Faculty of Mathematics and Computer Science (Faculty 1)

Data:	FUTHEO2 MA. / Examination number: 10722	Version: 04.05.2021	Start Year: SoSe 2022
Module Name:	**Ausgewählte Kapitel der Funktionentheorie**		
(English):	Selected Topics in Complex Analysis		
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 Theorie der Funktionen einer komplexen Veränderlichen 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 the theory of one complex variable. The abilities acquired in this course may serve in furthergoing lectures and student theses.		
Contents:	Es wird ein Überblick zu ausgewählten weiterführenden Themen der Funktionentheorie einer komplexen Veränderlichen gegeben. Mögliche Inhalte sind: Riemannsche Flächen und elliptische Funktionen, Hardy-Räume, Randwertaufgaben für holomorphe Funktionen (Riemann-Hilbert-Probleme), endliche Blaschkeprodukte als hyperbolische Polynome, u.a. Zu Kursbeginn wird in Abhängigkeit von der Zuhörerschaft entschieden, ob der Kurs in Deutsch oder Englisch stattfindet. This course gives an overview of varying topics in complex analysis. Possible subjects include: Riemann surfaces, elliptic functions, Hardy spaces, boundary value problems for holomorphic functions (Riemann-Hilbert problems), finite Blaschke products as hyperbolic polynomials, etc. 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:	Koosis: Introduction to H_p spaces. Schlag: A Course in Complex Analysis and Riemann Surfaces Simon: A comprehensive course in analysis (Bände 2A, 2B) Wegert: Nonlinear Boundary Value Problems for Holomorphic Functions and Singular Integral Equations		
Types of Teaching:	S1 (SS): In even-numbered years. / Lectures (2 SWS) S1 (SS): In even-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]		
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:	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.		
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:	PDE1 MA. / Examination number: 10715	Version: 04.05.2021	Start Year: WiSe 2021
Module Name:	**Grundlagen Partielle Differentialgleichungen**		
(English):	Basics in Partial Differential Equations		
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]		
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:	MEML MA / Examination number: 12303	Version: 10.05.2021	Start Year: SoSe 2023
Module Name:	**Methods in Machine Learning**		
(English):			
Responsible:	Sprungk, Björn / Prof. Dr.		
Lecturer(s):	Sprungk, Björn / Prof. Dr.		
Institute(s):	Faculty of Mathematics and Computer Science		
Duration:	1 Semester(s)		
Competencies:	Students can explain and apply common methods for several learning tasks such as supervised, unsupervised and online learning. In particular, they understand the basic theoretical background of these methods and can choose a suitbale algorithm for specific machine learning problems.		
Contents:	• Clustering methods (linkage-based, k-means, spectral clustering, Gaussian mixture models) • Dimensionality reduction (PCA, compressed sensing) • Online learning • Decision trees • Bayesian 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:	Christopher M. Bishop, Pattern Recognition and Machine Learning, Springer, 2006; Daniela Calvetti and Erkki Sommersalo, Mathematics of Data Science: A Computational Approach to Clustering and Classification, SIAM, 2020; 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		
Types of Teaching:	S1 (SS): Methods in Machine Learning / Lectures (2 SWS) S1 (SS): Methods in Machine Learning / Exercises (1 SWS)		
Pre-requisites:	**Mandatory:** Mathematik des maschinellen Lernens, 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 [30 to 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:	AOT2 MA. / Examination number: 10724	Version: 04.05.2021	Start Year: SoSe 2023
Module Name:	**Ausgewählte Themen der Angewandten Operatortheorie**		
(English):	Selected Topics in Applied Operator Theory		
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]		
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:	INVPROB MA. / Examination number: 10717	Version: 04.05.2021	Start Year: WiSe 2022
Module Name:	**Inverse Probleme**		
(English):	Inverse Problems		
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]		
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:	FOURANA MA. / Examination number: 10710	Version: 05.05.2021	Start Year: WiSe 2023
Module Name:	**Fourieranalysis**		
(English):	Fourier Analysis		
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]		
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:	DIFFGEO MA. / Examination number: 10720	Version: 04.05.2021	Start Year: WiSe 2022
Module Name:	**Differentialgeometrie**		
(English):	Differential Geometry		
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]		
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:	STOMATE. MA. Nr. 3221 / Examination number: 11709	Version: 05.07.2016	Start Year: WiSe 2016
Module Name:	**Stochastic Methods for Materials Science**		
(English):			
Responsible:	van den Boogaart, Gerald / Prof. Dr. Ballani, Felix / Dr. rer. nat.		
Lecturer(s):	van den Boogaart, Gerald / Prof. Dr. Ballani, Felix / Dr. rer. nat.		
Institute(s):	Institute of Stochastics		
Duration:	1 Semester(s)		
Competencies:	The student will understand the role of stochastic modelling and stochastic algorithms for computational material sciences. He/she will learn to select, implement and test stochastic algorithms and models in an applied context.		
Contents:	The lecture introduces examples of stochastic methods of material modeling, analysis and simulations: e.g. models and algorithms for the simulation of random structures (random mosaics, random composites, packing, ...) and random behavior (crack initiation, random loads, random fatigue, ...), statistical and stereological analysis of structural data and EBSD-crystal orientation measurements, Monte-Carle algorithms for material simulation, Markov-Chain-Monte-Carlo/Metropolis-Hastings algorithms for parameter estimation and structure reconstruction.		
Literature:	e.g. Chiu, Stoyan, Kendall, Mecke: Stochastic geometry and its applications, 3rd ed. Wiley, Chichester, 2013		
Types of Teaching:	S1 (WS): Lectures (2 SWS)		
Pre-requisites:	**Recommendations:** Basic knowledge of stochastic, statistic, geometry, continuum mechanics, computer programming, and either crystallography or basic group theory.		
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] AP: Programming Project		
Credit Points:	4		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): MP [w: 1] AP: Programming Project [w: 1]		
Workload:	The workload is 120h. It is the result of 30h attendance and 90h self-studies.		

Data:	PDE2 MA. / Examination number: 10716	Version: 04.05.2021	Start Year: SoSe 2022
Module Name:	**Ausgewählte Themen der Partiellen Differentialgleichungen**		
(English):	Selected Topics in Partial Differential Equations		
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 algorthims in the theory of partial differential equations.		
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:** Grundlagen Partielle Differentialgleichungen, 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]		
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:	ATANA. MA. / Examination number: 10721	Version: 05.05.2021	Start Year: WiSe 2021
Module Name:	**Aktuelle Themen der Analysis**		
(English):	Current topics in analysis		
Responsible:	Bernstein, Swanhild / Prof. Dr. Reissig, Michael / Prof. 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 forschungsbezogene Denkweisen, Methoden und Techniken der Analysis. Damit sind sie in der Lage, die erworbenen Fähigkeiten und Fertigkeiten bei Qualifikationsarbeiten auf dem Gebiet der Analysis anzuwenden. Students learn research-related ways of thinking, methods and techniques of mathematical analysis. These enable them to apply the acquired skills and abilities to qualification thesis in the field of analysis.		
Contents:	Aktuelle Forschungsthemen aus dem Bereich Analysis sollen durch Vorträge, Selbststudium anhand der (englischsprachigen) Originalliteratur wissenschaftlich durchdrungen und in einer Vorlesung dargestellt werden. Current research topics from the field of analysis are to be scientifically elaborated through lectures, self-study using the (English-language) original literature and presented in a lecture.		
Literature:	Aktuelle Publikationen und Monographien aus dem Bereich der Analysis. Recent publications and monographs in the field of analysis.		
Types of Teaching:	S1 (WS): Lectures (2 SWS) S1 (WS): Seminar (1 SWS)		
Pre-requisites:	**Recommendations:** Analysis 4 (Funktionalanalysis), 2021-05-04 Analysis 3 (Gewöhnliche Differentialgleichungen), 2021-05-04		
Frequency:	each semester		
Requirements for Credit Points:	For the award of credit points it is necessary to pass the module exam. The module exam contains: AP: Vortrag (60 min)		
Credit Points:	5		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: Vortrag (60 min) [w: 1]		
Workload:	The workload is 150h. It is the result of 45h attendance and 105h 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]		
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:	PP. MA. Nr. 3215 / Examination number: 44504	Version: 04.07.2018	Start Year: WiSe 2018
Module Name:	**Personal Programming Project**		
(English):			
Responsible:	Kiefer, Björn / Prof. PhD.		
Lecturer(s):	Hütter, Geralf / Dr. Ing. Rheinbach, Oliver / Prof. Dr. Prakash, Aruna / Dr.-Ing.		
Institute(s):	Institute of Mechanics and Fluid Dynamics Institute of Numerical Mathematics and Optimization		
Duration:	22 Week(s)		
Competencies:	The students will develop and document their own software tool for a subject relevant to the course Computational Materials Science (e.g., Dislocation or Molecular Dynamics, Finite Elements Method FEM, Discrete Element Method or advanced data analysis). Furthermore, they will use this method to simulate material behavior, to calculate a physical property or to analyze existing/own simulated data.		
Contents:	Most important ingredients are: Developing the tool, commenting the source file, documentation and running a successful example to verify the code.		
Literature:	None		
Types of Teaching:	S1 (WS): By the end of the second semester, the students decide on a topic. Then, the students design a concept for their project, which has to be discussed and approved by the responsible lecturer. After approval, the students register at examination office for the project. The final report has to be delivered within 22 weeks. / project (22 Wo)		
Pre-requisites:	**Recommendations:** None		
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: Final Report (source code, documentation, analysis of an example solved with their numerical tool) AP: Presentation and defending of the project [20 min]		
Credit Points:	7		
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP: Final Report (source code, documentation, analysis of an example solved with their numerical tool) [w: 4] AP: Presentation and defending of the project [w: 1]		
Workload:	The workload is 210h.		

Data:	MAML MA Nr. 3694 / Examination number: 12301	Version: 10.05.2021	Start Year: WiSe 2022
Module Name:	**Mathematik des maschinellen Lernens**		
(English):	Mathematics of Machine Learning		
Responsible:	Sprungk, Björn / Prof. Dr.		
Lecturer(s):	Sprungk, Björn / Prof. Dr.		
Institute(s):	Faculty of Mathematics and Computer Science		
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 (WS): each winter term / Lectures (3 SWS) S1 (WS): each winter term / 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 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]		
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:	MABV MA. / Examination number: 10712	Version: 04.05.2021	Start Year: SoSe 2022
Module Name:	**Mathematische Bildverarbeitung**		
(English):	Mathematical Image Processing		
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:	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 even-numbered years. / Lectures (3 SWS) S1 (SS): 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 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]		
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:	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.		
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:	STEST. MA. Nr. 3579 / Examination number: 20315	Version: 09.03.2017	Start Year: WiSe 2018
Module Name:	**Seminar Thesis in Electronic Structure Theory**		
(English):			
Responsible:	Kortus, Jens / Prof. Dr. rer. nat. habil.		
Lecturer(s):	Kortus, Jens / Prof. Dr. rer. nat. habil. Heitmann, Johannes / Prof. Dr. Schüürmann, Gerrit / Prof. Dr. Knupfer, Martin / Prof. Meyer, Dirk / Prof. Dr. rer. nat. Rheinbach, Oliver / Prof. Dr. Gumeniuk, Roman / Prof. Plamper, Felix / Prof. Dr. Sandfeld, Stefan / Prof. Dr.		
Institute(s):	Institute of Theoretical Physics Institute of Applied Physics Institute of Organic Chemistry Institute of Experimental Physics Institute of Numerical Mathematics and Optimization Institute of Physical Chemistry Institute of Mechanics and Fluid Dynamics		
Duration:	1 Semester(s)		
Competencies:	The student should transfer the skills that have been acquired in the first two semesters to a scientific question and prove the ability to apply present knowledge to a new problem and solve the latter independently. A written report and an oral presentation on the results further show the competence of presenting scientific data to an expert audience.		
Contents:	1. Working on a scientific question from within the field of electronic structure theory and solid state physics. 2. Writing an report on the theoretical backgound, experimental and/or computational approaches ulitized during the work and the results including a conclusion and outlook. 3. Presenting the strategy and results of the work in front of the other students and scientific university staff including a discussion afterwards. The topic can be constructed to explicitly include a programming part. In this case, an additional “code of practice” applies, that will be handed to the student. A couple of introductory talks on best practices in science and how to write scientific works like the master thesis, publications and reports will be given by the university staff and discussed within the group of hearers during the first part of the seminar. In the second part, the seminar talks of the students will be held.		
Literature:	Databases, typical literature and publications on the problem topic		
Types of Teaching:	S1 (WS): Individual thesis project / Seminar (12 SWS)		
Pre-requisites:	**Recommendations:** At least two obligatory and three specialization modules have to be passed.		
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*: Written report MP*: Oral presentation including discussion		

	* In modules requiring more than one exam, this exam has to be passed or completed with at least "ausreichend" (4,0), respectively.
Credit Points:	12
Grade:	The Grade is generated from the examination result(s) with the following weights (w): AP*: Written report [w: 3] MP*: Oral presentation including discussion [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 360h. It is the result of 180h attendance and 180h self-studies.

Data:	GLOBA MA. / Examination number: 10723	Version: 04.05.2021	Start Year: SoSe 2023
Module Name:	**Globale Analysis**		
(English):	Global Analysis		
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:** Differentialgeometrie, 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]		
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.		