Universität Rostock

Traditio et Innovatio

Fakultät für Informatik und Elektrotechnik

Module Handbook of the Masters Course of Study Computational Science and Engineering

2016, March 24

Unofficial translation of the german module handbook.
Please note that only the german version is legally binding.

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Category	Content
Name (German)	Advanced Computational Electromagnetics and Multiphysics
Subtitle	
Name (Englisch)	Advanced Computational Electromagnetics and Multiphysics
Credit points and total work load	9 credit points 270 hours
Contact person	Prof. Ursula van Rienen, IEF/IAE/Chair of Electromagnetic Fields and Waves
Language	English
Admission restriction	

Level	Master
Mandatory prerequisites	None
Recommended prerequisites	Computational Electromagnetics

Duration	1 semester
Term	Summer semesters

Learning and qualification objectives (competences)	- deepening knowledge for science and industrial design - competence to analyze and to solve complex problems in science and engineering - deepening of presentation skills
Course contents	- deeper insight into mathematical methods, numerical methods and computational techniques for solving problems of multidisciplinary character in science and engineering - advanced aspects of multiscale problems - deeper insight in numerical methods like Finite Elements, Boundary Elements and Finite Integration Technique - analysis of up to date research results in Computational Electromagnetism from literature - solving practical multidisciplinary problems of industrial and scientific interest - reading of a few research journal articles or book chapters and preparation of a presentation
Recommended literature	

Semester periods per week by type of course	Lecture 2 SWS Seminar 2 SWS Excercise 1 SWS Computer Excercise 2 SWS total 7 SWS
Work load for students	Präsenzzeit 98 hours Vor- und Nachbereitung der Präsenzzeit 82 hours Strukturiertes Selbststudium 40 hours Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 50 hours total workload 270 hours

Prerequisites for the final examination (type and extent)	*successful solution of a practical task*
Test performance/ requirements for a successful examination (type and extent)	1st exam: written examination (60 minutes) 2nd exam: presentation (30 minutes) + scientific discussion

Number	1350850

Category	Content
Name (German)	Advanced Electromagnetic Simulation and Multiphysics
Subtitle	
Name (Englisch)	Advanced Electromagnetic Simulation and Multiphysics
Credit points and total work load	6 credit points 180 hours
Contact person	Prof. Ursula van Rienen, IEF/IAE/Chair of Electromagnetic Fields and Waves
Language	English
Admission restriction	

Level	Master
Mandatory prerequisites	None
Recommended prerequisites	Numerical Simulation of Electromagnetic Fields

Duration	1 semester
Term	Summer semesters

Learning and qualification objectives (competences)	- deepening knowledge for science and industrial design - competence to analyze and to solve complex problems in science and engineering
Course contents	- mathematical methods, numerical methods and computational techniques for solving problems of multidisciplinary character in science and engineering - deeper insight in numerical methods like Finite Elements, Boundary Elements and Finite Integration Technique - touching important aspects of multiscale problems - solving practical multidisciplinary problems of industrial and scientific interest
Recommended literature	

Semester periods per week by type of course	Lecture 2 SWS Excercise 1 SWS Computer Excercise 2 SWS total 5 SWS
Work load for students	Präsenzzeit 56 hours Vor- und Nachbereitung der Präsenzzeit 54 hours Strukturiertes Selbststudium 30 hours Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 40 hours total workload 180 hours

Prerequisites for the final examination (type and extent)	*none*
Test performance/ requirements for a successful examination (type and extent)	1st exam: written examination (60 minutes) 2nd exam: practical examination (computer experiments)

Number	1350860

Category	Content
Name (German)	Advanced VLSI Design
Subtitle	
Name (Englisch)	Advanced VLSI Design
Credit points and total work load	6 180 hours
Contact person	Prof. Dr.-Ing. Dirk Timmermann
Language	English
Admission restriction	None

Level	Master studies - advanced
Mandatory prerequisites	Highly Integrated Systems
Recommended prerequisites	None

Duration	1 term
Term	Every summer term

Learning and qualification objectives (competences)	With successful completion of the module the attendees possess skills regarding current trends and developments in the field of integrated systems. Therefore, they possess future-oriented knowledge related to this area of expertise. • Reproduction, understanding, analysis and synthesis: design methods of highly integrated systems, design process of highly integrated systems, optimization of highly integrated systems • Personal and social skills, self-dependence and personal responsibility, cooperation and team work, presentation and communication skills, technical discourse in English

Course contents	• Basic and advanced number representations
	• Redundant representations
	• Rounding, overflow and handling
	• Calculation of expressions
	• Methods of computational arithmetic
	  ◦ Addition/subtraction
	  ◦ Multiplication
	  ◦ Division
	  ◦ CORDIC
	• Applications in digital signal processing and information technology

Recommended literature	http://www.imd.uni-rostock.de/lehre/lehrangebot/prof-d-timmermann/advanced-vlsi-design/

Semester periods per week by type of course	Practical course 1 SWS Total 1 SWS
Work load for students	Presence time 45 hours Preparation/processing of presence time 15 hours Practical work 120 hours Total workload 180 hours

Prerequisites for the final examination (type and extent)	None
Test performance/ requirements for a successful examination (type and extent)	Examination performance: project work (including presentations)

Number	1350870

Category	Content
Name (German)	Akustische Sensorik
Subtitle	
Name (Englisch)	Acoustic sensors
Credit points and total work load	6 credit points 180 hours
Contact person	IEF / Institute of General Electr. Engineering / Technische Elektronik und Sensorik
Language	German
Admission restriction	

Level	Master
Mandatory prerequisites	
Recommended prerequisites	

Duration	1 semester
Term	winter semester

Learning and qualification objectives (competences)	- Knowledge about the physics of Acoustic waves, wave equations - Knowledge about the properties of Acoustic waves - Knowledge about the design of Acoustic sensors - Knowledge about the signal processing of Acoustic sensors - Self-reliance and personal responsibility - General study techniques and interdisciplinary thinking
Course contents	- Physical description of Acoustic waves, wave equations - Properties of Acoustic waves - Properties of Acoustic waves - Design of Acoustic sensors and their applications - Signal processing for Acoustic sensors
Recommended literature	

Semester periods per week by type of course	Vorlesung 2 SWS Seminar 1 SWS Praktikumsveranstaltung 1 SWS total 4 SWS
Work load for students	Präsenzzeit 60 Std. Vor- und Nachbereitung der Präsenzzeit 20 Std. Strukturiertes Selbststudium 49 Std. Praxisphase 21 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 30 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	
Test performance/ requirements for a successful examination (type and extent)	exam: oral examination (30 minutes) or written examination (90 minutes)

Number	1350890

Category	Content
Name (German)	Analysis and Numerics of Partial Differential Equations
Subtitle	
Name (Englisch)	Analysis and Numerics of Partial Differential Equations
Credit points and total work load	9 credit points 270 hours
Contact person	MNF / Institute of Mathematics
Language	English
Admission restriction	

Level	Master
Mandatory prerequisites	Introduction to Numerics, English at B2 level
Recommended prerequisites	solid grounding in Calculus of one and several variables, Ordinary differential equations, Numerical analysis and Function series

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	Understanding of analytical foundations and numerical solution techniques for partial differential equations Competence in analytical and numerical methods for the solution of initial value and boundary value problems in the context of mathematical phyiscs
Course contents	Classification of PDEs, solutions by characteristics, separation techniques, variational methods, difference schemes, equivalence theorem, method of lines
Recommended literature	L.C.Evans: Partial Differential Equations, Amer. Math. Soc., G.B.Folland: Introduction to Partial Differential Equations, Princeton Univ. Press, J.D.Logan: Applied Partial Differential Equations, Springer, G.H.Golub, J.M.Ortega: Scientific Computing and Differential Equations, P.G.Ciarlet: The finite element method for elliptic problems., O.C.Zienkiewicz: The finite element method, McGraw-Hill, London, R.J.LeVeque: Numerical methods for conservation laws, Birkhäuser

Semester periods per week by type of course	lectures 4 hours per week exercises 2 hours per week total 6 hours per week
Work load for students	presence 84 hours preparation and repetition to lectures and exercises 60 hours literature research 10 hours problem solving, analytical and numerical 84 hours examination including preparation 32 hours. total workload 270 hours.

Prerequisites for the final examination (type and extent)	*None*
Test performance/ requirements for a successful examination (type and extent)	Written examination (120 minutes)

Number	2150520

Category	Content
Name (German)	Atome und Cluster
Subtitle	
Name (English)	Atoms and Clusters
Credit points and total work load	6 180 hours
Contact person	Prof. Meiwes-Broer, Prof. Fennel
Language	English
Admission restriction	none

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	The students become acquainted with experimental and theoretical methods of atomic and cluster physics. They acquire basic knowledge in this special field of physics and are aware of important recent developments and open questions. They know relevant advanced models to describe the physical phenomena. The students get familiar with mathematical methods, analytical as well as numerical, to solve typical problems in atomic and cluster physics. They know different approximations and are able to assess their advantages and drawbacks. The students are aware of pros and cons of advanced modern experimental techniques and know how these different methods complement each another. The students are able to start experimental or theoretical scientific work in a group working in this field.
Course contents	Atoms: electronic structure, atom-field interactions, QED effects (spontaneous emission), higher-order perturbation theory, magnetic and optical traps, Bose-Einstein condensates, cold fermions, atoms in strong fields, photoionization, generation of high harmonics, inner shell effects, electron correlations Clusters: bonding types, cluster generation, shell models, jellium approximation, electronic structure, fullerenes, nonmetal-metal transition, density-functional theory, polarizability, linear response, sum rules, collective resonances, spectroscopy, optical properties, spin effects, clusters in Helium droplets, on surfaces, in strong fields; nanoplasmas
Recommended literature	none

Semester periods per week (SWS) by type of course	Lecture 4 SWS Seminar 1 SWS Total 5 SWS
Work load for students	Classes 70 hrs. Preparation of classes, studying 60 hrs. Solving of excercises 30 hrs. Preparation/examination 20 hrs. Total work load 180 hrs.

Prerequisites for the final examination (type and extent)	50 % of achievable points solving exercises
Test performance (type and	Written examination (90 minutes) or oral examination (30 minutes)

extent)	*To be announced in the second week of the lecture period.*

Number	2350310

Category	Content
Name (German)	Bild-/Videoverarbeitung und Codierung
Subtitle	
Name (Englisch)	Image/Video Processing and Coding
Credit points and total work load	6 credit points 180 hours
Contact person	IEF/INT/Nachrichtentechnik
Language	English
Admission restriction	none

Level	Master
Mandatory prerequisites	none
Recommended prerequisites	Signal- und Systemtheorie (Signals and Systems)

Duration	1 Semester
Term	Winter

Learning and qualification objectives (competences)	Ability to apply the necessary information theoretical building blocks for image processing and compression into practical applications Modularization of image/video processing chains Systematic application of metrics toward image/video quality evaluation Development of solution approaches for image and video compession by example of existing standards Implementation of image processing algorithms in Matlab by elementary operators with the ability to transfer that knowledge to compiler based highlevel languages
Course contents	- Perception, Colors (CIE XYZ/L*a*b,Color Matching/Formats/Conversion) - Sampling / Quantization - Image Transformation - Image Improvement and Restoration - Image Segmentation - Features, Extraction, Descriptors - Pattern Recognition (Basics, Systems for classification, Neural Networks) - Data compression fundamentals - Methods, techniques and algorithms for data compression - Data reduction, Coding, Decorrelation - Image and Video coding standards and their specifics o JPEG, JPEG-2000 o Video Coding (H.26x, MPEG-x)
Recommended literature	Gonzalez, R.; Woods, E. : Digital Image Processing, Prentice Hall 2008 Rao K.R.: Techniques & Standards for Image, Video & Audio Coding, Prentice Hall 1996 Mitchell J. L. et al.: MPEG Video Compression Standard. Chapman and Hall 1997 Richardson I.: H.264 and MPEG-4 Video Compression, Wiley & Sons 2003

Semester periods per week by type of course	Vorlesung 3 SWS Seminar 1 SWS total 4 SWS
Work load for students	Präsenzzeit 56 Std. Vor- und Nachbereitung der Präsenzzeit 40 Std. Strukturiertes Selbststudium 70 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 14 Std. total workload 180 Std.

Prerequisites for the final examination (type and	*none*

extent)	
Test performance/ requirements for a successful examination (type and extent)	oral examination (30 min) or written examination (90 min) (type of exam announced within first half of semester)

Number	1350910

Category	Content
Name (German)	Biosystems Modelling and Simulation
Subtitle	
Name (Englisch)	Biosystems Modelling and Simulation
Credit points and total work load	6 credit points 180 hours
Contact person	IEF / Systems Biology and Bioinformatics
Language	English
Admission restriction	none

Level	Master
Mandatory prerequisites	
Recommended prerequisites	While this course is an introduction, a basic understanding of mathematical modelling (e.g. Markov processes, differential equations) is recommended. No prior knowledge of biological topics is necessary. The biological and bio-chemical background is introduced in the lectures.

Duration	1 semester
Term	Summer term

Learning and qualification objectives (competences)	This course is an introduction to the interdisciplinary research field of systems biology; combining systems theory with applications to biological systems. Using experimental data and information from biological databases, systems biology investigates networks of biochemical reactions that are underlying the functioning of living cells and disease mechanisms. This course introduces basic techniques for mathematical modelling and computational simulations of nonlinear dynamic systems. While the mathematics is of a general nature, dealing with basic stochastic and differential equation models of dynamic systems, we introduce applications and case studies from modern life sciences. The course enables to: • formulate Models of nonlinear dynamic systems • formulate Models of stochastic processes • translate a given (biological) problem into a mathematical representation • analyze the dynamical properties of the system with various mathematical methods
Course contents	• Biochemical reaction networks • Systems theory • Experimental data generation • Modelling biochemical reactions • Stochastic modeling and simulation • Nonlinear dynamics • Pathway modelling • Dynamic motifs and modules • Feedback, regulation and control • Tools and databases
Recommended literature	

Semester periods per week by type of course	Lecture 3 SWS Excercise 1 SWS total 4 SWS
Work load for students	Präsenzzeit 55 Std. Vor- und Nachbereitung der Präsenzzeit 45 Std. Lösen von Übungs- und Programmieraufgaben 30 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 50 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	
Test performance/ requirements for a successful examination (type and extent)	Exam: written examination (90 minutes)

Number	1150170

Category	Content
Name (German)	C++ / GUI
Subtitle	
Name (Englisch)	C++ / GUI
Credit points and total work load	6 credit points 180 hours
Contact person	IEF/Institut für Angewandte Mikroelektronik und Datentechnik (IMD)
Language	German
Admission restriction	none

Level	Bachelor
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 term
Term	every winter term

Learning and qualification objectives (competences)	Knowledge and understanding: Application and understanding of the main object-oriented programing paradigms (classes, objects, methods and abstract data types); good overview of the Qt programming library; god understanding of the working principles of a graphical system as well as its applications. Practical skills: Application of the design principles of a user-friendly interface; design and implementation of graphical user interfaces of moderate complexity. Self and social competences: project organization and completion as well as cooperation and team work.
Course contents	- the object-oriented programming paradigm in comparison to procedural programming languages - classes, objects, methods, and abstract data types - the standard class library - design and operating principles of graphical systems - the free library Qt and their most important concepts - fundamentals of user-friendly interface design
Recommended literature	

Semester periods per week by type of course	Lecture 3 SWS Project 3 SWS total 6 SWS
Work load for students	Lectures 42 Std. Laboratory work 42 Std. Project work 40 Std. Vor- und Nachbereitung der Präsenzzeit 20 Std. Strukturiertes Selbststudium 26 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 10 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	
Test performance/ requirements for a successful examination (type and extent)	1st Exam: oral examination (15 minutes) 2nd Exam: project presentation (15 minutes)

Number	1301040

Category	Content
Name (German)	Compact Modeling of Large Scale Dynamical Systems
Subtitle	
Name (Englisch)	Compact Modeling of Large Scale Dynamical Systems
Credit points and total work load	6 credit points 180 hours
Contact person	IEF/IGS/Mikro- und Nanotechnik elektronischer Systeme, Dr.-Ing. T. Bechtold
Language	english
Admission restriction	none

Level	Master
Mandatory prerequisites	none
Recommended prerequisites	Modul Modeling and Simulation of Mechatronic Systems

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	Extension and deepening of knowledge in fields of - Modeling and simulation techniques - Linear numeric algebra - System simulation of multi physical technical systems Expertise: - Generating complex descriptions of systems by using compacted numerical models - handling software tools for simulating of complex system models Personal and social: - Consistency check of simulation results - Handling with complex data volume
Course contents	The time dependent behaviour of microsystems, often including coupled physical effects (e.g., mechanical and electrical coupling), is of great importance for their design and application. Through the spatial discretization of the governing partial differential equations, for example using the finite element method, we obtain very large ordinary differential equation systems, which often cannot be solved efficiently. In this lecture students will be introduced to Model Order Reduction Methods, which allow to automatically obtain smaller/compact models, enabling so, efficient but accurate simulation of the same multi-physical phenomena. The methods will be demonstrated on a number of relevant microsystem applications.
Recommended literature	Athanasios C. Antoulas: Approximation of Large-Scale Dynamical Systems, (Society for Industrial and Applied Mathematics), 2005. T. Bechtold, E. B. Rudnyi, J. G. Korvink: Fast Simulation of Electro-Thermal MEMS: Efficient Dynamic Compact Models, (Springer Verlag), 2006. T. Bechtold, G. Schrag, L. Feng (eds), System-Level Modeling of MEMS, (Wiley-VCH Verlag GmbH & Co. KGaA, 2013.

Semester periods per week by type of course	Lecture 2 SWS Excercise 2 SWS total 4 SWS
Work load for students	Präsenzzeit 60 Std. Vor- und Nachbereitung der Präsenzzeit 60 Std. Strukturiertes Selbststudium 40 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 20 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	*Tutorial tasks respectively tasks for programming*
Test performance/ requirements for a successful examination (type and extent)	Exam: oral exam (30 minutes) group examination possible as well

Number	1351310

Category	Content
Name (German)	Computational Electromagnetics
Subtitle	
Name (Englisch)	Computational Electromagnetics
Credit points and total work load	9 credit points 270 hours
Contact person	Prof. Ursula van Rienen, IEF/IAE/Chair of Electromagnetic Fields and Waves
Language	English
Admission restriction	

Level	Master
Mandatory prerequisites	None
Recommended prerequisites	None

Duration	1 semester
Term	Winter semesters

Learning and qualification objectives (competences)	- knowledge and understanding of the fundamental theory and methods of the numerical simulation of electromagnetic fields - expertise in different numerical methods for electromagnetic field computation - hands-on experience and expertise in the application of numerical methods for the solution of rather basic tasks for the numerical simulation of electromagnetic fields - teamwork skills
Course contents	- fundamental ideas and methods of numerical simulation of electromagnetic fields
Recommended literature	

Semester periods per week by type of course	Lecture 2 SWS Excercise 2 SWS Computer Excercise 2 SWS total 6 SWS
Work load for students	Präsenzzeit 84 hours Vor- und Nachbereitung der Präsenzzeit 40 hours Strukturiertes Selbststudium 30 hours Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 40 hours total workload 180 hours

Prerequisites for the final examination (type and extent)	*none*
Test performance/ requirements for a successful examination (type and extent)	1st exam: written examination (60 minutes) 2nd exam: practical examination (computer experiments)

Number	1350920

Category	Content
Name (German)	Numerische Methoden in der Schiffshydromechanik
Subtitle	
Name (Englisch)	Computational Methods in Ship Hydromechanics
Credit points and total work load	6 credit points 180 hours
Contact person	Prof. Nikolai Kornev, MSF
Language	English
Admission restriction	none

Level	Master
Mandatory prerequisites	
Recommended prerequisites	Attendance of the lecture “Fluid Dynamics”

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	The aim of the lecture course is to give a general overview of fundamentals of modern numerical methods for simulation of flows around ship and offshore constructions. This knowledge will enable students to properly choose the numerical method and software code which are optimal for solution of different applied problems. They will be able to develop own simulation tools. In exercises they will learn the license free software code OpenFoam which is widely used in ship hydromechanics. The skill to use this code will be consolidated during the work on assignment.
Course contents	Basic equations of fluid dynamics. Finite difference method. Stability of finite difference method, criterion CFL. Artificial viscosity. Simple explicit time advance scheme for solution of the Navier Stokes Equation. Staggered grids. Poisson equation. Boundary conditions. Splitting schemes for solution of multidimensional problems. ADI method. Splitting according to physical processes. Fractional step method. Lax Wendroff scheme. Finite volume method. Integral form of Navier Stokes equations. Explicit and implicit formulations. Pressure correction methods: SIMPLE, PISO and SIMPLEC. Computational grids.
Recommended literature	Manuscript http://bookboon.com/en/lectures-on-computational-fluid-dynamics-ebook

Semester periods per week by type of course	Lecture 2 SWS Seminar 2 SWS total 4 SWS
Work load for students	Presence time (contact time) 60 Std. Preparation for lectures 30 Std. Self-study 60 Std. Preparation for exam/Assignment/Exam 30 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	1. Assignment „Calculation of the turbulent flow around a simple floating body using OpenFoam Toolkit “ 2. Exercises for lectures *Notification not later than in the second lecture week*
Test performance/ requirements for a	oral examination (30 Minutes)

successful examination (type and extent)	

Number	1551330

Category	Content
Name (German)	Computer Vision
Subtitle	
Name (Englisch)	Computer Vision
Credit points and total work load	6 credit points 180 hours
Contact person	IEF/IIN/Visual Computing/Prof. Dr. Oliver Staadt
Language	English
Admission restriction	none

Level	Master
Mandatory prerequisites	none
Recommended prerequisites	Attendance of the module "Grundlagen der Computergrafik"

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	Technical: - Comprehensive and advanced knowlege in computer vision Methodical: - Specialisation of individual methods in the area of computer vision Social: - Ability to participate in English-laguage courses Personal: - Specialisation based on individual career plans
Course contents	Selected topics in computer vision including: - Image Formation - Image Processing - Feature Detection and Matching - Image Stitching - Computational Photography - Stereo Correspondence - 3D Recognition - Image-based Rendering Additional topics based on research advances in computer vision and related fields.
Recommended literature	

Semester periods per week by type of course	Lecture 3 SWS Praktikumsveranstaltung 1 SWS total 4 SWS
Work load for students	Präsenzzeit 60 Std. Strukturiertes Selbststudium 100 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 20 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	*none*
Test performance/ requirements for a successful examination (type and extent)	Exam: oral exam (exam topic in integrated exam, MSc Visual Computing, 45 minutes) or oral exam (20 minutes) will be announced at latest the 2nd week of classes

Number	1151030

Category	Content
Name (German)	Datenbanken für Anwender
Subtitle	
Name (Englisch)	Databases for Users
Credit points and total work load	credit points 6 hours 180
Contact person	Prof. Dr. Andreas Heuer / IEF / Institute of Computer Science
Language	German
Admission restriction	

Level	Bachelor (foundation level) or Master (advanced level)
Mandatory prerequisites	
Recommended prerequisites	

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	The course presents an overview of concepts and languages in database systems as well as appropriate database design methods. The aim of this course is the ability to use database management systems, i.e. to design a database structure, to query databases, and to know further techniques such as updates, views, integrity constraints, privacy aspects, and some fundamental knowledge on the administration of database systems such as index structures and transaction concepts.
Course contents	Database Models, Database Design, Query Languages (including SQL), Other Database Operations, Views, Integrity Constraints, Privacy, Database System Components, Database Systems, Index Structures, Transaction Concepts.
Recommended literature	(English) Elmasri et al., Fundamentals of Database Systems, 7th Edition, Pearson, 2015 (German) Saake, G.; Sattler, K.-U.; Heuer, A.: Datenbanken Konzepte und Sprachen, MITP-Verlag, 5. Auflage 2013 Heuer, A., Saake, G., Sattler, K.; Datenbanken kompakt, MITP-Verlag, 2001

Semester periods per week by type of course	Vorlesung 2 SWS Seminar 1 SWS Praktikumsveranstaltung 1 SWS total 4 SWS
Work load for students	Präsenzzeit 60 Std. Vor- und Nachbereitung der Präsenzzeit 20 Std. Strukturiertes Selbststudium 49 Std. Praxisphase 21 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 30 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	*no*
Test performance/ requirements for a successful examination (type and extent)	exam: oral examination (30 minutes) or written examination (90 Minuten)

Number	1100590

Category	Content
Name (German)	Deutsch für Internationale Masterstudiengänge A1
Subtitle	
Name (English)	German for international Master's courses A1
Credit points and total work load	6 credit points 180 hours
Contact person	Language Center, Head of the German Department
Language	German
Admission restriction	none

Level	Level A1 (CEF)
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	2 semesters
Term	Winter / Summer

Learning and qualification objectives (competences)	The course focuses on the acquisition of basic grammatical structures and correct spelling as well as on practising pronunciation and intonation. Furthermore, the course aims at acquiring basic vocabulary and communication skills enabling students to understand simple texts and to communicate their ideas by using simple structures and a limited range of vocabulary.
Course contents	The course enables students to • cope with familiar everyday situations in their university environment appropriately; • reply to questions and ask for/ provide simple information; • read simple texts written in standard language and dealing with topics they are familiar with; • write simple texts and speak about topics of personal interest they are familiar with and to express their own impressions and opinions. Students learn and practise communication strategies such as paraphrasing, inferring the meaning of unknown vocabulary from the context, and learning strategies, such as using a dictionary.
Recommended literature	none

Semester periods per week by type of course	Language course A1.1. 4 h/ week Language course A1.2 4 h/ week total 8 h/ week
Work load for students	course attendance 118h preparation 56 h preparation for the examination 6 h total workload 180 h.

Prerequisites for the final examination (type and extent)	Regular attendance, at least 80%
Test performance/ requirements for a successful examination (type and extent)	1st Exam: written examination (60-90 minutes) 2nd Exam: oral exam (15 minutes)

Number	9109090

Category	Content
Name (German)	Deutsch für Internationale Masterstudiengänge A2.1
Subtitle	
Name (English)	German for international Master's courses A2.1
Credit points and total work load	6 credit points 180 hours
Contact person	Language Center, Head of the German Department
Language	German
Admission restriction	none

Level	Level A2.1 (CEF)
Mandatory prerequisites	Language skills at level A1 CEF which have to be proven in a placement test or by equivalent certificates
Recommended prerequisites	none

Duration	1 semester
Term	in general, each semester

Learning and qualification objectives (competences)	The course focuses on the acquisition of additional basic grammatical structures and correct spelling as well as practising pronunciation and intonation. Furthermore, the course aims at extending basic vocabulary and communication skills enabling students to understand coherent texts and to communicate their ideas using a limited range of vocabulary.
Course contents	The course enables students to • cope with more complex everyday situations in their university environment appropriately; • reply to questions and ask for/ provide more detailed information; • read texts written in standard language and dealing with topics they are familiar with; • write more complex texts and speak about topics of personal interest they are familiar with and to express their own impressions and opinions. Students continue practising communication strategies such as paraphrasing, inferring the meaning of unknown vocabulary from the context, and learning strategies, such as using a dictionary.
Recommended literature	none

Semester periods per week by type of course	Language course A 2.1. 4 h / week total 4 h / week
Work load for students	course attendance 56 h preparation 56 h self-study 62 h preparation for the examination 6 h total workload 180 h

Prerequisites for the final examination (type and extent)	Regular attendance (at least 80%) and successful completion of self-study tasks (at least 80%)
Test performance/ requirements for a successful examination (type and extent)	1st Exam: written examination (60-90 minutes) 2nd Exam: oral exam (15 minutes)

Number	9109100

Category	Content
Name (German)	Dynamik der Atmosphäre
Subtitle	
Name (English)	Dynamics of the Atmosphere
Credit points and total work load	3 90 hours
Contact person	Prof. Dr. E. Becker
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	The students get acquainted with observed phenomena and theoretical principles concerning the dynamics of the atmosphere. The students are able to start experimental or theoretical work in a scientific working group in this field. They acquire a basic knowledge in this special field of physics. They are aware of important recent developments in the field. They have therefore the fundament for a profound specialisation.
Course contents	Conservation laws in fluid physics and equations of motion for the atmosphere, quasi-geostrophic theory and Rossby waves in the atmosphere (especially interaction between wave and background flow, stratospheric warming, Stokes drift, residual circulation), internal gravity waves (especially WKB approximation and momentum deposition, quasi-biennual oscillation, summer-winter pole circulation in the mesosphere)
Recommended literature	no

Semester periods per week (SWS) by type of course	Lecture 2 SWS Seminar 0,5 SWS Total 2,5 SWS
Work load for students	Classes 35 hrs. Preparation of classes, studying 30 hrs. Solving of excercises 15 hrs. Preparation/examination 10 hrs. Total work load 90 hrs.

Prerequisites for the final examination (type and extent)	none
Test performance/ requirements for a successful examination (type and extent)	Written examination (45 minutes) or oral examination (20 minutes) *To be announced in the second week of the lecture period.*

Number	2350330

Category	Content
Name (German)	Einführung in die Atmosphärenphysik und in die Physik des Ozeans
Subtitle	
Name (English)	Introduction to Atmospheric Physics and Ocean Physics
Credit points and total work load	6 180 hours
Contact person	Prof. Dr. F.-J. Lübken (Atmosphärenphysik/ Atmospheric Physics) Dr. V. Mohrholz (Physik des Ozeans/ Ocean Physics)
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	The students become acquainted with concepts and phenomena in Atmospheric Physics and Ocean Physics. On this basis, they are able to start experimental or theoretical work in a scientific working group in this field. They have an overview of the relevant knowledge in these fields. They are aware of important recent developments. They acquire a basic experimental and theoretical knowledge in these fields, and have therefore the fundament for a profound specialisation.
Course contents	Fundamental physical processes in the atmosphere: Structure of the atmosphere, basic physical concepts and equations, energy balance, creation of layers, depth of penetration of solar radiation, ozone layer, equations of motion. Fundamental physical processes in the ocean: basic concepts, vertical structure Principles of ocean dynamics: equation of motion, reaction to forcing, waves, tides, thermohaline circulation, observational methods.
Recommended literature	none

Semester periods per week (SWS) by type of course	Lecture 4 SWS Excercise course 1 SWS Total 5 SWS
Work load for students	Classes 70 hrs. Preparation of classes, studying 60 hrs. Solving of excercises 30 hrs. Preparation/examination 20 hrs. Total work load 180 hrs.

Prerequisites for the final examination (type and extent)	Solution of 50 % of the requested exercises
Test performance/ requirements for a successful examination (type and extent)	Written examination (90 minutes) or oral examination (30 minutes) *To be announced in the second week of the lecture period.*

Number	2350190

Category	Content
Name (German)	Fehlerdiagnose und Fehlertoleranz in technischen Systemen
Subtitle	
Name (Englisch)	Fault diagnosis and fault tolerance in technical systems
Credit points and total work load	6 credit points 180 hours
Contact person	Prof. Torsten Jeinsch IEF/IAT/Chair of Control engineering
Language	German/English
Admission restriction	

Level	Master of science
Mandatory prerequisites	None
Recommended prerequisites	Basic knowledge of mathematical representation of dynamic systems, analysis of dynamic systems and control, e.g. the topics which are discussed in following B.Sc. lectures: - Fundamental of control engineering - Model-based automation

Duration	1 semester
Term	Winter semesters

Learning and qualification objectives (competences)	The main objective of this lecture is to cover the applications of control and optimization theory in fault diagnosis and fault-tolerant control of technical systems. The students will become familiar with different approaches to solve the diagnosis and fault-tolerant problems and learn their functionalities and constraints. In addition to the well-developed theories, the open problems and future trends will be discussed in this lecture. During this course, the students should be able apply and evaluate the fault diagnosis and fault-tolerant control in selected applications in maritime systems and automotive industry. Personal and social skills: Independence and self-responsibility, self-organization, project management and implementation, cooperation and team working, presentation and communication skills, interdisciplinary thinking
Course contents	Applications of model-based and data-driven diagnosis techniques, analysis of the technical systems, parameter estimation, residual generation, synthesis of fault tolerant system are the further topics which are covered in this lecture.
Recommended literature	- R.C. Dorf. R.H. Bishop : Modern control systems, 2005 - S.X. Ding, Model-based fault diagnosis techniques, 2013 - S.X. Ding, Data-driven Design of Fault Diagnosis and Fault-tolerant Control Systems, 2014 - M. Baseseville I. Nikiforov: Detection of Abrupt Changes – Theory and Application, 1993. - M. Blanke, M. Kinnaert, J. Lunze, M. Staroswiecki, Diagnosis and fault-tolerant control, 2006 - E. Russel, L.H. Chiang, R.D. Braatz, Data-driven methods for fault detection and diagnosis in chemical processes, 2000 - R. Isermann: Überwachung und Fehlerdiagnose in technischer Systeme, 1993

Semester periods per week by type of course	Vorlesung 2 SWS Seminar 2 SWS Praktikumsveranstaltung 1 SWS total 5 SWS
Work load for students	Präsenzzeit 70 Std. Vor- und Nachbereitung der Präsenzzeit 40 Std. Strukturiertes Selbststudium 30 Std.

	Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 40 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	*none*
Test performance/ requirements for a successful examination (type and extent)	Exam: oral examination (30 minutes) or written examination (90 minutes)

Number	1350670

Category	Content
Name (German)	Fluid Dynamik
Subtitle	
Name (Englisch)	Fluid Dynamics
Credit points and total work load	6 credit points 180 hours
Contact person	MSF/Prof. N. Kornev
Language	English
Admission restriction	none

Level	Master
Mandatory prerequisites	
Recommended prerequisites	Completed courses “Mathematics for engineers 1-3”

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	With the module, the students gain an understanding of the principles of fluid mechanics. They are capable of solving engineering problems of fluid statics and fluid dynamics in accordance with the methodology for calculation of flow forces and moments.
Course contents	Fluid properties. Continuity equation. Navier-Stokes equation. Potential flows. Bernoulli equation. Cavitation. Momentum theorem. Vortex flows. Theory of hydrodynamic similarity, Reynolds, Froude, Strouhal numbers. Turbulent and laminar flows. Boundary layer. Flow separation. Reynolds approach, Reynolds averaged Navier-Stokes equations.
Recommended literature	Eck, B.: Technical hydrodynamics, Band 1 und 2, Springer Verlag, 1991. Spurk, J.-H.: Hydrodynamics, Springer Verlag, 1993. Umdruck zur Vorlesung. Truckenbrodt, E.: Fluid mechanics, Band 1 und 2; Springer Verlag, 1980. Zierep, J.: Principles of hydromechanics; Springer Verlag, 1992.

Semester periods per week by type of course	Lecture 2 SWS Seminar 2 SWS total 4 SWS
Work load for students	Presence time (contact time) 60 Std. Preparation for lectures 30 Std. Self-study 60 Std. Preparation for exam/Assignment/Exam 30 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	Exercises for lectures
Test performance/ requirements for a successful examination (type and extent)	oral examination (30 Minutes)

Number	1551340

Category	Content
Name (German)	Foundations of Life, Light and Matter Research
Subtitle	
Name (English)	Foundations of Life, Light and Matter Research
Credit points and total work load	6 180 hours
Contact person	Prof. Dr. S. Speller, Prof. S. Lochbrunner
Language	English
Admission restriction	none

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	The students become acquainted with the basics of quantum mechanics in atomic, molecular and solid state physics. The know relevant models and approximations for the description of physical phenomena in these fields, and they can apply them. They know important experimental techniques for different physical quantities. They are able to familiarize themselves with advanced topics by using the literature.
Course contents	Quantum physics: wave particle dualism, wave function, Schrödinger equation Atomic physics: hydrogen atom, spin, shell model, periodic system, absorption and emission of light Molekular physics: bindung, rotation, vibration Solid state physics: crystal structure, band model, phonons
Recommended literature	no

Semester periods per week (SWS) by type of course	Lecture 3 SWS Excercise course 2 SWS Total 5 SWS
Work load for students	Classes 70 hrs. Preparation of classes, studying 50 hrs. Solving of excercises 40 hrs. Preparation/examination 20 hrs. Total work load 180 hrs.

Prerequisites for the final examination (type and extent)	Solution of 50 % of the requested exercises
Test performance/ requirements for a successful examination (type and extent)	Written examination (120 minutes) or oral examination (30 minutes) *To be announced in the second week of the lecture period.*

Number	2350560

Category	Content
Name (German)	Fundamentals of Photonics
Subtitle	
Name (English)	Fundamentals of Photonics
Credit points and total work load	9 270 hours
Contact person	Prof. Scheel, Prof. Hage
Language	English
Admission restriction	none

Level	Master course - advanced
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	The students have an overview of the relevant knowledge in the field. They are aware of important recent developments and open questions. The students become acquainted with experimental and theoretical methods of the field and their usefulness for particular physical problems. The students are familiar with mathematical techniques necessary to understand these methods. The students know pros and cons of different experimental methods, and how these different methods complement one another. They know relevant models and approximations to describe the physical phenomena. They are aware of the limits of the models.
Course contents	Geometric optics, refraction, reflection, Electromagnetic waves, diffraction, interference, polarisation, coherence, Nonlinear optics, 2nd order and 3rd order nonlinear effects, Field quantisation, quantum states and their properties Transformation optics, metamaterials, Laser physics, Photodetection
Recommended literature	no

Semester periods per week (SWS) by type of course	Lecture 4 SWS Excercise course 2 SWS Total 6 SWS
Work load for students	Classes 84 hrs. Preparation of classes, studying 96 hrs. Solving of excercises 60 hrs. Preparation/examination 30 hrs. Total work load 270 hrs.

Prerequisites for the final examination (type and extent)	Solution of 50 % of the requested exercises
Test performance/ requirements for a successful examination (type and extent)	Written examination (120 minutes) or oral examination (30 minutes) *To be announced in the second week of the lecture period.*

Number	2350350

Category	Content
Name (German)	Grundlagen der Quantenoptik
Subtitle	
Name (English)	Fundamentals of Quantum Optics
Credit points and total work load	6 180 hours
Contact person	Prof. Dr. Vogel, Prof. Dr. Hage
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	The students have an overview of the relevant knowledge in the field. They are aware of important recent developments and open questions. The students become acquainted with experimental and theoretical methods of the field and their usefulness for particular physical problems. The students are familiar with mathematical techniques necessary to understand these methods. The students know pros and cons of different experimental methods, and how these different methods complement one another. The students become aquianted with a special field of modern physics. On this basis, they are able to start experimental or theoretical work in a scientific working group in this field.
Course contents	quantum optical measurement schemes, phase-space distributions, reconstruction of quantum states;nonclassical properties of light and matter; verification of quantum entanglement and general nonclassical features; probing quantum physics (Bell inequality), quantum cryptography; nonclassical interferometry, quantum optomechanics.
Recommended literature	none

Semester periods per week (SWS) by type of course	Lecture 3 SWS Seminar 1 SWS Total 4 SWS
Work load for students	Classes 56 hrs. Preparation of classes, studying 64 hrs. Solving of excercises 40 hrs. Preparation/examination 20 hrs. Total work load 180 hrs.

Prerequisites for the final examination (type and extent)	Solution of 50% of the requested exercises
Test performance/ requirements for a successful examination (type and extent)	Written examination (90 minutes) or oral examination (30 minutes) *To be announced in the second week of the lecture period.*

Number	2350360

Category	Content
Name (German)	Hochintegrierte Systeme
Subtitle	
Name (Englisch)	Integrated Systems
Credit points and total work load	6 180 hours
Contact person	Prof. Dr.-Ing. Dirk Timmermann
Language	German
Admission restriction	None

Level	Bachelor studies - basics
Mandatory prerequisites	None
Recommended prerequisites	Digital systems

Duration	1 term
Term	Every summer term

Learning and qualification objectives (competences)	Professional competence • Basic understanding of VHDL • Understanding of CMOS technology and system design • Understanding of clocking concepts and clock distribution • Understanding of power consumption and low-power design Methodological competence • Application and analysis of synthesis techniques for CMOS sub-systems • Application of analysis techniques for robustness evaluation Personal and social skills • Self-dependence, personal responsibility • Self-organization during practical work • Presentation techniques
Course contents	• Introduction to VHDL • CMOS technology • System design • Testing • CMOS circuit logic • Clocking systems for CMOS circuits • Self-clocked and asynchronous systems • CMOS low-power techniques • CMOS sub-systems
Recommended literature	http://www.imd.uni-rostock.de/lehre/lehrangebot/prof-d-timmermann/hochint/

Semester periods per week by type of course	Lecture 3 SWS Seminar 2 SWS Practical course 1 SWS total 6 SWS
Work load for students	Presence time 50 hours Preparation/processing of presence time 20 hours Practical work 80 hours Preparation for examination 30 hours total workload 180 hours

Prerequisites for the final examination (type and extent)	None

Test performance/ requirements for a successful examination (type and extent)	Exam: written examination (90 minutes)

Number	1300970

Category	Content
Name (German)	Information Technology in Ship Design and Production
Subtitle	
Name (Englisch)	Information Technology in Ship Design and Production
Credit points and total work load	6 credit points 180 hours
Contact person	Prof. R. Bronsart, MSF
Language	English
Admission restriction	none

Level	Master
Mandatory prerequisites	
Recommended prerequisites	Sound knowledge in ship design and production, basic knowledge in CAD-Systems, Computer Aided Geometric Design (CAGD), good programming skills

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	Students will understand the fundamentals and will be able to judge upon the capabilities of IT tools. They will be able to identify requirements on these software systems based on a sound knowledge of the ship design and operation life cycle. A clear focus in ship one-of-a-kind design and production processes is applied. The understood necessity of an efficient information exchange between partners and tasks involved leads to the knowledge of suitable information exchange methods and tools. Process and product modelling techniques as a prerequisite for a successful information exchange can be applied by the students in specific exchange scenarios of ship product model data. They will understand how the underlying design principles are implemented and will experience the complexity of naval architectural and ship design software systems. Students will learn how to operate in complex and unpredictable and/or specialised contexts, and will get an overview of the issues governing good practice. In a teamwork project students will develop a small software tool specific to naval architectural design and analysis processes though achieving skills in programming and the implementation of data exchange scenarios. They can work effectively with a group as leader or member, can clarify tasks and make appropriate use of the capacities of group members. They are able to negotiate and handle conflicts with confidence in a project in which the participants contribute with different but integrated software components. Students will be able to demonstrate initiative and originality in problem solving, can act autonomously in planning and implementing tasks at a professional level while making decisions in complex and unpredictable situations. They will develop a comprehensive understanding of techniques and methodologies applicable to their own work.
Course contents	• Process analysis in ship design, production and operation: identification of roles(partners), tasks, tools and information flows in international ship design and production networks. • Fundamental differences between mass production and one-of-a-kind products like ships and offshore structures • CA-tools applied in ship design: input to, functions built in, output from, important links into the ship design and production network • Process modelling techniques, examples from shipbuilding processes product modelling, focus on different ship product data sets for different views in interdisciplinary tasks to be performed.

	• Modelling and transformation of information to be used in scenarios requiring multiple views. • Engineering change management in shipbuilding • Integration strategies, IT tools to support the in-house as well as cross-company cooperation in ship design networks • System architecture of selected tools specifically used in ship design.
Recommended literature	• lecture notes, handouts • proceedings of international conferences on ship design and production: COMPIT, IMDC, ICCAS, PRADS, ISSC, SNAME Ship Production Symposium • Journal of Ship Production

Semester periods per week by type of course	Lectures 2 SWS project 1 SWS total 3 SWS
Work load for students	lectures 28 hours Team Project 120 hours Self studies, preparation for exam 32 hours total workload 180 hours

Prerequisites for the final examination (type and extent)	*approved software component development in team project*
Test performance/ requirements for a successful examination (type and extent)	Exam: Oral examination 30 minutes

Number	1551350

Category	Content
Name (German)	Introduction to High Performance Computing
Subtitle	Computer Architecture, Networking, System Software, Application Programming
Name (Englisch)	Introduction to High Performance Computing
Credit points and total work load	9 credit points 270 hours
Contact person	IEF/IIN/Verteiltes Hochleistungsrechnen/Prof. Dr. Peter Luksch
Language	English
Admission restriction	keine

Level	Master
Mandatory prerequisites	keine
Recommended prerequisites	Vorkenntnisse in den Bereichen Rechnerarchitektur, Rechnernetze, Systemsoftware und Programmierung aus dem Bachelor-Studium sind empfehlenswert. Teilnehmern ohne solche Vorkenntnisse ist ein intensives Studium der genannten Begleitliteratur zu empfehlen und vor allem die aktive Teilnahme an den praktischen Übungen

Duration	1 Semester
Term	Winter

Learning and qualification objectives (competences)	Verständnis der Architektur moderner Universalrechner, insbesondere Hochleistungsrechnerarchitekturen, sowie ihrer Systemsoftware. Beherrschung der gängigen Standardprogrammiermodelle des Hochleistungsrechnens, z.B. OpenMP und MPI.
Course contents	- von-Neumann-Architektur Programmierung des von-Neumann-Rechners (prozedurale Programmersprache, z.B. C) - Betriebssysteme Grundlagen - Rechnernetze Grundlagen - Prozessorarchitekturen: Befehlsparallelismus, Mehrprozessorsysteme, Mehrkern-Prozessoren - Parallelrechner: Evolution, Klassifikation, Möglichkeiten und Grenzen der Parallelarbeit - Cluster Computing - Parallele Programmiermodelle, z.B. OpenMP, MPI - Parallelisierungsansätze für praktische Problemstellungen z.B. des wissenschafltich-technischen Rechnens - Werkzeuge zur Programmentwicklung, Fehlersuche und Leistungsanalyse
Recommended literature	David A. Patterson, John L. Hennessy: Computer Organization and Design: The Hardware/Software Interface (Morgan Kaufmann Series in Computer Architecture and Design), 2013, ISBN-13: 978-0124077263. Dennis M. Ritchie, Brian W. Kernighan: The C Programming Language. 2000. ISBN-13: 978-0131103627. Rohit Chandra: Parallel Programming in OpenMP. Morgan Kaufman Publishers, 2000. ASIN: B00JI0N9GK William Gropp: Using MPI: Portable Parallel Programming with the Message-Passing Interface. MIT Press, 2000. ASIN: B00LXN32ZS William Gropp: Using MPI-2: Portable Parallel Programming with the Message-Passing Interface. MIT Press, 2000. ASIN: B00EKZ1Y5G Weitere Literaturangaben in der Vorlesung.

Semester periods per week by type of course	Vorlesung 3 SWS Übung 1 SWS Praktikumsveranstaltung 2 SWS

	total 6 SWS
Work load for students	Präsenzzeit 84 Std. Vor- und Nachbereitung der Präsenzzeit 74 Std. Lösen von Übungsaufgaben 20 Std. Praxisphase 62 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 30 Std. total workload 270 Std.

Prerequisites for the final examination (type and extent)	*keine*
Test performance/ requirements for a successful examination (type and extent)	1.Prüfungsleistung: Klausur (120 Minuten) oder mündliche Prüfung (30 Minuten) Notengewichtung: 50 % 2. Prüfungsleistung: praktische Prüfung (erfolgreiche Bearbeitung der praktischen Programmieraufgaben) Notengewichtung: 50 %

Number	1151110

Category	Content
Name (German)	Einführung in die Numerische Mathematik
Subtitle	
Name (Englisch)	Introduction to Numerical Mathematics
Credit points and total work load	9 credit points 270 hours
Contact person	Dr. Wolfgang Peters, Institut für Mathematik
Language	English
Admission restriction	no

Level	Master
Mandatory prerequisites	Knowledge of English Language on the level B2
Recommended prerequisites	Reliable knowledge in Analysis, Algebra and Informatics

Duration	1 term
Term	Winterterm

Learning and qualification objectives (competences)	This module treats the basics of Numericals Mathematics and the implementation of numerical algorithms in MATLAB. The following competences will be taught: - Basics on classical numerical methods - The ability to implement simple numerical methods in a programming language (MATLAB) - The ability to choose the correct numerical method - The ability to assess the efficiency and stability of numerical methods
Course contents	- Direct and iterative methods for solving linear systems of equations - Least Squares Methods - Eigenvalue Problems - Roots of nonlinear equations and systems of equations - Interpolation by polynomials - Numerical differentiation and integration
Recommended literature	- G. Gramlich, W. Werner, Numerische Mathematik mit Matlab, dpunkt.verlag, 2000 - A. Quarteroni, R. Sacco, F. Saleri, Numerical Mathematics, Springer, 2000 - A. Quarteroni, F. Saleri, Wissenschaftliches Rechnen mit MATLAB, Springer, 2000 - http://www.mathworks.com/ - http://www.octave.org/

Semester periods per week by type of course	lecture 4 SWS exercise 2 SWS total 6 SWS
Work load for students	lectures and exercises 84 h preparations and postprocessing 84 h Solving tasks 42 h preparations for exam, exam 60 h total workload 270 h

Prerequisites for the final examination (type and extent)	*no*
Test performance/ requirements for a successful examination (type and extent)	written examination (120 minutes)

Number	2150510

Category	Content
Name (German)	Marine Turbulenz
Subtitle	
Name (English)	Marine Turbulence
Credit points and total work load	3 90 hours
Contact person	PD Dr. L. Umlauf
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - advanced
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	The students become acquainted with the special field Marine Turbulence. On this basis, they are able to start experimental or theoretical work in a scientific working group in this field. They have an overview of the relevant knowledge in these fields. They are aware of important recent developments.
Course contents	Phenomenology of turbulence, deterministic description (Navier-Stokes equations), statistical description (Reynolds-averaged equations), spectral theory of homogeneous turbulence, turbulence regimes in natural waters, statistical turbulence models, instrumentation.
Recommended literature	none

Semester periods per week (SWS) by type of course	Lecture 2 SWS Seminar 0,5 SWS Total 2,5 SWS
Work load for students	Classes 35 hrs. Preparation of classes, studying 30 hrs. Solving of excercises 15 hrs. Preparation/examination 10 hrs. Total work load 90 hrs.

Prerequisites for the final examination (type and extent)	solution of 50% of the requested exercises
Test performance/ requirements for a successful examination (type and extent)	Written examination (45 minutes) or oral examination (20 minutes) *To be announced in the second week of the lecture period.*

Number	2350370

Kategorie	Inhalt
Name (German)	Masterarbeit Computational Science and Engineering
Subtitle	
Name (Englisch)	Masters Thesis Computational Science and Engineering
credit points and total work load	30 credit points 900 hours
Contact person	IEF / Institute for General Electrical Engineering
Language	English
Admission restriction	none

Level	Master
Mandatory prerequisites	Achievement of at least 78 credit points in the mandatory and elective modules
Recommended prerequisites	depending on topic

Duration	1 semester
Term	each semester

Learning and qualification objectives (competences)	- knowledge and understanding: thorough autonomous work on a selected scientific topic under the supervision of a mentor - methodical expertise: literature research, selection and application of suitable tools and methods to solve tasks, rules of good scientific practice, use of quotations and avoidance of plagiarism, preparation of a topic for oral and written discourse - social competence: using mentoring and counselling offers, skills in presenting own results - self-competence: organization of autonomous scientific work in a given time frame, time management
Recommended literature	depending on topic

Semester periods per week by type of course	0,5 SWS consultation

Prerequisites for the final examination (type and extent)	none
Test performance/ requirements for a successful examination (type and extent)	1st examination: final thesis (20 weeks) 2nd examination: colloquium (40 minutes)

Number	1351350

Category	Content
Name (German)	Mathematik für Wirtschaftsinformatik 3
Subtitle	Discrete Structures and Optimization
Name (Englisch)	Mathematics for Business Information Systems 3
Credit points and total work load	credit points 6 hours 180
Contact person	MNF/IfMa/Prof. Dr. Konrad Engel
Language	German
Admission restriction	None

Level	Bachelor, fundamentals
Mandatory prerequisites	none
Recommended prerequisites	Mathematics for Electrical Engineering and Computer Science 1 and 2

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	Professional: Comprehension of fundamental concepts and proof techniques of Discrete Mathematics and Optimization Methodical: Prove and mathematical modeling of facts Social: Precision in technical terminology Yourselves: mathematical thinking
Course contents	1. Combinatorics (Basic formulas, Linear recurrence equations, principle of inclusion and exclusion) 2. Structures of Algebra (equivalence relations, elements of number theory, semigroups and groups, rings and fields) 3. Applications of Algebra (cryptography and the RSA-algorithm, elements of coding theory) 4. Linear Programming (problem formulation, graphic solution in the two-dimensional space, transformation into normal form, simplex method, duality, integer linear programming)
Recommended literature	D. Lau: Algebra und Diskrete Mathematik 1 und 2, Springer

Semester periods per week by type of course	Lecture 3 SWS Tutorial 1 SWS total 4 SWS
Work load for students	Attendence time 60 hours Postprocessing of attendence time 30 hours Self-study and solutions of problems 60 hours Preparation and execution of exams 30 hours total workload 180 hours

Prerequisites for the final examination (type and extent)	Solutions of problems for homework
Test performance/ requirements for a successful examination (type and extent)	exam: written examination (90 minutes)

	2100780

Category	Content
Name (German)	Mathematische Modelle in der Schiffstheorie
Subtitle	
Name (Englisch)	Mathematical Models in Ship Theory
Credit points and total work load	6 credit points 180 hours
Contact person	Prof. N. Kornev, MSF
Language	English
Admission restriction	none

Level	Master
Mandatory prerequisites	
Recommended prerequisites	Attendance in the lecture course "Fluid Dynamics"

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	The main objective is to give a general overview of mathematical models used in ship dynamics, ship manoeuvrability and offshore structures dynamics. Having successfully completed the module, the student will be able to demonstrate knowledge and understanding of ship and offshore structures motion at different operational conditions.
Course contents	Differential equation of motion of arbitrary objects in different media. Equations of ship manoeuvring. Determination of added mass. Steady manoeuvring forces. Calculation of steady manoeuvring forces using slender body theory. Forces on ship rudders. Yaw stability. Manoeuvrability Diagram. Experimental study of the manoeuvrability. Influence of different factors on the manoeuvrability. Application of CFD for manoeuvrability problems. Dynamics of offshore structures. More detailed information on course content can be taken from the textbook "Lectures on ship manoeuvrability" which can be downloaded from http://bookboon.com/de/lectures-on-ship-manoeuvrability-ebook
Recommended literature	Manuscript http://bookboon.com/de/lectures-on-ship-manoeuvrability-ebook

Semester periods per week by type of course	Lecture 2 SWS Seminar 2 SWS total 4 SWS
Work load for students	Presence time (contact time) 60 Std. Preparation for lectures 30 Std. Self-study 60 Std. Preparation for exam/Assignment/Exam 30 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	1. Assignment „Calculation of the ship dynamics using the Krylov Code " 2. Exercises for lectures Notification not later than in the second lecture week
Test performance/ requirements for a successful examination (type and extent)	oral examination (30 Minutes)

Number	1551360

Category	Content
Name (German)	Modeling and Simulation of Mechatronic Systems
Subtitle	
Name (Englisch)	Modeling and Simulation of Mechatronic Systems
Credit points and total work load	6 credit points 180 hours
Contact person	IEF/IGS/Mikro- und Nanotechnik elektronischer Systeme, Dr.-Ing. T. Bechtold
Language	english
Admission restriction	none

Level	Master
Mandatory prerequisites	none
Recommended prerequisites	Die Teilnehmer sind dazu aufgefordert, die für diese Vorlesung wichtigen Themen aus der Mathematik präsent zu haben. Dies sind die lineare Algebra und die (partiellen) Differentialgleichungen.

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	Wissenserweiterung und -vertiefung in Bereichen der - Modellierungsund numerische Simulationstechniken - Einsatz von Simulationswerkzeugen Kompetenzen: - Numerische Lösung partieller Differentialgleichungen, Finite Elemente Methode, Finite Differenzen Methode, Methode der gewichteten Residuen - Beherrschung industrierelevanter Softwarewerkzeugen zur Simulation komplexer System-Modelle, zum Einsatz kommen beispielsweise ANSYS, Simplorer, Maxwell Selbstund Sozialkompetenz: - Konsistenzprüfung von Simulationsergebnissen - Projektpräsentation und Verteidigung
Course contents	In this lecture the basic methods, as required for the simulation of micro-mechatronic systems, are discussed. Furthermore, a simulation project, using an industry-relevant simulation software, is carried out. Course topics are as follows: 1. Modeling: Partial differential equations, Buckingham Pi-Theorem 2. Meshing of the computational domain 3. Finite difference method for numerical solution of partial differential equations 4. Method of weighted residuals 5. Finite Element Method 6. Solution methods for linear systems 7. Post Processing 8. Application of industry-relevant simulation software
Recommended literature	S. Howison, „Practical Applied Mathematics Modelling, Analysis, Approximation“, Oxford University Press (2004). H. K. Versteeg, W. Malalasekera, „An Introduction to Computational Fluid Dynamics“, Pearson Education Limited, (2nd edition 2007). G. Smith, Numerical Solution of Partial Differential Equations: Finite Diference Methods, Oxford University Press, 1985. The Finite Element Method, Volume 1: The Basis, O. C. Zienkiewicz and R. L. Taylor, edited by McGraw-Hill, Oxford (2000). Finite Elements Analysis for Heat Transfer, H. C. Huang, A. S. Usmani, Springer Verlag Berlin Heidelberg (1994)

Semester periods per week by type of course	Lecture Excercise	2 SWS 1 SWS

	Project 1 SWS total 4 SWS
Work load for students	Präsenzzeit 60 Std. Vor- und Nachbereitung der Präsenzzeit 60 Std. Strukturiertes Selbststudium 40 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 20 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	*Anfertigung und Verteidigung des Simulationsprojekts*
Test performance/ requirements for a successful examination (type and extent)	Examination: written exam (150 minutes)

Number	1351320

Category	Content
Name (German)	Modellierung und Simulation der Turbulenz
Subtitle	
Name (Englisch)	Modelling and Simulation of Turbulence
Credit points and total work load	6 credit points 180 hours
Contact person	MSF/ Prof. N. Kornev
Language	English
Admission restriction	none

Level	Master
Mandatory prerequisites	
Recommended prerequisites	Attendance in the lecture course "Fluid Dynamics"

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	The aim of the lecture course is to provide a background knowledge on most aspects of physics of turbulence, statistical theory of turbulence and modern techniques of the turbulence simulation. This knowledge will enable students to properly choose the methods and software code which are optimal for solution of different engineering problems. In exercises they will learn the license free software code OpenFoam which is widely used for simulation of various turbulent flows. The skill to use this code will be consolidated during the work on assignment.
Course contents	Physics of turbulence. Vortex dynamics. Basic definitions of the statistical theory of turbulence. Reynolds averaging. Isotropic and homogeneous turbulence. Correlaton function. Kolmogorov theory K41. Dissipation rate. Kolmogorov hypotheses. Classification of methods for calculation of turbulent flows. Limitation of K41 theory. Reynolds averaged Navier Stokes equations. Reynolds stress models. K-epsilon model. K-omega model. Method of wall functions. Large Eddy Simulation. Filtering. LES equations. Smagorinsky model. Model of Germano, scale similarity models, mixed models. A-posteriori and a-priori tests. Hybrid URANS-LES methods. Detached Eddy Simulation. URO hybrid method.
Recommended literature	Manuscript http://bookboon.com/en/lectures-on-computational-fluid-dynamics-ebook

Semester periods per week by type of course	Lecture 2 SWS Seminar 2 SWS total 4 SWS
Work load for students	Presence time (contact time) 60 Std. Preparation for lectures 30 Std. Self-study 60 Std. Preparation for exam/Assignment/Exam 30 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	1. Assignment „Calculation of a simple canonical flow (turbulent boundary flow on a plate, channel, pipe) using OpenFoam Toolkit " 2. Exercises for lectures

	Notification not later than in the second lecture week
Test performance/ requirements for a successful examination (type and extent)	oral examination (30 Minutes)

Number	1550350

Category	Content
Name (German)	Modellierung und Simulation von kontinuierlichen und hybriden Systemen
Subtitle	
Name (Englisch)	Continuous and Hybrid Systems Modeling and Simulation
Credit points and total work load	6 180 hours
Contact person	IEF / Institute of Computer Science
Language	
Admission restriction	

Level	Bachelor
Mandatory prerequisites	Fundamentals of Computer Science, English Language Knowledge on the B2 Level of the Common European Reference Frame of Languages
Recommended prerequisites	

Duration	1 semester
Term	winter semester

Learning and qualification objectives (competences)	The goal of the lecture is to give an overview about methods of continuous hybrid modeling and simulation and their applications. The students will learn what problems to be aware about in planning, executing and analyzing simulation studies with hybrid systems models, and how to tackle those. Continuous hybrid modeling and simulation is located at the interface of computer science, control engineering, and applied mathematics and thus presents a rather wide field of research. We will approach continuous hybrid systems from the point of view of computer science and focusing on simulation rather than verification techniques.
Course contents	Extract: Block diagrams, numerical integration, hybrid automata, hybrid petri nets, multi-formalism approaches, executing hybrid models. Exemplary simulation systems: OpenModelica, Ptolemy, Charon, Simulink/Stateflow.
Recommended literature	

Semester periods per week by type of course	Integrierte Lehrveranstaltung 4 SWS total 4 SWS
Work load for students	Präsenzzeit 60 Std. Vor- und Nachbereitung der Präsenzzeit 20 Std. Strukturiertes Selbststudium 49 Std. Praxisphase 21 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 30 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	
Test performance/ requirements for a successful examination (type and extent)	exam: oral examination (30 minutes)

Number	1551370

Category	Content
Name (German)	Molekülphysik
Subtitle	
Name (English)	Molecular Physics
Credit points and total work load	9 270 hours
Contact person	Prof. Lochbrunner, Prof. Kühn
Language	English
Admission restriction	none

Level	Master course - advanced
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	The students have an overview of the relevant knowledge in molecular physics. The students become acquainted with experimental and theoretical methods of the field. On this basis, they are able to start experimental or theoretical work in a scientific working group in this field. They are aware of important recent developments in the field and of open questions. The students become acquainted with experimental and theoretical methods of the field and their usefulness for particular physical problems. The students are familiar with mathematical techniques necessary to understand these methods. The students know pros and cons of different experimental methods, and how these different methods complement one another. The students are able to read up on current topics of modern physics in the literature.
Course contents	Fundamentals: Molecular Schrödinger equation, Born-Oppenheimer approximation, potential energy surfaces, non-adiabatic transitions, conical intersections, electron structure theory, bond types, and structure of molecules. Dynamics: Rotation, libration, vibration, normal modes, anharmonicities, wave packet dynamics, system-bath coupling, dissipative dynamics, and rate theories. Elementary processes: Optical excitation, relaxation, dephasing, solvation, chemical reactions, charge transfer, and energy transfer. Systems: Isolated molecules and molecules in solution, biomolecules, supramolecular complexes and aggregates, molecular materials and organic electronics. Experimental techniques: Stationary and time-resolved absorption spectroscopy, fluorescence, infrared and THz spectroscopy, and Raman scattering.
Recommended literature	no

Semester periods per week (SWS) by type of course	Lecture 4 SWS Seminar 1 SWS Excercise course 1 SWS Total 6 SWS
Work load for students	Classes 84 hrs. Preparation of classes, studying 116 hrs. Solving of excercises 40 hrs. Preparation/examination 30 hrs. Total work load 270 hrs.

Prerequisites for the final examination (type and extent)	Presentation
Test performance/ requirements for a successful examination (type and extent)	Written examination (120 minutes) or oral examination (30 minutes) *To be announced in the second week of the lecture period.*

Number	2350380

Category	Content
Name (German)	Nature-Inspired Computing
Subtitle	
Name (Englisch)	Nature-Inspired Computing
Credit points and total work load	6 credit points 180 hours
Contact person	IEF/IMD/Technische System- und Anwendersoftware
Language	German, English
Admission restriction	none

Level	Master
Mandatory prerequisites	none
Recommended prerequisites	Einführung in die Praktische Informatik Knowledge of a procedural programming language, such as C or C++

Duration	1 term
Term	every summer term

Learning and qualification objectives (competences)	Knowledge and understanding: Upon the successful completion of this module, the students do have a good overview about well-known nature-inspired learning and optimization methods as far as they are relevant for the development and optimization of technical systems. This way, the students acquire interesting supplements that are quite orthogonal to traditions engineering concepts. Repetition, Understanding, and Application: Implementation and problem-specific application of nature-inspired learning procedures, application of artificial neural networks in technical systems. Analysis and Synthesis: Design and application of the concepts that are specific to autonomous, mobile agents. Assessment: Usage of the basic concepts of evolutionary optimization in technical problems. Self and social competences: Self-sufficiency and self-reliance, project organization and completion, cooperation and team work, trans-disciplinary mind setting.
Course contents	The design and development of technical systems, particularly their self-X features, may significantly benefit from the incorporation of nature-inspired methods, since they have evolved numerous optimal solutions in nature. This module describes a selection of these methods, and shows how they can be adapted to technical problems. The chosen content will be announced at the beginning of the class as it is influenced by current trents in research and development. along with required.
Recommended literature	

Semester periods per week by type of course	Lecture 2 SWS Seminar 1 SWS Excercise 2 SWS total 5 SWS
Work load for students	Lectures 42 Std. Laboratory work 42 Std. Project work 40 Std. Vor- und Nachbereitung der Präsenzzeit 20 Std. Strukturiertes Selbststudium 26 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 10 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	none
Test performance/ requirements for a successful examination (type and extent)	1st Exam: oral examination (15 minutes) 2nd Exam: work on project (40 hours)

Number	1351080

Category	Content
Name (German)	Nichtlineare Optik und Spektroskopie
Subtitle	
Name (English)	Nonlinear Optics and Spectroscopy
Credit points and total work load	9 270 hours
Contact person	Prof. Lochbrunner, Prof. Kühn, Prof. Meiwes-Broer
Language	English
Admission restriction	none
Level	Master course - advanced
Mandatory prerequisites	none
Recommended prerequisites	none
Duration	1 semester
Term	Summer
Learning and qualification objectives (competences)	The students have an overview of the relevant knowledge in Nonlinear Optics and Spectroscopy. The students become acquainted with experimental and theoretical methods of the field. On this basis, they are able to start experimental or theoretical work in a scientific working group in this field. They are aware of important recent developments in the field and of open questions. The students know relevant models and approximations to describe physical phenomena in the field. The students become acquainted with experimental and theoretical methods of the field and their usefulness for particular physical problems. The students are familiar with mathematical techniques necessary to understand these methods. The students know pros and cons of different experimental methods, and how these different methods complement one another. The students are able to read up on current topics of modern physics in the literature. The students are able to give a good-quality talk (presentation) on a complex topic of modern physics.
Course contents	Fundamentals: Propagation of light in matter, the concept of polarization, electromagnetic transitions, line width, symmetry and selection rules, correlation function, Brownian oscillator model, relaxation and dephasing. Linear Spectroscopy: Absorption, fluorescence, Franck-Condon factors, FTIR spectroscopy, Rayleigh, Raman, and resonance-Raman scattering, photoelectron and mass spectroscopy, molecular beams, and ion traps. Nonlinear light-matter-interaction: Nonlinear polarization, nonlinear susceptibilities, frequency mixing in nonlinear crystals, Kerr effect, self-phase modulation, multiphoton ionization, laser plasma, Coulomb explosion, attosecond pulses, and free electron laser. Nonlinear Spectroscopy: multiphoton, Doppler free, and saturation spectroscopy, response function, four wave mixing, pump-probe spectroscopy, photon-echo and multidimensional spectroscopy, and coherent control.
Recommended literature	none
Semester periods per week (SWS) by type of course	Lecture 4 SWS Seminar 1 SWS Excercise course 1 SWS Total 6 SWS
Work load for students	Classes 84 hrs. Preparation of classes, studying 116 hrs.

	Solving of excercises 40 hrs. Preparation/examination 30 hrs. Total work load 270 hrs.

Prerequisites for the final examination (type and extent)	50 % of achievable points solving exercises or presentation
Test performance/ requirements for a successful examination (type and extent)	Written examination (90 minutes) or oral examination (30 minutes) *To be announced in the second week of the lecture period.*

Number	2350400

Category	Content
Name (German)	Numerische Behandlung gewöhnlicher Differentialgleichungen
Subtitle	
Name (Englisch)	Numerical analysis of ordinary differential equations
Credit points and total work load	9 credit points 270 hours
Contact person	MNF/IfMA/Numerische Mathematik: Numerische Mathematik
Language	German
Admission restriction	none

Level	Bachelor, postgraduate
Mandatory prerequisites	none
Recommended prerequisites	Modules Differentialgleichungen, Numerische Mathematik; Knowledge of a programming language

Duration	1 term
Term	every winter term

Learning and qualification objectives (competences)	- Basic knowledge on the numerical solution of initial value problems for ordinary differential equations and the ability to implement these methods on a computer - Analytical background knowledge of such methods for the solution of ordinary differential equations and the ability to evaluate the aspects of the selection of a method and to evaluate its efficiency and numerical stability. - Knowledge on first elements of numerical methods for partial differential elements (finite difference method, finite element method).
Course contents	- One-step methods for the solution of initial value problems for ordinary differential equations (Convergence theory, error estimation, extrapolation) - Multi-step methods (Adams-Bashforth, Adams-Moulton), Predictor-corrector methodc, Gear methods - Stiff ordinary differential equations and differential-algebraic problems - Two-point boundary value methods for ordinary differential equations - Introduction to numerical methods for boundary value problems for partial differential equations (basic concepts for the method of finite differences and the finite element method)
Recommended literature	A detailed list of relevant literature is provided in the lecture.

Semester periods per week by type of course	Lecture 4 SWS Excercise 2 SWS total 6 SWS
Work load for students	Präsenzzeit 84 Std. Vor- und Nachbereitung der Präsenzzeit 86 Std. Strukturiertes Selbststudium 40 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 60 Std. total workload 270 Std.

Prerequisites for the final examination (type and extent)	At least 50% of the mandatory homework has to be solved successfully.
Test performance/ requirements for a successful examination (type and extent)	Exam: written examination (120 minutes) or oral examination (30 minutes)

Number	2100430

Category	Content
Name (German)	Numerische Behandlung partieller Differentialgleichungen
Subtitle	
Name (Englisch)	Numerical analysis of partial differential equations
Credit points and total work load	6 credit points 180 hours
Contact person	MNF/IfMA/Numerische Mathematik: Numerische Mathematik
Language	German
Admission restriction	none

Level	Master, postgraduate
Mandatory prerequisites	none
Recommended prerequisites	Modules: Module Analysis I: Funktionen einer Veränderlichen, Analysis II: Funktionen mehrerer Veränderlicher, Differentialgleichungen, Numerische Mathematik, Numerische Behandlung gewöhnlicher Differentialgleichungen, Partielle Differentialgleichungen

Duration	1 term
Term	every summer term

Learning and qualification objectives (competences)	- The ability to solve boundary value problems for elliptic partial differential equations as well as mixed initial-boundary value problems for parabolic and hyperbolic partial differential equations by means of the finite difference and finite element method. This includes the ability to implement these methods on a computer for simple model problems. - Analytical background knowledge of these methods for the solution of partial differential equations and the ability to evaluate the aspects of the selection of a method and to evaluate its efficiency and numerical stability.
Course contents	- Difference methods for elliptic boundary value problems and for parabolic and hyperbolic initial-boundary value problems - The Sturm-Liouville problem - Elliptic problems in Hilbert spaces: Lax-Milgram theorem, Ritz-Galerkin methods, approximation theorems - Finite element spaces: triangulations, finite elements, numerical cubature, error estimation - Multigrid methods: classical iterations and their smoothing properties, two-grid and multigrid iterations - Eigenvalue methods for elliptiic partial differential operators
Recommended literature	A detailed list of relevant literature is provided in the lecture.

Semester periods per week by type of course	Lecture 4 SWS total 4 SWS
Work load for students	Präsenzzeit 56 Std. Vor- und Nachbereitung der Präsenzzeit 64 Std. Strukturiertes Selbststudium 30 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 30 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	none
Test performance/ requirements for a successful examination (type and extent)	Exam: written examination (120 minutes) or oral examination (30 minutes)

Number	2150020

Category	Content
Name (German)	Numerische Methoden der Vielteilchenphysik
Subtitle	
Name (English)	Computational Many-particle Physics
Credit points and total work load	6 180 hours
Contact person	Prof. Dr. D. Bauer, Prof. T. Fennel
Language	German or English (to be announced in the second week)
Admission restriction	no

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	The students become acquainted with the numerical solution of problems in the field of many-particle physics. They can apply their knowledge to new problems and, on that basis, become qualified to start theoretical scientific work in a group working in this field. They are aware of important recent developments, challenges, and open questions in the field. The students get used to common theoretical methods of many-particle physics. They get introduced to different approximations, get familiar with mathematical techniques necessary to understand them, and know their pros and cons. The students are aware of relevant analytical as well numerical techniques used in this field. The students can assess the numerical effort of different methods, they know the limits of current computer power.
Course contents	Numerical tools: root finding, numerical integration, finite differences, extrapolation of numerical operators, solution of ordinary and partial differential equations (spectral methods, explicit and implicit propagators, iterative methods, convergence and stability analysis), Numerical methods: optimization (Ising model, simulated annealing), stochastic processes (random walk, diffusion, master equations), matrix inversion and eigenvalues (modes, Schrödinger equation, band structure), partial differential equations (initial values and boundary value problems, time-dependent Schrödinger equation, characteristics, multigrid methods), many particle simulation methods (density-functional theory, particle-in-cell, quantum/classical molecular dynamics) Many-particle physics: scattering theory, WKB methods, density matrix, kinetic theory, density functional theory, Kohn-Sham equations, local-density approximation, gradient expansion, exchange and correlation functionals, electronic structure of many-particle systems, time-dependent density-functional theory
Recommended literature	none

Semester periods per week (SWS) by type of course	Lecture 3 SWS Seminar 1 SWS Total 4 SWS
Work load for students	Classes 56 hrs. Preparation of classes, studying 50 hrs. Solving of excercises 54 hrs. Preparation/examination 20 hrs.

	Total work load 180 hrs.

Prerequisites for the final examination (type and extent)	Solving 50 % of the excercises, presentation of one solution in the seminar
Test performance/ requirements for a successful examination (type and extent)	Written examination (90 minutes) or oral examination (30 minutes) *To be announced in the second week of the lecture period.*

Number	2350410

Category	Content
Name (German)	Ozeanmodellierung
Subtitle	
Name (English)	Ocean Modeling
Credit points and total work load	3 90 hours
Contact person	Prof. Dr. H. Burchard
Language	German or English (to be announced in the second week)
Admission restriction	no

Level	Master course - advanced
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	The students become acquainted with the special field Ocean Modeling. On this basis, they are able to start experimental or theoretical work in a scientific working group in this field. They have an overview of the relevant knowledge in the field. They are aware of important recent developments.
Course contents	Consistence, stability and convergence of numerical methods, discretization methods in time for ordinary differential equations, shallow water equations, shifted grids, implicite and semi-implicite methods for models with free surface, construction principles for numerical ocean models, positive-definite advection methods
Recommended literature	none

Semester periods per week (SWS) by type of course	Lecture 2 SWS Seminar 0,5 SWS Total 2,5 SWS
Work load for students	Classes 35 hrs. Preparation of classes, studying 30 hrs. Solving of excercises 15 hrs. Preparation/examination 10 hrs. Total work load 90 hrs.

Prerequisites for the final examination (type and extent)	Solution of 50% of the requested exercises
Test performance/ requirements for a successful examination (type and extent)	Written examination (45 minutes) or oral examination (20 minutes) *To be announced in the second week of the lecture period.*

Number	2350420

Category	Content
Name (German)	Photonische Systeme
Subtitle	
Name (Englisch)	Photonic Systems
Credit points and total work load	6 credit points 180 hours
Contact person	IEF/IAE/Optoelektronik und Photonische Systeme
Language	German
Admission restriction	

Level	Master
Mandatory prerequisites	none
Recommended prerequisites	module "Techische Optik"

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	Fachkompetenz: - Wiedergabe und Verständnis grundlegender Begriffe - Verständnis photonischer Modellvorstellungen - Verständnis und Analyse komplexer optischer und photonischer Erscheinungen und Systeme - theoretische und praktische Synthese und Beurteilung einfacher photonischer Systeme Selbst- und Sozialkompetenz - Umgang mit empfindlichen optischen Komponenten - Beachtung Laserschutzbestimmungen
Course contents	- Optische und photonische Grundbegriffe - Modellvorstellungen: Geometrische Optik, Skalare Beugungstheorie, Elektromagnetiche Wellen, Streutheorien Quantenbeschreibung, Photonen-Materie-Interaktion - Photonische Systeme: Laser, Lichtwellenleiter, Quantenoptik, Photonische Messsysteme, photonische Kristalle, Hologramme - Anwendung photonischer Konzepte in Messund Übertragungssystemen
Recommended literature	E. Hecht: Optik, Oldenbourg Verlag Albrecht et al.: Laser Doppler and Phase Doppler Measurement Techniques, Springer Verlag Fomin: Speckle Photography for Fluid Mechanics Measurements, Springer Verlag Raffel et al.: Particle Image Velocimetry, Springer Verlag Schnars, Jueptner: Digital Holography, Springer Verlag Lourtioz: Photonic Crystals, Springer Verlag

Semester periods per week by type of course	Vorlesung 2 SWS Seminar 2 SWS Praktikumsveranstaltung 1 SWS total 5 SWS
Work load for students	Präsenzzeit 70 Std. Vor- und Nachbereitung der Präsenzzeit 30 Std. Strukturiertes Selbststudium 50 Std. Prüfungsvorbereitung/Prüfungsvorleistung/Prüfung 30 Std. total workload 180 Std.

Prerequisites for the final examination (type and extent)	*Teilnahme an Praktikumsversuchen und Seminar*

Test performance/ requirements for a successful examination (type and extent)	1. Examination: oral exam (30 minutes) 2. Examination: presentation (20 minutes)

Number	1351090

Category	Content
Name (German)	Physik der Ionosphäre
Subtitle	
Name (English)	Physics of the Ionosphere
Credit points and total work load	3 90 hours
Contact person	Prof. Dr. J. Chau
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	The students get acquainted with observed phenomena and theoretical principles concerning the physics of the ionosphere. The students are able to start experimental or theoretical work in a scientific working group in this field. They acquire a basic knowledge in this special field of physics. They are aware of important recent developments in the field. They have therefore the fundament for a profound specialisation.
Course contents	Electrodynamics of the Ionosphere, plasma instabilities in the Ionosphere, coupling of the Ionosphere with the lower and middle atmosphere as well as with the Magnetosphere.
Recommended literature	none

Semester periods per week (SWS) by type of course	Lecture 2 SWS Seminar 0,5 SWS Total 2,5 SWS
Work load for students	Classes 35 hrs. Preparation of classes, studying 30 hrs. Solving of excercises 15 hrs. Preparation/examination 10 hrs. Total work load 90 hrs.

Prerequisites for the final examination (type and extent)	none
Test performance/ requirements for a successful examination (type and extent)	Written examination (45 minutes) or oral examination (20 minutes) *To be announced in the second week of the lecture period.*

Number	2350430

Category	Content
Name (German)	Physik des Klimas
Subtitle	
Name (English)	Physics of Climate
Credit points and total work load	3 90 hours
Contact person	Prof. Dr. E. Becker (IAP)
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	The students get acqainted with relevant methods and approaches and have advanced knowledge of the physics of the climate. They are aware of important recent developments in the field. The students know several analytical methods and are able to start theoretical scientific work in a group working in this field.
Course contents	radiative transfer in the troposphere and greenhouse effect, boundary-layer theory and surface energy fluxes, moisture budget and convection, radiative-convective equilibrium, simple energy-balance model, Lorenz energy cycle, global energy balance, climate change
Recommended literature	none

Semester periods per week (SWS) by type of course	Lecture 2 SWS Excercise course 0,5 SWS Total 2,5 SWS
Work load for students	Classes 35 hrs. Preparation of classes, studying 30 hrs. Solving of excercises 15 hrs. Preparation/examination 10 hrs. Total work load 90 hrs.

Prerequisites for the final examination (type and extent)	Solution of 50% of the requested exercises
Test performance/ requirements for a successful examination (type and extent)	Written examination (45 minutes) or oral examination (20 minutes) *To be announced in the second week of the lecture period*

Number	2350440

Category	Content
Name (German)	Plasma- und Astrophysik
Subtitle	
Name (English)	Plasma Physics and Astrophysics
Credit points and total work load	9 270 hours
Contact person	Prof. Dr. Redmer
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - advanced
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	The students become acquainted with the basics of plasma physics and astrophysics. On this basis, they are able to start theoretical work in a scientific working group in these fields. The students have an overview of the relevant knowledge and current topics of interest. They know relevant theoretical methods as well as mathematical techniques and numerical procedures to solve problems in these fields. The students can evaluate the numerical effort of different methods, they know the limits of current computer power. They know different approximations and their pros and cons. The students are able to read up on current topics of modern physics in the literature and to give a survey on that.
Course contents	- plasma parameter: charged particle systems, fusion plasmas, astrophysical plasmas, warm dense matter, shock waves, high pressure physics - theory of dense plasmas: plasmas as Fermi systems, screening and correlation effects, effective Schrödinger equation, equation of state, mass action laws for dissociation and ionization - kinetic theory: Boltzmann equation, H theorem, relaxation time approximation, Chapman-Enskog method, transport coefficients, electrical conductivity - basics of density functional theory: Kohn-Sham theory, Hellmann-Feynman theorem, quantum molecular dynamics simulations, equation of state, pair distribution function, Kubo-Greenwood formula, application to warm dense matter - plasma diagnostics and laser-plasma interaction: ionization and scattering processes, dielectric function, dynamic structure factor, Landau damping, free electron lasers, x-ray Thomson scattering, inertial confinement fusion - physics of stars, brown dwarfs and planets: mass-radius relation and Lane-Emden equation, formation scenarios, thermal evolution of planets, gravity data and planetary interiors, extrasolar planets (detection methods and properties)
Recommended literature	none

Semester periods per week (SWS) by type of course	Lecture Seminar Excercise course Total	4 SWS 1 SWS 1 SWS 6 SWS

Work load for students	Classes 84 hrs. Preparation of classes, studying 116 hrs. Solving of excercises 40 hrs. Preparation/examination 30 hrs. Total work load 270 hrs.

Prerequisites for the final examination (type and extent)	50 % of achievable points solving exercises or presentation
Test performance/ requirements for a successful examination (type and extent)	Written examination (120 minutes) or oral examination (30 minutes) *To be announced in the second week of the lecture period.*

Number	2350460

Category	Content
Name (German)	Programmierbare Integrierte Schaltungen
Subtitle	
Name (Englisch)	Programmable Integrated Circuits
Credit points and total work load	6 credit points 180 hours
Contact person	IEF, Institute GS
Language	English, German
Admission restriction	none

Level	Master
Mandatory prerequisites	None
Recommended prerequisites	Basic skills in analysis and synthesis of analogue and digital electronic circuits.

Duration	2 semesters
Term	summer and winter terms (starting in summer term)

Learning and qualification objectives (competences)	Competence to implement primarily digital systems into programmable logic devices using different implementation tools and simulators.
Course contents	Structure of simple and complex Programmable Logic Devices (PLD). Mapping of digital modules to PLD. Field Programmable Gate Arrays. Design input methods. Hardware Description Languages. Simulation of digital designs. Functional, Gate-level-, Timing-simulation. Special problems in digital design. Practical exercises using CPLD and FPGA.
Recommended literature	Lecture scripts P. Ashenden: The System Designers Guide to VHD-AMS P. Ashenden: Digital Design – An Embedded Systems Approach Using Verilog

Semester periods per week by type of course	Lectures: 3 hours/week (2 winter, 1 summer) Exercises: 2 hours/week (1 winter, 1 summer) Total 5 hours/week
Work load for students	Presence at lectures and exercises 70 hours. Exercises include practical work and student project Preparation and wrap-up (lectures, exercises, project) 110 hours.

Prerequisites for the final examination (type and extent)	Completion of a student circuit development project.
Test performance/ requirements for a successful examination (type and extent)	1st exam: oral examination (20 minutes after 1st term) 2nd exam: oral defense of project work (20 minutes after 2nd term)

Number	1351100

Category	Content
Name (German)	Prozesse im Küstenozean
Subtitle	
Name (English)	Coastal Ocean Processes
Credit points and total work load	3 90 hours
Contact person	Prof. Dr. H. Burchard
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	The students have an overview of the relevant knowledge in costal oceanography. They are aware of important recent developments in the field. They have an idea how the phenomena in costal oceans can be observed. The students know several analytical methods used in this field.
Course contents	Shallow water equations, boundary layer flows, Ekman dynamics in shallow water, entainment, dense bottom currents, mixed layer, tidal flows, motion of the sea in shallow water, estuarine circulation
Recommended literature	no

Semester periods per week (SWS) by type of course	Lecture 2 SWS Seminar 0,5 SWS Total 2,5 SWS
Work load for students	Classes 35 hrs. Preparation of classes, studying 30 hrs. Solving of excercises 15 hrs. Preparation/examination 10 hrs. Total work load 90 hrs.

Prerequisites for the final examination (type and extent)	none
Test performance/ requirements for a successful examination (type and extent)	Written examination (45 minutes) or oral examination (20 minutes) *To be announced in the second week of the lecture period*

Number	2350470

Category	Content
Name (German)	Quantenoptik makroskopischer Systeme
Subtitle	
Name (English)	Quantum Optics of Macroscopic Systems
Credit points and total work load	6 180 hours
Contact person	Prof. Scheel, Prof. Hage, Institute of Physics
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - advanced
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	The students have an overview of the relevant knowledge in this special field. They are aware of important recent developments in the field and of open questions. The students become acquainted with experimental and theoretical methods of the field. The students know relevant models and approximations to describe physical phenomena in the field. The students become acquainted with experimental and theoretical methods of the field and their usefulness for particular physical problems. The students are familiar with mathematical techniques necessary to understand these methods. The students know pros and cons of different experimental methods, and how these different methods complement one another. On this basis, they are able to start experimental or theoretical work in a scientificworking group in this field.
Course contents	- Electromagnetic field quantisation in linear dielectric media, linear response theory - Propagation of nonclassical light through dielectric media, heat transfer - Coupling of atoms and molecules to medium-assisted fields - Modified spontaneous decay and spinflip lifetimes, Purcell effect, resonators - Quantum optomechanics - Decoherence processes - Dispersion forces (Casimir / Casimir-Polder force, van der Waals interactions) - Quantum reflection
Recommended literature	no

Semester periods per week (SWS) by type of course	Lecture 3 SWS Seminar 1 SWS Total 4 SWS
Work load for students	Classes 56 hrs. Preparation of classes, studying 64 hrs. Solving of excercises 40 hrs. Preparation/examination 20 hrs. Total work load 180 hrs..

Prerequisites for the final examination (type and extent)	none

Test performance (type and extent)	Written examination (90 minutes) or oral examination (30 minutes) *To be announced in the second week of the lecture period.*

Number	2350480

Category	Content
Name (German)	Scalable Computing
Subtitle	
Name (Englisch)	Scalable Computing
Credit points and total work load	6 credit points 180 hours
Contact person	IEF/IIN/Verteiltes Hochleistungsrechnen/Prof. Dr. Peter Luksch
Language	English
Admission restriction	None

Level	Master
Mandatory prerequisites	None
Recommended prerequisites	English language knowledge on the B2 level of the Common European Framework of Reference for Languages. Students should have attended the course "Introduction to High Performance Computing", which is a mandatory course in the CSE program.

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	Having completed this course, students will be able to design and implement parallel and programs for execution on clusters, in grid and cloud computing environments, using state-of-the-art methods and software tools for software development and performance analysis. They will acquire a sound understanding of cluster, grid, and cloud architectures that will enable them to understand performance analysis results and optimize their programs accordingly.
Course contents	- Review of High Performance Computing • Architectures • Programming Paradigms and Programming Models • Performance Metrics • Potential and Limitations of Parallel Computing - Cluster Computing • what is a cluster?, why clusters? types of clusters: High performace clusters, high throughput clusters, high availability clusters • High Performance Communication • Single System Image • Resource Management and Scheduling • Programming Paradigms and Programming Environments • The OpenMP Standard (Shared Memory Programming) • The Message Pasing Interface MPI • Accelerators • Tools for Parallel Program Development and Analysis - Computational Grids • Anatomy and Physiology of the Grid • The Globus Project • The Open Grid Services Architecture (OGSA) • Other important Grid projects • Grid Programming Environments • Grid Portals • Grid Applications • e-Science • Current Hot Topics • Future Challenges - Cloud Computing • Motivation, Concepts

	• Virtualization • Cloud Computing Applications • HPC in the Cloud • System Software Issues • Current Hot Topics • Research Challenges
Recommended literature	will be provided during the lecture

Semester periods per week by type of course	Integrierte Lehrveranstaltung 4 SWS total 4 SWS
Work load for students	Attendance time 56 hours Structured self-study 56 hours Solving problems 48 hours Exam preparation/prerequisites/examination 20 hours total workload 180 hours

Prerequisites for the final examination (type and extent)	*None*
Test performance/ requirements for a successful examination (type and extent)	Exam: written examination (90 minutes) or oral examination (20 Minuten) *To be announced in the second week of the lecture period.*

Number	1150250

Category	Content
Name (German)	Sensors and Actuators
Subtitle	
Name (English)	Sensors and Actuators
Credit points and Total work load	6 credit points 180 hours
Contact person	Prof. Dr.-Ing. habil. Kerstin Thurow / Dr.-Ing. Heidi Fleischer
Language	English
Admission restriction	Maximum number of participants: 20

Level	Master
Mandatory prerequisites	no
Recommended prerequisites	Basics of electrical engineering Basic knowledge of electronic devices English knowledge

Duration	1 semester
Term	Each winter semester

Learning and qualification objectives (competences)	The module imparts technical basics of selected operating principles of sensors and actuators and their application areas. Further main points are the classification of sensors and actuators as well as the knowledge of characteristics with technological and metrological point of view. Students will acquire knowledge of different sensor and actuator types, which are applied in the fields of industrial and laboratory automation as well as in mobile robotics. In addition to the theoretical foundations, the students determine practical skills in seminars with the main focus on characteristics and application of selected sensors and actuators. Furthermore, independence and individual responsibility, general learning and work techniques, self-organization and interdisciplinary thinking are imparted.
Course contents	• Characteristics, properties and parameters of sensors and actuators • Temperature sensors • Sensors for determining mechanical quantities of solids, liquids and gases • Optical sensors • Chemical and biological sensors • Complex sensor systems • Electromechanical, fluid power and unconventional actuators • Applications in the field of industrial and laboratory automation • Applications in the field of mobile robotics
Recommended literature	• Fraden, J.: *Handbook of modern sensors. Physics, designs, and applications*. Springer, 2010, ISBN: 978-1-441-96465-6. • Eggins, B.R.: *Chemical sensors and biosensors*. J. Wiley, 2002, ISBN: 0471899135. • Janocha, H.: *Actuators. Basics and applications*. Springer, 2004, ISBN: 3-540-61564-4. • Nof, S.Y.: *Springer Handbook of Automation*. Springer, 2009, ISBN: 978-3540788324.

Semester periods per week by type of course	Lecture 2 SWS Seminar 2 SWS Total 4 SWS
Work load for students	Presence 60 hrs. Preparation and follow-up of presence 20 hrs. Structured self-study 49 hrs. Practical phase 21 hrs. Exam preparation / Prerequisite / examination 30 hrs.

	Total workload 180 hrs.

Prerequisites for the final examination (type and extent)	• Successful completion of a seminar topic with practical experiment • Presentation of the seminar topic (PowerPoint presentation and demonstration of the experiment in the laboratory, about 30 minutes)
Test performance/ requirements for a successful examination (type and extent)	exam: written examination (120 minutes) or oral examination (30 minutes) This information will be published no later than the second week of lectures.

Number	1351330

Category	Content
Name (German)	Simulation Methods of Molecular Biophysics
Subtitle	
Name (English)	Simulation Methods of Molecular Biophysics
Credit points and total work load	3 90 hours
Contact person	Prof. Dr. O. Kühn / Institute of Physics
Language	English
Admission restriction	none

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	The students become acquainted with numerical simulations of biological systems om a molecular level. On this basis, they are able to evaluate theoretical models and their results or even to start theoretical work themselves in a scientific working group in this field. The students have an overview of this special field. The students know relevant models and approximations to describe physical phenomena in the field. The students are familiar with mathematical techniques necessary to understand these methods. The students know pros and cons of different numerical techniques, and how these different methods complement one another. The students are able to read up on current topics of modern physics in the literature.
Course contents	Fundamentals: motivation for simulations in the framework of classical mechanics from the Schrödinger equation, potential energy surfaces and force fields, hybrid quantum mechanics/molecular mechanics (QM/MM) methods, equations of motion in statistical ensembles, statistical analysis of simulation data, free energy calculations, reaction mechanisms, path integral and semi-classical approaches for nuclear quantum effects, stochastic techniques. Numerical techniques: integrating equations of motion, data analysis, approaches for efficient treatment of solvated bio-systems, acceleration of rare events, error analysis. Applications: structure and dynamics of proteins, binding energies, transport in membrane proteins.
Recommended literature	no

Semester periods per week (SWS) by type of course	Lecture 2 SWS Seminar 1 SWS Total 3 SWS
Work load for students	Classes 42 hrs. Preparation of classes, studying 28 hrs. Preparation/examination 20 hrs. Total work load 90 hrs.

Prerequisites for the final examination (type and extent)	none

Number	2350490

Category	Content
Name (German)	Software Lab Project
Subtitle	
Name (Englisch)	Software Lab Project
Credit points and total work load	6 credit points 180 hours
Contact person	IEF
Language	English
Admission restriction	none

Level	Master
Mandatory prerequisites	
Recommended prerequisites	depending on topic

Duration	1 semester
Term	each semester

Learning and qualification objectives (competences)	- knowledge and understanding: thorough autonomous work on a selected scientific topic under the supervision of a mentor - methodical expertise: literature research, selection and application of suitable tools and methods to solve tasks, rules of good scientific practice, use of quotations and avoidance of plagiarism, preparation of a topic for oral and written discourse - social competence: using mentoring and counselling offers - self-competence: organization of autonomous scientific work in a given time frame
Course contents	Within the frame of the Software Lab Project, students work on a given task during the semester. The Software Lab Project introduces a specified subject area. The instructor decides upon the topic. The given task is analyzed by the students with the help of their mentor; they explore the research status as well as possible solutions in literature, and practically implement as well as evaluate a solution. Finally, the results of the specialization will be presented.
Recommended literature	

Semester periods per week by type of course	Consultation 1 SWS Presentation 0,5 SWS
Work load for students	Exam preparation/prerequisites/examination 180 hours total workload 180 hours

Prerequisites for the final examination (type and extent)	none
Test performance/ requirements for a successful examination (type and extent)	1st exam: report (20 pages minimum) 2nd exam: presentation (20 minutes) + discussion (20 minutes)

Number	1351340

Category	Content
Name (German)	Spezielle Themen aus der Atmosphärenphysik
Subtitle	
Name (English)	Specific Topics of Atmospheric Physics
Credit points and total work load	3 90 hours
Contact person	Prof. Dr. J. Chau / Institute of Physics
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - advanced
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	The students get acquainted with special topic of atmospheric physics. The students are able to start experimental or theoretical work in a scientific working group in this field. They acquire a basic knowledge in this special field of physics. They are aware of important recent developments in the field. The students are familiar with the experimental and theoretical basics of atmospheric physics and have therefore the fundament for a profound specialisation.
Course contents	Ionospherical plasmas, radar methods in atmospheric physics, scattering mechanisms, plasma instabilities, coupling of atmosphere/ionosphere.
Recommended literature	no

Semester periods per week (SWS) by type of course	Lecture 2 SWS Seminar 0,5 SWS Total 2,5 SWS
Work load for students	Classes 35 hrs. Preparation of classes, studying 30 hrs. Solving of excercises 15 hrs. Preparation/examination 10 hrs. Total work load 90 hrs.

Prerequisites for the final examination (type and extent)	none
Test performance/ requirements for a successful examination (type and extent)	Written examination (45 minutes) or oral examination (20 minutes) *To be announced in the second week of the lecture period*

Number	2350500

Category	Content
Name (German)	Theoretische Ozeanographie I: Grundlagen und Wellenprozesse im rotierenden Ozean
Subtitle	
Name (English)	Theoretical Oceanography I: Basic Principles and Wave Processes in the Rotating Ocean
Credit points and total work load	3 90 hours
Contact person	Dr. M. Schmidt
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Winter

Learning and qualification objectives (competences)	The students get acqainted with the established theoretical methods in the field and are aware of important developments. They are able to apply analytical methods and to interpret current research results. The students are able to read up on current topics in the literature.
Course contents	wind-driven currents, wave processes (gravity waves, inertial waves, planetary waves), dispersion relations, Ekman balance, geostrophic balance, Green's function formalism for the solution of linearized equations of motion.
Recommended literature	none

Semester periods per week (SWS) by type of course	Lecture 2 SWS Excercise course 0,5 SWS Total 2,5 SWS
Work load for students	Classes 35 hrs. Preparation of classes, studying 30 hrs. Solving of excercises 15 hrs. Preparation/examination 10 hrs. Total work load 90 hrs.

Prerequisites for the final examination (type and extent)	Solution of 50% of the requested exercises
Test performance/ requirements for a successful examination (type and extent)	Written examination (45 minutes) or oral examination (20 minutes) *To be announced in the second week of the lecture period*

Number	2350530

Category	Content
Name (German)	Theoretische Ozeanographie II: Windgetriebene Zirkulation im geschichteten Ozean
Subtitle	
Name (English)	Theoretical Oceanography II: Wind-driven Circulation in the Layered Ocean
Credit points and total work load	3 90 hours
Contact person	Dr. M. Schmidt
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	Theoretische Ozeanographie I

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	Students become acquainted with selected themes of Theoretical Oceanography. From this and embedded in a research group, they are able to start scientific work in this field.They are aware of important recent developments in the field. They have an idea how the phenomena in costal oceans can be observed. The students know several analytical methods and are able to start experimental or theoretical scientific work in a group working in this field.
Course contents	baroclinic processes (upwelling) in eastern boundary currents, development of the balance of equatorial currents, quasi-geostrophic theory, Rossby waves in the ocean, development of subtropic cells (western and eastern boundary currents) Sverdrup balance, balance of the Antartic Circumpolar Current
Recommended literature	none

Semester periods per week (SWS) by type of course	Lecture 2 SWS Excercise course 0,5 SWS Total 2,5 SWS
Work load for students	Classes 35 hrs. Preparation of classes, studying 30 hrs. Solving of excercises 15 hrs. Preparation/examination 10 hrs. Total work load 90 hrs.

Prerequisites for the final examination (type and extent)	Solution of 50% of the requested exercises
Test performance/ requirements for a successful examination (type and extent)	Written examination (45 minutes) or oral examination (20 minutes) *To be announced in the second week of the lecture period*

Number	2350540

Category	Content
Name (German)	Virtual Reality
Subtitle	
Name (Englisch)	Virtual Reality
Credit points and total work load	6 credit points 180 hours
Contact person	Prof. Dr. Oliver Staadt
Language	English
Admission restriction	None

Level	Master
Mandatory prerequisites	None
Recommended prerequisites	Introduction to Computer Graphics

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	Technical: Comprehensive and advanced knowlege in virtual reality Methodical: Specialization of individual methods in the area of virtual reality Social: Ability to participate in English-laguage courses Personal: Specialization based on individual career plans
Course contents	Selected topics in computer vision including: - - Human Factors and Perception - - VR Input Devices - - VR Displays - - 3D Interaction - - Real-time Rendering - - Computer Animation - - Augmented Reality Additional topics based on research advances in virtual reality and related fields.
Recommended literature	None

Semester periods per week by type of course	Lecture 3 SWS Project 1 SWS total 4 SWS
Work load for students	attendance time 60 hours Strutured self-directed study 100 hours exam preparation/prerequisites/examination 20 hours total workload 180 hours

Prerequisites for the final examination (type and extent)	*None*
Test performance/ requirements for a successful examination (type and extent)	exam: oral exam (exam topic in integrated exam, MSc Visual Computing, 45 minutes) or oral examination (20 minutes)

Number	1151070

Category	Content
Name (German)	Weiterführende Konzepte der Atmosphärenphysik
Subtitle	
Name (English)	Advanced Concepts of Atmospheric Physics
Credit points and total work load	3 90 hours
Contact person	Prof. Dr. F.-J. Lübken (IAP)
Language	German or English (to be announced in the second week)
Admission restriction	none

Level	Master course - basic
Mandatory prerequisites	none
Recommended prerequisites	none

Duration	1 semester
Term	Summer

Learning and qualification objectives (competences)	The students are familiar with relevant concepts and phenomena in atmospheric physics. They are aware of important recent developments in the field. Based on their knowledge they are able to start theoretical or experimental scientific work in a group working in this field.
Course contents	Advanced physical processes in the atmosphere, radiative transport, altitude-dependent energy budget, fundamentals of the theory and observation of gravity waves, planetary waves, and turbulence.
Recommended literature	none

Semester periods per week (SWS) by type of course	Lecture 2 SWS Excercise course 0,5 SWS Total 2,5 SWS
Work load for students	Classes 35 hrs. Preparation of classes, studying 30 hrs. Solving of excercises 15 hrs. Preparation/examination 10 hrs. Total work load 90 hrs.

Prerequisites for the final examination (type and extent)	Solution of 50% of the requested exercises
Test performance/ requirements for a successful examination (type and extent)	Written examination (45 minutes) or oral examination (20 minutes) *To be announced in the second week of the lecture period*

Number	2350550