10		
Frequency:	every 2 years in the summer semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: MP [30 min]		
	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Credit Points:	6		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1]		
Workload:	The workload is 180h. It is the result of 60h attendance and 120h self-studies.		

Daten:	WAVE. MA. Nr. 900 / Prüfungs-Nr.: 10709	Stand: 13.12.2022	Start: SoSe 2019
Modulname:	**Wavelets**		
(englisch):	Wavelets		
Verantwortlich(e):	Bernstein, Swanhild / Prof. Dr.		
Dozent(en):	Bernstein, Swanhild / Prof. Dr.		
Institut(e):	Institut für Angewandte Analysis		
Dauer:	1 Semester		
Qualifikationsziele / Kompetenzen:	Die Studierenden sollen die grundlegenden Eigenschaften, Gemeinsamkeiten und Unterschiede von Kurzzeit-Fouriertransformation und Wavelets kennen und bei konkreten Anwendungen die Vor- bzw. Nachteile der Methoden abschätzen können. Students should know the basic properties, similarities and differences of short-time Fourier transforms and wavelets and be able to assess the advantages and disadvantages of the methods in concrete applications.		
Inhalte:	Inhalt des Moduls sind verschiedene Wavelets, die Konstruktion einer Multiresolutionanalysis sowie Frames. Speziell werden behandelt (Contents of this module are different wavelets, the construction of a multiresolution analysis and frames. Specifically covered are): • Haar-Wavelets (Haar wavelets) • Haar-Multiresolutionanalysis (Haar multiresolution analysis) • Diskrete Haar-Transformation (Discrete Haar transform) • Allgemeine Multiresolutionanalysis (General multiresolution analysis) • Konstruktion von Wavelets im Fourierbereich (Construction of wavelets in the Fourier domain) • Daubechies-Wavelets (Daubechies wavelets) • Kaskaden-Algorithmus (Cascade Algorithm) • Bi-orthogonale Wavelets (Bi-orthogonal wavelets) • Frames (Frames)		
Typische Fachliteratur:	D.K. Ruch, P.J. van Fleet, Wavelet Theory: An Elementary Approach with Applications, Wiley, John Wiley & Sons, Inc., 2009, M.A. Pinsky, Introduction to Fourier Analysis and Wavelets, Graduate Studies in Mathematics, Volume 102, American Mathematical Society, 2002, C. Blatter, Wavelets -- Eine Einführung, Vieweg, 2003, W. Bäni: Wavelets, Eine Einführung für Ingenieure, Oldenbourg-Verlag, 2002.		
Lehrformen:	S1 (SS): [(*) Das Modul kann auch in englischer Sprache abgehalten werden. Die Bekanntgabe erfolgt zu Semesterbeginn.] - In geraden Jahren. / Vorlesung (3 SWS) S1 (SS): (*) - In geraden Jahren. / Übung (1 SWS)		
Voraussetzungen für die Teilnahme:	**Empfohlen:** Analysis 3, 2015-04-07 Mathematik für Ingenieure 1 (Analysis 1 und lineare Algebra), 2020-02-07 Analysis 2, 2021-04-21 Mathematik für Ingenieure 2 (Analysis 2), 2020-02-07		
Turnus:	alle 2 Jahre im Sommersemester		
Voraussetzungen für die Vergabe von Leistungspunkten:	Voraussetzung für die Vergabe von Leistungspunkten ist das Bestehen der Modulprüfung. Die Modulprüfung umfasst: MP [30 min]		
Leistungspunkte:	6		

Note:	Die Note ergibt sich entsprechend der Gewichtung (w) aus folgenden(r) Prüfungsleistung(en): MP [w: 1]
Arbeitsaufwand:	Der Zeitaufwand beträgt 180h und setzt sich zusammen aus 60h Präsenzzeit und 120h Selbststudium.

Herausgeber: Die Rektorin der TU Bergakademie Freiberg
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