

UNIVERSITÄT ZU LÜBECK

Module Guide for the Study Path

Master CLS

Version from 1. April 2019



mathematics

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computational life science / life sciences

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computational life science / imaging

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neuroscience

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CS3100 - Signal processing (SignalV)			
Duration:	Turnus of offer:		Credit points:
1 Semester	Semester each winter semester		4
 Course of study, specific field and term: Bachelor Medical Informatics before 2014 (compulsory), computer science, 5th semester Master CLS (compulsory), mathematics, 1st semester Bachelor Computer Science before 2014 (compulsory), foundations of computer science, 5th semester 			
Classes and lectures:Workload:• Signal processing (lecture, 2 SWS)• 55 Hours private studies• Signal processing (exercise, 1 SWS)• 45 Hours in-classroom work• 20 Hours exam preparation			studies room work reparation
 20 Hours exam preparation Contents of teaching: Linear time-invariant systems Impulse response Convolution Fourier transform Fourier transform Transfer function Correlation and energy density of deterministic signals Sampling Discrete-time signals and systems Discrete-time Fourier transform z-Transform FIR and IIR filters Block diagrams FIR filter design Discrete Fourier transform (DFT) Fast Fourier transform (FFT) 			
 Qualification-goals/Competencies: Students are able to explain the fundamentals of linear system theory. They are able to describe the basic elements of signal processing. They will have a command of methods for the description and analysis of continuous-time and discrete-time signals and systems. They are able to design digital filters and know various structures for their implementation. They are able to explain the basic techniques for describing and processing of random signals. 			
Grading through: • Exercises • Written or oral exam as announced b	by the examiner		
Is requisite for: • Image processing (CS3203)			
Requires: • Analysis 1 (MA2000-KP08, MA2000)			
Responsible for this module: • Prof. DrIng. Alfred Mertins Teacher: • Institute for Signal Processing • Prof. DrIng. Alfred Mertins Literature:			



 A. Mertins: Signaltheorie: Grundlagen der Signalbeschreibung, Filterbänke, Wavelets, Zeit-Frequenz-Analyse, Parameter- und Signalschätzung - Springer-Vieweg, 3. Auflage, 2013

Language:

• offered only in German



CS3203 - Image processing (Bildverarb)			
Duration:	Turnus of offer:		Credit points:
1 Semester each summer semester		4	
 Course of study, specific field and term: Bachelor Computer Science before 2014 (optional subject), specialization field bioinformatics, 6th semester Bachelor Medical Informatics before 2014 (compulsory), computer science, 6th semester Master CLS (compulsory), mathematics, 2nd semester Bachelor Computer Science before 2014 (compulsory), specialization field robotics and automation, 6th semester Bachelor Computer Science before 2014 (compulsory), specialization field robotics and automation, 6th semester Bachelor Computer Science before 2014 (optional subject), central topics of computer science, 5th or 6th semester 			
Classes and lectures:Workload:• Image processing (lecture, 2 SWS)• 55 Hours private studies• Image processing (exercise, 1 SWS)• 45 Hours in-classroom work• 20 Hours exam preparation			
Contents of teaching: Introduction, interest of visual information Fourier transformation Sampling and sampling theorem Filtering Image enhancement Edge detection Multiresolution concepts: Gaussian and Laplacian Pyramid, wavelets Principles of image compression Segmentation Morphological image processing			
 Qualification-goals/Competencies: Students will have basic knowledge of two-dimensional system theory. They are able to describe the main techniques for image analysis and image enhancement. They are able to apply the learned principles in practice. 			
Grading through: Exercises programming project Written or oral exam as announced by the examiner 			
Requires: • Signal processing (CS3100) • Analysis 1 (MA2000-KP08, MA2000)			
Responsible for this module: • Prof. DrIng. Alfred Mertins Teacher: • Institute for Signal Processing • Prof. DrIng. Alfred Mertins			
 Literature: A. K. Jain: Fundamentals of Digital Image Processing - Prentice Hall, 1989 Rafael C. Gonzalez, Richard E. Woods: Digital Image Processing - Prentice Hall 2003 			
Language: • offered only in German			



CS3205-KP04, CS3205 - Computer Graphics (CompGrafik)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	each summer semester		4		
 Course of study, specific field and term: Bachelor Medical Informatics since 2019 in planning (optional subject), computer science, 4th to 6th semester Bachelor Computer Science since 2016 (optional subject), major subject informatics, arbitrary semester Bachelor Robotics and Autonomous Systems (optional subject), computer science, 5th or 6th semester Bachelor IT-Security (optional subject), computer science, arbitrary semester Bachelor Medical Informatics since 2014 (optional subject), computer science, 5th or 6th semester Bachelor Medical Informatics since 2014 (optional subject), computer science, 5th or 6th semester Bachelor MES since 2014 (optional subject), computer science and electrical engineering, 4th or 6th semester Bachelor Media Informatics (compulsory), media informatics, 6th semester Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 5th or 6th semester Bachelor Medical Informatics before 2014 (optional subject), computer science, 4th to 6th semester Bachelor Medical Informatics before 2014 (optional subject), computer science, 5th or 6th semester Bachelor Computer Science before 2014 (optional subject), computer science, 5th or 6th semester Bachelor Science Defore 2014 (optional subject), computer science, 5th or 6th semester Bachelor CLS (optional subject), mathematics, 6th semester Bachelor CLS (optional subject), mathematics, 2th semester Bachelor Computer Science before 2014 (optional subject), central topics of computer science, 5th or 6th semester Bachelor CLS (optional subject), mathematics, 2th semester Bachelor Computer Science before 2014 (optional subject), central topics of computer science, 5th or 6th semester Bachelor Computer Science before 2014 (optional subject), central topics of computer science, 5th or 6th semester 					
Classes and lectures:		Workload:			
 Computer Graphics (lecture, 2 SWS) Computer Graphics (exercise, 1 SWS))	55 Hours private45 Hours in-class20 Hours exam p	studies room work reparation		
 Homogeneous coordinates and geometrical transformations Planar and perspective projections Polygon meshes Bezier curves and surfaces B-spline curves and surfaces Culling and Clipping Hidden surface removal Raster graphics algorithms Illumination and shading 					
Qualification-goals/Competencies: Knowledge and understanding of th Ability to implement the basic algor Ability to assess the possibilities and 	e basic concepts, algorithn ithms I limitations of the learned	ns and methods techniques			
Grading through: • Exercises • written exam	Grading through: • Exercises • written exam				
Requires: Inear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)					
Responsible for this module: • Prof. Dr. rer. nat. habil. Heinz Handel Teacher: • Institute of Medical Informatics • Dr. rer. nat. Jan Ehrhardt Literature:	S				
Foley et. al: Grundlagen der Comput	ergrafik - Addison-Wesley,	1994			



Language:

offered only in German



CS4220 - Statistical Pattern Recognition (SME)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	not available anymore		4		
 Course of study, specific field and term: Master MES before 2014 (optional subject), mathematics, 1st semester Master CLS (compulsory), mathematics, 1st or 3rd semester Master MES before 2014 (advanced curriculum), imaging systems, signal and image processing, 1st semester Master Computer Science before 2014 (compulsory), computer science mandatory courses, 1st semester 					
Classes and lectures: • Pattern Recognition (lecture, 2 SWS)		Workload: • 55 Hours private	studies		
Pattern Recognition (exercise, 1 SWS	5)	 45 Hours in-class 20 Hours exam p	room work reparation		
Contents of teaching:					
 Introduction to probability theory Principles of feature extraction and pattern recognition Bayes decision theory Discriminance functions Neyman-Pearson test Receiver Operating Characteristic Parametric and nonparametric density estimation kNN classifiers Linear classifiers Support vector machines and kernel trick Random Forest Neural Nets Feature reduction and feature transforms Validation of classifiers Selected application scenarios: acoustic scene classification for the selection of hearing-aid algorithms, acoustic event recognition, attention classification based on EEG data speaker and emotion recognition 					
Qualification-goals/Competencies: Students are able to describe the ma They are able to explain the basic ele They are able to use feature extraction 	ain elements of feature extr ements of statistical modeli on, feature reduction and p	raction and pattern recogni ing. pattern classification technic	ition. ques in practice.		
 Grading through: Exercises Written or oral exam as announced by the examiner 					
Responsible for this module: • Prof. DrIng. Alfred Mertins Teacher: • Institute for Signal Processing • Prof. DrIng. Alfred Mertins					
Literature:					
R. O. Duda, P. E. Hart, D. G. Storck: Pattern Classification - New York: Wiley					
Language:offered only in German					
Notes: Preliminary examination results can be provided at the beginning of each Semester. If preliminary examination results are required, they					



have to be positively attested.





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CS5159 - Ubiquitous Computing (UbiqComp)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	not available anymore		4		
Course of study, specific field and term • Master CLS (optional subject), mat • Bachelor CLS (optional subject), m • Master Computer Science before 2 • Master Computer Science before 2	: hematics, 2nd or 3rd seme athematics, 5th or 6th sem 2014 (optional subject), adv 2014 (optional subject), spe	ester nester vanced curriculum organic co ecialization field media inforr	omputing, 2nd or 3rd semester natics, 2nd or 3rd semester		
Classes and lectures:		Workload:			
Ubiquitous Computing (lecture wi	th exercises, 3 SWS)	 60 Hours private 45 Hours in-clas 15 Hours exam 	e studies and exercises sroom work preparation		
 Contents of teaching: The Technology trends: information technology, new materials Wireless communication and mobile computing Spontaneous networking Context awareness: location, context, and situation Smart labels (RFIDs) and wireless chipcards Embedded systems and sensors Energy aspects Wearable computing Interaction with invisible computers Software infrastructures Selected research projects Applications scenarios 					
 Qualification-goals/Competencies: Understand fundamental challenges, concepts, approaches, and limitations of UC Follow and judge recent UC research papers Design, implementation, and analysis of exemplary UC systems 					
Grading through: • Viva Voce or test					
Responsible for this module: • Prof. DrIng. Thilo Pionteck (Nachfolger NN) Teacher: • Institute of Computer Engineering • Prof. DrIng. Thilo Pionteck (Nachfolger NN)					
 Literature: Friedemann Mattern (Ed.): Die Informatisierung des Alltags - Leben in smarten Umgebungen - Springer-Verlag, 2007 Elgar Fleisch, Friedemann Mattern (Eds.): Das Internet der Dinge - Ubiquitous Computing und RFID in der Praxis - Springer-Verlag, 2005 					
Language: • offered only in German					



MA3445-KP04, MA3445 - Graph Theory (Graphen)						
Duration:	Turnus of offer:	Credit points:				
1 Semester	every second year	4				
 Course of study, specific field and term: Bachelor Medical Informatics since 2019 in planning (optional subject), mathematics, 4th to 6th semester Bachelor IT-Security (optional subject), mathematics, arbitrary semester Bachelor Robotics and Autonomous Systems (optional subject), mathematics, 5th or 6th semester Bachelor Medical Informatics since 2014 (optional subject), mathematics, 5th or 6th semester Bachelor Medical Informatics since 2014 (optional subject), mathematics, 5th or 6th semester Master MES since 2014 (optional subject), mathematics / natural sciences, 1st or 2nd semester Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 5th or 6th semester Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester Bachelor CLS (optional subject), mathematics, 5th or 6th semester Bachelor CLS (optional subject), mathematics, 5th or 6th semester Bachelor CLS (optional subject), mathematics, 5th or 6th semester Bachelor CLS (optional subject), mathematics, 5th or 6th semester 						
Classes and lectures:	v	Vorkload:				
Graph theory (lecture, 2 SWS)Graph theory (exercise, 1 SWS)		55 Hours private studies45 Hours in-classroom work20 Hours exam preparation				
 Hamiltonian graphs and degree seq Menger's theorem - new proofs Matchings and decompositions of g The theorems of Turan and Ramsey Vertex and edge colourings The four colour theorem 	uences raphs					
Qualification-goals/Competencies: Ability to solve discrete problems us Knowledge of proof techniques and Knowledge of fundamental and sele 	ing graph theoretical methods ideas of discrete mathematics ected recent research results					
Grading through:						
ExercisesOral examination						
Requires: • Linear Algebra and Discrete Structur • Linear Algebra and Discrete Structur	es 2 (MA1500-KP08, MA1500) es 1 (MA1000-KP08, MA1000)					
Responsible for this module: PD Dr. rer. nat. Hanns-Martin Teichert Teacher: Institute for Mathematics PD Dr. rer. nat. Hanns-Martin Teichert 						
Literature:	l iterature					
 Literature: F. Harary: Graph Theory - Reading, MA:.Addison-Wesley 1969 R. Diestel: Graphentheorie - Berlin: Springer 2000 D. Jungnickel: Graphen, Netzwerke und Algorithmen - Mannheim: BI-Wissenschaftsverlag1994 J. Bang-Jensen, G. Gutin: Digraphs: Theory, Algorithms and Applications - London: Springer 2001 B. Bollobas: Modern Graph Theory - Berlin: Springer 1998 						
Language:						



• offered only in German





MA4041 - Numerical Linear Algebra (NumLinAlg)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	Currently not available		4		
Course of study, specific field and ter • Bachelor CLS (optional suject), n • Master CLS (optional subject), m	m: nathematics, 6th semester athematics, 2nd or 3rd seme	ster			
Classes and lectures:Workload:• Numerical Linear Algebra (lecture, 2 SWS)• 65 Hours private studies• Numerical Linear Algebra (exercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation					
Contents of teaching: • Iterative solving of big linear eq • Numerics of eigenvalue problen	uation systems ns				
 Qualification-goals/Competencies: Students know the most important algorithms of scientific computing. They know how to handle high-dimensional problems. They are able to handle computer specific problems like Cache and BLAS. They are able to implement practical problems originating from life sciences. Interdisciplinary qualifications: Students can transfer theoretical concepts to practical problems. Students have experience in implementation. Students can abstract practical problems. 					
Grading through: Exercises Presentation of one's own solution of an exercise programming project Written or oral exam as announced by the examiner 					
Requires: • Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500) • Analysis 2 (MA2500-MML)					
Responsible for this module: • Prof. Dr. rer. nat. Jan Modersitzki Teacher: • Institute of Mathematics and Image Computing • Prof. Dr. rer. nat. Jan Modersitzki • N.N.					
 Literature: A. Meister: Numerik linearer Gleichungssysteme - Vieweg+Teubner, 2011 G. Strang: Computational Science and Engineering - Wellesley-Cambridge Press, 2007 P. Van Dooren, S. P. Bhattacharyya, V. Olshevsky, R. H. Chan, A. Routray: Numerical Linear Algebra in Signals, Systems and Control - Springer, 2011 					
Language: • German and English skills required					



MA4100 - Survival Analysis (UeberlAna)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	irregularly		4	
Course of study, specific field and term: • Master CLS (optional subject), math	ematics, arbitrary semester			
Classes and lectures: • Survival Analysis (lecture, 2 SWS) • Survival Analysis (exercise, 1 SWS)	sses and lectures:Workload:• Survival Analysis (lecture, 2 SWS)• 90 Hours private st• Survival Analysis (exercise, 1 SWS)• 15 Hours exam pre• 15 Hours in-classro• 15 Hours in-classro		studies reparation room work	
Contents of teaching: • Introduction to survival analysis • Kaplan-Meier survival curves • Log rank test • The Cox proportional hazard model and its characteristics • Evaluating the proportional hazards assumption • Stratified Cox model • Tobit Model				
Qualification-goals/Competencies: Modelling competence for survival Understanding of specific problems Knowledge of the most important s 	times with the analysis of censor tatistical methods for surviv	ed data ⁄al and their limits		
Grading through: • Exercises • Oral examination • written exam				
Requires: • Stochastics 2 (MA4020-KP04, MA402 • Stochastics 1 (MA2510-KP04, MA25 • Biostatistics 2 (MA2600-KP04, MA26 • Biostatistics 1 (MA1600-KP04, MA16	20) 10) 00) 00, MA1600-MML)			
Responsible for this module: Prof. Dr. rer. nat. Andreas Ziegler Teacher: Institute of Medical Biometry and Statistics Prof. Dr. rer. nat. Andreas Ziegler 				
Literature: • Kleinbaum DG, Klein M: Survival Analysis: A Self-Learning Text - 2005 - ISBN: 978-0-387-23918-7				
Language: • English, except in case of only Germ	an-speaking participants			





	MA4200 - Integ	ralgleichungen (Inte	gral)	
Duration:	Turnus of offer:		Credit points:	
1 Semester	every third semester	r	4	
Course of study, specific fie • Master CLS (optional s • Bachelor CLS (optiona	ld and term: subject), mathematics, arbitrary seme l subject), mathematics, 6th semeste	ester er		
Classes and lectures: • Integralgleichungen (• Integralgleichungen (lecture, 2 SWS) exercise, 1 SWS)	Workload: • 0 Hours		
Contents of teaching: • Volterrasche Integralg • Fredholmsche Integra • Numerische Lösungsv	Jleichungen Igleichungen rerfahren			
Qualification-goals/Compet Modellierung praktisc Verständnis des Zusar Klassifizierung von Int Praktische Umsetzung	z encies: her Probleme der Life Sciences durc nmenhangs zwischen Integralgleich regralgleichungen g theoretischer Algorithmen	h Integralgleichungen ungen und Differentialgle	ichungen	
Grading through: • Exercises • programming project • Oral examination • written exam				
Requires: • Analysis 2 (MA2500-M	ML)			
Responsible for this module • Prof. Dr. rer. nat. Jürge Teacher: • Institute for Mathemation • Prof. Dr. rer. nat. Jürge	e: en Prestin tics en Prestin			
Language: • offered only in Germa	n			



MA4330 - Biosignal analysis (BioSA)				
Duration: Turnus of offer: Credit points:			Credit points:	
1 Semester	each summer semester		4	
Course of study, specific field and term: • Master MES since 2014 (optional sub • Master MES before 2014 (optional su • Master Computer Science before 201 • Master CLS (compulsory), mathemati	ject), mathematics / natura bject), mathematics, 2nd s 4 (compulsory), advanced ics, 2nd semester	al sciences, arbitrary semest emester curriculum analysis, 2nd se	er mester	
Classes and lectures: • Biosignal analysis (lecture, 2 SWS) • Biosignal analysis (exercise, 1 SWS)	Classes and lectures:Workload:• Biosignal analysis (lecture, 2 SWS)• 65 Hours private studies and exercises• Biosignal analysis (exercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation			
Contents of teaching: Hilbert spaces Fourier series and Fourier transformation generalized functions discrete wavelet tranformation least square techniques application to biological and medical data 				
 Qualification-goals/Competencies: Students have deepened knowledges of the mathematical background of signal analysis They master different methodsof one-dimensional signal analysis They have practical skills in the application of these methods They have skills in working with Mathematica or MatLab 				
Grading through: • Exercises • written exam				
Requires: • Analysis 2 (MA2500-KP04, MA2500)				
Responsible for this module: • Prof. Dr. rer. nat. Karsten Keller Teacher: • Institute for Mathematics • Prof. Dr. rer. nat. Karsten Keller • Prof. Dr. rer. nat. Jürgen Prestin				
 Literature: S. Mallat: A wavelet tour of signal processing - Academic Press, 1998 A. N. Kolmogorov, S.V. Fomin: Reelle Funktionen und Funktionalanalysis - Deutscher Verlag der Wissenschaften 1975 				
• offered only in German				





MA4341 - Time series analysis (Zeitreihen)						
Duration:	Turnus of offer:		Credit points:			
1 Semester	irregularly		4			
Course of study, specific field and term • Master CLS (optional suject), math • Bachelor CLS (optional subject), m	: iematics, arbitrary semester iathematics, 6th semester					
Classes and lectures: • Time series analysis (lecture, 2 SW • Time series analysis (exercise, 1 SV	Workload: 2 SWS) 65 Hours private studies and exercises 1 SWS) 45 Hours in-classroom work • 10 Hours exam preparation		studies and exercises sroom work preparation			
Contents of teaching:						
 Simple discriptive and explorative Linear time series models: MA-pro Time series and models with long Time series in the frequency domain on linear methods by examples analysis and modelling of data from 	 Simple discriptive and explorative methods: smoothing, differentiating, autocorrelation, cross correlation Linear time series models: MA-processes, AR-processes, ARIMA-processes Time series and models with longe-range dependencies Time series in the frequency domain:autocorrelation function, spectral density and its estimation nonlinear methods by examples analysis and modelling of data from life sciences (software: R, Mathematica, SPSS) 					
Qualification-goals/Competencies: Students have basic knowledge o They master simple linear method They have competencies in analyst 	f concepts and ideas of time s Is of time series analysis sis and modelling of real-worl	eries analysis d time series				
Grading through: Exercises Oral examination written exam 						
Requires:						
• Stochastics 2 (MA4020-MML)						
Responsible for this module: Prof. Dr. rer. nat. Karsten Keller Teacher: Institute for Mathematics Prof. Dr. rer. nat. Karsten Keller 						
litoraturo						
 R. Schlittgen, B.Streitberg: Zeitreihenanalyse - Oldenburg-Verlag, München, Wien 1994 P.J. Brockwell, R.A. Davis: Time Series: Theory and Methods - Springer, New York 1991 						
Language: offered only in German						
Notes: Prerequisites for admission to the examination can be determined at the beginning of the semester. If such prerequisites are defined, they must have been fulfilled prior to the first attempt at the examination and must have been rated as positive.						



MA4400 -	MA4400 - Chaos and Complexity of Biological Systems (CKBS)				
Duration:	Turnus of offer:		Credit points:		
1 Semester	irregularly		4		
 Course of study, specific field and term: Bachelor CLS (optional subject), mathematics, 5th or 6th semester Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester Master Computer Science before 2014 (optional subject), specialization field bioinformatics, 2nd or 3rd semester Master MES before 2014 (advanced curriculum), biophysics and biomedical optics, 1st or 2nd semester Master CLS (optional subject), mathematics, arbitrary semester 					
Classes and lectures:		Workload:			
 Chaos and Complexity of Biological 5 Chaos and Complexity of Biological 5 	Systems (lecture, 2 SWS) Systems (exercise, 1 SWS)	65 Hours private45 Hours in-class10 Hours exam p	studies and exercises room work reparation		
Contents of teaching:					
 Time-discrete dynamical systems and Nonlinearity and chaos Ergodicity Symbolic dynamics Information-theoretic complexity me Ordinal time series analysis Biological and medical applications, 	 Time-discrete dynamical systems and stochastic processes Nonlinearity and chaos Ergodicity Symbolic dynamics Information-theoretic complexity measures Ordinal time series analysis Biological and medical applications, in particular EEG analysis 				
Qualification-goals/Competencies: Students get insights into basic aspe They have skills in analyzing and mo They have competencies in simulating 	ects of nonlinear dynamics deling complex data and ti ng and illustrating nonlinea	me series r dynamic phenomena			
Grading through:					
 Exercises Written or oral exam as announced by the examiner 					
Requires: • Stochastics 1 (MA2510-KP04, MA2510) • Analysis 1 (MA2000-KP08, MA2000)					
Responsible for this module:					
• Prof. Dr. rer. nat. Karsten Keller					
Teacher: Institute for Mathematics					
• FIUL DI. TEL HAL NAISLEN KEITER					
 Literature: M. Brin, G. Stuck: Introduction to Dynamical Systems - Cambridge University Press 2002 J. M. Amigó: Permutation Complexity in Dynamical Systems - Springer 2010 R. L. Devaney: An Introduction to Chaotic Dynamical Systems - Westview Press 2003 					
Language:					
depends on the chosen courses					
Notes:					



lecture notes in English

Prerequisites for admission to the examination can be determined at the beginning of the semester. If such prerequisites are defined, they must have been fulfilled prior to the first attempt at the examination and must have been rated as positive.



MA4405 - Nonlinear dynamic systems (NLinDynSys)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	irregularly		4		
Course of study, specific field and term • Bachelor CLS (optional subject), n • Bachelor CLS (optional subject), c • Master CLS (optional subject), matl • Master CLS (optional subject), cor	1: nathematics, 4th or 6th sem omputer science, 4th or 6th nematics, arbitrary semeste nputer science, arbitrary se	nester n semester r mester			
Classes and lectures: • Nonlinear dynamic systems (lectu • Nonlinear dynamic systems (exer	Workload:cture, 2 SWS)• 65 Hours private studiescercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation				
Contents of teaching: • • • • • • • • • • • • • • • • • • •					
Qualification-goals/Competencies: • • • • •					
Grading through: • Written or oral exam as announce • Oral examination • Exercises	ed by the examiner				
Requires: • Linear Algebra and Discrete Struc • Analysis 2 (MA2500-MML)	tures 1 (MA1000-KP08, MA	1000)			
Responsible for this module: • PD Dr. rer. nat. Jens Christian Clau Teacher: • Institute for Neuro- and Bioinform • PD Dr. rer. nat. Jens Christian Clau Literature: • Argyris, Faust, Haase: Die Erforsch • Jetschke: Mathematik der Selbsto • Heinz Georg Schuster: Determinis • Edward Ott: Nonlinear Dynamics	issen natics issen nung des Chaos organisation stic Chaos and Chaos				



Language:

• German and English skills required





MA4410 - Approximation Theory (Approx)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	irregularly		4		
Course of study, specific fiel • Bachelor CLS (optional • Master Computer Scient • Master CLS (optional st	d and term: subject), mathematics, 5th or 6th sen nce before 2014 (optional subject), ad ubject), mathematics, arbitrary semest	nester vanced curriculum analysis, 2 ter	nd or 3rd semester		
Classes and lectures:		Workload:			
 Approximation theory Approximation theory	action theory (lecture, 2 SWS)• 65 Hours private studies and exercisesaction theory (exercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation				
Contents of teaching: • Fundamentals of functional analysis • Best approximation • Linear methods, trigonometric kernels • Theorems of Jackson and Bernstein • Moduli of continuity • Singular integrals • Theorem of BanachSteinhaus • Interpolation methods • Stability inequalities					
Qualification-goals/Compete • Learning the basic prir • Understanding the rela • Knowledge of the basi	encies: nciples of approximation theory ationship between order of converger c approximation methods	nce and smoothness			
Grading through: • Exercises • Written or oral exam as announced by the examiner					
Responsible for this module: Prof. Dr. rer. nat. Jürgen Prestin Teacher: Institute for Mathematics Prof. Dr. rer. nat. Jürgen Prestin 					
Literature: P. L. Butzer, R. J. Nessel: Fourier Analysis and Approximation - Birkhäuser Verlag 1971 A. Schönhage: Approximationstheorie - de Gruyter 1971 					
English, except in case of only German-speaking participants					



MA4420 - Mathematics of Linear Inverse Problems (MathInvPro)				
Duration:	Turnus of offer: Credit points:		Credit points:	
1 Semester	irregularly		4	
Course of study, specific field and term: • Master CLS (optional subject), mat • Bachelor CLS (optional subject), mat	hematics, arbitrary semeste athematics, 5th or 6th seme	r ester		
Classes and lectures:		Workload:		
 Mathematics of Linear Inverse Prol Mathematics of Linear Inverse Prol 	ɔlems (lecture, 2 SWS) ɔlems (exercise, 1 SWS)	55 Hours private45 Hours in-class20 Hours exam p	studies sroom work preparation	
Contents of teaching: • Ill-posed linear operator equations • Spectral decomposition of compact operators • Stabilization of ill-posed problems • Regularization methods • Numerical realization • Application examples of linear inverse problems Qualification-goals/Competencies:				
Study of the mathematical theory Learning analytical and numerical	and the regularization poss methods for the solution of	iblities of ill-posed linear inv f linear inverse problems	verse problems	
Grading through: • Exercises • Oral examination				
Responsible for this module:				
• Dr. rer. nat. Wolfgang Erb				
Teacher: • Institute for Mathematics				
Dr. rer. nat. Wolfgang Erb				
Literature: • Engl, Hanke, Neubauer: Regularization of Inverse Problems - Kluwer, 2000 • Kirsch: An Introduction to the Mathematical Theory of Inverse Problems - Springer, 1996 • Louis: Inverse und schlecht gestellte Probleme - Teubner, 1989 • Rieder: Keine Probleme mit Inversen Problemen - Vieweg, 2003 Language:				
offered only in German				





MA4430 - Approximation on Spheres (ApproxSph)					
Duration:	Turnus of offer:	Credit points:			
1 Semester	irregularly	4			
Course of study, specific field and ter • Master CLS (optional subject), m • Master Computer Science before • Bachelor CLS (optional subject),	m: hathematics, arbitrary semest e 2014 (optional subject), adv mathematics, 5th or 6th sem	er vanced curriculum analysis, 2nd or 3rd semester lester			
Classes and lectures:Workload:• Approximation on spheres (lecture, 2 SWS)• 65 Hours private studies and exercises• Approximation on spheres (exercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation					
Contents of teaching: • Polynomial systems on spheres • Approximation methods • Fast algorithms • Scattered data	Contents of teaching: Polynomial systems on spheres Approximation methods Fast algorithms Scattered data 				
 Qualification-goals/Competencies: Learning the basic principles of approximation theory on spheres Understanding the function systems on spheres Knowledge of the basic approximation methods on spheres 					
Grading through: Exercises Written or oral exam as announced by the examiner 					
Responsible for this module: Prof. Dr. rer. nat. Jürgen Prestin Teacher: Institute for Mathematics Prof. Dr. rer. nat. Jürgen Prestin 					
 Literature: V. Michel: Lectures on Constructive Approximation - Fourier, Spline, and Wavelet Methods on the Real Line, the Sphere, and the Ball - Birkhäuser Verlag, Boston, 2013 W. Freeden, T. Gervens, and M. Schreiner: Constructive Approximation on the Sphere (With Applica- tions to Geomathematics) - Oxford Science Publication, Clarendon Press, 1998 					
 Language: English, except in case of only German-speaking participants 					





MA4451 - Evolutionary Dynamics (EvoDyn)				
Duration:	Turnus of offer:	Credit points:		
1 Semester	not available anymore	4		
Course of study, specific field • Master CLS (optional su • Bachelor CLS (optional s	l and term: bject), mathematics, arbitrary semeste subject), mathematics, 5th or 6th seme	r ister		
Classes and lectures:Workload:• Evolutionary Dynamics (lecture, 2 SWS)• 65 Hours private studies• Evolutionary Dynamics (exercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation		 Workload: 65 Hours private studies 45 Hours in-classroom work 10 Hours exam preparation 		
Contents of teaching: Stochastic models of population genetics Dynamic systems Basics of classical game theory Evolutionary game theory Applications of evolutionary dynamics to medical problems 				
Qualification-goals/Compete Knowledge of elementa Basic knowledge in gan Modelling and simulation 	ncies: ary models in evolutionary dynamics ne theory on competence			
Grading through: • Exercises • Oral examination				
Responsible for this module: • Prof. Dr. Arne Traulsen Teacher: • Institute for Mathematics • Prof. Dr. Arne Traulsen • Andere Dozenten				
Literature: • M.A. Nowak: Evolutiona • J. Hofbauer and K. Sigm	ry Dynamics - Exploring the equations nund: Evolutionary Games and Populat	of life - Harvard University Press, 2006 ion Dynamics - Cambridge University Press, 1998		
Language: • offered only in English				



MA4452 -	Evolutionary Game Theory - from	Basics to Recent Developments (EvoGameTh)
Duration:	Turnus of offer:	Credit points:
1 Semester	not available anymore	4
Course of study, specific t • Master CLS (optiona • Bachelor CLS (optio	f ield and term: al subject), mathematics, arbitrary semeste nal subject), mathematics, 5th or 6th seme	r ster
Classes and lectures:Workload:• Evolutionary Game Theory - from Basics to Recent Developments (lecture, 2 SWS)• 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation• Evolutionary Game Theory - from Basics to Recent Developments (blockseminar (compact course), 1 SWS)• 10 Hours exam preparation		 Workload: 65 Hours private studies 45 Hours in-classroom work 10 Hours exam preparation
Contents of teaching: • Basics of classical ge • Deterministic and s • The evolution of co • Repeated games • Adaptive dynamics	ame theory tochastic evolutionary game theory operation and punishment	
Qualification-goals/Comp • Familiarity with ma • Understanding of re • Familiarity with scie	Detencies: thematical concepts of classical and evolut ecent developments and recently publishe entific communication at the interface bet	ionary game theory d literature in the field veen applied mathematics and biology
Grading through: • written summary of • Oral presentation	f an original research paper	
Responsible for this mod Prof. Dr. Arne Trauls Teacher: Institute for Mather Prof. Dr. Arne Trauls Andere Dozenten	ule: ;en natics ;en	
Literature: • M.A. Nowak: Evolut • K. Sigmund: The cal	ionary Dynamics - Exploring the equations Iculus of selfishness - Princeton University	of life - Harvard University Press, 2006 Press, 2010
Language: • offered only in Engl	ish	
Notes: The lecture is offered	in German only if desired by all participan	:S.



MA4453 - Evolutionary Dyn	amics: Populati	on Genetic and Ecological Models (EvDyPopEco)
Duration: Tu	rnus of offer:	Credit points:
1 Semester irre	egularly	4
Course of study, specific field and term: • Master CLS (optional subject), mathemat • Bachelor CLS (optional subject), mathem	tics, arbitrary semest atics, 5th or 6th sen	rer hester
Classes and lectures:		Workload:
 Evolutionary Dynamics: Population Genetic and Ecological Models (lecture, 2 SWS) Evolutionary Dynamics: Population Genetic and Ecological Models (exercise, 1 SWS) 65 Hours private studies 45 Hours in-classroom work 10 Hours exam preparation 		
Contents of teaching:		
 Basics of mathematical population gene Discrete stochastic models Genetic drift Natural selection Diffusion approximation Coupling of genetic and ecological mod 	tics els	
Qualification-goals/Competencies: The students can explain the basic biolo The students can construct simple stoch The students can perform approximation 	gical and mathemat astic models and an ns of simple models.	ical concepts of population genetics. alyse them formally.
Grading through: • Exercises • Oral examination		
Responsible for this module: • Prof. Dr. Arne Traulsen Teacher: • Institute for Mathematics		
 Prof. Dr. Arne Traulsen N.N.		
Literature: • J. H. Gillespie: Population genetics - A co	oncise guide - Johns	Hopkins University Press, 2004
Language: • offered only in English		
Notes: The lecture is offered in German only if des	sired by all participa	nts.
For admission to the oral exam students m	ust have obtained a	t least 50% of the points in the exercises.



Duration: Turnus of offer: credit points: 1 Senester irregularly 4 Course of study, specific field and term: · Master CIS (optional subject), mathematics, arbitrary senester - Classes and lectures: · Morkbad: · Evolutionary Game Theory - from Basics to Recent Developments (exture, 2 SW) Workbad: · Evolutionary Game Theory - from Basics to Recent Developments (exture, 2 SW) • 65 Hours in-classroom work • 10 Hours exam preparation Contents of teaching: • 8asics of classical game theory • Deterministic and stochastic evolutionary game theory • The evolution of cooperation and punktment • Repeated games • Applications in genetics, ecology and social dynamics - Qualification-goals/Competencies: • The students can explain and apply the basic concepts of game theory. • They can construct evolutionary game? - • Prof. Dr. Ame Traulsen • Prof. Dr. Ame Traulsen - Teacher: • Instruct for Mathematics • Prof. Dr. Ame Traulsen - • Nu. - Language: • offered only in English - Notes: • The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises.	MA4454 -	Evolutionary Dynami	cs: Game Theory (Evi	DyGameTh)		
1 Semester irregularly 4 Course of study, specific field and term: Master CLS (optional subject), mathematics, arbitrary semester Bachelor CLS (optional subject), mathematics, arbitrary semester Workload: Classes and lectures: 65 Hours private studies Productionary Game Theory - from Basics to Recent Developments (lecture, 2 SWS) Workload: Contest of teaching: 65 Hours private studies Basics of classical game theory 10 Hours exam preparation Deterministic and stochastic evolutionary game theory 10 Hours exam preparation Deterministic and stochastic evolutionary game theory 10 Hours exam preparation The evolution of cooperation and punishment Respected games Repeated games Application-gals/Competencies: They can construct evolutionary games formally. State Cancer State S	Duration:	Turnus of offer:		Credit points:		
Course of study, specific field and term: • Master CLS (optional subject), mathematics, shi or 6th semester Classes and lectures: • Evolutionary Game Theory - from Basics to Recent Developments (lecture, 2 SWS) • 65 Hours private studies • Evolutionary Game Theory - from Basics to Recent Developments (sexercise, 1 SWS) • 10 Hours exam preparation Contents of teaching: • 8asics of classical game theory • Deterministic and stochastic evolutionary game theory • 10 Hours exam preparation • Developments (sexercise, 1 SWS) • 00 Hours exam preparation Contents of teaching: • 8asics of classical game theory • Deterministic and stochastic evolutionary game theory • 10 Hours exam preparation • Deterministic and stochastic evolutionary game theory • The evolution of cooperation and punishment • Repeated games • Applications in genetics, ecology and social dynamics Coalification-goals/Competencies: • The students can explain and apply the basic concepts of game theory. • The vice an analyse evolutionary games formally. Grading through: • Caracises • Oral examination • Prof. Dr. Arne Traulsen • Not. Literature: • Non. • Institute for Mathematics • Sport Dr. Arne Traulsen </td <td>1 Semester</td> <td>irregularly</td> <td></td> <th>4</th>	1 Semester	irregularly		4		
Classes and lectures: Workload: • Evolutionary Game Theory - from Basics to Recent Developments (lecture, 2 SWS) • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation Contents of teaching: • Basics of classical game theory • Deterministic and stochastic evolutionary game theory • The evolution of cooperation and punishment • Repeated games • Applications in genetics, ecology and social dynamics • 10 Hours exam preparation Cualification-goals/Competencies: • The students can explain and apply the basic concepts of game theory. • They can construct evolutionary games formally. Crading through: • Exercises • Oral examination • Pref. Dr. Ame Traulsen • Prof. Dr. Ame Traulsen • NN. Literature: • MaxA. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 • Broom & Bychtar: Game-Theoretical Models in Biology - Chapman & Hall, 2013 Literature: • Affered only in English Notes: The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises.	Course of study, specific field and term: • Master CLS (optional subject), math • Bachelor CLS (optional subject), math	ematics, arbitrary semester hematics, 5th or 6th semes	ter			
 Evolutionary Game Theory - from Basics to Recent Developments (lecture, 2 SWS) Evolutionary Game Theory - from Basics to Recent Developments (exercise, 1 SWS) Contents of teaching: Basics of classical game theory Deterministic and stochastic evolutionary game theory The evolution of cooperation and punishment Repeated games Applications in genetics, ecology and social dynamics Coulification-goals/Competencies: The students can explain and apply the basic concepts of game theory. They can construct evolutionary games formally. Grading through: Exercises Oral examination Responsible for this module: Prof. Dr. Ame Traulsen NN. Literature: MA. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 Broom & Rychtar: Game-Theoretical Models in Biology - Chapman & Hall, 2013 Language: offered only in English Notes: The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises. 	Classes and lectures: Workload:					
Contents of teaching: Basics of classical game theory • Deterministic and stochastic evolutionary game theory • The evolution of cooperation and punishment • Repeated games • Applications in genetics, ecology and social dynamics Qualification-goals/Competencies: • The students can explain and apply the basic concepts of game theory. • They can construct evolutionary models based on game theoretic interactions. • They can construct evolutionary models based on game theoretic interactions. • They can construct evolutionary games formally. Grading through: • Exercises • Oral examination Responsible for this module: • Prof. Dr. Arme Traulsen • Institute for Mathematics • Prof. Dr. Arme Traulsen • NN. Literature: • MA. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 • Broom & Rychtar: Game-Theoretical Models in Biology - Chapman & Hall, 2013 Language: • offered only in English Notes: The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises.	 Evolutionary Game Theory - from Basics to Recent Developments (lecture, 2 SWS) Evolutionary Game Theory - from Basics to Recent Developments (exercise, 1 SWS) 		 65 Hours private studies 45 Hours in-classroom work 10 Hours exam preparation 			
Qualification-goals/Competencies: • The students can explain and apply the basic concepts of game theory. • They can construct evolutionary models based on game theoretic interactions. • They can analyse evolutionary games formally. Grading through: • Exercises • Oral examination Responsible for this module: • Prof. Dr. Arne Traulsen Teacher: • Institute for Mathematics • Prof. Dr. Arne Traulsen • NN. Literature: • MA. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 • Broom & Rychtar: Game-Theoretical Models in Biology - Chapman & Hall, 2013 Language: • offered only in English Notes: The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises.	Contents of teaching: • Basics of classical game theory • Deterministic and stochastic evoluti • The evolution of cooperation and p • Repeated games • Applications in genetics, ecology ar	onary game theory unishment ıd social dynamics				
Grading through: • Exercises • Oral examination Responsible for this module: • Prof. Dr. Arne Traulsen Teacher: • Institute for Mathematics • Prof. Dr. Arne Traulsen • N.N. Literature: • M.A. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 • Broom & Rychtar: Game-Theoretical Models in Biology - Chapman & Hall, 2013 Language: • offered only in English Notes: The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises.	Qualification-goals/Competencies: The students can explain and apply They can construct evolutionary modeling the students and apply They can analyse evolutionary gameling 	the basic concepts of game dels based on game theore es formally.	e theory. tic interactions.			
Responsible for this module: • Prof. Dr. Arne Traulsen Teacher: • Institute for Mathematics • Prof. Dr. Arne Traulsen • N.N. Literature: • M.A. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 • Broom & Rychtar: Game-Theoretical Models in Biology - Chapman & Hall, 2013 Language: • offered only in English Notes: The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises.	Grading through: Exercises Oral examination 					
 Prof. Dr. Arne Traulsen Teacher: Institute for Mathematics Prof. Dr. Arne Traulsen N.N. Literature: M.A. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 Broom & Rychtar: Game-Theoretical Models in Biology - Chapman & Hall, 2013 Language: offered only in English Notes: The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises. 	Responsible for this module:					
 Institute for Mathematics Prof. Dr. Arne Traulsen N.N. Literature: M.A. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 Broom & Rychtar: Game-Theoretical Models in Biology - Chapman & Hall, 2013 Language: offered only in English Notes: The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises. 	Prof. Dr. Arne Traulsen					
 Prof. Dr. Arne Traulsen N.N. Literature: M.A. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 Broom & Rychtar: Game-Theoretical Models in Biology - Chapman & Hall, 2013 Language: offered only in English Notes: The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises. 	Institute for Mathematics	Institute for Mathematics				
 Literature: M.A. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 Broom & Rychtar: Game-Theoretical Models in Biology - Chapman & Hall, 2013 Language: offered only in English Notes: The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises. 	 Prof. Dr. Arne Traulsen N.N. 					
 Language: offered only in English Notes: The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises. 	 Literature: M.A. Nowak: Evolutionary Dynamics - Exploring the equations of life - Harvard University Press, 2006 Broom & Rychtar: Game-Theoretical Models in Biology - Chapman & Hall, 2013 					
Notes: The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises.	Language: • offered only in English					
The lecture is offered in German only if desired by all participants. For admission to the oral exam students must have obtained at least 50% of the points in the exercises.	Notes:					
For admission to the oral exam students must have obtained at least 50% of the points in the exercises.	The lecture is offered in German only if desired by all participants.					



MA4500-KP04, MA4	500 - Mathematical N	lethods in Image Pro	cessing (MatheBildv)	
Duration:	Turnus of offer:		Credit points:	
1 Semester	every second winter semester		4	
Course of study, specific field and term: Master Medical Informatics (optional Master MES since 2014 (optional sub Master MES before 2014 (optional sub Master Computer Science before 20 Master MES before 2014 (advanced Master Computer Science before 20 Master CLS (compulsory), mathemat Master Medical Informatics since 20	l subject), medical image pr oject), mathematics / natura ubject), mathematics, 1st or 14 (optional subject), advan curriculum), imaging system 14 (compulsory), advanced o ics, 1st or 3rd semester 19 in planing (optional subje	ocessing, 1st or 2nd seme l sciences, 1st or 3rd seme 3rd semester ced curriculum imaging sy ns, signal and image proce curriculum numerical image ect), medical image proces	ster ster rstems, 2nd or 3rd semester ssing, 1st or 3rd semester je processing, 2nd or 3rd semester sing, 1st or 2nd semester	
Classes and lectures: • Mathematical Methods in Image Pro • Mathematical Methods in Image Pro	Classes and lectures:Workload:• Mathematical Methods in Image Processing (lecture, 2 SWS)• 65 Hours private studies and exercises• Mathematical Methods in Image Processing (exercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation			
Contents of teaching: Image processing Digital images Operators in the spatial domain Operators in the Fourier domain Deblurring Total variation Segmentation Level-set methods 				
Qualification-goals/Competencies: • Students have a solid mathematical • They can compare and assess typica • They can derive typical mathematic • They understand fundamental oper • They understand fundamental discr • They understand typical numerical r • They are able to implement fundam • Interdisciplinary qualifications: • Students have advanced skills in model • They are experienced in implement • They are think abstractly about prace	understanding of typical im Il mathematical image proce al methods for image proces ators in image processing. etization techniques. methods for image processin ental numerical methods for odeling. epts into practical solutions. ation. ctical problems.	age processing methods. essing methods. ssing. ng. r image processing.		
Grading through: Exercises Presentation of one's own solution of an exercise Written or oral exam as announced by the examiner 				
 Is requisite for: Calculus of Variations and Partial Differential Equations (MA5034-KP04, MA5034) 				
Requires: • Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500) • Analysis 2 (MA2500-KP04, MA2500)				
Responsible for this module: • Prof. Dr. rer. nat. Jan Modersitzki				



Teacher:

Institute of Mathematics and Image Computing
Prof. Dr. rer. nat. Jan Modersitzki
Prof. Dr. rer. nat. Jan Lellmann
_iterature:
Gonzales/Woods: Digital Image Processing - Prentice Hall, 2007
Russ: The Image Processing Handbook - CRC Press, 2011
Handels: Medizinische Bildverarbeitung - Vieweg+Teubner, 2009
.anguage:
German and English skills required
Notes:
Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they must be completed and passed before taking the exam for the first time.



MA4510 - Wavelet Theory (Wavelet)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	irregularly		4	
Course of study, specific field and ter • Master Computer Science befor • Master CLS (optional subject), n	r m: e 2014 (optional subject), adv nathematics, arbitrary semeste	vanced curriculum analysis, 2 er	2nd or 3rd semester	
Classes and lectures: • Wavelet Theory (lecture, 2 SWS) • Wavelet Theory (exercise, 1 SWS)		 Workload: 65 Hours private studies and exercises 45 Hours in-classroom work 		
Contents of teaching: Haar system discrete Haar transformation orthonormal wavelet bases Multiresolution Analysis algorithms for reconstruction and decomposition multivariate generalizations 				
 Qualification-goals/Competencies: Kenntnis der Grundlagen der Waveletanalysis Verständnis von Anwendungen in der Signalanalyse, Arbeiten mit Wavelettoolboxen 				
 Grading through: exercises and project assignments Written or oral exam as announced by the examiner 				
Responsible for this module: • Prof. Dr. rer. nat. Jürgen Prestin Teacher: • Institute for Mathematics • Prof. Dr. rer. nat. Jürgen Prestin				
Literature: • : • :				
• offered only in German				



MA4610 - Stochastic processes and modeling (StochPrzMd)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	normally each year in the	e winter semester	4		
Course of study, specific field and term: • Master MES since 2014 (optional sub • Master Computer Science before 20 • Master CLS (compulsory), mathemat	uject), mathematics / natur 14 (optional subject), adva ics, 1st or 3rd semester	al sciences, 1st or 2nd se nced curriculum stochas	mester tics, 2nd or 3rd semester		
Classes and lectures:Workload:• Stochastic processes and modeling (lecture, 2 SWS)• 55 Ho• Stochastic processes and modeling (exercise, 1 SWS)• 45 Ho• 20 Ho		Workload: • 55 Hours priva • 45 Hours in-cl • 20 Hours exar	ad: 55 Hours private studies and exercises 15 Hours in-classroom work 20 Hours exam preparation		
Contents of teaching: • Conditional expectation • Stochastic processes • Filtrations • Martingales • Brownian motion	Contents of teaching: • Conditional expectation • Stochastic processes • Filtrations • Martingales • Brownian motion				
Qualification-goals/Competencies: To develop some insight into stocha Training of a stochastic way of think Application of basic ideas and conce 	istic processes based on se ing epts of stochastic analysis	elected classes of process	ses		
Grading through: • Exercises • Written or oral exam as announced by the examiner					
Requires: • Stochastics 2 (MA4020-MML) • Stochastics 1 (MA2510-KP04, MA2510)					
Responsible for this module: • Prof. Dr. rer. nat. Andreas Rößler Teacher: • Institute for Mathematics • Prof. Dr. rer. nat. Andreas Rößler					
Literature: • : • : • Ioannis Karatzas, Steven E. Shreve: B	rownian Motion and Stoch	nastic Calculus - Springer	Verlag, 2nd edition, 1991		
Language: • German and English skills required					





MA4611 - Markov-Prozesse (MarkovProz)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	not available anymore		4	
Course of study, specific field • Master CLS (optional su • Bachelor CLS (optional	d and term: ıbject), mathematics, arbitrary semester subject), mathematics, 5th or 6th seme	ster		
Classes and lectures:		Workload:		
 Markov-Prozesse (lecture, 2 SWS) Markov-Prozesse (exercise, 1 SWS) 		 60 Hours private studies and exercises 45 Hours in-classroom work 15 Hours exam preparation 		
Contents of teaching:				
Grading through: • Exercises • Written or oral exam as	announced by the examiner			
Responsible for this module: • Prof. Dr. rer. nat. Karste Teacher: • Institute for Mathemati • Prof. Dr. rer. nat. Karste • Prof. Dr. rer. nat. Jürger	n Keller cs n Keller n Prestin			
Language: • offered only in German				




MA4612 - Numerik dynamischer Systeme (NumDynSyst)				
Duration:	Turnus of offer:	Credit points:		
1 Semester	not available anymore	4		
Course of study, specific field • Master CLS (optional suj • Master MES before 2014 • Bachelor CLS (optional s	and term: ject), mathematics, arbitrary semester (optional subject), mathematics, 1st subject), mathematics, 6th semester	or 2nd semester		
Classes and lectures:		Workload:		
 Numerik dynamischer Systeme (lecture, 2 SWS) Numerik dynamischer Systeme (exercise, 1 SWS) 		 65 Hours private studies 45 Hours in-classroom work 10 Hours exam preparation 		
 Kontinuierliche dynamis Modellierungsaspekte Qualification-goals/Competent Modellierung, Simulatice Numerische Umsetzung Anwendung auf praxismission 	sche Systeme (Systeme gewöhnlicher ncies: on und Analyse lebender Systeme) der einzelnen Ansätze elevante Fragestellungen	Differentialgleichungen)		
Grading through: • Exercises • written exam				
Responsible for this module: • Prof. Dr. rer. nat. Jan Mo Teacher: • Institute for Mathematic • Prof. Dr. rer. nat. Jan Mo	dersitzki :s dersitzki			
Language: • offered only in German				



MA4614	- Numerical methods for partia	l differential equatior	is (NumMethPDE)	
Duration:	Turnus of offer:		Credit points:	
1 Semester	irregularly		4	
Course of study, specific field • Bachelor CLS (optional s • Master CLS (optional sub	and term: ubject), mathematics, 5th or 6th semester pject), mathematics, arbitrary semester	er		
 Classes and lectures: Numerical methods for partial differential equations (lecture, 2 SWS) Numerical methods for partial differential equations (exercise, 1 SWS) 		 Workload: 55 Hours private studies 45 Hours in-classroom work 20 Hours exam preparation 		
Contents of teaching: • Numerics for partial diffi • Discretization of initial a • Numerical approximatic • Error analysis • Stability and consistency	erential equations Ind boundary value problems In schemes Y			
Qualification-goals/Competer • To impart basic principle • To learn methods of pro • Accomplished handling	ncies: es of numerics for partial differential equ oofs as well as the application of results f of essential concepts and results as well	nations rom numerics for partial dif as of selected advanced to	ferential equations pics	
Grading through: • Exercises • Written or oral exam as a	announced by the examiner			
Requires: • Numerics 2 (MA4040-MI • Numerics 1 (MA3110-MI • Linear Algebra and Discu • Linear Algebra and Discu • Analysis 2 (MA2500-MM • Analysis 1 (MA2000-KP0	ML) ML) rete Structures 2 (MA1500-KP08, MA1500 rete Structures 1 (MA1000-KP08, MA1000 L) 8, MA2000)	D) D)		
Responsible for this module: • Prof. Dr. rer. nat. Andrea Teacher: • Institute for Mathematic • Prof. Dr. rer. nat. Andrea • MitarbeiterInnen des Ir	s Rößler s Rößler hstituts			
Language: • offered only in German				
Notes: Literature will be announc	ed in the lecture.			
Criteria for admission to th	ne examination will be established by the	e lecturer.		



MA4615 - Numerical methods for stochastic processes (NumStochPr)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	irregularly		4	
Course of study, specific field and term: • Master MES before 2014 (optional su • Bachelor CLS (optional subject), mat • Master CLS (optional subject), mathe	ubject), mathematics, 1st or hematics, 5th or 6th semes ematics, arbitrary semester	2nd semester ter		
Classes and lectures: Workload:				
 Numerical methods for stochastic processes (lecture, 2 SWS) Numerical methods for stochastic processes (exercise, 1 SWS) Storikidation 55 Hours private studies 45 Hours in-classroom work 20 Hours exam preparation 			studies room work reparation	
Contents of teaching: • Basic principles of stochastic proces • Stochastic differential equations • Discrete time approximations for so • Numerical schemes for strong and v	ses in continuous time lutions of stochastic differe veak approximations	ntial equations		
Qualification-goals/Competencies: To impart basic principles of stochas To learn methods of proof as well as Accomplished handling of essential 	stic processes and of some s the application of algorith concepts and results as we	numerical schemes ms Il as of selected advanced t	topics	
Grading through: • Exercises • Written or oral exam as announced	by the examiner			
Requires: • Stochastics 2 (MA4020-KP04, MA4020) • Stochastics 1 (MA2510-KP04, MA2510)				
Responsible for this module: • Prof. Dr. rer. nat. Andreas Rößler Teacher: • Institute for Mathematics • Prof. Dr. rer. nat. Andreas Rößler				
Literature: P. E. Kloeden, E. Platen: Numerical So P. E. Kloeden, E. Platen, H. Schurz: No G. N. Milstein, M. V. Tretyakov: Stoch	olution of Stochastic Differe umerical Solution of SDE Th aastic Numerics for Mathem	ential Equations - Springer- rough Computer Experime atical Physics - Springer-Ve	Verlag, Berlin, 1999 ents - Springer-Verlag, Berlin, 2002 erlag, Berlin, 2004	
Language: • offered only in German				
Notes: Criteria for admission to the examinati	on will be established by th	ne lecturer.		





MA4616 - Advanced Numerics (HoehereNum)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	irregularly		4	
Course of study, specific field and term: • Master MES before 2014 (optional s • Bachelor CLS (optional subject), ma • Master CLS (optional subject), math	ubject), mathematics, arbit thematics, 5th or 6th seme ematics, arbitrary semester	rary semester ster		
Classes and lectures: Workload:				
 Advanced Numerics (lecture, 2 SWS) Advanced Numerics (exercise, 1 SWS) 45 Hours in-classroom work 20 Hours exam preparation 			studies room work reparation	
 Contents of teaching: Numerics for ordinary differential equations One-step methods, local and global error analysis Orders of consistence and convergence Stiff differentual equations, implicit schemes, stability 				
 Qualification-goals/Competencies: To impart basic principles of numer To learn methods of proofs as well Accomplished handling of essential 	ics for differential equatior as the application of results l concepts and results as w	is s from numerics for different ell as of selected advanced t	tial equations opics	
Grading through: • Exercises • Written or oral exam as announced	by the examiner			
Requires: • Numerics 2 (MA4040-MML) • Numerics 2 (MA4040) • Numerics 1 (MA3110-MML) • Numerics 1 (MA3110-KP04, MA3110)				
Responsible for this module: • Prof. Dr. rer. nat. Andreas Rößler Teacher:				
Institute for Mathematics				
Prof. Dr. rer. nat. Andreas Rößler				
Language: • offered only in German				
Notes:				
Literature will be announced in the le	cture.			
Criteria for admission to the examination will be established by the lecturer.				



	MA4617 - Stochastic dif	ferential equations (St	ochDiff)		
Duration:	Turnus of offer:		Credit points:		
1 Semester	irregularly		4		
Course of study, specific field Master CLS (optional support) 	l and term: Ibiect), mathematics, arbitrary semes	ter			
		····			
 Classes and lectures: Stochastic differential equations (lecture, 2 SWS) Stochastic differential equations (exercise, 1 SWS) 		• 55 Hours priva • 45 Hours in-cla	 • 55 Hours private studies • 45 Hours in-classroom work 		
		• 20 Hours exam	preparation		
Contents of teaching: • Stochastic processes, B • Stochastic integration • Ito formula • Stochastic differential e	rownian motion equations				
Qualification-goals/Compete • To impart basic princip • To learn methods of pr • Accomplished handling	encies: les of stochastic processes and stoch oof as well as the application of resul g of essential concepts and results as	astic differential equations Its from stochastic analysis well as of selected advance	d topics		
Grading through: • Exercises • Written or oral exam as	announced by the examiner				
Requires: • Stochastic processes ar • Stochastics 2 (MA4020- • Stochastics 1 (MA2510-	id modeling (MA4610) KP04, MA4020) KP04, MA2510)				
Responsible for this module: • Prof. Dr. rer. nat. Andre Teacher: • Institute for Mathemati • Prof. Dr. rer. nat. Andre	as Rößler cs as Rößler				
Literature: • Bernt Oksendal: Stocha • Ioannis Karatzas, Steve • Philip Protter: Stochast • K. L. Chung, R. J. Williar	stic Differential Equations: An Introdu n E. Shreve: Brownian Motion and Sto ic Integration and Differential Equations: Introduction to Stochastic Integra	uction with Applications - Sp ochastic Calculus - Springer ons - Springer Verlag, 2010 tion - Birkhäuser, 2nd editio	oringer Verlag, 6th edition, 2010 /erlag, 2nd edition, 1991 n, 1990		
Language: • German and English sk	ills required				
Notes: Criteria for admission to t	he examination will be established b	y the lecturer.			



MA4618 - Introdu	iction to stochastic pa	rtial differential equ	ations (EinfSPDEs)
Duration:	Turnus of offer:		Credit points:
1 Semester	irregularly		4
Course of study, specific field and term:			
Master CLS (optional subject), mathe	matics, arbitrary semester		
Classes and lectures:		Workload:	
Introduction to stochastic partial diff	erential equations (lecture,	• 55 Hours private	studies
2 SWS) Introduction to stochastic partial diff 	erential equations	 45 Hours in-class 20 Hours exam p 	room work preparation
(exercise, 1 SWS)		20 Hours chain p	
Contents of teaching:			
Gaussian measures on Hilbert spaces	5		
 Infinite-dimensional Brownian motio Martingales on Banach spaces 	n		
Stochastic integration in Hilbert space	ces		
 Existence of solutions for SPDEs Numerical methods for the approxim 	nation of solutions		
To impart basic principles of the theorem	ory for stochastic partial diff	erential equations	
 To learn methods of proofs as well as 	s the application of results f	rom the theory for stochas	stic partial differential equations
Accomplished handling of essential of the second seco	concepts and results as well	as of selected advanced t	topics
Grading through:			
 Exercises Written or oral example appounded by 	w the examiner		
Requires:			
 Stochastic differential equations (MA Stochastic processes and modeling (I 	.4617) MA4610)		
• Stochastics 2 (MA4020-MML)			
Stochastics 1 (MA2510-KP04, MA2510	0)		
Responsible for this module:			
 Prof. Dr. rer. nat. Andreas Rößler 			
Institute for Mathematics			
Prof Dr. rer. nat. Andreas Bößler			
MitarbeiterInnen des Instituts			
Language:			
offered only in German			
Notes			
Literature will be announced in the lect	ture.		
Criteria for admission to the examination	on will be established by the	e lecturer.	





MA4630 - Fourier Analysis (FourierAna)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	irregularly		4	
Course of study, specific field and term • Bachelor CLS (optional suject), ma • Master MES before 2014 (optiona • Master CLS (optional subject), ma	1: Ithematics, 5th or 6th semeste I subject), mathematics, 1st or thematics, arbitrary semester	er r 2nd semester		
Classes and lectures:Workload:• Fourier Analysis (lecture, 2 SWS)• 65 Hours private studies• Fourier Analysis (exercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation			studies room work reparation	
Contents of teaching: • Theory of the Fourier transform • Fourier transform in the Hilbert sp • Summability methods • Applying Fourier transforms in so • Laplace and Mellin transforms • Numerical aspects and relation to	oace Iving differential equations o discrete Fourier transforms			
 Qualification-goals/Competencies: Knowledge of integral transforms A comprehensive understanding 	for the Fourier transform			
Grading through: • Exercises • written exam				
Responsible for this module: • Prof. Dr. rer. nat. Jürgen Prestin Teacher: • Institute for Mathematics • Prof. Dr. rer. nat. Jürgen Prestin				
Literature: • Chandrasekharan, K.: Classical For	urier Transforms - Springer 19	89		
Language: • offered only in German				



MA4650 - Matrix algebra (MatrixAlg)				
Duration:	Turnus of offer:	Credit points:	Max. group size:	
1 Semester	irregularly	4	20	
Course of study, specific field a • Master CLS (optional subj • Master MES before 2014 (• Bachelor CLS (optional su	and term: ect), mathematics, arbitrary semester optional subject), mathematics, 1st ser bject), mathematics, 6th semester	mester		
Classes and lectures:		Workload:		
 Matrix algebra (lecture, 2 SWS) Matrix algebra (exercise, 1 SWS) Matrix algebra (exercise, 1 SWS) 45 Hours in-classroom work 15 Hours exam preparation 			exercises	
 Contents of teaching: Properties of matrices Special matrices Quadratic forms Decompositions Generalized inverses Differentiation Probability calculation Derivation and calculation of estimators Design matrices Linear hypotheses Examples: multiple linear regression, weighted least-squares estimation, shrinkage estimation Qualification-goals/Competencies: Understanding of typical derivation techniques needed for generalized linear models and multivariate methods Command of matrix algebra Application of linear algebra to linear models 				
Grading through: written exam 				
Requires: • Biostatistics 1 (MA1600-K • Analysis 2 (MA2500-MML	P04, MA1600, MA1600-MML))			
Responsible for this module: • Prof. Dr. rer. nat. Andreas Ziegler Teacher: • Institute of Medical Biometry and Statistics • Prof. Dr. rer. nat. Andreas Ziegler • Dr. Reinhard Vonthein				
Literature: • K. Schmidt, G. Trenkler: Ei 9783540330073 • H. Toutenburg: Lineare M • L. Fahrmeir, T. Kneib, S. La • Michael Healy: Matrices for	nführung in die Moderne Matrix-Algeb Iodelle - Physica: Heidelberg 1992 und ang: Regression: Modelle, Methoden un or Statistics - ISBN 9780198507024	ora: Mit Anwendungen in der Statistik 2006, ISBN 978-3790815191 nd Anwendungen - Springer: Heidelbe	- Springer: Heidelberg 2006, ISBN erg 2007, ISBN 9783642343339	
Language:				

• offered only in German





MA4660 - Prognostic models (PM)				
Duration:	Turnus of offer:	Credit points:	Max. group size:	
1 Semester	irregularly	4	20	
Course of study, spe • Master MES be • Master CLS (op	e cific field and term: efore 2014 (optional subject), mathemati ptional subject), mathematics, arbitrary s	ics, 1st or 2nd semester semester		
Classes and lectures: Workload:				
 Prognostic models (lecture, 2 SWS) Prognostic models (exercise, 1 SWS) Prognostic models (exercise, 1 SWS) 45 Hours in-classroom work 15 Hours exam preparation 				
Contents of teachin	g:			
 Aims and app General appro Classical statis Approaches to Alternative ap machines 	lications of prognostic models bach to develop valid prognostic models stical approaches to develop prognostic no o validate prognostic models proaches to develop prognostic models	models : Classification and Regression Trees, e	ensemble methods, support vector	
Qualification-goals/ • Understandin • Mastering the • Mastering the • Mastering diff • Applying basi	Competencies: g the application as well as the general a most important classical statistical appro most important alternative approaches erent methods to validated prognostic n c approaches by hand and more comple	approach to develop valid prognostic oaches to develop prognostic models to develop prognostic models nodels x approaches computer-based	models	
Grading through: • written exam				
Requires: • Biostatistics 2 • Statistics - Pra	(MA2600-KP04, MA2600) ctical Course (MA3210)			
Responsible for this • Prof. Dr. rer. n. Teacher: • Institute of Me • Prof. Dr. rer. b • Prof. Dr. rer. n.	module: at. Andreas Ziegler edical Biometry and Statistics iol. hum. Inke König at. Andreas Ziegler			
Language: • offered only ir	n German			



MA4661-KP08, MA4661 - Genetic Epidemiology 2 (GenEpi2)					
Duration:	Turnus of offer:	Credit points:	Max. group size:		
1 Semester	each summer semester	8	20		
Course of study, specific fiel • Bachelor CLS starting 2 • Master CLS starting 20 • Bachelor CLS (optional • Master CLS (optional s	d and term: 2016 (optional subject), mathematics 16 (optional subject), MML with spec I subject), mathematics, 6th semester ubject), mathematics, arbitrary semes	, 6th semester ialization in Genetic Statistics, 2 ster	nd semester		
Classes and lectures:		Workload:			
 Genetic Epidemiology 2 (lecture, 2 SWS) Genetic Epidemiology 2 (exercise, 1 SWS) Genetic Epidemiology 2 (practical course, 2 SWS) 135 Hours private studies 75 Hours in-classroom work 30 Hours exam preparation 			studies oom work eparation		
Contents of teaching:					
 Model-based linkage a Model-free linkage and Model-free linkage and Linkage analysis for que Sample size estimation Data analysis for gene Data analysis for gene 	analysis: Linkage of two markers, linka alysis: Tests for sib-pairs alysis: Extensions to many markers ar uantitative phenotypes: Haseman-Els n for linkage analysis tic association studies expression studies	age of one marker with one phe nd extended pedigrees ton method and its extensions, v	notype variance components models		
 The students are able They are able to name They are able to apply They are able to apply They can conduct a state They can conduct basis They have the method They have the method They have the method They have the communication They have the communication 	to describe the most important study and describe the most important ap basic test statistics manually and int more complex test statistics using th andard quality control in genetic asso- ic analyses of genetic association studies andard quality control in gene express ic analyses of gene expression studies dological competence to solve large- ement competence to organize their ds competence to develop solutions was unication competence to present idea	 designs for genetic epidemiolo proaches for linkage analysis wi erpret the results. computer and interpret the re- ociation studies in R. dies in R. sion studies in R. s in R. scale tasks cost- and time- efficie own work and that of collaboration with limited resources (time, per us and solutions in oral and written 	gical linkage studies within families. th qualititative and quantitative phenotypes. esults. ently. tors involved in the project. sonnel, etc.) that comply with general en form.		
Grading through:					
 continuous, successful written exam	participation in practical course				
ls requisite for:					
Seminar Genetic Epide	Seminar Genetic Epidemiology (MA5129-KP04, MA5129)				
Requires: • Statistics - Practical Co • Genetic Epidemiology	urse (MA3210) 1 (MA3200-KP04, MA3200)				
Responsible for this module	:				
• Prof. Dr. rer. biol. hum.	Inke König				
Teacher:					
Institute of Medical Bio	ometry and Statistics				
Prof. Dr. rer. biol. hum. Inke König					

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Literature:

• Ziegler A, König IR.: A statistical approach to genetic epidemiology. Concepts and applications. - 2010. ISBN: 978-3-527-32389-0

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Language:

offered only in German

Notes:

Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they must be completed and passed before taking the exam for the first time.



	MA4670 - Con	nbinatorics (Kombi)	
Duration:	Turnus of offer:		Credit points:
1 Semester	r every second year 4		4
Course of study, specific fit • Master MES before 20 • Master CLS (optional • Bachelor CLS (option	e ld and term: 014 (optional subject), mathematics, 1st subject), mathematics, arbitrary semest al subject), mathematics, 5th or 6th sen	e or 2nd semester er nester	
Classes and lectures: Workload:			
 combinatorics (lecture, 2 SWS) combinatorics (exercise, 1 SWS) 45 Hours in-classroom wor 20 Hours exam preparation 		studies room work reparation	
Contents of teaching: Permutations, combi Partitions Generating functions Recurrence equation Sums and differences Inclusion - exclusion	nations, variations ; s s		
Qualification-goals/Compe • Learning the basics of • Knowledge of differe • Teaching fundament	etencies: of combinatorics ent proof techniques and combinatorial cal results and deepening some selected	approaches I aspects of combinatorics	
Grading through: • Exercises • Oral examination			
Requires: • Linear Algebra and D • Linear Algebra and D • Analysis 1 (MA2000-H	viscrete Structures 2 (MA1500-KP08, MA viscrete Structures 1 (MA1000-KP08, MA KP08, MA2000)	1500) 1000)	
Responsible for this modul • PD Dr. rer. nat. Hanns Teacher: • Institute for Mathema • PD Dr. rer. nat. Hanns	l e: 5-Martin Teichert atics 5-Martin Teichert		
Literature:			
Peter Tittmann: EinfüRichard A. Brualdi: In	ihrung in die Kombinatorik - Spektrum / troductory Combinatorics - Pearson Pre	Akademischer Verlag 2000 ntice Hall 2004	
Language: • offered only in Germ	an		



MA4675 - Algebra (Algebra)			
Duration:	Turnus of offer:	Credit points:	
1 Semester	every second year 4		
Course of study, specific field • Bachelor CLS (optional s • Master CLS (optional su	a nd term: subject), mathematics, 5th or 6th sem bject), mathematics, arbitrary semest	lester er	
Classes and lectures: Workload:			
 Algebra (lecture, 2 SWS) Algebra (exercise, 1 SWS) SWS) 45 Hours in-classroom work 20 Hours exam preparation 			
Contents of teaching: • Groups (semigroups, su • Rings (units, ring homo • Field extensions (field c splitting field of a polyn • Geometric construction	bgroups, homomorphisms, invariant morphisms, polynomial rings, quotier haracteristic, prime fields, field degre iomial) is (compass-and-straightedge constru	subgroups, isomorphism theorems, products of groups) nt fields, ideals) e, algebraic and transcendent elements, algebraical field extensions, action, field of constructible points, constructing regular polygons)	
Qualification-goals/Competer • Learning the basics of a • Knowledge of different • Teaching fundamental	ncies: lgebra proof techniques and algebraic appro results and deepening some selected	oaches aspects of algebra	
Grading through: • Exercises • Oral examination			
Requires: • Linear Algebra and Disc • Linear Algebra and Disc	rete Structures 2 (MA1500-KP08, MA1 rete Structures 1 (MA1000-KP08, MA1	1500) 1000)	
Responsible for this module: • PD Dr. rer. nat. Hanns-W Teacher: • Institute for Mathematic • PD Dr. rer. nat. Hanns-W	lartin Teichert cs lartin Teichert		
Literature: • G. Fischer: Lehrbuch de • M. Artin: Algebra - Birkh • B. L. van der Waerden: A	r Algebra - Vieweg, 2011 (2. Auflage) iäuser, 1998 Algebra I - Springer, 1993 (9. Auflage)		
Language: • offered only in German			





MA4700 - Angewandte Analysis (AngewAna)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	each winter semester		4		
Course of study, specific field and ter • Master MES before 2014 (optior • Master CLS (optional subject), m • Bachelor CLS (optional subject),	m: nal subject), mathematics, 1st s nathematics, arbitrary semester mathematics, 6th semester	emester			
Classes and lectures: • Applied Analysis (lecture, 2 SWS • Applied Analysis (exercise, 1 SW	lasses and lectures:Workload:• Applied Analysis (lecture, 2 SWS)• 60 Hours private studies• Applied Analysis (exercise, 1 SWS)• 45 Hours in-classroom work• 15 Hours exam preparation				
 Contents of teaching: Maße und ihre Konstruktion Messbare Funktionen, Integration, Konvergenzsätze Produktmaße, Fubini Satz von Radon-Nikodym Lebesgue-Maße, Transformationsformel Kurven- und Oberflächenintegrale Integralsätze Partielle Differentialgleichungen erster Ordnung (Zusammenhang mit Systemen gewöhnlicher Diffferentialgleichungen) Klassifikation von Gleichungen zweiter Ordnung Beispielhafte Behandlung der drei Grundtypen 					
 Qualification-goals/Competencies: Anwendungsbereites Verständr Räumen Einführung in die Theorie partie Erlernen hierzu grundlegender Stärkung des Verständnisses für 	nis der abstrakten Maß- und Int eller Differentialgleichungen analytischer Hilfsmittel ^r Modellierung	egrationstheorie und ihrer	r konkreten Anwendungen in euklidischen		
Grading through: • Exercises • written exam					
Responsible for this module: • Prof. Dr. rer. nat. Jürgen Prestin Teacher: • Institute for Mathematics • Prof. Dr. rer. nat. Jürgen Prestin					
Language: • offered only in German					





MA4710 - Functional Analysis (FunkAna)				
Duration:	Turnus of offer: Credit poin		Credit points:	
1 Semester	irregularly		4	
Course of study, specific field • Master MES before 2014 • Master CLS (optional su • Bachelor CLS (optional s	l and term: 4 (optional subject), mathematics, 1s bject), mathematics, arbitrary semes subject), mathematics, 5th or 6th ser	t or 2nd semester ter nester		
Classes and lectures:Workload:• Functional Analysis (lecture, 2 SWS)• 55 Hours private stude• Functional Analysis (exercise, 1 SWS)• 45 Hours in-classroo• 20 Hours exam prep		studies room work reparation		
Contents of teaching: • Metric spaces and their • Banach spaces, Hilbert s • Duality, Hahn-Banach tl • Bounded linear operato • L^p-spaces and the the • Weak topologies and re	topology spaces and their geometry heorems ors, open mapping principle orem of Riesz-Fischer flexive spaces			
Qualification-goals/Compete Learning the basic tech Study of the fundament 	ncies: niques for the analysis of linear func tal principles of functional analysis	tionals and operators on Bana	ch and Hilbert spaces	
Grading through: • Exercises • Oral examination				
Responsible for this module: • Dr. rer. nat. Wolfgang En Teacher: • Institute for Mathematic • Dr. rer. nat. Wolfgang En	rb cs rb			
Literature: • Hirzebruch, Scharlau: Ei • Rudin: Functional Analy • Heuser: Funktionalanaly • Hille, Phillips: Functiona	nführung in die Funktionalanlysis - E rsis - McGraw Hill, 1991 ysis - 4. Auflage, Teubner, 2006 Il Analysis and Semi-Groups - AMS, 1	81-Hochschulbücher, 1991 957		
Language: • offered only in German				



MA4720 - Orthogonal Series in Banach Spaces (ORiBanachR)					
Duration:	Turnus of offer:	Credit points:			
1 Semester	irregularly	4			
Course of study, specific field • Master CLS (optional sul • Bachelor CLS (optional s	and term: bject), mathematics, arbitrary semes: subject), mathematics, 5th or 6th sen	ter nester			
Classes and lectures:Workload:• Orthogonal Series in Banach Spaces (lecture, 2 SWS)• 65 Hours private studies• Orthogonal Series in Banach Spaces (exercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation					
Contents of teaching: • Conditional und uncond • General existence- and i • Haar and Franklin System	ditional convergence and bases in ge non-existence results concerning ba ms as bases in the spaces Lp, H1 and	eneral Banach spaces sis especially in the spaces L1 and C(I) I BMO			
Qualification-goals/Competer • A competent knowledg	n cies: e of the construction methods of ba	ses in special Banach spaces			
Grading through: Oral examination planning and conductin active participation in the 	g exercises in a two-person-team ne exercises				
Responsible for this module: • Dr. Jörn Schnieder Teacher: • Institute for Mathematics • Dr. Jörn Schnieder					
Literature: • Kashin, B. S., Saakyan, A.	. A.: Orthogonal Series - AMS 1989				
Language: • offered only in German					





MA4740 - Fractal Geometry (FraktGeo)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	irregularly		4	
Course of study, specific field and term: • Master CLS (optional subject), mathe • Bachelor CLS (optional subject), mat	ematics, arbitrary semeste hematics, 5th or 6th sem	er ester		
Classes and lectures: • Fractal Geometry (lecture, 2 SWS) • Fractal Geometry (exercise, 1 SWS)	Classes and lectures: Workload: • Fractal Geometry (lecture, 2 SWS) • 65 Hours private studies • Fractal Geometry (exercise, 1 SWS) • 45 Hours in-classroom work • 10 Hours exam preparation			
Contents of teaching: • Exploring classical fractal sets (e.g. se • Geometric characterisation by mean • Further geometric characteristics (re • Thermodynamic formalism and sym	 Contents of teaching: Exploring classical fractal sets (e.g. self-similar sets, Mandelbrot set and Julia sets) Geometric characterisation by means of dimensions and determination of these dimensions Further geometric characteristics (refining the notions of dimension) Thermodynamic formalism and symbolic dynamics 			
Qualification-goals/Competencies: The students are familiar with classic They can characterise highly irregulation 	al fractal sets and are ab r sets with regard to the	le to classify them. ir roughness.		
Grading through: Exercises Oral examination 				
Responsible for this module: • Dr. Sabrina Kombrink Teacher: • Institute for Mathematics • Dr. Sabrina Kombrink				
 Literature: K. J. Falconer: Fractal Geometry. Mathematical foundations and applications - 2. edition, John Wiley & Sons, Inc., Hoboken, NJ, 2003 K. J. Falconer: Techniques in fractal geometry - John Wiley & Sons Ltd., Chichester, 1997 B. B. Mandelbrot: The fractal geometry of nature - W. H. Freeman and Co., San Francisco, Calif., 1982 				
Language: • offered only in German				
Notes: For admission to the oral exam students must have obtained at least 50% of the points in the exercises.				





	MA4800 - Differen	nzialgeometrie (Dif	fgeo)	
Duration:	Turnus of offer:		Credit points:	
1 Semester	every second year	every second year		
Course of study, specific field and • Master MES before 2014 (op • Master CLS (optional subjec • Bachelor CLS (optional subj	d term: otional subject), mathematics, 1st t), mathematics, arbitrary semest ect), mathematics, 6th semester	t or 2nd semester ter		
Classes and lectures: • Differenzialgeometrie (lectu • Differenzialgeometrie (exer	Ind lectures:Workload:ifferenzialgeometrie (lecture, 2 SWS)• 60 Hours private studiesifferenzialgeometrie (exercise, 1 SWS)• 45 Hours in-classroom work• 15 Hours exam preparation			
Contents of teaching: • • • • • • • • • • • • • • • • • • •				
Qualification-goals/Competencie • • •	s:			
Grading through: • Exercises • Written or oral exam as ann	ounced by the examiner			
Responsible for this module: • Prof. Dr. Reinhard Schuster Teacher: • Institute for Mathematics • Prof. Dr. Reinhard Schuster				
Language: • offered only in German				



MA4801 - Elliptische Funktionen (EllipFunk)					
Duration:	Turnus of offer:	Turnus of offer:			
1 Semester	every second year		4		
Course of study, specific field a • Master CLS (optional sub • Bachelor CLS (optional sub	and term: ject), mathematics, arbitrary semest ubject), mathematics, 5th or 6th sem	er nester			
Classes and lectures:Workload:• Elliptische Funktionen (lecture, 2 SWS)• 60 Hours private studies• Elliptische Funktionen (exercise, 1 SWS)• 45 Hours in-classroom work• 15 Hours exam preparation		ite studies assroom work n preparation			
Contents of teaching:					
Qualification-goals/Competen • •	cies:				
Grading through: • Exercises • Written or oral exam as a	nnounced by the examiner				
Responsible for this module: • Prof. Dr. Reinhard Schust Teacher: • Institute for Mathematics • Prof. Dr. Reinhard Schust	er ; er				
Language: • offered only in German					



MA4802 - S	pezielle und allgemei	ne Relativitätstheorie	e (RelatiTheo)	
Duration:	Turnus of offer:		Credit points:	
1 Semester	every second year		4	
Course of study, specific field and term: • Master MES before 2014 (optional s • Master CLS (optional subject), math • Bachelor CLS (optional subject), ma	ubject), mathematics, 1st or ematics, arbitrary semester thematics, 5th or 6th semes	2nd semester ter		
Classes and lectures:		Workload:		
 Spezielle und allgemeine Relativitätstheorie (lecture, 2 SWS) Spezielle und allgemeine Relativitätstheorie (exercise, 1 SWS) 		 60 Hours private studies 45 Hours in-classroom work 15 Hours exam preparation 		
Contents of teaching:				
Grading through: • Exercises • Written or oral exam as announced	by the examiner			
Responsible for this module:				
Prof. Dr. Reinhard Schuster				
Teacher:				
Institute for Mathematics				
Prof. Dr. Reinhard Schuster				
Language: • offered only in German				



MA4803 - Number Theory (Zahlentheo)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	every second year		4		
Course of study, specific field and term: • Master CLS (optional subject), math • Bachelor CLS (optional subject), math	nematics, arbitrary semester hthematics, 5th or 6th semes	ter			
Classes and lectures: • Number Theory (lecture, 2 SWS) • Number Theory (exercise, 1 SWS)	Classes and lectures:Workload:• Number Theory (lecture, 2 SWS)• 60 Hours private studies• Number Theory (exercise, 1 SWS)• 45 Hours in-classroom work• 15 Hours exam preparation				
Contents of teaching:		4			
 Divisibility of integers, Farey sequencees, Fibonacci Numbers Approximation of real numbers by rational numbers Modulo operations: Complete and reduced residue system, Theorems of Euler and Fermat Representation of natural numbers sums of 2, 3 or 4 squares Quadratic residues Quadratic reciprocity Prime number criteria and pseudo prime numbers Pythagorean triples Rational points on curves of degree 2 Number theoretic functions Prime number theorem, prime numbers in arithmetic progression Riemann zeta function and its functional equation Known problems and conjectures, i.e. Goldbach conjecture Stochastic prime numbers 					
 Qualification-goals/Competencies: Theoretical knowledge of the mentioned topics Historical and most recent issues Solve questions in this filed Recognize interdisciplinary aspects 					
Grading through: • Exercises • Written or oral exam as announced	 Grading through: Exercises Written or oral exam as announced by the examiner 				
Responsible for this module: • Prof. Dr. Reinhard Schuster Teacher: • Institute for Mathematics • Prof. Dr. Reinhard Schuster					
Literature: Chandrasekharan: Einführung in di Bundschuh: Einführung in die Zahl Menzer: Zahlentheorie: Fünf ausge Remmert u. Ullrich: Elementare Zah Rempe: Primzahltests für Einsteige Scharlau, Opolka: Von Fermat bis M Scheid: Zahlentheorie - Spektrum 2 Schmidt: Einführung in die algebra Weil: Zahlentheorie - Spektrum 199 Winogradow: Elemente der Zahlen	e analytische Zahlentheorie entheorie - Springer 1992 wählte Themenstellungen d hlentheorie - Birkhäuser 1999 r: Zahlentheorie - Algorithmi Ninkowski: Eine Vorlesung ük 2003 ische Zahlentheorie - Spring 22 theorie - Prestel-Verlag 1956	- Springer Lecture Notes 20 er Zahlentheorie - Oldenbo 5 ik - Kryptographie - Vieweg per Zahlentheorie und ihre l er 2009	008 ourg Wissenschaftsverlag 2010 +Teubner 2009 Entwicklung - Springer 2009		



Language:

offered only in German





MA4804 - Special Functions (SpeFunktio)						
Duration:	Turnus of offer:		Credit points:			
1 Semester	irregularly		4			
Course of study, specific field a • Master CLS (optional subj • Bachelor CLS (optional su	i nd term: ject), mathematics, arbitrary semeste ibject), mathematics, 5th or 6th semi	er ester				
Classes and lectures:		Workload:				
 Special Functions (lecture, 2 SWS) Special Functions (exercise, 1 SWS) 45 Hours in-classroom 15 Hours exam prepar 		e studies ssroom work preparation				
Contents of teaching:						
 Algebrations with complex numbers Exponential function, angle functions, hyperbolic angle functions, derived functions Gamma and beta functions Hypergeometric function Bessel function, Legendre function, Laguerre function, Tscheybyscheff function, Hermite function, Jacobi hypergeometric function Elliptic functions, theta functions Number theoretic functions Riemann zeta function Used mathematical theories and concepts: Complex function theory Infinite products Differential equations (ordinary, partial) Functional equations Integral representation Taylor series expansions for eigenvalues and eigenfunctions (using space and time, defined on geometric objects) Producing functions (a Taylor series in two variables is considered as a series in one variable and the coefficients are special functions ir the other variable) Addition theorems Fourier transformations 						
Qualification-goals/Competen	cies:					
 Theoretical knowlege of 1 Historical and latest quest Solve questions in this fie Recognize interdisciplina 	 Theoretical knowlege of the mentioned topics Historical and latest questions Solve questions in this field Recognize interdisciplinary aspects 					
Grading through:						
ExercisesWritten or oral exam as a	ExercisesWritten or oral exam as announced by the examiner					
Responsible for this module:						
Prof. Dr. Reinhard Schuste	er					
Institute for Mathematics	I eacher: Institute for Mathematics					
Prof. Dr. Reinhard Schuste	er					
 Andrews G.E., Askey R., R. Courant, R., Hilbert, D.: M Erdélyi, A., Magnus, W., C Fichtenholz, G.M.: Differe 	oy R.: Special Functions.Encyclopedia ethoden der mathematischen Physil Dberhettinger, F., Tricomi, F.: Higher ntial- und Integralrechnung, Band 1	a of Mathematics and its Ap k - Springer 1993 Transcendental Functions - -3 - H. Deutsch 1997	plication 71 - Cambridge University Press 2006 McGraw-Hill, New York, 1953			



- Hurwitz, A., Courant, R.: Vorlesungen über Allgemeine Funktionentheorie und Elliptische Funktionen Springer 2000
- Stegun, I. A., Abramowitz, M.: Handbook of Mathematical Functions Dover Press
- Strampp, W., Ganzha, V., Vorozhtsov, E.: Höhere Mathematik mit Mathematica, Bd.4, Funktionentheorie, Fouriertransformationen und Laplacetransformationen: Funktionentheorie, Fourier- und Laplacetransformation Vieweg 1997
- Wawrzynczyk, A.: Group Representations and Special Functions Reidel Publishing Company 1983
- Whittaker, E. T., Watson, G. N.: A Cource of Modern Analysis Cambridge University Press 1902 ... 1999

Language:

• offered only in German



MA4940 - Test and estimation theory (TestSchetz)				
Duration:	Turnus of offer:	Credit points:		
1 Semester	each summer semester	4		
Course of study, specific field and term: • Master CLS (compulsory), mathema	tics, 2nd semester			
 Classes and lectures: Test and estimation theory (lecture, 2 SWS) Test and estimation theory (exercise, 1 SWS) 		 Workload: 60 Hours private studies 45 Hours in-classroom work 15 Hours exam preparation 		
 Contents of teaching: Point estimation (one parameter): F completeness, Theorem of Rao-Blac Exponential families, properties, main Likelihood ratio test, properties of sever function 	Properties of point estimator ckwell) aximum likelihood estimatio statistical tests, Lemma of Ne	s (weak consistency, unbiasedness, Theorem of Rao-Crámer, sufficiency, n in exponential families yman-Pearson, unbiasedness, monotone density ratios		
 Qualification-goals/Competencies: Knowledge of the theoretical foundations of testing and estimation Application of the theorems by Rao-Crámer and Rao-Blackwell Knowledge of the main characteristics of the linear exponential family Application of the fundamental lemma by Neyman-Pearson 				
Grading through: • written exam				
Requires: • Stochastics 2 (MA4020-KP04, MA4020) • Stochastics 1 (MA2510-KP04, MA2510) • Biostatistics 2 (MA2600-KP04, MA2600) • Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)				
Responsible for this module: • Prof. Dr. rer. nat. Andreas Ziegler Teacher: • Institute of Medical Biometry and Statistics • Prof. Dr. rer. nat. Andreas Ziegler • Dr. Reinhard Vonthein				
Literature: • E.L. Lehmann, Joseph P. Romano: Testing Statistical Hypotheses - ISBN-13 9780387988641 • E.L. Lehmann, George Casella: Theory of Point Estimation - ISBN-13 9780387985022				
Language: • offered only in German				





MA4944 - Multivariate Statistics (MultivStat)					
Duration:	Turnus of offer: Credit points:		vints:		
1 Semester	irregularly	4			
Course of study, specific field and • Bachelor CLS (optional subjec • Master CLS (optional subject)	term: :t), mathematics, 6th semester , mathematics, 2nd semester				
Classes and lectures:		Workload:			
 Multivariate Statistics (lecture, 2 SWS) Multivariate Statistics (exercise, 1 SWS) Multivariate Statistics (exercise, 1 SWS) 45 Hours in-classroom work 20 Hours exam preparation 					
Contents of teaching: Multivariate regression Discriminance analysis Logistic regression Cluster analysis Principal components and face 	Contents of teaching: Multivariate regression Discriminance analysis Logistic regression Cluster analysis Principal components and factor analysis 				
Qualification-goals/Competencies: • Identification of applications • Knowledge of the fundament	in which multivariate statistical tal ideas of various multivariate	methods are required methods			
Grading through: • written exam					
Requires: • Biostatistics 2 (MA2600-KP04, MA2600) • Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML) • Stochastics 2 (MA4020-KP04, MA4020) • Stochastics 1 (MA2510-KP04, MA2510)					
Responsible for this module: • Prof. Dr. rer. nat. Andreas Ziegler Teacher: • Institute of Medical Biometry and Statistics • Prof. Dr. rer. nat. Andreas Ziegler • Dr. Reinhard Vonthein					
 Literature: Ludwig Fahrmeir, Alfred Hamerle, Gerhard Tutz: Multivariate statistische Verfahren - ISBN-13 9783110138061 					
Language: • offered only in German					



	MA4947 - Nonparar	metric statistics (NichtpSt	tat)	
Duration:	Turnus of offer:		Credit points:	
1 Semester	irregularly		4	
Course of study, specific fie • Master CLS (optional	eld and term: subject), mathematics, 2nd semester			
Classes and lectures:Workload:• Nonparametric statistics (lecture, 2 SWS)• 65 Hours private studies• Nonparametric statistics (exercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation		studies room work reparation		
 Contents of teaching: Recall and extension: properties of parametric procedures Fundametal limit theorems (quantiles, U-statistics, M-estimators, rank statistics, empirical processes) Nonparametric estimation of functionals, confidence intervals, comparison to parametric methods Rank tests Selected applications in life sciences (reading and critique of medical publications, analysis of data from recent projects) 				
Qualification-goals/Compe • Know the nonparame • Understand pros and • Competence in the se	tencies: etric statistical procedures of highest p cons of parametric and nonparametr election of suitable procedures in app	practical importance ic methods with resprect to effi lied work	ciency, robustness and interpretability	
Grading through: • Exercises • Oral examination • written exam				
Requires: • Stochastics 2 (MA402 • Stochastics 1 (MA251 • Biostatistics 2 (MA260 • Biostatistics 1 (MA160	0-KP04, MA4020) 0-KP04, MA2510))0-KP04, MA2600))0-KP04, MA1600, MA1600-MML)			
Responsible for this modul • Prof. Dr. rer. nat. And Teacher: • Institute of Medical B • Prof. Dr. rer. nat. And • Dr. Reinhard Vonthein Literature: • Herbert Büning, Götz	e: reas Ziegler iometry and Statistics reas Ziegler n Trenkler: Nichtparametrische statistis	sche Methoden - ISBN-13 97831	10163513	
Language: • offered only in Germa	an			





MA4950 - Logistische Regression (LogRegress)			
Duration:	Turnus of offer:	Credit points:	
1 Semester	every second year	4	
Course of study, specific field • Master CLS (optional sul • Bachelor CLS (optional s	and term: bject), mathematics, arbitrary semest subject), mathematics, 5th or 6th sem	er iester	
Classes and lectures:		Workload:	
 Logistische Regression (lecture, 2 SWS) Logistische Regression (exercise, 1 SWS) 		 60 Hours private studies 45 Hours in-classroom work 15 Hours exam preparation 	
Contents of teaching: • • • Qualification-goals/Competer • •	ncies:		
Grading through: • Exercises • Written or oral exam as	announced by the examiner		
Responsible for this module: • Prof. Dr. rer. nat. Andreas Ziegler Teacher: • Institute of Medical Biometry and Statistics • Prof. Dr. rer. nat. Andreas Ziegler			
Language: offered only in German			



MA4960 - Linear Models (LinModelle)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	irregularly		4	
Course of study, specific field and term: • Master CLS (optional subject), mathe • Bachelor CLS (optional subject), mat	ematics, arbitrary semester hematics, 6th semester			
Classes and lectures:Workl• Linear models (lecture, 2 SWS)•• Linear models (exercise, 1 SWS)•••		Workload: • 65 Hours private • 45 Hours in-classi • 10 Hours exam p	Norkload: • 65 Hours private studies • 45 Hours in-classroom work • 10 Hours exam preparation	
Contents of teaching: • • • • • • • •				
Qualification-goals/Competencies: •				
Grading through:Written or oral exam as announced by the examiner				
Requires: • Biostatistics 1 (MA1600-KP04, MA1600, MA1600-MML)				
Responsible for this module: • Prof. Dr. rer. nat. Andreas Ziegler Teacher: • Institute of Medical Biometry and Statistics • Prof. Dr. rer. nat. Andreas Ziegler				
Literature: • : • :				
Language: • offered only in German				





MA4962 - Generalized Linear Models (VLModelle)			
Duration:	Turnus of offer:		Credit points:
1 Semester	irregularly	irregularly 4	
Course of study, specific f	field and term:		
Bachelor CLS (optionMaster CLS (optional	nal subject), mathematics, 5th or 6th ser al subject), mathematics, arbitrary semes	mester ster	
Classes and lectures:		Workload:	
 Generalized Linear Models (lecture, 2 SWS) Generalized Linear Models (exercise, 1 SWS) 46 Hours private studies 36 Hours in-classroom work 24 Hours programming 14 Hours exam preparation 		rivate studies I-classroom work rogramming xam preparation	
Contents of teaching:			
 General overview of weighted least squa Continuous response Discrete response m Ordered logistic and Multinomial logit ar Introduction to pan 	f generalized linear models (GLM): - deri ares,- goodness of fit and residuals se models: Gaussian, log-normal, Gamma nodels:- dichotomous: logit, probit, clog d probit regression nd probit model sel models	ivation of GLM functions, na, log-Gamma for surviva llog, loglog, - count data:	- GLM algorithms: Fisher scoring, iteratively Il analysis, inverse Gaussian Poisson, negative binomial, geometric
 Knowledge of the th Competence for the Competence to dete Knowledge of conce Knowledge for the a Competence in para 	neoretical foundation of the generalized e critical appraisal of regression models ect algorithmic issues in generalized line eptual problems with models using cate adequate interpretation of study results ameter interpretation and regression dia	d linear model and its app ear models egorical dependent varial agnostics	plication
Grading through: • written exam			
Requires: • Biostatistics 2 (MA20	600-KP04, MA2600)		
Responsible for this mode • Prof. Dr. rer. nat. And Teacher: • Institute of Medical • Prof. Dr. rer. nat. And	Jle: dreas Ziegler Biometry and Statistics dreas Ziegler		
Literature:			
 Dobson, Annette J & 2008 Hardin, James W & I 	& Barnett, Adrian: An Introduction to Ge Hilbe, Joseph M: Generalized Linear Moc	eneralized Linear Models, dels and Extensions, 3rd e	3rd ed Chapman & Hall/CRC: Boca Raton (FL), ed College Station (TX), Stata Press, 2012
Language: • offered only in Gern	nan		



MA4970 - Design of Experiments and Variance Analysis (VplVarianz)		
Duration:	Turnus of offer:	Credit points:
1 Semester	irregularly	4
Course of study, specific field an • Master Computer Science • Master CLS (optional subje • Bachelor CLS (optional subje	n d term: before 2014 (optional subject), specia ect), mathematics, 1st or 3rd semester oject), mathematics, 5th semester	lization field medical informatics, 3rd semester
Classes and lectures:		Workload:
 Design of Experiments and Design of Experiments and 	d Variance Analysis (lecture, 2 SWS) d Variance Analysis (exercise, 1 SWS)	 50 Hours private studies 30 Hours in-classroom work 25 Hours programming 15 Hours exam preparation
Contents of teaching: • Ability to calculate general • Knowledge of the different • Knowledge of the advantal • Ability to interpret a suital • Ability to implement a suital • Ability to express the ANC • Ability to express and anal • Ability to draw up and and	lized inverse aces between experiments and observ ages of the statistical design of multifa ble experimental ANOVA design table experimental ANOVA design DVA model as regression model by ma lyze models with repeated measurem alyze diagrams for an abstract of the re	ational studies ctorial experiments trix notation ents esults and a model diagnosis
Qualification-goals/Competenc • Comprehension of the the • Comprehension of the the	ies: eoretical principles of the design of exp eoretical principles of the analysis of va	periments ariance
Grading through: • written exam		
Requires: • Biostatistics 2 (MA2600-KF • Linear Models (MA4960) • Biostatistics 1 (Ungenutzt/	204, MA2600) MA1600-MML)	
Responsible for this module: • Prof. Dr. rer. nat. Andreas 2 Teacher: • Institute of Medical Biome	Ziegler try and Statistics	
• Prof. Dr. rer. nat. Andreas A	Liegier	
Literature: • Kursbuch: Montgomery, D Sons, New York. ISBN 978- • Supplementary literature: 978-3-446-41595-9 • Supplementary literature: ed John Wiley & Sons, N	Douglas C. 2012: Design and Analysis o -1-118-09793-9 Kleppmann, Wilhelm. 2008: Taschenb Mason, Robert L., Gunst, Richard F., He ew York. ISBN 0-471-37216-1	f Experiments. 8th ed. International Student Version - John Wiley & uch Versuchsplanung. 5. Auflage - Carl Hanser, Wien. ISBN ess, James L. 2003: Statistical Design and Analysis of Experiments. 2nd
Language: • offered only in German		



MA5008 - Mathematical course (PraktMathe)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	on request 8 (Typ B)			
Course of study, specific field and • Master CLS (optional suject),	term: mathematics, 2nd or 3rd seme	ster		
Classes and lectures: Workload: • Mathematical course (practical course, 6 SWS) • 210 Hours in-classroom workload • 30 Hours written report				
		 210 Hours in-classroom work 30 Hours written report		
Contents of teaching: Planning and execution of a Presenting the methods and 	project by mathematical methers and the second s	ods port		
 Qualification-goals/Competencies Ability to analyze a given pro Ability to make oneself famil Ability to integrate partial re Proficiency in documenting 	: oblem and to develop mathem iar with adequate mathematica sults into the overall solution and presenting results	atical approaches for it al structures without any hel	р	
Grading through: • Written report				
Responsible for this module: Studiengangsleitung MML Teacher: Institute of Mathematics and Image Computing Institute for Mathematics 				
Language: • English, except in case of on	y German-speaking participant	ts		



MA5009-KP04, MA5009 - Master's Seminar mathematics (MSMathe)			
Duration:	Turnus of offer:	Credit points:	
1 Semester each semester 4		4	
Course of study, specific field • Minor in Teaching Mathe • Master CLS starting 2016 • Master CLS (optional sub	and term: ematics, Master of Education (compuls (optional subject), Interdisciplinary m ject), mathematics, 3rd semester	sory), mathematics, 3rd semester nodules, 3rd semester	
Classes and lectures: • Advanced Master's Semi	nar mathematics (seminar, 2 SWS)	 Workload: 30 Hours oral presentation (including preparation) 30 Hours in-classroom work 30 Hours private studies 30 Hours written report 	
Contents of teaching: • The students study a scie • They present the topic ir	entific topic of their specialization. written form.		
Qualification-goals/Competen The students have gaine They are able to present They are able to supply a They have gained experi They understand scientif Grading through:	cies: d experience of familiarizing themselv the result of their studies in compreh a coherent overview of a complex scie ence of holding scientific discussions. ic presentations and know how to cri	ves with the details of a given scientific topic. ensible written form. entific area in a comprehensive oral presentation. tically examine them in open discussions.	
oral presentationterm paper			
Responsible for this module: Prof. Dr. rer. nat. Jürgen f Teacher: Institute of Medical Biom Institute of Mathematics Institute for Mathematics Prof. Dr. rer. nat. Jürgen f Prof. Dr. rer. nat. Jan Moo Prof. Dr. rer. nat. Jan Moo Prof. Dr. rer. nat. Andreas Prof. Dr. rer. nat. Karsten Prof. Dr. rer. nat. Jan Lellt Prof. Dr. rer. nat. Andreas	Prestin netry and Statistics and Image Computing Prestin dersitzki is Rößler Keller mann ke König is Ziegler		
Language: • English, except in case of	f only German-speaking participants		





MA5030-KP04, MA5030 - Image Registration (Bildregist)		
Duration:	Turnus of offer:	Credit points:
1 Semester	every second winter seme	ester 4
Course of study, specific field Master Medical Informa Master MES since 2014 Master Computer Scient Master MES before 2014 Master MES before 2014 Master CLS (optional su Master Computer Scient Master Medical Informa	and term: tics (optional subject), medical image p (optional subject), mathematics / natura ce before 2014 (optional subject), advar 4 (optional subject), mathematics, 1st or 4 (advanced curriculum), imaging syster bject), mathematics, 1st or 3rd semester ce before 2014 (optional subject), advar tics since 2019 in planing (optional subj	rocessing, 1st or 2nd semester il sciences, 1st semester iced curriculum imaging systems, 2nd or 3rd semester 3rd semester ns, signal and image processing, 1st or 3rd semester r iced curriculum numerical image processing, 2nd or 3rd semester fect), medical image processing, 1st or 2nd semester
Classes and lectures:		Workload:
Image Registration (lectImage Registration (exe	ure, 2 SWS) rcise, 1 SWS)	 65 Hours private studies and exercises 45 Hours in-classroom work 10 Hours exam preparation
Contents of teaching: Introduction and basic Interpolation Deformation models Landmark-based registri Parametric registration Non-parametric registration 	principles ration ation and regularization strategies	
Qualification-goals/Compete Students know the funce They are able to transla They have experience v Interdisciplinary qualifie Students have advance They can translate theo They are experienced in They can think abstract	ncies: damental concepts in image registration te concrete problems into suitable mod vith parametric and non-parametric regi cations: d skills in modeling. retical concepts into practical solutions. n implementation. ly about practical problems.	ı. els. istration problems.
Grading through: • Exercises • Presentation of one's or • Written or oral exam as	wn solution of an exercise announced by the examiner	
Requires: • Linear Algebra and Disc • Analysis 2 (MA2500-KPC	rete Structures 2 (MA1500-KP08, MA150 14, MA2500))0)
Responsible for this module: • Prof. Dr. rer. nat. Jan Mc Teacher: • Institute of Mathematic • Prof. Dr. Martin Leucker • Prof. Dr. rer. nat. Jan Mc	idersitzki s and Image Computing idersitzki	
Literature: • Goshtasby: 2D and 3D I • Modersitzki: Numerical	mage Registration - Wiley 2005 Methods for Image Registration - Oxfore	d University Press 2004



must be completed and passed before taking the exam for the first time.

Module Guide

 Modersitzki: FAIR: Flexible Algorithms for Image Registration - SIAM 2009 Rohr: Landmark-Based Image Analysis - Kluwer 2001
 Language: German and English skills required
Notes: Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they

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MA5032-KP04, MA5032 - Numerical Me	thods for Image Computing (NumerikBV)
Duration: Turnus of offer:	Credit points:
Semester every second summer set	mester 4
 Course of study, specific field and term: Master MES since 2014 (optional subject), mathematics / natura Master Medical Informatics (optional subject), medical image p Master MES before 2014 (optional subject), advanced curriculu Master Computer Science before 2014 (optional subject), advar Master CLS (optional subject), mathematics, 2nd or 4th semest Master Medical Informatics since 2019 in planing (optional subject) 	al sciences, arbitrary semester processing, 1st or 2nd semester im imaging systems, 2nd or 4th semester nced curriculum numerical image processing, 2nd or 3rd semester er pject), medical image processing, 1st or 2nd semester
Classes and lectures	Workload:
 Numerical Methods for Image Computing (lecture, 2 SWS) Numerical Methods for Image Computing (exercise, 1 SWS) 	 65 Hours private studies and exercises 45 Hours in-classroom work 10 Hours exam preparation
Contants of toaching:	
 Discretization Numerical methods for partial differential equations Multilevel and multiscale approaches Optimization methods Multigrid methods Operator splitting 	
 The students are familiar with fundamental numerical concept. They have experience in realizing practical solutions. They can implement numerical algorithms on a computer. They understand selected methods for solving large linear syst They can implement selected methods for solving large linear syst Interdisciplinary qualifications: Students have advanced skills in modeling. They can translate theoretical concepts into practical solutions They are experienced in implementation. They can think abstractly about practical problems. 	s in image computing. tems. systems.
Grading through:	
 Exercises Presentation of one's own solution of an exercise Written or oral exam as announced by the examiner 	
Responsible for this module:	
Prof. Dr. rer. nat. Jan Modersitzki	
Teacher:Institute of Mathematics and Image Computing	
 Prof. Dr. rer. nat. Jan Modersitzki Prof. Dr. rer. nat. Jan Lellmann 	
l iterature:	
 Nocedal Wright: Numerical Optimization - Springer, 2006 Modersitzki: FAIR: Flexible Algorithms for Image Registration - Section - Section	SIAM, 2009 198
Language:	



German and English skills required

Notes:

Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they must be completed and passed before taking the exam for the first time.



MA5034-KP04, MA5	034 - Calculus of Variation	is and Partial Differ	ential Equations (VariPDE)
Duration:	Turnus of offer:		Credit points:
1 Semester	every second summer sem	lester	4
Course of study, specific field and ter Master MES since 2014 (optional Bachelor CLS (optional subject), Master Medical Informatics (option Master MES before 2014 (option Master Computer Science befor Master MES before 2014 (advan Master CLS (optional subject), n Master Medical Informatics since	rm: Il subject), mathematics / natural mathematics, 4th or 6th semeste ional subject), medical image pro- nal subject), mathematics, 2nd or e 2014 (optional subject), advanc ced curriculum), imaging system nathematics, 2nd or 4th semester e 2019 in planing (optional subje	sciences, arbitrary seme er ocessing, 1st or 2nd sem 4th semester ced curriculum numerica s, signal and image proc r ect), medical image proc	ester ester al image processing, 2nd or 3rd semester essing, 2nd or 4th semester essing, 1st or 2nd semester
Classes and lectures:		Workload:	
 Calculus of Variations and Partial Differential Equations (lecture, 2 SWS) Calculus of Variations and Partial Differential Equations (exercise, 1 SWS) Calculus of Variations and Partial Differential Equations (exercise, 1 SWS) 		e studies and exercises ssroom work preparation	
Contents of teaching:			
 Fundamentals of functional ana Introduction to the calculus of Introduction to partial different Applications in image and data 	Ilysis variations ial equations processing		
 Students understand variationa They are able to formulate basi They understand the connectio They can derive optimality cond They understand the mathemaa They can implement selected for They can formulate selected prace Interdisciplinary qualifications: Students have advanced skills in They can translate theoretical c They are experienced in implement They can think abstractly about 	I modeling. c physical problems in a variatior ns between variational methods ditions for energy functionals. tical theory behind selected varia undamental variational problems actical problems in the variationa n modeling. oncepts into practical solutions. nentation.	nal setting. and partial differential e ational problems. I setting.	equations.
Grading through:			
 Exercises Presentation of one's own solut Written or oral exam as announ 	tion of an exercise ced by the examiner		
Responsible for this module:			
Prof. Dr. rer. nat. Jan Modersitzk	i		
Teacher:			
 Institute of Mathematics and Im 	age Computing		
 Prof. Dr. rer. nat. Jan Modersitzk Prof. Dr. rer. nat. Jan Lellmann 	i		
Litoraturo:			
 Chan & Shen: Image Processing Modersitzki: Flexible Algorithm: Vogel: Computational Methods 	and Analysis - SIAM s for Image Registration - SIAM for Inverse Methods - SIAM		



• Aubert, Kornprobst: Mathematical Problems in Image Processing: Partial Differential Equations and the Calculus of Variations - Springer

Scherzer, Grasmair, Grossauer, Haltmeier, Lenzen: Variational Methods in Imaging - Springer

Language:

German and English skills required

Notes:

Prerequisite tasks for taking the exam can be announced at the beginning of the semester. If any prerequisite tasks are defined, they must be completed and passed before taking the exam for the first time.



MA	5129-KP04, MA5129 - Semir	nar Genetic Epidemiology	(SemGenEpi)
Duration:	Turnus of offer:	1	Credit points:
1 Semester	each winter semester		4
Course of study, specific field • Master CLS starting 201 • Master CLS (optional su • Master CLS (compulsory	l and term: 6 (compulsory), MML with specializ ject), mathematics, 3rd semester ı), computational life science / biost	ation in Genetic Statistics, 3rd ser atistics, 3rd semester	mester
Classes and lectures: Workload: • Seminar Genetic Epidemiology (seminar, 2 SWS) • 90 Hours work on an inpresentation • 30 Hours in-classroom • 30 Hours in-classroom		an individual topic with written and oral oom work	
Contents of teaching: • Become acquainted wit written and oral form	h current topics in genetic epidemi	ology overall and in detail, typica	ally using a current scientific publication, in
Qualification-goals/Compete • The students have the rinto scientific perspecti • They are competent to • They have the commun • They have the commun	ncies: methodological competence to mas ve. present their results comprehensive ication competence to orally prese ication competence to take an active	ster the thorough analysis of a cir ely in written form. nt a scientifically complex topic i ve part in a scientific discussion.	rcumscribed scientific topic and to put it n a coherent way.
Grading through: • Oral presentation and v	vritten report		
Requires: • Genetic Epidemiology 2 • Genetic Epidemiology 1	2 (MA4661-KP08, MA4661) (MA3200-KP04, MA3200)		
Responsible for this module: • Prof. Dr. rer. biol. hum. I Teacher: • Institute of Medical Bion • Prof. Dr. rer. biol. hum. I	nke König metry and Statistics nke König		
Language: • English, except in case of	of only German-speaking participan	ts	
Notes: Specialized literature will Prerequisite tasks for takin must be completed and p	be named in class. ng the exam can be announced at t bassed before taking the exam for th	he beginning of the semester. If a	any prerequisite tasks are defined, they





Γ

M	A5610 - Selected stoch	astic processes (Stoch	ıPrz2)
Duration:	Turnus of offer:		Credit points:
1 Semester	not available anymore		4
 Course of study, specific field and tern Bachelor CLS (optional suject), ma Master CLS (optional subject), ma Master Computer Science before 	1: athematics, 6th semester thematics, 2nd or 4th semest 2014 (optional subject), adva	er nced curriculum stochastics	s, 2nd or 3rd semester
Classes and lectures:Workload:• Selected stochastic processes (lecture, 2 SWS)• 65 Hours private studies• Selected stochastic processes (exercise, 1 SWS)• 45 Hours in-classroom work• 10 Hours exam preparation		studies room work vreparation	
Contents of teaching: • branching processes • Poisson process • birth-and-death processes • reneval processes • Brownian and fractional Brownian motion • life science applications			
Qualification-goals/Competencies: Mastering some important classe 	s of stochastic processes and	understanding possible ap	plications
Grading through: • Oral examination			
Requires: • Stochastics 2 (MA4020-KP04, MA4	4020)		
Responsible for this module: • Prof. Dr. rer. nat. Andreas Ziegler • Prof. Dr. rer. nat. Karsten Keller Teacher: • Institute of Medical Biometry and Statistics • Institute for Mathematics • Prof. Dr. rer. nat. Karsten Keller • Prof. Dr. rer. nat. Karsten Keller • Prof. Dr. rer. nat. Karsten Keller			
Literature: • R. Durrett: Probability: Theory and • S. Karlin und H.M. Taylor: A First C	d Examples - 3rd. edition, The Course in Stochastic Processes	omson, 2005 s - 2rd. edition, Academic Pr	ress, 1975
Language: • offered only in German			



MA5990-KP30, MA5990 - Master's thesis in Computational Life Science (MaArbMML)			
Duration:	Turnus of offer: C		Credit points:
1 Semester	each semester		30
Course of study, specific field and term: • Master CLS starting 2016 (compulso • Master CLS (compulsory), mathemat	ry), Interdisciplinary modul ics, 4th semester	es, 4th semester	
Classes and lectures:Workload:• Master's thesis (supervised self studies, 1 SWS)• 870 Hours private studies• Colloquium (presentation (incl. preparation), 1 SWS)• 30 Hours oral presentation (including preparation)		e studies esentation (including preparation)	
Contents of teaching: • Individual studies under supervision	1		
 Qualification-goals/Competencies: Ability to solve a complex scientific problem with state-of-the-art methods Experience in writing a scientific thesis within a given time period Becoming an expert in a special subfield of mathematics Experience in working with scientific literature Presentation skills 			
Grading through: oral presentation Written report 			
Responsible for this module: • Prof. Dr. rer. nat. Jürgen Prestin Teacher: • Institutes of the Department of Computer Science/ Engineering • Alle prüfungsberechtigten Dozentinnen/Dozenten des Studienganges			
Language: • thesis can be written in German or English			
Notes: The basic prerequisite for starting the Master's thesis is the successful completion of 75 credits.			



ME4030-KP04, ME4030 - Inverse Problems in Imaging (InversProb)			
Duration:	Turnus of offer:		Credit points:
1 Semester	each summer semester		4
 Course of study, specific field and term: Master Medical Informatics since 2019 in planing (optional subject), medical image processing, 1st or 2nd semester Master Auditory Technology (optional subject), Auditory Technology, 2nd semester Master Robotics and Autonomous Systems (optional subject), Medical Engineering Science, 1st or 2nd semester Master MES since 2014 (optional subject), Medical Engineering Science, 1st or 2nd semester Master MES before 2014 (optional subject), mathematics, 1st or 2nd semester Master Computer Science before 2014 (optional subject), advanced curriculum signal and image processing, 2nd or 3rd semester Master Computer Science before 2014 (optional subject), specialization field robotics and automation, 3rd semester Master Computer Science before 2014 (optional subject), specialization field medical informatics, 3rd semester Master Computer Science before 2014 (optional subject), advanced curriculum imaging systems, 2nd or 3rd semester Master MES before 2014 (advanced curriculum), imaging systems, signal and image processing, 1st or 2nd semester Master MES before 2014 (advanced curriculum), imaging systems, signal and image processing, 1st or 2nd semester 			
Classes and lectures:		Workload:	
 Tomographische Verfahren II: Invers Bildgebung (lecture, 2 SWS) Tomographische Verfahren II: Invers Bildgebung (exercise, 1 SWS) 	e Probleme bei der e Probleme bei der	 55 Hours private 45 Hours in-class 20 Hours exam p 	studies room work reparation
 Introduction to inverse and ill-posed problems on the basis of selected examples (including seismology, impedance tomography, heat conduction, computed tomography, acoustic) Concept of ill-posedness of the inverse problem (Hadamard) Singular value decomposition and generalized inverse Regularization methods (eg Tikhonov, Phillips, Ivanov) Deconvolution Image restoration (deblurring, defocusing) Statistical methods (Bayes, maximum likelihood) Computed Tomography, Magnetic Particle Imaging 			
 Qualification-goals/Competencies: Students are able to explain the concept of ill-posedness of the inverse problem and distinguish given inverse problems regarding good or bad posedness. They are able to formulate inverse problems of mathematical imaging and solve (approximate) with suitable numerical methods. They can assess the condition of a problem and the stability of a method. They master different regularization methods and are able to apply them to practical problems. They know methods to determine a suitable regularization. They can use methods of image reconstruction and restoration on real measurement data. 			
Grading through: • Written or oral exam as announced I	Grading through: • Written or oral exam as announced by the examiner		
Responsible for this module: • Prof. Dr. rer. nat. Thorsten Buzug Teacher: • Institute of Medical Engineering • Prof. Dr. rer. nat. Thorsten Buzug			
Literature: Kak and Slaney: Principles of Compute	iterized Tomographic Imag	ing - SIAM Series 33, New Y	′ork, 2001

- Natterer and Wübbeling: Mathematical Methods in Image Reconstruction SIAM Monographs, New York 2001
- Bertero and Boccacci: Inverse Problems in Imaging IoP Press, London, 2002



- Andreas Rieder: Keine Probleme mit inversen Problemen Vieweg, Wiesbaden, 2003
- Buzug: Computed Tomography Springer, Berlin, 2008

Language:

• offered only in German



ME4040 - Quante	enphysik der medizir	nischen Diagnostik ur	nd Therapie (QDT)
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		4
Course of study, specific field and term: • Master MES since 2014 (optional sub • Master MES before 2014 (advanced o • Master CLS (optional subject), mathe	oject), Medical Engineering curriculum), imaging syster ematics, 2nd or 3rd semeste	Science, 1st or 2nd semest ns, signal and image proce er	ter essing, 1st or 2nd semester
Classes and lectures:		Workload:	
Quantenphysik der medizinischen Diagnostik und Therapie (seminar, 2 SWS) SOURT		 60 Hours private 35 Hours in-class 25 Hours exam p 	studies sroom work preparation
Contents of teaching: Uncertainty and metrology Elementary particles in medical tech Schrödinger equation: electrons in th Quantum mechanical foundations o Quantum mechanical effects in mag Radiotherapy: cross sections, proton Quantum statistics in the nuclear me Infrared imaging and Planck's radiat Synchrotron radiation in diagnosis a Semiconductor detectors for biomed	nology he wave picture f electron, atomic force and netic resonance imaging a and ion therapy; Interactio edical diagnostics ion law nd therapy dical imaging	d scanning tunneling micro nd spectroscopy ons between radiation fielo	oscopy I and matter
 Qualification-goals/Competencies: Students are able to explain the role They can explain a number of diagnimportant. They can name the pros and cons of They can use the mathematical form 	of various quantum-mech ostic and therapeutic proce competing procedures in nulation of quantum mecha	anical processes in medica edures, for which the unde radiotherapy. anics to explain basic effect	l diagnostics and therapy. rstanding of quantum mechanics is ts.
Grading through: • presentation • Oral examination			
Responsible for this module: • Prof. Dr. rer. nat. Magdalena Rafecas Teacher: • Institute of Medical Engineering • Prof. Dr. rer. nat. Thorsten Buzug • Prof. Dr. rer. nat. Martin Koch • Prof. Dr. rer. nat. Magdalena Rafecas			
Literature: • is selected individually:			
 Languages: offered only in German German and English skills required 			





MZ4373-KP03, MZ4373 - Human Genetics (HumGen)			
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		3
Course of study, specific field and term: Master Medical Informatics (optional Master CLS starting 2016 (compulsor Master CLS (compulsory), computation Master CLS (optional suject), mathem Master Medical Informatics since 201	l subject), bioinformatics, 1 ry), MML with specialization onal life science / biostatis natics, arbitrary semester 19 in planing (optional sub	st or 2nd semester n in Genetic Statistics, 1st se tics, 1st semester ject), bioinformatics, 1st or	emester 2nd semester
Classes and lectures:		Workload:	
Human Genetics for MML (lecture, 2 SWS) 40 Hours private 30 Hours in-class 20 Hours exam p		 40 Hours private 30 Hours in-class 20 Hours exam p 	studies room work reparation
Contents of teaching: Human genome Heredity Genetics of mitochondria Mutations, detection and nomenclature of sequence variations Polymorphisms and SNP Linkage analyses Repetitive sequences Methods: isolation, amplification, screening, and analysis of nucleic acids Data bases Epigenetics 			
 Qualification-goals/Competencies: Students are able to explain basic pr and their application for medical bio 	inciples of heredity, the or metrics.	ganization of the human ge	enome, the relevance of sequence variations,
Grading through: • written exam			
Responsible for this module: • Prof. Dr. rer. nat. Christine Zühlke Teacher: • Institute of Human Genetics • Prof. Dr. rer. nat. Christine Zühlke • Dr. Andreas Dalski • MitarbeiterInnen des Instituts			
Literature: • Tom Strachan & Andrew P. Read: Mo	lekulare Humangenetik - 3	3. Auflage (2005)	
Language: • offered only in German			



EC4	4020-KP04, EC4020 - Agile	Project Management	t (Prjktmng)
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		4
Course of study, specific field and • Master Psychology (optional • Master Interdisciplinary Cour • Master psychology (optional • Master CLS (optional suject), • Master Entrepreneurship in I	term: subject), interdisciplinary comperses (optional subject), Interdiscip subject), interdisciplinary comperinterdisciplinary competence, 3rd Digital Technologies (optional sub	tence, arbitrary semester linary modules, arbitrary se tence, arbitrary semester d semester pject), interdisciplinary com	emester ipetence, arbitrary semester
Classes and lectures:Workload:• Project Management (lecture with exercises, 3 SWS)• 60 Hours private studies• 45 Hours in-classroom work• 15 Hours exam preparation		e studies ssroom work preparation	
 Contents of teaching: Within this module students agile project management. Interdependencies. The popular methods Scrum principles. Also goals is to sensitive sturant the uniqueness of each Finally the students should be the context and focus will be students. 	will get insights to the foundation Forough a mix of from theory and a and Kanban are trained so that t dents towards change manageme project is another aspect that wil be able to select a fitting method e on software development proje	ons and disciplines of project l practice students will expo the students are enabled to ent through projects, which l be covered within this mo based on the requirements ects.	ct management. Focus will be especially on erience the different methods and their o understand roles/, processes and agile n is typically a challenging aspect. The variance odule. s and plan first steps to structure the project.
 Qualification-goals/Competencies The students identify the mamanagement and to plan ar The students are able to plan part of the practical exercise The students can define per module. The students are able to work improve. 	s: ajor roles and processes in small a nd execute projects. n and execute different process st is. sonal development area in the co rk in a team, take over responsibil	and simple projects and get teps in a project. Especially ontext of project work based lity and trained to critical re	a broader knowledge about agile project the importance and impact of soft skills are d on their experience and reflections during the eflect their own behavior in a team and finally
Grading through: • portfolio exam • written exam • written homework • presentation			
Responsible for this module: • Prof. Dr. Christian Scheiner Teacher: • Institute for Entrepreneurshi • Dr. Sascha Schorr	p and Business Development		
Literature: • Röpstorff, S., & Wiechmann, • Leopold, Klaus, et al.: Kanbar • Andersen, J.: Retrospektiven	R.: Scrum in der Praxis: Erfahrung n in der IT - (2012) in agilen Projekten: Ablauf, Rege	en. Problemfelder und Erfo In und Methodenbausteine	lgsfaktoren - (2012) 2 - (2013)
Language: • offered only in German			



Notes:

(Formerly EC4020)

Formerly Projektmanagement





	MA5330 - Projektm	anagement (ProjMM	1L)
Duration:	Turnus of offer:		Credit points:
1 Semester	irregularly		4
Course of study, specific field and term: • Master CLS (optional suject), interdi	sciplinary competence, 3rd	d semester	
Classes and lectures:		Workload:	
See EC4020: Project management (course, 3 SWS)	O Hours	
Contents of teaching: •			
Qualification-goals/Competencies: •			
Grading through: • as announced by examiner			
Responsible for this module: • Prof. Dr. Christian Scheiner			
• Institute for Entrepreneurship and B	Business Development		
Language: • German and English skills required			



Γ

PS1030-KP04, PS1030 - English for Bachelor and Master students MLS (Engl)			
Duration:	Turnus of offer:		Credit points:
1 Semester	each summer semester		4
 Course of study, specific field and term: Bachelor MLS starting 2016 (optional suject), interdisciplinary competence, arbitrary semester Bachelor Biophysics (optional subject), no specific field, 6th semester Master MES since 2014 (optional subject), no specific field, 2nd semester Bachelor MES since 2014 (optional subject), no specific field, 4th or 6th semester Master MLS (optional subject), interdisciplinary competence, arbitrary semester Bachelor Computer Science before 2014 (optional subject), computer science, arbitrary semester Bachelor MES before 2014 (optional subject), Medical Engineering Science, arbitrary semester Master CLS (optional subject) interdisciplinary competence arbitrary semester 			
 Bachelor MLS (optional subject), inte Bachelor MLS starting 2018 (optional 	rdisciplinary competence, a l subject), interdisciplinary c	rbitrary semester ompetence, arbitrary sem	ester
Classes and lectures: • English for Bachelor and Master stud	 Classes and lectures: English for Bachelor and Master students MLS (exercise, 4 SWS) 60 Hours in-classroom work 60 Hours private studies 		room work studies
Contents of teaching: • Exercise:The content follows a curric • Creating a CV in English	ulum, modified depending	on the given skills and the	e thematic interests of the participants.
Qualification-goals/Competencies: Acquisition of basic skills in spoken a Improvement of communication in B Improvement of reading and writing 	and written English English 9 of texts in English, includin	g technical literature	
Grading through: Exercises continuous, successful participation in course written exam 			
Responsible for this module: • B. Sc. Sara Meitner Teacher: •			
• B. Sc. Sara Meitner			
Literature:- Publications and articles			
Language: • offered only in English			



PS5810-KP04, PS5810 - Scientific Teaching and Tutoring (WLehrKP04)			
Duration:	Turnus of offer:	Credit points:	
1 Semester	each semester	4 (Тур В)	
Course of study, specific fiel Master Interdisciplinar Bachelor Interdisciplin Master CLS starting 20 Master Robotics and A Master Entrepreneursh Master Media Informat Master MES since 2014 Bachelor MES since 20 Master Computer Sciel Master CLS (optional s Master Computer Sciel	Id and term: y Courses (optional subject), Interdiscipli ary Courses (optional subject), Interdiscipli 16 (optional subject), Interdisciplinary m autonomous Systems (optional subject), hip in Digital Technologies (optional subjett), tics (optional subject), interdisciplinary co 4 (optional subject), no specific field, 1st o 14 (optional subject), no specific field, ar nce since 2014 (optional subject), interdi uject), interdisciplinary competence, 3rd nce before 2014 (optional subject), interdi	nary modules, arbitrary semester olinary modules, arbitrary semester odules, 3rd semester interdisciplinary competence, 1st or 2nd semester ect), interdisciplinary competence, arbitrary semester ompetence, arbitrary semester or 2nd semester bitrary semester sciplinary competence, arbitrary semester semester disciplinary competence, arbitrary semester	
 Classes and lectures: Theory and Practice of Good Teaching (seminar, 1 SWS) Work as a tutor in a lecture (practical course, 2 SWS) 		 Workload: 60 Hours private studies and exercises 45 Hours oral presentation (including preparation) 15 Hours in-classroom work 	
Contents of teaching: • Organizing and runnir • Basic didactics of scier • Practical work in tutor	ng a scientific lecture ntific teaching ials		
Qualification-goals/Compet • Ability to run a tutoria • Basic pedagogical and	encies: l and to explain topics of the relevant sul l didactical skills	bfield of informatics.	
Grading through: • continuous participation	on in all courses of the module		
Responsible for this module • Prof. Dr. rer. nat. Jürge Teacher: • Institute for Mathemat • Dr. Jörn Schnieder	:: n Prestin tics		
Language: • depends on the chose	n courses		



	PS5830-KP04, PS5830 - Star	t-up and New Busine	ss (StartUp)
Duration:	Turnus of offer:		Credit points:
1 Semester	not available anymore	not available anymore 4 (Typ B)	
Course of study, specific field Master Media Informati Bachelor Robotics and Master Medical Informati Master MES since 2014 Bachelor MES since 2014 Master Computer Scient Bachelor MES before 20 Bachelor Computer Scient Master CLS (optional su Master Computer Scient	d and term: ics (optional subject), Interdisciplinary Autonomous Systems (optional subje- atics (optional subject), interdisciplinar (optional subject), no specific field, 1s 4 (optional subject), no specific field, ice since 2014 (optional subject), inter 014 (optional subject), interdisciplinar ence 2014 and 2015 (optional subject iject), interdisciplinary competence, 2 ice before 2014 (optional subject), inter	modules, arbitrary semeste ct), interdisciplinary compe- y competence, 1st or 2nd s t or 2nd semester arbitrary semester disciplinary competence, ar , competence, arbitrary sen , central topics of compute nd or 3rd semester erdisciplinary competence,	er tence, 5th or 6th semester semester rbitrary semester nester er science, 5th or 6th semester 2nd or 3rd semester
Classes and lectures:		Workload:	
 Start-up and New Busir Start-up and New Busir 	 • Start-up and New Business (seminar, 1 SWS) • Start-up and New Business (practical course, 1 SWS) • Start-up and New Business (practical course, 1 SWS) • 45 Hours private studies • 30 Hours in-classroom work • 30 Hours written report • 15 Hours oral presentation (including preparation) 		
 Entre-/ Intrapreneurshi Business Modelling Technology product, va Target groups, custome Sales channels, marketi Key ressources / activiti costs and financing, inc special subjects: quality 	p alue propositions, and customer bene er segments, and customer relations ing and sources of income ies / partners cluding funding programs y, acceptance for trading, legal form o	fit f organization, a.o.	
Qualification-goals/Compete • The students have gain • They have acquired a s • They are able to develo • They are able to assess	encies: ned basic insights in the field of Start-u ound knowledge of business modellir op a business plan based on a particul the chances and risks of a start-up an	ıp, new product developmo ıg and planing. ar project. d new product / new busin	ent and new business development. ness development.
Grading through:			
 oral presentation Written report continuous, successful successful addressing of contributions to the distance 	participation in course of the project goals scussion		
Responsible for this module:			
Prof. Dr. Martin Leucker	r		
Teacher:	chapleau and Dreatamping Languag		
Dr. Raimund Mildner		es	
• Aktuelle Forschungsart	ikel werden in der Veranstaltung beka	inntgegeben.:	
Language: • offered only in German			





	CS5410 - Artificial Life (ArtiLife)					
Duration:	Turnus of offer: Credit points:					
1 Semester	ester irregularly 4					
Course of study, specific fie • Master CLS (optional s • Master CLS (optional s • Master Computer Scie • Master Computer Scie • Master Biophysics (op	Id and term: subject), computer science, arbitrary subject), life sciences, arbitrary semest nce before 2014 (optional subject), sp nce before 2014 (optional subject), sp tional subject), Elective, 1st or 2nd ser	emester er pecialization field robotics pecialization field bioinfor mester	and automation, 3rd semester matics, 3rd semester			
Classes and lectures:		Workload:				
 Artificial Life (lecture, Artificial Life (exercise) 	 Artificial Life (lecture, 2 SWS) Artificial Life (exercise, 1 SWS) Artificial Life (exercise, 1 SWS) 45 Hours in-classroom work 15 Hours exam preparation 					
Contents of teaching:						
 Properties, flavors and Artificial chemistry an Introduction to inform Introduction to statist Complex networks an Evolutionary algorithm Emergence Cellular automata Game of life Tierra Ant algorithms 	 Properties, flavors and kinds of (artificial) life Artificial chemistry and self-replicating code Introduction to information theory Introduction to statistical mechanics and thermodynamics Complex networks and NK models Evolutionary algorithms Emergence Cellular automata Game of life Tierra 					
Qualification-goals/Compet • Understanding criteria • Understanding of • Understanding (and a • Understanding the pr • Knowledge of the main	Qualification-goals/Competencies: • Understanding criteria and definitions of • Understanding of • Understanding (and ability to apply) evolutionary algorithms • Understanding the principles of complex networks • Knowledge of the main models of artificial life					
Grading through: • Exercises • Written or oral exam as announced by the examiner						
Responsible for this module	2:					
 PD Dr. rer. nat. Jens Christian Claussen Teacher: Institute for Neuro- and Bioinformatics Prof. Dr. rer. nat. Thomas Martinetz PD Dr. rer. nat. Jens Christian Claussen 						
Literature: • Christoph Adami: Introduction to Artificial Life - Springer Verlag, 1998						
Language: • English, except in case of only German-speaking participants						



MZ2200-MML - Physiology (PhysioMML)				
Duration:	Turnus of offer: Credit points:			
1 Semester	not available anymore		6	
Course of study, specific field and term: • Master CLS (optional subject), life sci	iences, 3rd semester			
Classes and lectures:	Classes and lectures: Workload:			
• Physiology (lecture, 4 SWS)		90 Hours private60 Hours in-class	studies room work	
 Contents of teaching: 1. Molecular physiology: 1.1 Electrical activity and action potentials 1.2 Synapses, transmitters, and receptors 1.3 Molecular contraction and cellular movement 1.4 Molecular physiology of the senses 2. Integrative physiology: 2.1 Blood (oxygen transport, defense, coagulation) 2.2 Hormones and second messengers 2.3 Heart and circulation 2.4 Breathing mechanics and gas exchange 2.5 Kidney (epithelial transport physiology) 				
 Qualification-goals/Competencies: Understanding of cellular and molecular functions of life Understanding of integrative functions of human body systems in health Interpretation of physiological functions in human body 				
Grading through: • continuous, successful participation • written exam	in course			
Responsible for this module: • Prof. Dr. med. Cor de Wit Teacher: • Institut of Physiology • Prof. Dr. med. Cor de Wit • Prof. Dr. med. Wolfgang Jelkmann • Prof. Dr. rer. nat. Horst Pagel • Dr. rer. nat. Reinhard Depping • Dr. rer. nat. Thomas Hellwig-Bürgel				
 Literature: RF Schmidt, F Lang (Hrsg): Physiolologie des Menschen - 30. Aufl, Springer, Heidelberg R Klinke, HC Pape, S Silbernagl (Hrsg): Physiologie - 5. Aufl, Thieme, Stuttgart Silverthorn: Human Physiology Deetjen, Speckmann: Physiologie 				
offered only in German				



CS5255 - Elements of Audio and Image Coding (AudioBild)					
Duration:	Turnus of offer: Credit points:				
1 Semester	1 Semester irregularly		4		
Course of study, specific field and term: Master CLS (optional subject), imagin Master Computer Science before 20' Master Computer Science before 20' Master Computer Science before 20'	ng systems, arbitrary semes 14 (optional subject), advar 14 (optional subject), specia 14 (optional subject), specia	ter iced curriculum signal and alization field robotics and a alization field media inform	image processing, 2nd or 3rd semester automation, 3rd semester atics, 2nd or 3rd semester		
Classes and lectures:		Workload:			
 Elements of Audio and Image Codin Elements of Audio and Image Codin 	g (lecture, 2 SWS) g (exercise, 1 SWS)	 55 Hours private studies 45 Hours in-classroom work 20 Hours exam preparation 			
Contents of teaching:					
 Introduction to information theory Fundamentals of data compression and quantization Wavelets, transforms, and filterbanks for coding Principles of perceptual audio coding Standardized audio coders, such as mp3 and AAC Lossless audio coding Principles and standards of image compression (JPEG, JPEG2000) Progressive image compression Visual perception and masking Principles of video coding Principles of video coding Principles of video coding 					
Qualification-goals/Competencies:					
 Students are able to describe the dif They are able to implement optimal They are able to explain various app 	ferent models of auditory a transforms and coding tec lications of the above men	nd visual perception. hniques. tioned principles in audio, i	mage, and video coding.		
Grading through: • Exercises • Written or oral exam as announced b	Grading through: Exercises Written or oral exam as announced by the examiner 				
Responsible for this module: • Prof. DrIng. Alfred Mertins Teacher: • Institute for Signal Processing • Prof. DrIng. Alfred Mertins					
 Literature: K. Sayood: Introduction to Data Compression - San Diego: Academic Press, 2nd edition 2000 					
Language: • offered only in German					



ME3520-MML - Compulsory optional project in imaging (WPPrBildg)				
Duration:	Turnus of offer: Credit points:		Credit points:	
1 Semester	each winter semester		6	
Course of study, specific field and term: • Master CLS (optional subject), imagir	ng systems, 3rd semester			
Classes and lectures: • Compulsory optional project in imaging (project work, 3 SWS)		Workload: • 95 Hours group v • 55 Hours private • 30 Hours written	vork studies report	
 Contents of teaching: Participation in recent research projects of the Institute of Medical Engineering Project planning and problem analysis Writing requirement specifications Project coordination and work load distribution Project management Interface definition Implementation Validation Hands-on tests Project handover 				
Qualification-goals/Competencies: The students learn working methods They learn and enhance their capaci By working in groups, the skills to we 	s in entering a current resea ty to documentat and prese ork in teams and division of	urch project at the Institute ent project results. Flabor can be improved.		
Grading through: • Written report • continuous, successful participation • contributions to the discussion	in course			
Responsible for this module: • Prof. Dr. rer. nat. Thorsten Buzug Teacher: • Institute of Medical Engineering • Prof. Dr. rer. nat. Thorsten Buzug • MitarbeiterInnen des Instituts				
Literature: Latest journal publications made available at the beginning of the project: 				
offered only in German				



	CS2500-KP04, CS2500 - Robotics (Robotik)			
Duration:	Turnus of offer:		Credit points:	
1 Semester	each winter semester	each winter semester 4		
Course of study, specific field an Bachelor Medical Information Bachelor Computer Science Bachelor Robotics and Autor Bachelor IT-Security (option Bachelor MES since 2014 (o Bachelor Medical Information Bachelor Computer Science Bachelor Computer Science Bachelor Computer Science Master CLS (optional subject Bachelor MES before 2014 (o Bachelor Computer Science)	d term: cs since 2019 in planning (optional since 2016 (optional subject), maj pnomous Systems (compulsory), Ro tal subject), computer science, arbit ptional subject), computer science cs since 2014 (optional subject), mage 2014 and 2015 (optional subject), a 2014 and 2015 (compulsory), species before 2014 (optional subject), a before 2014 (optional subject), ce ct), computer science, 3rd semester optional subject), Medical Engineer before 2014 (compulsory) species	subject), medical computer or subject informatics, arbit obotics and Autonomous Sy trary semester and electrical engineering, edical computer science, 5th central topics of computer cialization field robotics and pplied computer science, 4 ntral topics of computer sci r	r science, 4th to 6th semester rrary semester stems, 3rd semester 5th semester h or 6th semester science, 5th semester I automation, 3rd semester th to 6th semester ence, 5th semester	
 Classes and lectures: Robotics (lecture, 2 SWS) Robotics Exercise (exercise, 	ies and lectures: Workload: • Robotics (lecture, 2 SWS) • 55 Hours private studies • Robotics Exercise (exercise, 1 SWS) • 45 Hours in-classroom work • 20 Hours exam preparation		e studies sroom work oreparation	
 excinplicity, the dimension of robots. The constraints of robots and the constraints of robots. This parallel kinematics. Movement: Robot movement well as methods to determ Robot Control: Techniques calibration as a typical application as a typical application. 	lirect and inverse kinematics for ty part deals with the transfer of the ents along trajectories/geometric p ine the configuration space and to of control theory and examples of ication of robotics is explained in o	pical 6-jointed industrial rok results and mathematical m aths are analyzed. Different perform velocity planning a programming techniques ir detail.	boots is explained. nodels of part 1 onto robotic systems with techniques of path planning are presented as and kinematics. n robotics are introduced. Sensor and systems	
Overlification and /Commeter di				
 Qualification-goals/Competencie The students are able to so They have gained basic understand transformations, Euler-/Tail They made first experience They comprehend the com The students gained an instant 	es: lve application-oriented exercises derstanding for the kinematic featu -Bryan-Angles, quaternions, etc.) s with the programming of simple plexity and necessity for different ight into simple methods for syste	with mathematical backgrou ures of serial and simple par robotic applications. path and dynamic planning m and sensor calibration.	und self-dependent, timely and in team work. allel robots (includes knowledge of techniques.	
Grading through:				
• written exam				
Is requisite for: • Lab Course Robotics and A	utomation (CS3501-KP04, CS3501)			
Requires: • Analysis 1 (MA2000-KP08, N • Linear Algebra and Discrete	/A2000) e Structures 1 (MA1000-KP08, MA1)	000)		
Responsible for this module: • Prof. DrIng. Achim Schwei Teacher: • Institute for Robotics and C	kard ognitive Systems			



 Prof. DrIng. Achim Schweikard Prof. Dr. rer. nat. Floris Ernst
Literature:
A. Schweikard, F. Ernst: Medical Robotics - Springer Verlag, 2015 M. Spong et al. Bobet Medicing and Control - Wiley & Spong 2005
 M. spong et al.: Robot Modeling and Control - Wiley & Sons, 2005 HJ. Siegert, S. Bocionek:: Robotik: Programmierung intelligenter Roboter - Springer Verlag, 1996
JP. Merlet: Parallel Robots - Springer Verlag, 2006 M. Haum Handhush, Back stille, Springer Verlag, 2007
 M. Haun: Handbuch Robotik - Springer Verlag, 2007 S. Niku: Introduction to Robotics: Analysis, Control, Applications - Wiley & Sons, 2010
Language:
offered only in German



CS2700-KP04, CS2700 - Databases (DB)					
Duration:	n: Turnus of offer: Credit points:				
1 Semester	each summer semester 4				
 Course of study, specific field and term: Bachelor Medical Informatics since 2019 in planning (compulsory), computer science, 3rd semester Bachelor Computer Science since 2016 (compulsory), foundations of computer science, 4th semester Bachelor Robotics and Autonomous Systems (optional subject), computer science, 5th or 6th semester Bachelor IT-Security (compulsory), computer science, 4th semester Bachelor Biophysics (optional subject), computer science, 6th semester Bachelor MES before 2014 (optional subject), computer science, 4th or 6th semester Bachelor MES since 2014 (optional subject), computer science, and electrical engineering, 4th or 6th semester Bachelor Media Informatics (compulsory), foundations of computer science, 4th semester Bachelor Media Informatics (compulsory), foundations of computer science, 4th semester Bachelor Media Informatics (compulsory), foundations of computer science, 4th semester Bachelor Media Informatics (compulsory), foundations of computer science, 4th semester Bachelor Media Informatics (compulsory), foundations of computer science, 4th semester Bachelor Computer Science 2014 and 2015 (compulsory), foundations of computer science, 4th semester Bachelor Medical Informatics before 2014 (compulsory), computer science, 2nd semester Bachelor Medical Informatics before 2014 (compulsory), computer science, 2nd semester Bachelor Medical Informatics before 2014 (compulsory), computer science, 2nd semester Bachelor CLS (optional subject), computer science, 6th semester Bachelor CLS (optional subject), computer science, 6th semester 					
Classes and lectures:		Workload:			
 Databases (lecture, 2 SWS) Databases (exercise, 1 SWS) 		55 Hours private45 Hours in-class20 Hours exam p	studies sroom work preparation		
 Contents of teaching: Introduction, conceptual view of database systems, conceptual data modeling with the Entity-Relationship (ER) modeling language The relational data model* Referential integrity, keys, foreign keys, functional dependencies (FDs)* Canonical mapping of entity types and relationships into the relational data model* Update, insertions, and deletion anomalies* Relational algebra as a query language* Database normalization, closure w.r.t. FD set, canonical cover of FD sets, normal forms, correct and dependency preserving decomposition of relation schemata, multi-value dependencies, inclusion dependencies Practical query language: SQL* Selection, projection, join, aggregation, grouping, sorting, difference, relational algebra in SQL* Data management* Integrity constraints Storage structures and database architecture* Characteristics of storage media, I/O complexity* DBMS architecture: disk space manager, buffer manager, files and access methods, record allocation strategies (row-wise, column-wise, mixed) Query processing* Indexing techniques, ISAM index, B+-tree index, hash index* Sorting: Two-way merge sort, blockwise processing, selection trees, query execution plans, join operator: nested loops join, blockwise nested loops join, index-based joins, sort-merge join, partition-based join with hashing* Addition operators: grouping and duplicate elimination, selection, projection, pipeline principle Query optimization* Cost metrics, Estimating sizes of intermediate tables, selectivity* Join optimization, physical plan properties, interesting orders, query transformation* Index cuts, bitmap indexes Transactions and recovery* ACID, anomalies, serializability, locks, 2-phase commit protocol, concurrent access to index structures, isolation levels* Implementation of transaction w.r.t. ACID, shadow pages, write ahead log, snapshots 					
 Qualification-goals/Competencies: Basic understanding of database principles Knowledge about relational database design Knowledge of database query languages such as relational algebra and SQL Knowledge about principles of concurrent data access Introduction of database implementation techniques to allow for estimating resources required for answering queries 					
Grading through: • Exercises • written exam					
Is requisite for: • Nonstandard Databases and Data Mining (CS3130-KP08) • Nonstandard Database Systems (CS3202-KP04, CS3202)					



Requires:
 Introduction to Programming (CS1000-KP08, CS1000SJ14-MML/MI, CS1000SJ14-MIW) Introduction to Programming (CS1000-KP10, CS1000SJ14)
Responsible for this module:
Prof. Dr. rer. nat. habil. Ralf Möller
Teacher:
Institute of Information Systems
Prof. Dr. rer. nat. habil. Ralf Möller
Literature:
A. Kemper, A, Eickler: Datenbanksysteme - Eine Einführung - Oldenbourg-Verlag
Language:
offered only in German



CS3050-KP04, CS3050 - Coding and Security (CodeSich)					
Duration:	Turnus of offer: Credit points:				
1 Semester	each summer semester		4		
1 Semestereach summer semester4Course of study, specific field and term:• Bachelor Computer Science since 2016 (compulsory), Canonical Specialization Web and Data Science from WS19, 2nd semester• Bachelor Medical Informatics since 2019 in planning (optional subject), computer science, 4th to 6th semester• Bachelor Computer Science since 2016 (optional subject), major subject informatics, arbitrary semester• Bachelor Computer Science since 2016 (optional subject), Canonical Specialization Web and Data Science WS16-SS19, 2nd semester• Bachelor Computer Science since 2016 (optional subject), Canonical Specialization SSE, 2nd semester• Bachelor Robotics and Autonomous Systems (optional subject), computer science, 5th or 6th semester• Bachelor IT-Security (compulsory), IT-Security, 2nd semester• Bachelor Medical Informatics since 2014 (optional subject), computer science, 5th or 6th semester• Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 6th semester• Bachelor Computer Science 2014 and 2015 (optional subject), central topics of computer science, 6th semester• Bachelor Computer Science 2014 and 2015 (optional subject), central topics of semultary and safety, 2nd semester• Bachelor Computer Science before 2014 (optional subject), advanced curriculum security, 2nd semester• Bachelor Computer Science before 2014 (optional subject), computer science, 4th to 6th semester• Bachelor Computer Science before 2014 (optional subject), computer science, 4th to 6th semester• Bachelor Computer Science before 2014 (optional subject), computer science, 4th to 6th semester• Bachelor Computer Science before 2014 (optional subject), computer					
Classes and lectures: • Coding and Security (lecture, 2 SWS) • Coding and Security (exercise, 1 SWS	Classes and lectures: Workload: • Coding and Security (lecture, 2 SWS) • 65 Hours private studies and exercises • Coding and Security (exercise, 1 SWS) • 45 Hours in-classroom work • 10 Hours exam preparation				
 information, entropie discrete sources and channels coding systems, error-tolerant codes codes for digital media, compression threats to IT-systems formal definition of security properti security primitives 	Contents of teaching: information, entropie discrete sources and channels coding systems, error-tolerant codes codes for digital media, compression threats to IT-systems formal definition of security properties security primitives 				
Qualification-goals/Competencies: • detailed knowledge of the basics of information and coding theory • deep knowledge of the concept of information • being able to model information sources and communication networks • being able to formalize the security of IT-systems • knowing scenarios of attacks and protection methods					
Exercises Viva Voce or test					
Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000)					
Responsible for this module: • Prof. Dr. Rüdiger Reischuk Teacher: • Institute for Theoretical Computer Science • Prof. Dr. Rüdiger Reischuk • Prof. Dr. Maciej Liskiewicz					



Literature:

- R. Roth: Introduction to Coding Theory Cambridge Univ. Press 2006
- D. Salomon: Coding for Data and Computer Communications Springer 2005
- D. Salomon: Data Privacy and Security Springer 2003
- Pieprzyk, Hardjono, Seberry: Fundamentals of Computer Security Springer 2003
- M. Stamp: Information Security: Principles and Practice Wiley 2006

Language:

German and English skills required



	CS3202-KP04, CS3202 - Nonstandard Database Systems (NDB)				
Duration:	uration: Turnus of offer: Credit points:				
1 Semester	not available anymore 4				
Course of study, specific fi Bachelor IT-Security Bachelor Medical Info Bachelor Media Info Bachelor Computer S Bachelor Medical Info Master Computer Sc Master CLS (optional Bachelor CLS (optional Bachelor CDS (optior Master Computer Sc Bachelor Computer Sc	eld and term: (optional subject), computer science, arbi ormatics since 2014 (optional subject), co matics (optional subject), computer scien Science 2014 and 2015 (optional subject), ormatics before 2014 (optional subject), a ience before 2014 (optional subject), spec suject), computer science, arbitrary seme nal subject), computer science, 6th semest ience before 2014 (optional subject), adva Science before 2014 (optional subject), ce	trary semester mputer science, 5th or 6th ser ce, 5th or 6th semester central topics of computer sc pplied computer science, 4th ialization field media informa ster er nnced curriculum distributed i ntral topics of computer scien	mester ience, 5th or 6th semester to 6th semester tics, 2nd or 3rd semester information systems, 2nd or 3rd semester ice, 5th or 6th semester		
Classes and lectures:		Workload:			
 Nonstandard Databa Nonstandard Databa 	ase Systems (lecture, 2 SWS) ase Systems (exercise, 1 SWS)	 65 Hours private st 45 Hours in-classro 10 Hours exam pression 	tudies oom work eparation		
 Sequence Databases Databases for data s Databases for incom Probabilistic databases Databases with ansy 	treams (window concept) plete information (e.g., constraint databa ses ver ranking (top-k queries)	Ses)			
 Qualification-goals/Competencies: Knowledge:Students can name the main features of standard databases and, in addition, can explain which non-standard database models emerge if features are dropped. They can describe the main ideas behind non-standard databases presented in the course by explaining the main features of respective query languages (syntax and semantics) as well as the most important implementation techniques used for their practical realization. Skills:Students can apply query languages for non-standard data models introduced in the course to retrieve desired structures from sample datasets in order to satisfy information needs specified textually in natural language. Students are able to represent data in the relational data model using encoding techniques presented in the course such that they can demonstrate how new formalisms relate to or can be implemented in SQL (in particular, SQL-99). In case an SQL transformation cannot be found, students can explain and apply dedicated algorithms for query answering. Students can demonstrate how index structures help answering queries fast by showing how index structures are built, updated, and exploited for query answering. The participants of the course can derive query answers by evaluating queries step by step and by deriving optimized query execution plans. Social skills:Students work in teams to handle assignments, and they are encouraged to present their solution to other students in small presentations (in lab classes). In addition, self-dependence is fostered by giving pointers to query leaduages for various formalism presented in the classes). In addition, self-dependence is fostered by giving pointers to query evaluation engines for various formalism presented in the classes of the students and query languages by self-controlled work. 					
Grading through:					
 Exercises Written or oral exam as announced by the examiner 					
Requires: • Databases (CS2700-KP04, CS2700)					
Responsible for this module: • Prof. Dr. rer. nat. habil. Ralf Möller Teacher:					



- Institute of Information Systems
- Prof. Dr. rer. nat. habil. Ralf Möller

Literature:

- S. Abiteboul, P. Buneman, D. Suciu: Data on the Web From Relations to Semistructured Data and XML Morgan Kaufmann, 1999
- J. Chomicki, G. Saake (Eds.): Logics for Databases and Information Systems Springer, 1998
- P. Rigaux, M. Scholl, A. Voisard: Spatial Databases With Applications to GIS Morgan Kaufmann, 2001
- P. Revesz: Introduction to Constraint Databases Springer, 2002
- P. Revesz: Introduction to Databases- From Biological to Spatio-Temporal Springer 2010
- S. Ceri, A. Bozzon, M. Brambilla, E. Della Valle, P. Fraternali, S. Quarteroni: Web Information Retrieval Springer, 2013
- S. Chakravarthy, Q. Jiang: Stream Data Processing A Quality of Service Perspective Springer, 2009
- D. Suciu, D. Olteanu, Chr. Re, Chr. Koch: Probabilistic Databases Morgan & Claypool, 2011
- -----

Language:

• offered only in German



CS4000 - Algorithmics (ALG)					
Duration: Turnus of offer: Credit points:			Credit points:		
1 Semester	each winter semester		4		
Course of study, specific field and term:					
 Master CLS (optional subject), compt Master Computer Science before 201 	uter science, 1st or 3rd sem 4 (compulsory), computer	ester science mandatory courses	s, 1st semester		
Classes and lectures:		Workload:			
 Algorithmics (lecture with exercises, 3 SWS) 65 Hours private studies and exercises 45 Hours in-classroom work 10 Hours exam preparation 			studies and exercises room work reparation		
Contents of teaching:					
 satisfiability and constraint satisfaction randomized search discrete optimization problems, linear Las-Vegas- and Monte-Carlo-algorithm complexity analysis of algorithmic problems approximation algorithms heuristic search 	on problems ar programming Ims roblems				
Qualification-goals/Competencies:					
 ability to model real problems in an ability to design efficient algorithms good practice in applying basic algo skill in analyzing algorithms, in partice 	algorithmic manner for complex problems rithmic techniques cular with respect to corrre	ctness and complexity			
Grading through: • exercises and project assignments • Viva Voce or test					
ls requisite for:					
 Seminar Algorithmics and Complexit Advanced Algorithmics and Data Stri Computer Algebra (CS4018) 	y Theory (CS5099) uctures (CS4008)				
Requires:					
 Theoretical Computer Science (CS20) Algorithm Design (CS3000-KP04, CS3) 	00-KP08, CS2000) 3000)				
Responsible for this module:					
Prof. Dr. Rüdiger Reischuk					
Teacher:					
 Prof. Dr. naciej Liskiewicz 					
Literature:					
 Aho, Hopcroft, Ullman: Design and Analysis of Computer Algorithms - Addison Wesley, 1978 Motwani, Raghavan: Randomized Algorithms - Cambridge University Press, 2000 Mitzenmacher, Upfal: Probability and Computing - Cambridge University Press, 2005 Kreher, Stinson: Combinatorial Algorithms - CRC Press, 1999 Williamson, Shmoys: The Design of Approximation Algorithms - Cambridge University Press, 2011 					



Language:

• offered only in German





CS4003 - Computational Complexity (Komplex)						
Duration:	Turnus of offer:		Credit points:			
1 Semester	normally each year in the summer semester		4			
 Course of study, specific field and term: Master Computer Science before 2014 (optional subject), specialization field IT security and safety, 2nd or 3rd semester Master Computer Science before 2014 (compulsory), advanced curriculum algorithmics and complexity theory, 2nd or 3rd semester Master CLS (optional subject), computer science, 2nd semester 						
Classes and lectures: • Computational Complexity (lecture v	lasses and lectures:Workload:• Computational Complexity (lecture with exercises, 3 SWS)• 65 Hours privat• 45 Hours in-class• 10 Hours exam		studies and exercises room work reparation			
Contents of teaching: • structure of time and space classes • comparison of different reducibilities • circuit complexity • probabilistic complexity classes • Polynomial Hierarchy • separation of complexity classes • oracle Turing machines and relativisation						
 Qualification-goals/Competencies: ability to classify problems according to various complexity measures knowledge of relations between different machine models and complexity measures understanding of the terms diagonalisation, simulation, configuration graph, reductions and completeness, relativisation, and logical characterisation 						
Grading through: • Exercises • Oral examination						
Requires: • Algorithmics (CS4000)						
Responsible for this module: • Prof. Dr. Rüdiger Reischuk Teacher: • Institute for Theoretical Computer Science • Prof. Dr. Rüdiger Reischuk • Prof. Dr. Rüdiger Reischuk • Prof. Dr. rer. nat. Till Tantau						
Literature: • : • : • : • : • :						
• English, except in case of only Germa	an-speaking participants					



CS4018 - Computer Algebra (CompAlgebr)						
Duration:	Turnus of offer:		Credit points:			
1 Semester	not available anymore		4			
 Course of study, specific field and term: Master CLS (optional suject), computer science, arbitrary semester Master Computer Science before 2014 (optional subject), advanced curriculum algorithmics and complexity theory, 2nd or 3rd semester 						
Classes and lectures: • Computer Algebra (lecture with exercises, 3 SWS) •		Workload: • 65 Hours private • 45 Hours in-class • 10 Hours exam p	 Vorkload: 65 Hours private studies and exercises 45 Hours in-classroom work 10 Hours exam preparation 			
Contents of teaching: • • • • Polynome, Matrizen • Multiplikationsalgorithmen, FFT, DFT • Gr • formale Differentiation und						
Qualification-goals/Competencies: • • • •						
Grading through: • exercises and project assignments • Oral examination						
Requires: • Algorithmics (CS4000)						
Responsible for this module: • Prof. Dr. Rüdiger Reischuk Teacher: • Institute for Theoretical Computer S • Prof. Dr. Rüdiger Reischuk	cience					
Literature: • : • :						
Language:English, except in case of only German-speaking participants						





CS4020 - Specification and Modelling (SpezMod)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	each winter semester	each winter semester 4			
 Course of study, specific field and term: Master CLS (optional subject), computer science, arbitrary semester Master Computer Science before 2014 (compulsory), computer science mandatory courses, 1st semester 					
Classes and lectures: • Specification and Modelling (lecture, 2 SWS) • Specification and Modelling (exercise, 1 SWS)		 Workload: 60 Hours private studies and exercises 45 Hours in-classroom work 15 Hours exam preparation 			
 Contents of teaching: Introduction to modelling and specification Modelling concepts (data, streams, traces, diagrams, tables) Modelling software components (state, behaviour, structure, interface) Modelling concurrency Algebraic specification Composing, refining, analysing and transforming specifications and models Specification languages and tools for specification and modelling 					
 Qualification-goals/Competencies: The students can argue on the importance of specifications and models for software development. Sie können wichtige Spezifikations- und Modellierungstechniken charakterisieren, anwenden, anpassen und erweitern. They can model and specify simple software/hardware system in an adequate way. They can describe a system from different views and on different levels of abstraction. They can apply specifications and modelsin software development. 					
Grading through: • Exercises • Written or oral exam as and	nounced by the examiner				
Responsible for this module: • Prof. Dr. Martin Leucker Teacher: • Institute of Software Technology and Programming Languages • Dr. Annette Stümpel • Prof. Dr. Martin Leucker					
 Literature: V.S. Alagar, K. Periyasamy: Specification of Software Systems - Springer 2011 M. Broy, K. Stølen: Specification and Development of Interactive Systems - Springer 2001 J. Loeckx, HD. Ehrich, M. Wolf: Specification of Abstract Data Types - John Wiley & Sons 1997 D. Bjorner: Software Enginneering 1-3 - Springer 2006 U. Kastens, H. Kleine Büning: Modellierung - Grundlagen und formale Methoden - Hanser 2005 					
German and English skills required					



СЅ4330-КР04, С	S4330 - Image Analysis and Vis	sualization in Diagnostics and	l Therapy (BAVIS)			
Duration:	Turnus of offer:	Credit points:	Max. group size:			
1 Semester	each summer semester	4	99			
 Course of study, specific field and term: Master MES before 2014 (advanced curriculum), imaging systems, signal and image processing, 2nd semester Master CLS (optional suject), computer science, arbitrary semester Master Computer Science before 2014 (compulsory), specialization field medical informatics, 2nd semester Master MES since 2014 (optional subject), Medical Engineering Science, 1st or 2nd semester 						
 Classes and lectures: Image Analysis and Visualization Systems in Diagnostics and Therapy (lecture, 2 SWS) Image Analysis and Visualization Systems in Diagnostics and Therapy (exercise, 1 SWS) 		 Workload: 55 Hours private studies and exercises 45 Hours in-classroom work 20 Hours exam preparation 				
 Contents of teaching: Methods and algorithms for the analysis and visualization of medical images including current research activities in the field of medical image computing. The following methods and algorithms are explained: Data driven segmentation of multispectral image data Random Decision Forests for the segmentation of medical image data Convolutional Neural Networks and Deep Learning in Medical Image Processing live wire segmentation segmentation with active contour models and deformable models level set segmentation statistical shape models image registration atlas-based segmentation and multi atlas segmentation using non-linear registration visualization techniques in medicine direct volume rendering, ray tracing, ray casting haptic 3D interactions in virtual bodies virtual reality techniques in medical applications 						
Qualification-goals/Competen Increase knowledge in m Knowledge of the individ Understanding of the un Ability to select appropr Implementation of the m Application to practical p Overview of medical image 	icies: nedical image processing and visualizati dual steps of pattern recognition iderlying algorithms iate methods for a given problem nethods problems age processing techniques with many ex	on kamples				
Grading through: Exercises Written or oral exam as announced by the examiner 						
Requires: • Image and Signal Processing in Medicine 1 (CS3310-INF)						
Responsible for this module: • Prof. Dr. rer. nat. habil. H Teacher: • Institute of Medical Infor • Prof. Dr. rer. nat. habil. H	einz Handels matics einz Handels					


Literature:

- H. Handels: Medizinische Bildverarbeitung 2. Auflage, Vieweg u. Teubner 2009
- T. Lehmann: Handbuch der Medizinischen Informatik München: Hanser 2005
- M. Sonka, V. Hlavac, R. Boyle: Image Processing, Analysis and Machine 2nd edition. Pacific Grove: PWS Publishing 1998
- B. Preim, D. Bartz: Visualization in Medicine Elsevier, 2007

Language:

• offered only in German



CS4385-KP08, CS4385 - Autonomous Learning Agents (ALA)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	each winter semester		8	
 Course of study, specific field and term: Master CLS (optional subject), computer science, 1st or 2nd semester Master Robotics and Autonomous Systems (optional subject), computer science, 1st or 2nd semester (optional subject), computer science, 1st or 2nd semester 				
Classes and lectures: • See CS4385 T: Autonomous Learning • See CS4385 T: Autonomous Learning	ng Agents (lecture, 4 SWS) ng Agents (exercise, 2 SWS) • 30 Hours exam pr		e studies room work reparation	
Contents of teaching:				
 Rational autonomous agents as a formal basis for the design of information retrieval and robotic systems Repetition of stochastics and generative models for discrete data, Gauss-models and their application for information retrieval, vector space model with probabilistic information retrieval Dynamic graphical probability models (dynamic Bayesian netzworks, Markov assumptions, state transition and sensor models, computational Problems, such as filtering, prediction, smoothing, most probable state sequence), hidden-Markov-models, kalman filter, conditional random field, exact and approximate methods for the solution of computational problems, automatic Determination of Parameters and structure of dynamic graphical probability models. Application: POS-tagging, semantic annotation Mixed models, latent linear models (LDA, LSI, PCA). Application: Determination of themes, multimedia Interpretation for web search (identification of known entities, elimination of duplicates, interpretation of content, probabilistic Evaluation of interpretations, link analysis, network analysis) Generation of plans, decision making under uncertainty: utilitarism, decision networks, value of information, sequential decision making problems with partial observability (POMDP), dynamic decision networks, parameter- and structure determination via repeated amplification (reinforcement learning). Application: Determination of dynamic information search plans Interaction of agents: game theory, decisions and Actions of multiple agents (Nash equilibrium, Bayes-Nash equilibrium), social decisions (elections, preferences, paradoxes, Arrow's Theorem), mechanisms, design of mechanisms (controlled autonomy), bilateral mechanisms: Rules of encounter. Application: Exchange of interpretations between search agents. First order probabilistic logic, probabilistic doxastic temporal logic. Application: Design and exchange of symbolic annotations and interpretations for multimedal web data, asso				
 Qualification-goals/Competencies: Knowledge: Students are able to explain the agent abstraction and the application of information retrieval in the web (web mining) as rational behaviour. Students are able to explain details of the architecture of mining agents (goals, utility, environment). Students are able to discuss cooperative and non-cooperative agents in the context of decision making. Students are able to explain the relevant tools for representation (e.g. Bayesian networks) and algorithms for the computation of stati and dynamic Scenarios, in order to equip agents with the ability to cope with uncertainty during information retrieval in real world scenarios. Students are able to explain techniques for the automatic computation of employed representations and models. Students are able to describe and design decision making processes for simple and sequential contests, in order to equip agents with decision making competences (e.g. to determine further search options within the web). Thus, Scenarios can be handled, in which agents have full or partial access to the state of the context system and may estimate the value of information that may be possible t acquire for specificied tasks. The students have Knowledge to explain classical and modern techniques for the effective accumulation of unstructured data with symbolic descriptions (interpretation of multimedia Contents, annotation) Skills: 				

- Students are able to select representatins and forms of cooperation for subprocesses and agents for the design of web search and robotic systems.
- Based on multimodal data, students are able to design mining systems to evaluate explicitly defined units of data (text documents, relational data, pictures, videos) for the purpose of returning a symbolic, summarizing description.



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Module Guide

 Students are able to design competition-based systems with autonomous agents, constructed by various parties. The interaction or cooperation of web mining agents then generates mutual benefit. Students are able to treat problems of coordination and decision making in multi-agent scenarios via consensus protocols. Social skills and self-reliance: The participants practice cooperative programming: They are able to explain problems to their partner and develop Solutions. The students communicate in english. Via online-quizzes and supplementary material for self-study, students are able to evaluate and increase their knowledge continuously. The students' work on exercise problems allows to practice giving feedback.
Grading through:
 exercises and project assignments exam type depends on main module
Requires:
• Statistics 1 (PY1800-KP06)
 Stochastics 1 (MA2510-KP04, MA2510) Databases (CS2700-KP04, CS2700)
Linear Algebra and Discrete Structures 2 (MA1500-KP08, MA1500)
 Linear Algebra and Discrete Structures 1 (MA1000-KP08, MA1000) Algorithms and Data Structures (CS1001-KP08, CS1001)
Responsible for this module:
Siehe Hauptmodul
Teacher:
Institute of Information Systems
Prof. Dr. rer. nat. habil. Ralf Möller
Literature:
D. Koller, N. Friedman: Probabilistic Graphical Models: Principles and Techniques - MIT Press, 2009
 Chr. Manning, P. Raghavan, H. Schütze: Introduction to Information Retrieval - Cambridge University Press. 2008 K. Murphy: Machine Learning: A. Probabilistic Perspective - MIT Press. 2012
 S. Russel, P. Norvig: Artificial Intelligence: A Modern Approach - Pearson Education, 2010
• Y. Shoham, K. Leyton-Brown: Multiagent-Systems: Algorithmic, Game-Theoretic, and Logical Foundations - Cambridge University Press, 2009
Language:
offered only in English



CS4405-KP04, CS4405 - Neuroinformatics (NeuroInf)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	each summer semester		4		
Tsemester 14 Course of study, specific field and term: • • Master CLS starting 2016 (compulsory), computer science, 2nd semester • • Master Robotics and Autonomous Systems (optional subject), computer science, 1st or 2nd semester • • Master MES since 2014 (optional subject), computer science and electrical engineering, arbitrary semester • • Master MES before 2014 (optional subject), mathematics, 2nd semester • • Bachelor MES before 2014 (optional subject), optional subject medical engineering science, 6th semester • • Master Computer Science before 2014 (optional subject), advanced curriculum organic computing, 2nd or 3rd semester • • Master Computer Science before 2014 (optional subject), advanced curriculum intelligent embedded systems, 2nd or 3rd semester • • Master Computer Science before 2014 (optional subject), advanced curriculum intelligent embedded systems, 2nd or 3rd semester • • Master Computer Science before 2014 (optional subject), advanced curriculum intelligent embedded systems, 2nd or 3rd semester • • Master Computer Science before 2014 (compulsory), specialization field robotics and automation, 2nd semester • • Master Computer Science before 2014 (compulsory), specialization field bioinformatics, 2nd semester • • Master CLS (compulsory), computer science, 2nd semester •					
Classes and lectures:		Workload:			
 Neuroinformatics (lecture, 2 SWS) Neuroinformatics (exercise, 1 SWS) 		55 Hours private45 Hours in-class20 Hours exam p	studies room work reparation		
Contents of teaching: • The human brain and abstract neuro • Learning with a single neuron:* Pero • Network architectures:* Hopfield-Ne • Unxupervised Learning:* k-means, N Qualification-goals/Competencies: • The students are able to understand	 Contents of teaching: The human brain and abstract neuron models Learning with a single neuron:* Perceptrons* Max-Margin Classification* LDA and logistic Regression Network architectures:* Hopfield-Networks* Multilayer-Perceptrons* Deep Learning Unxupervised Learning:* k-means, Neural Gas and SOMs* PCA & ICA* Sparse Coding Qualification-goals/Competencies: 				
 The students are able to understand They know abstract neuronal model They are able to derive a learning ru They are able to apply (and implement 	and they are able to name from a given error function ent) the proposed learning	single neuron and the brai e practical applications for on. rules and approaches to so	in as a whole. the different variants. Ilve unknown practical problems.		
Grading through: • Exercises • Written or oral exam as announced b	Grading through: Exercises Written or oral exam as announced by the examiner 				
Responsible for this module: • Prof. Dr. rer. nat. Thomas Martinetz Teacher: • Institute for Neuro- and Bioinformatics • Prof. Dr. rer. nat. Thomas Martinetz • Prof. Dr. rer. nat. Amir Madany Mamlouk					
Literature: S. Haykin: Neural Networks - London J. Hertz, A. Krogh, R. Palmer: Introduc T. Kohonen: Self-Organizing Maps - E H. Ritter, T. Martinetz, K. Schulten: Ne Addison Wesley, 1991 Language:	: Prentice Hall, 1999 ction to the Theory of Neur Berlin: Springer, 1995 euronale Netze: Eine Einfüh	al Computation - Addison ¹ rung in die Neuroinformat	Wesley, 1991 ik selbstorganisierender Netzwerke - Bonn:		



	CS4440-KP04, CS4440 - Moleo	ular Bioinformatics (MolB	Biolnfo)
Duration:	Turnus of offer:	Cre	edit points:
1 Semester	each winter semester	4	
Course of study, specific field • Master CLS starting 2016 • Master MES before 2014	and term: (optional subject), computer science (advanced curriculum), biophysics ar	3rd semester d biomedical optics, 2nd semest	er
 Master CLS (optional sub Master Computer Scienc 	ject), computer science, 1st or 3rd se e before 2014 (compulsory), specializ	nester ation field bioinformatics, 1st sen	nester
Classes and lectures:		Workload:	
Molecular BioinformaticMolecular Bioinformatics	atics (lecture, 2 SWS)• 55 Hours private studiesatics (exercise, 1 SWS)• 45 Hours in-classroom work• 20 Hours exam preparation		
Contents of teaching:			
 Methods for fast genome Analysis of data describin Advanced usage of biologian 	e comparison ng gene expression profiles and sequ ogical databases (for sequences, motil	ence variation s, structures, gene regulation an	d interactions)
Qualification-goals/Competen	cies:		
 The students can apply i They can use and design They are able to detect s 	ndexing based software to Next Gene databases for molecularbiological re tatistically significant changes in Mic	ration sequence data. search. oarray data.	
Grading through: • Exercises • Written or oral exam as a	nnounced by the examiner		
Requires:			
Introduction to Bioinform	natics (CS1400-KP04, CS1400)		
Responsible for this module:			
• Prof. Dr. rer. nat. Thomas	Martinetz		
Teacher:			
 Institute for Neuro- and I 	Bioinformatics		
 Prof. Dr. Bernhard Haubo Prof. Dr. rer. nat. Thomas MitarbeiterInnen des In 	old Martinetz stituts		
Literature:			
M. S. Waterman: Introdu	ction to Computational Biology - Lon	don: Chapman and Hall 1995	
 B. Haubold, T. Wiehe: Int R. Durbin, S. Eddy, A. Kro Press 	roduction to Computational Biology gh, G. Mitchison: Biological sequence	Birkhäuser 2007 analysis. Probabilistic models - C	Cambridge, MA: Cambridge University
 J. Setubal, J. Meidanis: In D. M. Mount: Bioinforma 	troduction to computational molecul tics - Sequence and Genome - New Y	ar - Pacific Grove: PWS Publishing ork: Cold Spring Harbor Press	g Company
Language: • offered only in German			





CS4513-KP12, CS4513 - Web and Data Science (WebScience)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	each winter semester		12		
Course of study, specific field Master CLS (optional sub Master Entrepreneurship Master Computer Science 	and term: ject), computer science, arbitrary seme in Digital Technologies (advanced mod e since 2014 (advanced module), advar	ster dule), technology field com nced curriculum, 2nd or 3rc	nputer science, 2nd or 3rd semester d semester		
Classes and lectures:	Classes and lectures: Workload:				
 CS5130 T: Foundations of Ontologies and Databases for Information Systems (lecture with exercises, 3 SWS) CS5131 T: Web Mining Agents (lecture with exercises, 6 SWS) 		 180 Hours private 135 Hours in-clas 45 Hours exam p 	e studies sroom work reparation		
Contents of teaching:					
 The term Web and Data Science refers to the study of the connection between data on the web and associated web services for the benefit of humans. Phenomena of technical, economic and social contexts of a system design perspective are examined so that web and data analysis drive new applications for people. Web and Data Science introduces the basics of the analysis and design of large networked information systems. The lack of a global control for distributed data (with different structure) and the lack of formal structure is an essential element we investigate in this module. The modules sets out how autonomous units can analyze data in a controlled cooperation scenario such that data can become information for humans and formally defined requirements are met. For more information see the module parts. Qualification-goals/Competencies: Students will gain in-depth knowledge, solid skills and extensive expertise in the field of information systems, so that, for example, latest achievements of Web search engines can be exploited (see, e.g., Google Knowledge Vault), and students can successfully work in research projects as well as practical projects in industry.					
Grading through: • exercises and project ass • Oral examination	ignments				
Responsible for this module: • Prof. Dr. rer. nat. habil. Ralf Möller Teacher: • Institute of Information Systems • Prof. Dr. rer. nat. habil. Ralf Möller • Dr. Özgür Özçep					
Language:• offered only in English					
Notes: A combination with the ad management, and for perfi-	vance IFIS module Data Management (orming complementary practical work i on in Data Management it is assumed in	CS4508) is useful for study in the field of parallel proce n Web and Data Science th	ing aspects of distributed and mobile data essing of large data volumes. In contrast to pat rather than data, interpretation processes		

Other complementary advanced modules such as Internet Technologies or Learning Systems offer interesting perspectives as well.

are mobile in the form of agents. Agents have the task to autonomously determine and integrate a high-level data interpretation which is

This module will be replaced by CS4514-KP12 Intelligent Agents.

ultimately communicated to a user process.



Duration:	Turnus of offer:	Credit points:	
1 Semester	each winter semester	4	
Course of study, specific field and a • Master CLS (module part), cor • Master Entrepreneurship in D • Master Computer Science sine	t erm: nputer science, arbitrary semeste igital Technologies (module part) ce 2014 (module part), module p	er), module part, arbitrary semester art, arbitrary semester	
 Classes and lectures: Foundations of Ontologies ar Systems (lecture, 2 SWS) Foundations of Ontologies ar Systems (exercise, 1 SWS) 	I lectures:Workload:idations of Ontologies and Databases in Information erms (lecture, 2 SWS)• 60 Hours private studies • 45 Hours in-classroom work • 15 Hours exam preparationerms (exercise, 1 SWS)• 15 Hours exam preparation		
 Contents of teaching: Fundamentals of databases, of Ontology based data access (Ontology evolution and onto Data exchange and data integontological constraints as we Data stream processing (e.g., Non-symbolic data and their interpretation), syntax, semar Data- and ontology-oriented 	conceptual modeling languages (OBDA) logy integration gration (schema mappings, dupli Il as with incomplete data) for sensor networks, robotics, we symbolic annotations (e.g., for ap ntics, hybrid decision and comput process analysis (e.g., for biologic	(ontologies), query languages, processes, and agents cate detection, inconsistency handling, integration with relational and eb agents) with OBDA and complex event processing (CEP) oplications in bioinformatics/computational biology and for media tation problems and their complexity, (analysis of) algorithms cal pathways) and process design (e.g., for non-trivial business process	
 Qualification-goals/Competencies: Knowledge: The module aims overview of concepts, metho such as the web. Skills: The students get a basi limitations of information sys and completeness (Does the possible to formulate all requi it take the system to come up logical modeling skills using a time-based and event data), a acquires the ability to assess logical models where necessa Social Competence und Indep solutions in short presentation 	at introducing the students to t ds, and theories for understandin c understanding of logical and fo tems, be it concrete ones or thos system produce what is expected ired queries? What are equivalen with an answer? How much spa eal application scenarios from in and medicine (sensor networks, g which logical model is suitable fo iry. bendent Work: Students work in ns. Independent work is promote	he formal basics of databases and ontologies, so that they get an ng, analyzing, and designing information systems in open large contex ormal methods, which allows them to assess the possibilities and the that still have to be designed. Assessment parameters are correctnes d? If so, does it produce all results?) as well as expressiveness (Is it at query languages?) and, last but not least, performance (How long do acce does it need?). In addition to these analysis skills, students receive dustry (business processing, integration of data resources, processing genomic ontologies, annotation). Based on these, the student not only or which application scenario, but also the ability to construct their ow groups to solve small exercises and project problems and sketch their ed by exercises with practical ontology and database systems.	
Grading through: • exercises and project assignm • exam type depends on main	ients module		
Is requisite for: • Web-Mining Agents (CS5131-	KP08, CS5131)		
Responsible for this module: • Siehe Hauptmodul Teacher: • Institute of Information System	ms		



Literature:

- S. Abiteboul, R. Hull, V. Vianu: Foundations of Databases Addison-Wesley, 1995
- M. Arenas, P. Barcelo, L. Libkin, and F. Murlak: Foundations of Data Exchange Cambridge University Press, 2014
- F. Baader, D. Calvanese, D.L. McGuinness, D. Nardi, and P.F. Patel-Schneider (Eds.): The Description Logic Handbook: Theory,
- Implementation, and Applications Cambridge University Press, 2010
- S. Chakravarthy, Q. Jiang: Stream Data Processing A Quality of Service Perspective Springer, 2009
- L. Libkin: Elements Of Finite Model Theory (Texts in Theoretical Computer Science. An Eatcs Series) SpringerVerlag, 2004

Language:

offered only in English

Notes:

Prerequisites for this module are:

- Algorithm and Data Structures (CS1001)
- Linear Algebra and Discrete Structures I+II (MA1000, MA1500)
- Databases (CS2700)

Recommended additional modules:

- Logic (CS1002)
- Bachelor Project Computer Science (CS3701), topic: logic programming
- Nonstandard Database Systems (CS3202)



Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		4
Course of study, specific field and t • Master CLS (optional subject), • Master Media Informatics (opt • Master Medical Informatics (opt	erm: computer science, arbitrary sem ional subject), computer science ptional subject), ehealth / infoma	ester , arbitrary semester ıtics, 1st or 2nd semeste	r
Classes and lectures: Workload: • Foundations of Ontologies and Databases in Information Systems (lecture, 2 SWS) • 60 Hours private studies • Foundations of Ontologies and Databases in Information Systems (exercise, 1 SWS) • 15 Hours exam preparation			ate studies lassroom work m preparation
 Contents of teaching: Fundamentals of databases, contrology based data access (a Ontology evolution and ontol Ontology evolution and ontol Ontological constraints as well ontological constraints as well Data stream processing (e.g., a Non-symbolic data and their stream interpretation), syntax, semant Data- and ontology-oriented ontology-oriented ontology 	onceptual modeling languages (OBDA) logy integration gration (schema mappings, duplic I as with incomplete data) for sensor networks, robotics, we symbolic annotations (e.g., for ap tics, hybrid decision and comput process analysis (e.g., for biologic	ontologies), query langu cate detection, inconsist b agents) with OBDA an plications in bioinforma cation problems and the cal pathways) and proces	ages, processes, and agents ency handling, integration with relational and d complex event processing (CEP) tics/computational biology and for media ir complexity, (analysis of) algorithms ss design (e.g., for non-trivial business processes)
 Qualification-goals/Competencies: Knowledge: The module aims overview of concepts, method such as the web. Skills: The students get a basic limitations of information syst and completeness (Does the spossible to formulate all requires the system to come up logical modeling skills using retime-based and event data), a acquires the ability to assess velogical models where necessare Social Competence und Independent of the solutions in short presentation 	at introducing the students to the ds, and theories for understandin c understanding of logical and fo tems, be it concrete ones or those system produce what is expected ired queries? What are equivalent with an answer? How much space eal application scenarios from ind and medicine (sensor networks, g which logical model is suitable fo ry. bendent Work: Students work in g ns. Independent work is promote	ne formal basics of datal g, analyzing, and design rmal methods, which all e that still have to be de l? If so, does it produce a t query languages?) and ce does it need?). In add dustry (business process enomic ontologies, ann r which application scen groups to solve small ex- ed by exercises with prace	bases and ontologies, so that they get an sing information systems in open large contexts, ows them to assess the possibilities and signed. Assessment parameters are correctness all results?) as well as expressiveness (Is it , last but not least, performance (How long does lition to these analysis skills, students receive ing, integration of data resources, processing of otation). Based on these, the student not only hario, but also the ability to construct their own ercises and project problems and sketch their ctical ontology and database systems.
Grading through: • exercises and project assignm • written exam	ents		
Is requisite for: • Web-Mining Agents (CS5131-	KP08, CS5131)		
Responsible for this module: • Prof. Dr. rer. nat. habil. Ralf Mö			



Literature:

- S. Abiteboul, R. Hull, V. Vianu: Foundations of Databases Addison-Wesley, 1995
- M. Arenas, P. Barcelo, L. Libkin, and F. Murlak: Foundations of Data Exchange Cambridge University Press, 2014
- F. Baader, D. Calvanese, D.L. McGuinness, D. Nardi, and P.F. Patel-Schneider (Eds.): The Description Logic Handbook: Theory,
- Implementation, and Applications Cambridge University Press, 2010
- S. Chakravarthy, Q. Jiang: Stream Data Processing A Quality of Service Perspective Springer, 2009
- L. Libkin: Elements Of Finite Model Theory (Texts in Theoretical Computer Science. An Eatcs Series) SpringerVerlag, 2004

Language:

offered only in English

Notes:

Prerequisites for this module are:

- Algorithm and Data Structures (CS1001)
- Linear Algebra and Discrete Structures I+II (MA1000, MA1500)
- Databases (CS2700)

Recommended additional modules:

- Logic (CS1002)
- Bachelor Project Computer Science (CS3701), topic: logic programming
- Nonstandard Database Systems (CS3202)





CS5131-KP08, CS5131 - Web-Mining Agents (WebMining)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	each winter semester		8		
Course of study, specific field and a • Master CLS (optional subject) • Master Media Informatics (op • Master Medical Informatics (o • Master Medical Informatics si	t erm: , computer science, arbitrary ser tional subject), computer scienc ptional subject), ehealth / infon nce 2019 in planing (optional su	mester ce, arbitrary semester natics, 1st or 2nd semester ubject), ehealth / infomatics,	, 1st or 2nd semester		
Classes and lectures:		Workload:			
 Web-Mining Agents (lecture, 4 SWS) Web-Mining Agents (Excercises with project, 2 SWS) 90 Hours in-classroom work 30 Hours exam preparation 		ate studies ssroom work preparation			
 Probabilities and generative models for discrete data Gaussian models, Bayesian and frequentist statistics, regression, Probabilistic graphical models (e.g., Bayesian networks), learning parameters and structures of probabilistic graphical models (BMA, MAP, ML, EM algorithm), probabilistic classification, probabilistic relational models Probabilistic reasoning over time (dynamic Bayesian networks, Markov assumption, transition model, sensor model, inference problems: filtering, prediction, smoothing, most-likely explanation, hidden Markov models, Kalman filters, exact inferences and approximations, learning dynamic Bayesian networks) Mixture models, latent linear models (LDA, LSI, PCA), sparse linear models, Decision tree and version space acquisition from data streams, ensemble learning Decision making under uncertainty (utility theory, decision networks, value of information, sequential decision problems, value iteration, policy iteration, MDPs, decision-theoretic agents, POMDPs, reduction to multidimensional continuous MDPs, dynamic decision networks, Reinforcement learning) Clustering: distance measures, k-means clustering, nearest neighbor clustering Game theory, decisions with multiple agents (Nash equilibrium, Bayes-Nash equilibrium), social choice (voting, preferences, paradoxes, Arrow's Theorem, mechanism design (controlled autonomy), rules of encounter Multimedia interpretation for web (re-)search (named entity recognition, duplicate elimination, probabilistic ranking of interpretations, link analysis (e.g., citations), social network analysis under uncertainty utility and networks and recommendation Qualification-goals/Competencies: Knowledge: Students can explain the agent abstraction, define web mining of rational behavior, and give details about the design of mining agents (goals, utilities, environments). The notion of adversarial agent cooperation can be discussed in terms of deci					
addition, students can define state of the environment. In t and they can recall technique making in a multi-agent setti techniques. Students can exp they can enumerate basic ma basis of incrementally incomi explain how axioms, features algorithms (deep learning for performance of learned class learning theory. Algorithms for Skills: Students can select an analysis applications, such as	decision making procedures in his context, students can descri s for measuring the value of inf ng in terms of different types of lain the difference between inst ichine learning technique for ea ng data. For dealing with uncer , parameters, or structures used data analysis). Students are also ifiers can be improved by ensen or reinforcement learning can a appropriate agent architecture information retrieval, students	simple and sequential settin be techniques for solving (p formation. Students can exp f equilibria, social choice fun tance-based and model-bas ich of the two basic approact tainty, students can describ i in these formalisms can be o able to sketch different clu nble learning, and they can lso be explained by student for concrete agent data ana can derive decision trees an	ngs, with and without complete access to the partially observable) Markov decision problems, plain coordination problems and decision actions, voting protocol, and mechanism design and learning approaches for data analysis, and ches, either on the basis of static data, or on the suitable representation formalisms, and they learned automatically with different ustering techniques. They depict how the summarize how this influences computational cs. alysis application scenarios. For simplified data and apply basic optimization techniques. For		

those applications they can also create Bayesian networks/dynamic Bayesian networks and apply bayesian reasoning for simple queries. Students can also apply different sampling techniques for simplified agent scenarios. For simple and complex decision making students can compute the best action or policies for concrete settings. In multi-agent situations students are able to apply techniques for finding different equilibria states, e.g., Nash equilibria. For multi-agent decision making students will apply different voting



protocols and compare and explain the results. Students derive decision trees and, in turn, propositional rule sets from static data as well and temporal or streaming data. Students present and apply the basic idea of first-order inductive leaning. They apply the BMA, MAP, ML, and EM algorithms for learning parameters of Bayesian networks and compare the different algorithms. They are also able to carry out Gaussian mixture learning. Students can describe basic clustering techniques and explain the basic components of those techniques. Students compare related machine learning techniques, e.g., k-means clustering and nearest neighbor classification. They can distinguish various ensemble learning techniques and compare the different goals of those techniques.

Social skills (social competence, self dependence): Students practice peer programming. They explain problems and solutions to their
peer. They communicate in English. Using on-line quizzes and accompanying material for self study, students can assess their
competence level continuously and adjust it appropriately. Working on exercise problems, they receive additional feedback.

Grading through:

- exercises and project assignments
- written exam

Responsible for this module:

• Prof. Dr. rer. nat. habil. Ralf Möller

Teacher:

• Institute of Information Systems

• Prof. Dr. rer. nat. habil. Ralf Möller

Literature:

- M. Hall, I. Witten and E. Frank: Data Mining: Practical Machine Learning Tools and Techniques Morgan Kaufmann, 2011
- D. Koller, N. Friedman: Probabilistic Graphical Models: Principles and Techniques MIT Press, 2009
- K. Murphy: Machine Learning: A Probabilistic Perspective MIT Press, 2012
- S. Russel, P. Norvig: Artificial Intelligence: A Modern Approach Pearson Education, 2010
- Y. Shoham, K. Leyton-Brown: Multiagent-Systems: Algorithmic, Game-Theoretic, and Logical Foundations Cambridge University Press, 2009

Language:

· offered only in English

Notes:

- Prerequisites for this module are:
- Algorithm and Data Structures (CS1001)
- Linear Algebra and Discrete Structures I+II (MA1000, MA1500)
- Databases (CS2700)
- Stochastics (MA2510) or Statistics (PY1800)

Recommended additional modules:

- Logic (CS1002)
- Artificial Intelligence (CS3204)
- Bachelor Project Computer Science (CS3701), topic: logic programming
- Foundations of Ontologies and Databases for Information Systems (SC5130)
- Web-based Information Systems (CS4130)



CS5150-KP04, CS5150 - Organic Computing (OrganicCom)				
Duration:	Turnus of offer:		Credit points:	
Semester irregularly 4			4	
Course of study, specific field and term: Master Medical Informatics since 201 Master Medical Informatics (optional Master Computer Science before 2014 Master CLS (optional subject), compu Master Computer Science before 201 Master Computer Science before 201	9 in planing (optional sub subject), bioinformatics, 1 (optional subject), advancec uter science, arbitrary sem 4 (compulsory), advanced 4 (optional subject), speci	ject), bioinformatics, 1st or st or 2nd semester l curriculum parallel and dist ester l curriculum organic compu alization field robotics and	2nd semester ributed system architecutres, 2nd or 3rd semester uting, 2nd or 3rd semester automation, 3rd semester	
Classes and lectures:		Workload:		
 Organic Computing (lecture, 2 SWS) Organic Computing (exercise, 1 SWS) 	 Organic Computing (lecture, 2 SWS) Organic Computing (exercise, 1 SWS) Organic Computing (exercise, 1 SWS) 45 Hours in-classroom work 15 Hours exam preparation 			
Contents of teaching: • Basic principles of Organic Computing • Self-organization and emergence • Architecture and design of Organic Computing systems • Organic Computing for distributed systems • Organic Computing in Neuro- and Bionformatics • Organic Grid • Autonomous Systems				
Qualification-goals/Competencies: Students are able to utilize the princ They are able to explain the principle They are able to analyze emergence 	iples of organic computing es of Organic Computing. behavior in Organic Comp	g on exemplary designs. buting systems.		
Grading through: Oral examination written exam 				
Responsible for this module: • Prof. DrIng. Heiko Hamann Teacher: • Institute of Computer Engineering • Prof. DrIng. Heiko Hamann				
Literature: • C. Müller-Schloer, H. Schmeck, T. Ung • R. P. Würtz: Organic Computing - Spi • C. Klüver, J. Kluever, J. Schmidt: Mod	gerer: Organic Computing inger, 2008 ellierung komplexer Proze	A Paradigm Shift for Con sse durch naturanaloge Ve	nplex Systems - Birkhäuser, 2011 rfahren - Springer Vieweg 2012	
offered only in German				





Γ

)uration:	Turnus of offer		Credit points:
	overy second comestor		
Semester			
Course of study, specific field and term Master Auditory Technology (opti Master MES since 2014 (optional s Master CLS (optional suject), com Master Medical Informatics (optional Master Medical Informatics (optional Master Medical Informatics since 2	: onal subject), Auditory Techn subject), Medical Engineering outer science, arbitrary semes nal subject), computer science, al subject), computer science, 2019 in planing (optional subj	ology, 1st or 2nd seme Science, arbitrary seme ster e, 1st or 2nd semester , arbitrary semester ject), Medical Data Scie	ster ester nce / Artificial Intelligence, 1st or 2nd semester
Classes and lectures:		Workload:	
 Speech and Audio Signal Processing (lecture, 2 SWS) Speech and Audio Signal Processing (exercise, 1 SWS) Speech and Audio Signal Processing (exercise, 1 SWS) 45 Hours in-classroom work 20 Hours exam preparation 			vate studies classroom work m preparation
Contents of teaching:			
 Physical models of the auditory Sy Dynamic compression Spectral analysis: Spectrum and co Spectral perception and masking Vocal tract models Linear prediction Coding in time and frequency doi Speech synthesis Noise reduction and echo compete Source localization and spatial reg Basics of automatic speech recogilation 	epstrum mains nsation production nition		
 Qualification-goals/Competencies: Students are able to describe the They are able to describe the prod auditory perception. They are able to present basic knowners They can describe and use signal 	basics of human speech prod cess of human auditory perce owledge of statistical speech processing methods for source	duction and the corresp ption and the correspo modeling and automat ce separation and room	onding mathematical models. nding signal processing tools for mimicing ic speech recognition. I-acoustic measurements.
Grading through:			
ExercisesWritten or oral exam as announce	d by the examiner		
Responsible for this module: • Prof. DrIng. Alfred Mertins Teacher: • Institute for Signal Processing • Prof. DrIng. Alfred Mertins			
Literature:			
 L. Rabiner, BH. Juang: Fundamer J. O. Heller, J. L. Hansen, J. G. Proa 	ntals of Speech Recognition - kis: Discrete-Time Processing	Upper Saddle River: Pre of Speech Signals - IEE	entice Hall 1993 E Press
Language: • offered only in German			



Prerequisites are exercises. These must have been done and graded before the first exam.

Mentioned in SGO MML under CS5260 (without SJ14).



CS5275-KP04, CS5275 - Selected Topics of Signal Analysis and Enhancement (AMSAV)				
Duration:	Turnus of offer:	Cr	redit points:	
1 Semester	every second semester	4		
 Course of study, specific field and term: Master Medical Informatics since 2019 in planing (optional subject), Medical Data Science / Artificial Intelligence, 1st or 2nd semester Master MES since 2014 (optional subject), Medical Engineering Science, arbitrary semester Master Medical Informatics (optional subject), medical image processing, 1st or 2nd semester Master CLS (optional subject), computer science, arbitrary semester Master Computer Science before 2014 (optional subject), specialization field bioinformatics, 3rd semester Master MES before 2014 (advanced curriculum), imaging systems, signal and image processing, 1st or 2nd semester Master Computer Science before 2014 (optional subject), advanced curriculum signal and image processing, 2nd or 3rd semester Master Computer Science before 2014 (optional subject), specialization field robotics and automation, 3rd semester Master Computer Science before 2014 (optional subject), specialization field robotics and automation, 3rd semester Master Computer Science before 2014 (optional subject), specialization field robotics and automation, 3rd semester 				
Classes and lectures:		Workload:		
 Selected Topics of Signal Analysis ar SWS) Selected Topics of Signal Analysis ar 1 SWS) 	nd Enhancement (lecture, 2 nd Enhancement (exercise,	 55 Hours private studies 45 Hours in-classroom 20 Hours exam prepared 	dies m work aration	
Contents of teaching: Introduction to statistical signal anal Autocorrelation and spectral estimat Linear estimators Linear optimal filters Adaptive filters Multichannel signal processing, beau Compressed sensing Basic concepts of multirate signal pr Nonlinear signal processing algorith Application scenarios in auditory tec measurement, noise reduction, deco	lysis tion mforming, and source separ rocessing ms :hnology, enhancement, and privolution (listening-room c	ation I restauration of one- and hig ompensation), inpainting	her-dimensional signals, Sound-field	
Qualification-goals/Competencies:				
 Students are able to explain the basi They are able to describe and apply Students are able to describe the co They are able to describe and apply They are able to describe the conception of the second the second term of term of	ic elements of stochastic sig linear estimation theory. ncepts of adaptive signal pr the concepts of multichann ot of compressed sensing. multirate systems. applications of nonlinear ar ent linear optimum filters an	nal processing and optimum ocessing. el signal processing. d adaptive signal processing. d nonlinear signal enhancem	filtering. ent techniques on their own.	
Grading through: • Exercises				
Written or oral exam as announced b	by the examiner			
Responsible for this module: • Prof. DrIng. Alfred Mertins Teacher: • Institute for Signal Processing • Prof. DrIng. Alfred Mertins				
Literature:				
 A. Mertins: Signaltheorie: Grundlage 	n der Signalbeschreibung. F	ilterbänke. Wavelets. Zeit-Frei	guenz-Analyse. Parameter- und	

A. Mertins: Signaltheorie: Grundlagen der Signalbeschreibung, Filterbänke, Wavelets, Zeit-Frequenz-Analyse, Parameter- und



Signalschätzung - Springer-Vieweg, 3. Auflage, 2013 • S. Haykin: Adaptive Filter Theory - Prentice Hall, 1995

Language:

• German and English skills required



CS5430 - Seminar Machine Learning (SemMaschL)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	each semester		4	
Course of study, specific field • Master CLS (optional sub • Master Computer Science • Master Computer Science	and term: oject), computer science, arbitrary so te before 2014 (optional subject), sp te before 2014 (optional subject), sp	emester pecialization field robotics and pecialization field bioinformati	automation, 3rd semester cs, 3rd semester	
Classes and lectures: Workload: • Seminar Machine Learning (seminar, 2 SWS) • 70 Hours private studies • 30 Hours in-classroom work • 20 Hours work on an individual topic with wright presentation		e studies sroom work on an individual topic with written and oral		
Contents of teaching: • Independent study of a	specific field of machine learning			
Qualification-goals/CompeterThe students are able toThey are able to present	ncies: read and understand scientific pub corally and in a written paper the co	lications in the field of machin ontent of scientific publication	ne learning. is in the field of machine learning.	
Grading through: • oral presentation • term paper				
Responsible for this module: • Prof. Dr. rer. nat. Thomas Martinetz Teacher: • Institute for Neuro- and Bioinformatics • Prof. Dr. rer. nat. Thomas Martinetz • Prof. DrIng. Erhardt Barth • MitarbeiterInnen des Instituts Language:				
German and English skil	ls required			



CS5440-KP04, CS5440 - Seminar Neuro- and Bioinformatics (SemNeurBio)			
Duration:	Turnus of offer:		Credit points:
1 Semester	irregularly		4
 Course of study, specific field and term Master Computer Science before Master CLS (optional subject), cor Master Biophysics (optional subject) 	1: 2014 (optional subject), speci nputer science, arbitrary seme ct), Elective, 1st or 2nd semes	ialization field bioinformatio ester ster	cs, 3rd semester
Classes and lectures: Workload: • Seminar Neuro- and Bioinformatics (seminar, 2 SWS) • 70 Hours private studies • 30 Hours in-classroom work • 20 Hours work on an individual topic with written an presentation		studies sroom work n an individual topic with written and oral	
Contents of teaching: • Introduce students to a current re	esearch topic in Neuro- and B	ioinformatics	
Qualification-goals/Competencies: The students are able to read and They are able to present orally an They can master basic scientific n They can summarize a scientific t They can give an intelligible and They have communication component 	l understand scientific publica d in a written paper the contr nethodology. opic in written form. concise oral presentation of a etency to discuss a current res	ations in the field of neuro- ent of scientific publication current research topic. search topic.	uand bioinformatics. s in the field of neuro- and bioinformatics.
Grading through: oral presentation term paper 			
Responsible for this module: • Prof. DrIng. Erhardt Barth • Prof. Dr. rer. nat. Thomas Martinetz Teacher: • Institute for Neuro- and Bioinformatics • Prof. Dr. rer. nat. Thomas Martinetz • MitarbeiterInnen des Instituts			
Language: • English, except in case of only Ge	rman-speaking participants		



	CS5450-KP04, CS5450 - M	achine Learning (Maso	chLern)
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		4
Course of study, specific field and Master Auditory Technolog Master CLS starting 2016 (or Master MES since 2014 (opt Master MES before 2014 (opt Master MES before 2014 (ad Master Medical Informatics Master CLS (optional suject Master Computer Science b Master Computer Science b Master Medical Informatics	d term: y (optional subject), computer scien ptional subject), computer science, ional subject), computer science ar ptional subject), mathematics, 1st of dvanced curriculum), imaging syste (optional subject), computer science), computer science, arbitrary seme before 2014 (optional subject), spec pefore 2014 (optional subject), spec since 2019 in planing (optional sub	nce, 1st semester , 3rd semester nd electrical engineering, ar or 2nd semester ems, signal and image proce ce, 1st or 2nd semester isalization field robotics and ialization field bioinformatic oject), Medical Data Science	bitrary semester essing, 1st or 2nd semester automation, 3rd semester cs, 3rd semester / Artificial Intelligence, 1st or 2nd semester
Classes and lectures:		Workload:	
Machine Learning (lecture,Machine Learning (exercise	Machine Learning (lecture, 2 SWS) Machine Learning (exercise, 1 SWS) Achine Learning (exercise,		studies sroom work preparation
 Deep learning Limits of induction and imp Qualification-goals/Competencie Students can understand a They can explain and apply They can chose and then even They can understand and even 	vortance of data ponderation :s: nd explain various machine-learnin different machine learning metho valuate an appropriate method for xplain the limits of automatic data	ig problems. ds and algorithms. a particular learning proble analysis.	m.
Grading through:	· 		
Exercises Oral examination			
Responsible for this module: • Prof. DrIng. Erhardt Barth Teacher: • Institute for Neuro- and Bio	informatics		
 Prof. DrIng. Erhardt Barth Prof. Dr. rer. nat. Thomas Martinetz 			
Literature: • Chris Bishop: Pattern Recog • Vladimir Vapnik: Statistical	nition and Machine Learning - Spr Learning Theory - Wiley-Intersciend	inger ISBN 0-387-31073-8 :e, ISBN 0471030031	
Language: • English, except in case of o	nly German-speaking participants		
Notes:			
Prerequisites for admission to	the examination can be determine	ed at the beginning of the s	emester. If such prerequisites are defined,

they must have been fulfilled prior to the first attempt at the examination and must have been rated as positive.





MA4640 - Sampling in der Signalanalyse (SampSignal)				
Duration:	Turnus of offer:	Credit points:		
1 Semester	irregularly	4 (Тур В)		
Course of study, specific fi • Bachelor CLS (option • Master MES before 2 • Master CLS (optional	feld and term: nal suject), mathematics, 5th or 6th semest 014 (optional subject), mathematics, 1st o I subject), computer science, arbitrary sem	er r 2nd semester ester		
Classes and lectures: Workload:		Workload:		
• Sampling-Verfahren in der Signalanalyse (seminar, 2 SWS)		 70 Hours private studies 30 Hours in-classroom work 20 Hours work on an individual topic with written and oral presentation 		
Contents of teaching: • Hilberträume, Basen und Frames • Endliches und Unendliches Sampling • Anwendungen auf lineare gewöhnliche Differentialgleichungen • Multi-band und Multi-channel Sampling • Sampling und Eigenwert-Probleme				
Qualification-goals/Compo • • •	etencies:			
Grading through: oral presentation Written report participation in discussions 				
Responsible for this modu	le:			
Prof. Dr. rer. nat. Jürg	Prof. Dr. rer. nat. Jürgen Prestin			
Ieacher: Institute for Mathem	atics			
Prof. Dr. rer. nat. lürc	gen Prestin			
offered only in German				



	LS2000-MML - Bioche	emistry 1 (Bioche1MML)	
Duration:	Turnus of offer:	Credit points:	
1 Semester	each winter semester	6	
Course of study, specific field • Master CLS (optional su	l and term: bject), computational life science / life	sciences, 1st or 3rd semester	
Classes and lectures:Workload:• Biochemistry 1 (lecture, 4 SWS)• 90 Hours private studies• 60 Hours in-classroom work• 30 Hours exam preparation			
Contents of teaching: • Characteristics of biosys • Proteins: structure and • Enzymes: structure, fun • Intermediary metabolis • Biomembranes and cell	stems, biomolecules dynamics ction and regulation m respiration		
Qualification-goals/Compete Understanding structur Understanding biochen Knowledge of biochem 	ncies: es and functions of biochemical impor nical interrelations and their importanc ical separation and analysis procedures	tant biomolecules e for cellular metabolism s	
Grading through: • written exam			
Responsible for this module: • Prof. Dr. rer. nat. Rolf Hi Teacher: • Institute of Biochemistry • Prof. Dr. rer. nat. Rolf Hi • Prof. Dr. rer. nat. Stefan • Dr. math. et dis. nat. Jer	lgenfeld y Igenfeld Anemüller oen Mesters		
Literature: • Berg/Tymoczko/Stryer: • Voet/Voet: Biochemistry • Lehninger: Principles of • Alberts et al.: Molecular Language:	Biochemistry 7th ed. y 4th ed. Biochemistry 5th ed. Biology of the Cell 5th ed.		
offered only in English			
Notes: Compulsory elective subje	ect for students specializing in life scier	nce	



	LS2300-KP08, LS2301 - Biophysical Chemistry (BPCKP08)			
Duration:	Turnus of offer:		Credit points:	
1 Semester	each summer semester		8	
Course of study, specific field a Bachelor MLS starting 201 Master CLS starting 2016 (Bachelor Biophysics (comp Master CLS (optional subje Bachelor MLS (compulsor) Bachelor MLS starting 201	nd term: 6 (compulsory), life sciences, 4th ser compulsory), MML with specializatio pulsory), biophysics, 4th semester ect), computational life science / life /), life sciences, 4th semester 8 (compulsory), life sciences, 4th ser	nester on in Life Science, 2nd se sciences, 2nd semester nester	emester	
Classes and lectures:		Workload:		
 Biophysical Chemistry (lecture, 3 SWS) Biophysical Chemistry (exercise, 1 SWS) Biophysical Chemistry (practical course, 3 SWS) 		160 Hours pr80 Hours in-c	ivate studies :lassroom work	
Contents of teaching:				
 What is Biophysical Chem Basics of NMR spectroscop Basics of mass spectrome Theoretical calculation of Basics of chemical thermodynamics of ligan Basics of chemical kinetics Basics of enzyme kinetics Practical: NMR, Molecular Modeling 	istry? by molecules - Quantum mechanics or dynamics d binding s , experiments with a focus on therm	molecular mechanics? odynamics and kinetics		
Qualification-goals/Competenc	ies:			
 Acquire basic knowledge Insight into properties (e.g. basic knowledge to comp Application of laws of the recognition reactions in b Acquire basic knowledge Acquisition of skills to wo 	on spectroscopic techniques to anal g. structure, dynamics, spectroscopic ute molecules rmodynamics to describe chemical r iological systems to analyze time courses of chemical rk independently and self-determine	yze (bio)molecules. Focu properties) of molecule eactions and biological reactions and biological ed in the laboratory	us is on NMR and mass spectrometry techniques es employing theoretical models. Acquisition of processes with a focus on binding and processes	
Grading through: • written exam				
Requires:				
 Biological Chemistry (LS2600-KP06, LS2601) General Chemistry (LS1100-KP04) Organic Chemistry (LS1600-KP10, LS1600-MLS) 				
Responsible for this module:				
• Prof. Dr. rer. nat. Thomas	Peters			
Teacher:				
 Institute of Chemistry and 	Metabolomics			
Prof. Dr. rer. nat. ThomasPD Dr. phil. nat. Thomas V	Peters /eimar			
Literature:				

• Peter Atkins and Julio de Paula: Physical Chemistry for the Life Sciences - Oxford, University Press, Freeman and Company, 2006, ISBN



0-1992-8095-9

- Thomas Engel und Philip Reid: Physikalische Chemie Pearson Studium, 2006, ISBN 13: 978-3-8273-7200-0
- van Holde, Johnson & HoPrentice Hall: Principles of Physical Biochemistry New Jersey, 1998, 2006, ISBN 0-13-720459-0
- Atkins: Physical Chemistry Oxford University Press, Oxford Mel-bourne Tokyo, 1998, ISBN 0-19-850101-3 Paperback, Deutsche Ausgabe (dritte Auflage) bei Wiley VCH, 2002: ISBN 3-527-30236-0 Wiley-VCH, Weinheim
- Fersht, W. H.: Structure and Mechanism in Protein Science New York, 1999, ISBN 0-7167-3268-8
- Cantor & Schimmel: Biophysical Chemistry, Parts I-III Freeman and Company, New York, 1980, ISBN 0-71671188-5 Paperback
- H. Friebolin: Ein- und zweidimensionale NMR-Spektroskopie Wiley-VCH

Language:

• offered only in German

Notes:

Prerequisite for examination is the successful participation in the excercises and oral presentation. The practical course takes place in September as compact course. Prerequisite LS1600 and LS2600.



LS2300-MML, LS2300-KP04 - Biophysical Chemistry (BPCMML)			
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		4
Course of study, specific field and term: • Master CLS (compulsory), computa	ational life science / life scienc	ces, 1st semester	
Classes and lectures:		Workload:	
 Biophysical Chemistry (lecture, 3 SWS) Biophysical Chemistry (exercise, 1 SWS) 80 Hours private studies 40 Hours in-classroom work 		studies room work	
Contents of teaching: Lecture:Structural principles of bio Molecular mechanics NMR spectroscopy ThermodynamicsLigand binding KineticsLigand binding Excercises:Parallel to the lectures p Practicals Teams of two students (s Polarimetric determination of the l Surface plasmon resonance to det Structural characterization of biom Structural analysis of molecules us	logical macromolecules presentation of related sub to some scripts are in English):D kinetics of the hydrolysis of s ermine association constants nolecules using molecular mc ing one and two dimensiona	pics letermination of dissociatio ucrose and thermodynamic para odeling I NMR experiments	on constants using fluorescence spectroscopy meters
 Qualification-goals/Competencies: Structural principles of biological macromolecules Basic thermodynamics and kinetics, enzyme kineticsBasics of molecular mechanics NMR spectroscopy and structure analysis (phenomenological Basic thermodynamics and kinetics, enzyme kinetics Scientific documentation and presentation of data; scientific reading of texts in English; improvement of teamwork skills Acquisition of skills to work independently and self-determined in the laboratory 			
Grading through: • Exercises • protocols • written exam			
Requires: • Physics 2 (ME1020-MLS) • Physics 1 (ME1010-KP06, ME1010-MLS) • Organic Chemistry (LS1600-MLS)			
Responsible for this module: • Prof. Dr. rer. nat. Thomas Peters Teacher: • Institute of Chemistry and Metabolomics • Prof. Dr. rer. nat. Thomas Peters • PD Dr. phil. nat. Thomas Weimar			
Literature: • Peter Atkins and Julio de Paula: Ph 0-1992-8095-9	ysical Chemistry for the Life !	Sciences - Oxford, Universi	ty Press, Freeman and Company, 2006, ISBN

- Thomas Engel und Philip Reid: Physikalische Chemie Pearson Studium, 2006, ISBN 13: 978-3-8273-7200-0
- van Holde, Johnson & HoPrentice Hall: Principles of Physical Biochemistry New Jersey, 1998, 2006, ISBN 0-13-720459-0
- Atkins: Physical Chemistry Oxford University Press, Oxford Mel-bourne Tokyo, 1998, ISBN 0-19-850101-3 Paperback, Deutsche Ausgabe (dritte Auflage) bei Wiley VCH, 2002: ISBN 3-527-30236-0 Wiley-VCH, Weinheim



- Fersht, W. H.: Structure and Mechanism in Protein Science New York, 1999, ISBN 0-7167-3268-8
- Cantor & Schimmel: Biophysical Chemistry, Parts I-III Freeman and Company, New York, 1980, ISBN 0-71671188-5 Paperback
- H. Friebolin: Ein- und zweidimensionale NMR-Spektroskopie Wiley-VCH
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Language:

offered only in German

Notes:

Basics for the Examination are the subjects of Cap. 1-3 of lessons, and practical course



LS2510-MML - Biochemistry 2 (Bioche2MML)				
Duration:	Turnus of offer:	Turnus of offer: Credit		
1 Semester	each summer semester		6	
Course of study, specific fiel • Master CLS (optional s	ld and term: ubject), computational life science / life	e sciences, 2nd semester		
Classes and lectures: • Biochemistry 2 (lecture, 4 SWS)		 Workload: 90 Hours private studies 60 Hours in-classroom work 30 Hours exam preparation 		
Contents of teaching: • Structure and functior • Signal transduction an • Viruses • Amino acid metabolis	n of DNA and RNA nd hormones m			
Qualification-goals/Compet • Understanding structu • Understanding bioche • Understanding the pri	encies: ures and functions of biochemical impo emical interrelations and their importar inciples of complex cell biological proce	ortant biomolecules nce for cellular metabolism esses		
Grading through: • written exam				
Responsible for this module • Prof. Dr. rer. nat. Rolf H Teacher: • Institute of Biochemist • Dr. math. et dis. nat. Je • Prof. Dr. rer. nat. Stefan • Prof. Dr. rer. nat. Rolf H	eroen Mesters n Anemüller Hilgenfeld			
Literature: • Berg/Tymoczko/Stryer • Voet/Voet: Biochemist • Lehninger: Principles o • Alberts et al.: Molecula	r: Biochemistry 7ed - Freeman, 2012 rry 4th ed. of Biochemistry 5th ed. ar Biology of the Cell 5th ed.			
Language: • offered only in English	1			





LS3500 - Introduction into Structural Analysis (EinStrukAn)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	each summer semester		6	
Course of study, specific field and • Master CLS (compulsory), cor • Bachelor MLS (compulsory), I	term: nputational life science / life scienc ife sciences, 6th semester	ces, 2nd semester		
Classes and lectures:	Classes and lectures: Workload:			
 Introduction into Structural Analysis (lecture, 2 SWS) Introduction into Structural Analysis (seminar / exercises, 2 SWS) Introduction into Structural Analysis (seminar / exercises, 2 SWS) Introduction into Structural Analysis (seminar / exercises, 2 SWS) 		ate studies ssroom work		
Contents of teaching:				
 Crystal growth: precipitant at Crystal morphology: symmet X-ray diffraction: Bragg's law, Phase determination: Patters Part B: Basic NMR spectrosco systems, the classical vector it The nuclear Overhauser effect Identification and characterist the cross-saturation experime Building blocks for NMR expetion Part C: Basics of mass spectro Ion sources and their fields of Mass analysers Structural analysis of biomole 	nd phasediagram rry and space groups , reciprocal lattice and the Ewald-s on map and molecular replacemen py for the investigation of biomole model et sation of protein-ligand interaction ent eriments ometry:Indroduction and basics f application ecules	phere construction nt ecular structures: Basics o ns: The transfer nOe, the S	f NMR spectroscopy: NMR experiments, Spin GTD-NMR-experiment, the HSQC experiment,	
Qualification-goals/Competencies	•			
 The students will acquire bas macromolecules. The empha Furthermore, the students w 	sic skills in selected biophysical tec sis is on understanding the concer ill learn how to elucidate the struc	hniques to analyze the st pts behind these techniq ture of small organic mol	ructure and dynamics of biological ues. ecules	
Grading through:				
 attendance at exercises attendance, >90% presentation written exam 				
Responsible for this module:				
 Prof. Dr. rer. nat. Thomas Pet 	ers			
Teacher:	Teacher:			
 Research Center Borstel Institute of Biochemistry Institute of Chemistry and Metabolomics 				
• Prof. Dr. rer. nat. Thomas Pet	ers			
 Prof. Dr. rer. nat. Rolf Hilgenfe Dr. math. et dis. nat. Jercon M 	eld Aesters			
 PD Dr. rer. nat. Karsten Seege 	nesters Pr			
Dr. Dominik Schwudke	Dr. Dominik Schwudke			
Literature: • Wird den aktuellen Gegeben	heiten angepasst und in der Vorle	sung angegeben. Siehe a	uch in den entsprechenden Skripten:	



- Teil B: Horst Friebolin: Ein- und zweidimensionale NMR-Spektroskopie. Eine Einführung Wiley-VCH
- Alexander Mc Pherson: Introduction to Macromolecular Crystallography 1st edition, 2003, Wiley

Language:

• offered only in German



LS4020 A - Module part LS4020A: Crystallography (StrAnaKris)			
Duration:	Turnus of offer:	Credit points:	Max. group size:
1 Semester	each winter semester	3	60
Course of study, spec Master MLS sta Master Infection Master Biophys Master CLS star Master MLS star Master Infection Master CLS (mod Master MLS (mod	ific field and term: rting 2018 (module part), structure biolog n Biology ab 2018 (module part), Interdisc ics (module part), biophysics, 1st semeste ting 2016 (module part), MML with specia rting 2016 (module part), structure biolog n Biology (module part), Interdisciplinary odule part), computational life science / lif podule part), structure biology, 1st semeste	y, 1st semester ciplinary modules, 1st semester alization in Life Science, 3rd semest y, 1st semester modules, 1st semester e sciences, 3rd semester er	er
Classes and lectures:		Workload:	
Crystallography	/ (lecture, 2 SWS)	60 Hours private s30 Hours in-classro	tudies oom work
Contents of teaching Crystal growth, X-rays, X-ray so X-ray diffraction Protein structur multiple isomo Crystallography Practical exerci- interpretation o Site visit at the Qualification-goals/C They have a ge They have the f Sphere constru They have the f They can calcul They have the f	precipitant and phase diagram, crystal m urces, X-ray diffraction, Bragg's law, recip in by electrons, Fourier analysis and synthe re determination by X-ray diffraction, crys rphous replacement (MIR), multi-wavelen y and the drug discovery process: studying ses employing an X-ray generator (collect of electron density maps) Synchrotron DESY (Hamburg) ompetencies: neral scientific competence in macromole methodological competence to grow pro- methodological competence to tackle the ate and interprete electron density maps methodological competence, to apply stru- communication competency to convey th	orphology, symmetry and space grocal lattice and Ewald-sphere consesis tallographic phase problem, Patter gth anomalous diffraction (MAD) g protein-ligand interactions ion of a diffraction image) and the ecular X-ray diffraction analysis tein crystals by hanging or sitting c interpret (salt or protein) the diffrac e phase problem either by MR, MIR ucture- or fragment-based technique e principles of X-ray diffraction the	roups, crystallogenesis struction son map, molecular replacement (MR), computer (MR; calculation and lrops ction image of a crystal using the Ewald or MAD ues for lead compound identification ory
Grading through:see Notes			
Responsible for this module: • Prof. Dr. rer. nat. Christian Hübner • Prof. Dr. rer. nat. Thomas Peters Teacher: • Institute of Biochemistry • Dr. math. et dis. nat. Jeroen Mesters • Prof. Dr. rer. nat. Rolf Hilgenfeld			
Literature: • Jan Drenth: Prii	nciples of Protein X-ray Crystallography - :	Science+Business Media, LLC, New	York
Language: • offered only in	English		



Notes:

Is part of Module:

- LS4021-KP06 (former LS4020-IB) -> Prof. Hübner
- LS4020-KP06 (former LS4020-MLS) and LS4020-KP12 -> Prof. Peters

4 exercises, 2 hours each, are offered in addition to the lecture. Dates are given at the start of the semester.

For Master MLS with specialization Structure Biology the module is mandatory.





LS4020 B -	Module part LS4020B	: NMR Spectroscopy ((StrAnaNMR)
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		3
 Course of study, specific field and term: Master Infection Biology ab 2018 (module part), Interdisciplinary modules, 1st semester Master Biophysics (module part), biophysics, 1st semester Master CLS starting 2016 (module part), MML with specialization in Life Science, 3rd semester Master MLS starting 2016 (module part), structure biology, 1st semester Master Infection Biology (module part), Interdisciplinary modules, 1st semester Master CLS (module part), computational life science / life sciences, 3rd semester Master MLS (module part), structure biology, 1st semester 			
Classes and lectures:		Workload:	
NMR-Spectroscopy (lecture, 2 SWS)	60 Hours private30 Hours in-class	studies room work
Contents of teaching: Lecture topics: Assignment of NMR spectra Description of the NOESY experiment using the vector model Chemical Exchange and Transfer-NOEs Multidimensional NMR spectroscopy Assignment strategy for peptides Introduction into the product operator formalism (POF) Description of the ACSY and of the HSQC experiment using POF NMR experiments for the assignment of proteins NMR structural analysis of proteins Experiments to probe the motions of protein Qualification-goals/Competencies: Advanced techniques to assign and analyze NMR spectra Understanding of NMR experiments based on the product operator formalism Basic knowledge about NMR experiments to analyze structure and dynamics of proteins Grading through: see Notes Responsible for this module:			
Teacher: • Institute of Chemistry and Metabolomics • Prof. Dr. rer. nat. Thomas Peters DD Down of Kenter 6			
 James Keeler: Understanding NMR Spectroscopy - Wiley : Malcolm H. Levitt: Spin Dynamics - Basics of Nuclear Magnetic Resonance - Wiley-VCH D. Neuhaus & M. P. Williamson: The Nuclear Overhauser Effect in Structural and Conformational Analysis - Wiley-VCH Timothy Claridge: High-Resolution NMR Techniques in Organic Chemistry - Pergamon Press : Current scientific literature 			
Language: offered only in English			



Notes:

This lecture is a part of modules:

- LS4021-KP06 (former LS4020-IB) -> Prof. Hübner
- LS4020-KP06 (former LS4020-MLS) and LS4020-KP12 -> Prof. Peters

Exercises are integrated into the lectures.

It is a compulsory module part for the Master MLS with a focus on structural biology.





LS4	LS4020 C - Module part LS4020C: Single Molecule Methods (Einzelstru)				
Duration:	Turnus of offer:	Credit points:			
1 Semester	each winter semeste	r 3			
Course of study, specific field Master MLS starting 201 Master Infection Biology Master Biophysics (mod Master CLS starting 201 Master MLS starting 201 Master Infection Biology Master CLS (module par Master MLS (module par	l and term: 18 (module part), structure biology, y ab 2018 (module part), Interdiscip lule part), biophysics, 1st semester 6 (module part), MML with speciali 16 (module part), structure biology, y (module part), Interdisciplinary m rt), computational life science / life rt), structure biology, 1st semester	1st semester blinary modules, 1st semester zation in Life Science, 3rd semester 1st semester odules, 1st semester sciences, 3rd semester			
Classes and lectures:		Workload:			
Single Molecule Methods (lecture, 2 SWS) 60 Hours private stu 30 Hours in-classroo		 60 Hours private studies 30 Hours in-classroom work			
 Photo physics Microscopy techniques Protein labeling Fluorescence resonance Single molecule enzyme Single molecule proteir Physical basics of optica Protein folding with optical 	e energy transfer ology n folding al tweezers tical tweezers				
Qualification-goals/Compete Understanding of the p Understanding of the b Understanding of the li 	ncies: hysical basics of single molecule m enefits of single molecule methods mits of single molecule methods	ethods ;			
Grading through: • see Notes					
Responsible for this module: • Siehe Hauptmodul Teacher: • Institute of Physics • Prof. Dr. rer. nat. Christia	an Hübner				
Literature: • Lakowicz, Joseph R: Prir • Markus Sauer, Johan Ho Molecules - ISBN: 978-3	nciples of Fluorescence Spectroscop ofkens, Jörg Enderlein: Handbook o -527-31669-4	oy - ISBN 978-0-387-46312-4 f Fluorescence Spectroscopy and Imaging: From Ensemble to Single			
Language: • offered only in English					
Notes:					



Is module part of:

- LS4021-KP06 (former LS4020-IB) -> Prof. Hübner
- LS4020-KP06 (former LS4020-MLS) and LS4020-KP12 -> Prof. Peters

This module part is identical to LS4020 C-MIW without seminar. For Master MLS with specialization in structure biology the module is mandatory.


LS4020 D - Module pa	LS4020 D - Module part LS4020D: Microscopy: techniques and applications (StrAnaMikr)			
Duration:	Turnus of offer:		Credit points:	
1 Semester	each winter semester		3	
Course of study, specific field and terms Master Infection Biology ab 2018 (Master Biophysics (module part), b Master CLS starting 2016 (module Master MLS starting 2016 (module Master Infection Biology (module p Master CLS (module part), comput Master MLS (module part), structur Master MLS starting 2018 (module	module part), Interdisciplina iophysics, 1st semester part), MML with specializatio part), structure biology, 1st part), Interdisciplinary modu ational life science / life science re biology, 1st semester part), structure biology, 1st	ry modules, 1st semester on in Life Science, 3rd sen semester les, 1st semester nces, 3rd semester semester	nester	
Classes and lectures:		Workload:		
Microscopy: techniques and applic	ations (lecture, 2 SWS)	60 Hours priva30 Hours in-cla	te studies assroom work	
 2-photon microscopy 2-photon microscopy Light sources and detectors Fluorescent Dyes; GFP and genetic Labelling/identifying cell compone Protein-protein Interactions in livin Photo-activatable/-switchable Fluc Advanced 3D-Fluoresence Microsco In vivo imaging in tissues and livin Applications of Flow Cytometry & Electron Microscopy: TEM, Immune Microscopy (SEM) Bioluminescence; high-content scie Data storage/formats; Course discompany 	cally encoded fluorescence n ents using fluorescence tech ng cells: FRET, FLIM; Biosenso prescent Proteins; Fluorescer copy, STED, PALM, STORM g animals Fluorescence-activated Cell ogold label; Survey of cell ul reening; outlook: emerging t ussion; and then: Cinema o	narkers; Live Cell/tissue in niques ors nt Timers Sorting trastructure; Correlative E echnologies f the Cell	naging: considerations/limitations M/light microscopy; Scanning Electron	
 Qualification-goals/Competencies: Basics of light and fluorescence m Detailed knowledge of methods fo Applications of live cell imaging, in 	icroscopy and electron micro or labelling and visualization n vivo imaging and quantita	oscopy of proteins and subcellul tive fluorescence techniqu	ar compartments ues	
Grading through: • see Notes				
Responsible for this module: Siehe Hauptmodul Teacher: Institute for Biology Prof. Dr. rer nat. Rainer Duden 				
Literature: • -: http://micro.magnet.fsu.edu/prir • -: http://www.microscopyu.com/sr • -: http://www.olympusmicro.com/ Language: • offered only in English	ner/index.html nallworld/			



Notes:

Is module part of:

- LS4021-KP06 (former LS4020-IB) -> Prof. Hübner
- LS4020-KP06 (former LS4020-MLS) and LS4020-KP12 -> Prof. Peters

For Master MLS with specialization in Structure Biology the module is mandatory.

(Contribution to lecture, Biology 60%) (Contribution to lecture, Biomedical Optics 40%)



	LS4020-MLS - Structu	ure Analysis (StrAna)	
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		6
Course of study, specific field and term: • Master CLS (optional subject), comp • Master MLS (compulsory), structure	outational life science / life sc biology, 1st semester	iences, 3rd semester	
Classes and lectures: • Part of the module A: Crystallograp • Part of the module B: NMR-Spectro • Part of the module C: Single Molecu • Part of the module D: Microscopy: t (lecture, 2 SWS)	hy (lecture, 2 SWS) scopy (lecture, 2 SWS) ule Methods (lecture, 2 SWS) echniques and applications	Workload: • 120 Hours private studies WS) • 60 Hours in-classroom work re, 2 SWS) plications	
Contents of teaching:See module parts A to D			
Qualification-goals/Competencies: • See module parts A to D			
Grading through: • written exam			
Responsible for this module: • Prof. Dr. rer. nat. Thomas Peters Teacher: • Institute of Physics • Institute of Biology • Institute of Biochemistry • Institute of Chemistry and Metabole • Prof. Dr. rer. nat. Thomas Peters • Prof. Dr. rer. nat. Thomas Peters • Prof. Dr. rer. nat. Rolf Hilgenfeld • Dr. math. et dis. nat. Jeroen Mesters • PD Dr. rer. nat. Karsten Seeger • Prof. Dr. rer. nat. Christian Hübner • Prof. Dr. rer nat. Rainer Duden	omics		
Language: • English, except in case of only Germ	nan-speaking participants		
Notes: This modul has 4 parts: LS4020A-D. BSc in Molecular Life Science or relate One written examination with all part	ed fields. s, each valued 25%.		





ME2050 - Theoretical Physics 2 (TheoPhys2)			
Duration:	Turnus of offer:		Credit points:
1 Semester	irregularly		4
Course of study, specific fie • Master CLS (optional • Bachelor MES before	e ld and term: subject), computational life science / l 2014 (compulsory), physics, 4th semes	ife sciences, arbitrary semester ster	
Classes and lectures:		Workload:	
Theoretical Physics 2Theoretical Physics 2	(lecture, 2 SWS) (exercise, 1 SWS)	e, 2 SWS) • 55 Hours private studies ee, 1 SWS) • 45 Hours in-classroom work • 20 Hours exam preparation	
Contents of teaching:			
 Schrödinger equation Double slit experimen Expectation values ar Hilbert space and diff One-dimensional qua Harmonic oscillator Ladder operators, op Connection between Central forces and point 	nt and wave-particle duality nd uncertainty relation ferential operators; momentum operat antum systems erator algebras and commutator relati wave and matrix quantum mechanics otential; torque	ons	
Qualification-goals/Compe	tencies:		
 Understanding the base In-depth recall of Fou Acquisition of solutio Thorough acquaintar 	asic concepts, foundations and mathe urier methods by their application in w on methods for differential equations nee of handling operators, expectation	matical structure of quantum r ave mechanics values and commutator relatio	nechanics ons
Grading through:			
solving exercises andWritten or oral exam	presenting solutions as announced by the examiner		
Requires:			
 Analysis 2 (MA2500-N Analysis 2 (MA2500-K Analysis 2 (MA2500-K 	/ML) (P05, MA2500-MLS) (P04, MA2500)		
Responsible for this modul	e:		
• Prof. Dr. rer. nat. Chris	stian Hübner		
Teacher:			
Institute of Medical EInstitute of Physics	 Institute of Medical Engineering Institute of Physics 		
 Prof. Dr. rer. nat. Christian Hübner Prof. Dr. rer. nat. Thorsten Buzug 			
Literature:			
 Thorsten Fließbach: C Gerald Grawert: Quar H. Haken, H. C. Wolf: 	 Thorsten Fließbach: Quantenmechanik - Spektrum Akademischer Verlag Gerald Grawert: Quantenmechanik - Aula Verlag H. Haken, H. C. Wolf: The Physics of Atoms and Quanta - Springer 		
 Richard P. Feynman, J. J. Sakurai, Jim Napo 	 Richard P. Feynman, Leighton, Sands: The Feynman Lectures on Physics, Vol. 3 - Oldenbourg J. J. Sakurai, Jim Napolitano: Modern Quantum Mechanics - Pearson 		
Language:			
 English, except in cas 	e of only German-speaking participant	ts	





M	Z4120 A - Module part A: Bi	ology of Infections (BiomInfecb)
Duration:	Turnus of offer:	Credit poi	nts:
1 Semester	each summer semester	6	
Course of study, specific field and • Master Nutritional Medicine • Master CLS (module part), o • Master MLS (module part),	d term: e in planning (module part), life sci computational life science / life scie cell biology, 2nd semester	ences, 2nd semester nces, 3rd semester	
Classes and lectures: • Specific Topics of Infection • Specific Topics of Infection	Biology (lecture, 2 SWS) Biology (seminar, 2 SWS)	Workload:120 Hours private studies60 Hours in-classroom work	
Contents of teaching: Infectious diseases, viral, pr	okaryotic and eukaryotic infectious	agents, parasites, zoonotic diseases	
 Qualification-goals/Competencie Students will have detailed They have a detailed under understand mechanisms of They have knowledge of in They will improve their abil Grading through: presentation written oram 	knowledge of infectious agents, in standing of antimicrobial defence vaccination and immune deficience vivo and in vitro techniques of infe ity to present data and to scientific	fectious diseases and their pathomecha nechanisms at the cellular and molecula ies. ction biology. problems in English.	inisms ar level. They are able to
 Written exam Responsible for this module: Prof. Ph.D. Tamás Laskay Teacher: Research Center Borstel Department of Infectious D Prof. Ph.D. Tamás Laskay Dr. rer. nat. Bianca Schneid Dr. rer. nat. Christoph Hölsc PD Dr. rer. nat. Norbert Reil Prof. Dr. Ulrich Schaible Dr. rer. nat. Tobias Dallenga Dr. rer. nat. Gabi Schramm 	iseases and Microbiology er her ing emann		
Literature: • : - Books, Original publication Language: • offered only in English	ons and Reviews		



Notes:

Part of the module MZ4120 BSc in Molecular Life Science or in related fields One choise of two



MZ5110 - Medical Cell Biology 1 (MZB1)				
Duration:	Turnus of offer:		Credit points:	
1 Semester	each winter semester		6	
Course of study, specific field and term: • Master MLS (compulsory), cell biolog • Master CLS (optional subject), comp	gy, 1st semester utational life science / life s	ciences, 3rd semester		
Classes and lectures: • See MZ5110 A: Immunology (course • See MZ5110 B: Neuroscience 1 (course) • See MZ5110 C: Frontiers in Frontiers Research (course, 4 SWS)	e, 4 SWS) rse, 4 SWS) : in Metabolic Medicine	Vorkload: • 120 Hours in-classroom work • 60 Hours private studies bolic Medicine		
• Lecture MZ5110 A: Immunology, B:	Neuroscience 1 and C: Fron	tiers in Metallic Medicine F	esearch	
Qualification-goals/Competencies: • see MZ5110 Part A: Immunology, Pa	rt B: Neuroscience 1 and C:	Frontiers in Metallic Medie	ine Research	
 see MZ5110 Part A: Immunology, Part B: Neuroscience 1 and C: Frontiers in Metallic Medicine Research Grading through: presentation continuous, successful participation in course written exam Responsible for this module: Prof. Dr. rer. nat. Rudolf Manz Teacher: Medical Clinic I Institute of Experimental and Clinical Pharmacology and Toxicology Institute for Systemic Inflammation Research (ISEF) Prof. Dr. rer. nat. Rudolf Manz Prof. Dr. rer. nat. Coll Jöhren Prof. Dr. rer. nat. Coll Jöhren Prof. Dr. rer. nat. Colla Jöhren Prof. Dr. Jens Mittag Dr. rer. nat. Carla Schulz Dr. Stefanie Fliedner Prof. Dr. rer. nat. Henrik Oster 				
Language: • offered only in English				
Notes: MLS: one of three choices (Consists of MZ5110 A, MZ5110 B, MZ5	5110 C)			



MZ51	10 A - Medical Cell Biology	1: Part A: Immunolo	ogy (MZB1Almmu)
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		6
Course of study, specific field at • Master MLS (module part) • Master CLS (module part),	nd term: neuroscience, 1st semester computational life science / life sci	ences, 3rd semester	
Classes and lectures: Immunology (lecture 2 S)	VS)	• 120 Hours pr	rivate studies
 Immunology (seminar, 2 S 	WS)	 60 Hours in-c 	classroom work
Contents of teaching: Lecture: Introduction to in Cells of the innate immun Innate immune system; pa Complement and inflamm Introduction into the adag Antigen-presentation and Immunological memory Immune system and infek Signal transduktion in imm Organs and tissues of the Immunpathogenesis I: alle Immunpathogenesis II: au Immunprivileged Organs Hematopoiesis and hema Experimental and clinicall Seminar: PCR ELISA/ELISPOT Flow cytometry II: FACS-An Flow cytometry II: Practice Conventional and confoca Methods in signal transdu Migration: transwell assay 2-Photon microscopy Animal models in life scient Genetically modified mice	nmunology e system athogen recognition lation trive immune system T cell activation tion I: bacteria, worms, fungi tion II: Viruses nune cells immune system, homing rgy and asthma toimmune diseases copoietic stem cells y applied biologicals ealysis FACS-Sort al course at the ISEF (MACS, Analysi I microscopy ction e adhesion test etc. Ince I: conventional transgenics and KC	is, Sort) D mice	
Qualification-goals/Competenc	es:		
 Students are able to: Name cells of the immune Name organs that belong Name mechanisms, cells a and fungal infections Name and allocate function Name and allocate the fur Name molecules of the constructure and funct Name and allocate function Name the functions of immune Name molecules and meconstruction Describe the principal sequence 	system and allocate their function to the immune system and allocate nd molecules of the innate and ada ons of molecules important for B cel actions of molecules and antigen-pi mplement system and allocate the on of the distinct antibody classes ons of molecules important for hom ons of molecules important for the i nunological memory hanisms involved in the development unce of an immune reaction durin	s e their functions aptive immune system ar II -T cell co-cooperation resenting cells important ir functions for immune p ning and migration of imr initiation and resolution o ent of B cell and T cell me ng infection and after vac	nd allocate their functions during bacterial, viral t for T cell activation and differentiation protection and immune diseases mune cells of inflammation emory ccination



Name genetic, molecular and cellular disturbances of the immune system relevant for immune deficiency, autoimmune and allergic diseases
 Describe the basic mechanisms of signal transduction in immune cells
 Name mechanisms and molecules involved in hematopoiesis
Name and explain immunological methods
Present and discuss scientific data
Grading through:
presentation
 continuous, successful participation in course
• written exam
Responsible for this module:
Prof. Dr. rer. nat. Rudolf Manz
Teacher:
Institute for Systemic Inflammation Research (ISEF)
Prof. Dr. rer. nat. Rudolf Manz
Prof. Dr. med. Jörg Köhl
Prof. Dr. rer. nat. Marc Ehlers
Literature:
Janeway, Travers, Walport, Shlomchik: Immunologie - Spektrum Akademischer Verlag
• : Original- und Obersichtsartikei
Language:
offered only in English
Notes:
(Part of the module MZ5110)
(Part of the module MZ5110)



MZ5110 B - Medical Cell Biology 1: Part B: Neuroscience 1 (MZB1BNeur1)			
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		6
Course of study, specific field • Master MLS (module par • Master CLS (module part • Master Biophysics (module)	and term: t), neuroscience, 1st semester :), computational life science / life scie Jle part), advanced curriculum, 1st ser	ences, 3rd semester mester	
Classes and lectures:		Workload:	
Neuroscience 1 (lecture,Neuroscience 1 (seminar	2 SWS) r, 2 SWS)	 120 Hours private studies 60 Hours in-classroom work 	
Contents of teaching:			
 Micro- and macroscopic Electrical activity of neur Channels and transporte Synaptic transmission Neurotransmitters and t Intracellular signaling in Plasticity and memory Circadian rhythms and s The visual system Development of the ner 	anatomy of the CNS rons ers in neurons heir receptors neurons leep vous system		
Understanding basics of Understanding the struct Understanding neuronal Introduction to example Grading through:	neuroscience ture and development of the brain excitation and signal transmission s of behavior and plasticity		
 presentation continuous, successful p written exam 	articipation in course		
Responsible for this module:			
Prof. Dr. rer. nat. Rudolf <i>I</i>	Vanz		
Teacher: • Medical Clinic I • Department of Neurosur • Institut of Physiology • Institute of Experimental • Prof. Dr. rer. nat. Olaf Jöh	gery l and Clinical Pharmacology and Toxi hren	cology	
 Prof. Dr. med. Cor de Wit Prof. Dr. rer. nat. Henrik (Prof. Dr. med. Markus Sc PD Dr. rer. nat. Christina 	t Dster hwaninger Zechel		
Literature:			
 Nicholls: From Neuron to Seiten, Palgrave Macmill Purves: Neuroscience - 19 Brady: Basic Neurochem Press; 8th Edition (2011) : Original publications ar 	o Brain: A Cellular and Molecular Appr an; 5th edition (2012 SBN-10: 0878936955, 858 Seiten, Palg istry: Principles of Molecular, Cellular, nd Reviews	roach to the Function of rave Macmillan; 5th editi and Medical Neurobiolo	the Nervous System - ISBN-10: 0878936092, 679 on. (2011) gy - ISBN-10: 0123749476, 1096 Seiten, Academic

• : Original publications and Reviews _____



Language:

• offered only in German

Notes:

Part of the module MZ5110 MLS: one of two choises



MZ5110 C - Medica	MZ5110 C - Medical Cell Biology 1: Part C: Frontiers in Metabolic Medicine Research (MZCFronMet)				
Duration:	Turnus of offer:	Credit points:	Max. group size:		
1 Semester	each winter semester	6	10		
Course of study, specific field a • Master CLS (module part • Master MLS (module par	Course of study, specific field and term: Master CLS (module part), computational life science / life sciences, 3rd semester Master MLS (module part), cell biology, 1st semester 				
Classes and lectures: • Frontiers in Metabolic M • Frontiers in Metabolic M	edicine Research (lecture, 2 SWS) edicine Research (seminar, 2 SWS)	Workload: • 120 Hours private studies • 60 Hours in-classroom work			
Contents of teaching: • Central regulation of adi • Thyroid hormones • Central adipokine action • Tumor metabolism • Chronometabolism • Nutrient barriers	pose tissues				
 Qualification-goals/Competencies: Know about some current themes in metabolic physiology and medicine Know about some experimental paradigms to address metabolism-related problems Understand the molecular basis of metabolic disorders and know how to develop strategies for experimentally addressing scientific problems 					
Grading through: • presentation • continuous, successful pa • written exam	articipation in course				
Requires: • Module part LS3250 B: M	letabolic Medicine (LS3250 B)				
Responsible for this module: • Prof. Dr. rer. nat. Henrik Oster Teacher: • Institute for Systemic Inflammation Research (ISEF) • Prof. Dr. med. Sebastian Schmid • Prof. Dr. Jens Mittag • Dr. rer. nat. Carla Schulz • Dr. Stefanie Fliedner • Prof. Dr. rer. nat. Henrik Oster • Prof. Dr. med. Christian Sina					
 Literature: Keith N. Frayn: Metabolic Regulation: A Human Perspective - Wiley-Blackwell (2010), ISBN : 978-1-4051-8359-8 : Original- und Übersichtsartikel 					
Language: • German and English skill	s required				
N 1 4					

Notes:



Part of the module MZ5110 If their is space in the course students can participate even if they did not pass modul LS3250-B. MLS: compulsory, 1. Term, either MZ5110 A, MZ5110 B or MZ5110 C needs to be selected.



	CS4250-KP04, CS4250 - Co	omputer Vision (C	compVision)
Duration:	Turnus of offer:		Credit points:
1 Semester	each summer semester		4
Course of study, specific field and Master Biomedical Engineer Master CLS starting 2016 (op Master MES since 2014 (opti Master Media Informatics (o Master Computer Science be Master CLS (compulsory), co Master CLS (compulsory), co Master Computer Science be Master Biophysics (optional	I term: ing (optional subject), advanced co ptional subject), computer science, onal subject), computer science ar ptional subject), computer science efore 2014 (optional subject), adva omputational life science / imaging vanced curriculum), imaging syste efore 2014 (optional subject), adva efore 2014 (compulsory), specializa efore 2014 (compulsory), specializa efore 2014 (optional subject), adva subject), Elective, 2nd semester	urriculum, 2nd semest , 2nd or 3rd semester nd electrical engineeri e, arbitrary semester Inced curriculum imag J, 2nd semester ems, signal and image Inced curriculum signa ation field robotics and ation field bioinformat Inced curriculum intel	ter ng, 1st or 2nd semester ging systems, 2nd or 3rd semester processing, 2nd semester al and image processing, 2nd or 3rd semester d automation, 2nd semester tics, 2nd semester ligent embedded systems, 2nd semester
Classes and lectures:		Workload:	
 Computer Vision (lecture, 2 Computer Vision (exercise, 1 	SWS) I SWS)	55 Hours p45 Hours ir20 Hours e	rivate studies n-classroom work xam preparation
 Sensors, cameras, optics and Image features: edges, intrir Range imaging and 3-D cam Motion and optical flow Object recognition Example applications 	d projections nsic dimension, Hough transform, l neras	Fourier descriptors, sn	akes
Qualification-goals/Competencies • Students can understand th • They can explain and perfor • They can explain and apply • They can indicate appropria	s: e basics of computer vision. m camera choice and calibration. the basic methods for feature extr te methods for different kinds of c	action, motion estima computer-vision applic	tion, and object recognition. cations.
• Exercises • Oral examination			
Responsible for this module: • Prof. DrIng. Erhardt Barth Teacher: • Institute for Neuro- and Bioi • Prof. DrIng. Erhardt Barth	nformatics		
Literature: • Richard Szeliski: Computer V • David Forsyth and Jean Pon	/ision: Algorithms and Application ce: Computer Vision: A Modern Ap	s - Springer, Boston, 2 pproach - Prentice Hall	011 l, 2003
Language: • English, except in case of on	ly German-speaking participants		
Notes:			



Prerequisites for admission to the examination can be determined at the beginning of the semester. If such prerequisites are defined, they must have been fulfilled prior to the first attempt at the examination and must have been rated as positive.

Prerequisites for admission to the examination: Successful participation in the exercises, minimum pass percentage: 70 %





ME4000 - Imaging Systems 1 (BildgbSys1)			
Duration:	Turnus of offer:		Credit points:
1 Semester	each winter semester		4
Course of study, specific fi Master Computer Sci Master Computer Sci Master Computer Sci Master Computer Sci Master CLS (compuls	eld and term: ence before 2014 (compulsory), speciali ence before 2014 (optional subject), adv ence before 2014 (optional subject), spe ence before 2014 (optional subject), adv ory), computational life science / imagin	zation field robotics and vanced curriculum signal ecialization field medical vanced curriculum imagi ng, 1st semester	automation, 1st semester l and image processing, 2nd or 3rd semester informatics, 3rd semester ng systems, 2nd or 3rd semester
Classes and lectures:		Workload:	
 Imaging systems 1 (I Imaging systems 1 (e 	ecture, 2 SWS) exercise, 1 SWS)	 55 Hours pri 45 Hours in- 20 Hours ex 	ivate studies -classroom work am preparation
Contents of teaching:			
 Signal processing (re Mathematical method X-Ray (fundamental Computed Tomogrative and statistical 	capitulation of fundamental principles in ods in image reconstruction and signal p principles, quantum statistics) phy * devices, * current and past techno stical image reconstruction, * image artif	n signal processing) rocessing logy, * signal processing facts, * technical and clin	I, * Fourier-based 2D and 3D image reconstruction, ical applications, * dose.
Qualification-goals/Compe	etencies:		
 Students are able to create an overview of the signal chain for medical imaging. They are able to explain the mathematical background for the reconstruction of CT images. They are able to explain the basics for the creation of X-ray. They are able to list all generations of CT devices and explain differences and advances. They are able to apply the Fourier transform. They are able to explain the mathematical basics for the two-dimensional image reconstruction. They are able to create and apply an algebraic approach for the reconstruction of CT images. They are able to create and apply an statistical approach for the reconstruction of CT images. They are able to outline the differences between two dimensional and three dimensional image reconstruction. They are able to transfer methods from two dimensional to three dimensional image reconstruction. 			mages. es. onstruction. images. images. ional image reconstruction. e reconstruction.
Grading through:			
Oral examination			
Responsible for this modu Prof. Dr. rer. nat. Tho Teacher: Institute of Medical E Prof. Dr. rer. nat. Tho 	le: rsten Buzug ingineering rsten Buzug		
l :*			
 Literature: T. M. Buzug: Computed Tomography, From Photon Statistics to Modern Cone Beam CT - Springer-Verlag, Berlin/Heidelberg, 2008 T. M. Buzug: Einführung in die Computertomographie, Mathematisch-physikalische Grundlagen der Bildrekonstruktion - Springer-Verlag, Berlin/Heidelberg, 2004 			
Language: • offered only in Englis	h		



ME4020 - Imaging Systems 2 (BildgbSys2)				
Duration: Turnus of offer: Credit points: Max. group size:				
1 Semester	each winter semester	4	99	
 Course of study, specific field and term: Master Computer Science before 2014 (optional subject), advanced curriculum imaging systems, 2nd or 3rd semester Master CLS (compulsory), computational life science / imaging, 2nd semester 				
Classes and lectures: Imaging Systems 2 (lecture) Imaging Systems 2 (exercised)	ıre, 2 SWS) cise, 1 SWS)	Workload:5)• 55 Hours private studies/S)• 45 Hours in-classroom work• 20 Hours exam preparation		
 Contents of teaching: Physical fundamentals of magnetic resonance imaging: nuclear magnetic resonance, relaxation mechanisms, principles of position encodingprinciples of spatial encoding, relaxation) Construction of basic imaging sequences, weighting Concept of k-space Coherence pathways Hardware components of a clinical MR system Possible sources of hazard for patients Influence of measurement parameters on signal-to-noise ratio Causes of image artefacts 				
 Qualification-goals/Competencies: The students can explain the physical principles of NMR and MRI. They can explain the idea behind important imaging sequences, using a pulse sequence diagram. They can recognise the causes of important image artefacts. They can list advantages and disadvantages of MRT, compared to other imaging techniques. They can list possible sources of hazard for patients, explain their causes and point out strategies for avoiding these. 				
Grading through: • Oral examination				
Responsible for this module: • Prof. Dr. rer. nat. Martin Koch Teacher: • Institute of Medical Engineering • Prof. Dr. rer. nat. Martin Koch				
Literature: • Liang, ZP., Lauterbur, P. C.: Principles of Magnetic Resonance Imaging: A Signal Processing Perspective - IEEE Press, New York 2000				
Language: • German and English skills required				
Notes: In summer semester 2015 t	his course is replaced by ME44	13 Nuklear Imaging for MML studen	ts.	



ME4413 - Nuclear Imaging (NuklBG)					
Duration:	Turnus of offer:		Credit points:		
1 Semester	each summer semester		4		
 Course of study, specific field and term: Master CLS (compulsory), computational life science / imaging, 2nd semester 					
Classes and lectures: • Nuclear Imaging (lecture, 2 SWS) • Nuclear Imaging (exercise, 1 SWS)		 Workload: 45 Hours in-classroom work 40 Hours private studies 20 Hours in-classroom exercises 15 Hours exam preparation 			
 Contents of teaching: Physical, biological and medical basics of nuclear imaging Scintigraphy Positron emission tomography (PET) Single photon emission computed tomography (SPECT) Clinical and preclinical applications 					
 Qualification-goals/Competencies: Students are able to explain the physical principles and phenomena of nuclear imaging. They can describe relevant phenomena and procedures mathematically. They can understand the basics of nuclear medicine. They can explain the applications of nuclear imaging techniques. They can name and explain the advantages and disadvantages and limitations of nuclear imaging methods. 					
Grading through: • Written or oral exam as announced by the examiner					
Responsible for this module: Prof. Dr. rer. nat. Magdalena Rafecas Teacher: Institute of Medical Engineering Prof. Dr. rer. nat. Magdalena Rafecas 					
 Literature: S. R. Cherry, J. A. Sorenson, M. E. Phelps: Physics in Nuclear Medicine - Elsevier, 2012 M. N. Wernick, J. N. Aarsvold: Emission Tomography: The Fundamentals of PET and SPECT - Elsevier, 2004 D. L. Bailey, D. W. Townsend, P. E. Valk, M N. Maisey (Editors): Positron Emission Tomography: Basic Sciences - Springer, 2005 					
Language: • offered only in English					





MZ4	010-KP04, MZ4010 - Cl	inical Epidemiology ((KlinEpi)		
Duration:	Turnus of offer:		Credit points:		
1 Semester	each winter semester		4		
Course of study, specific field and term • Bachelor Medical Informatics sinc • Master CLS starting 2016 (compu • Bachelor Medical Informatics sinc • Bachelor Medical Informatics befor • Master CLS (compulsory), comput • Master Computer Science before	: e 2019 in planning (optional sory), MML with specializatio e 2014 (compulsory), medical ore 2014 (compulsory), medical ational life science / biostatis 2014 (compulsory), specializa	subject), medical computer n in Genetic Statistics, 3rd s computer science, 5th sen al computer science, 3rd se tics, 1st semester tion field medical informat	r science, 4th to 6th semester semester nester emester ics, 3rd semester		
Classes and lectures:		Workload:			
 Clinical Epidemiology (lecture, 2 SWS) Clinical Epidemiology (exercise, 1 SWS) 		 55 Hours private studies and exercises 45 Hours in-classroom work 20 Hours exam preparation 			
 Introduction to epidemiology Diagnosis Frequencies Registers and data sources Geographical epidemiology Study designs (RCT, cohort study, case control study, cross sectional study) Effect measures Causality Chance, bias and confounding Control of errors Outbreak investigation 					
 Qualification-goals/Competencies: Students are able to explain technical terms such as disease register, incidence, prevalence, mortality, lethality, standardization. They are able to explain and interpret epidemiological measures. They are able to assess which study design is appropriate for a certain research question. They are able to identify possible sources of error, bias and confounding and how they affect the study results. They are able to assess causal inferences in the context of different study types. They are able to critically appraise data, results, and epidemiological research methods as well as scientific literature in the context of medicine and epidemiology. Grading through: Exercises 					
written exame-tests					
Responsible for this module: • Prof. Dr. med. Alexander Katalinic Teacher: • Institute for Social Medicine and R • Prof. Dr. med. Alexander Katalinic • MitarbeiterInnen des Instituts	pidemiology				
Literature: • L. Gordis: Epidemiology - Oxford: • R. H. Fletcher: Clinical Epidemiolo • :	Elsevier; 5th edition 2013 gy. The Essentials Lippincot	t Williams & Wilki; 5th rev.	edition 2012		



Language:

• offered only in German



MZ4374-KP03, MZ4374 - Molecular Human Genetics (MolHumGen)					
Duration:	Turnus of offer:	Credit	t points:		
1 Semester	each winter semester	3 (Тур	3 (Тур В)		
Course of study, specific fie • Master CLS starting 2 • Master Medical Inforr • Master CLS (compuls • Master Medical Inforr	eld and term: 1016 (compulsory), MML with specializ matics (optional subject), bioinformati ory), computational life science / biost matics since 2019 in planing (optional	ation in Genetic Statistics, 1st semester s, 1st or 2nd semester atistics, 1st semester subject), bioinformatics, 1st or 2nd sen	nester		
Classes and lectures:		Workload:			
Molecular Human Genetics (practical course, 2 SWS)		60 Hours private studies30 Hours in-classroom work			
Contents of teaching:					
 Safety instructions Isolation of nucleic ac Preparation and sepa Amplification of nucleic Restriction of nucleic Theoretical considera Data base search 	cids aration of nucleic acids eic acids (PCR) : acids ation of pedigrees				
Qualification-goals/Compe • Students can perforn	e tencies: n fundamental molecular genetic expe	riments, they get basic knowledge in l	aboratory work		
Grading through: • continuous, successfu	ul participation in practical course, >80	%			
Requires: • Human Genetics (MZ	4373-KP03, MZ4373)				
Responsible for this modul • Prof. Dr. rer. nat. Chrit Teacher: • Institute of Human G • Prof. Dr. rer. nat. Chrit	le: stine Zühlke enetics stine Zühlke				
Dr. Andreas Dalski Literature:					
Lecture notes: -					
Language: • offered only in Germa	an				



MZ4120 B	- Module part MZ4120) B: Neuroscience 2 (B	iomNeuro2)	
Duration:	Turnus of offer:		Credit points:	
1 Semester	each summer semester		6	
 Course of study, specific field and term: Master Nutritional Medicine in plan Master CLS (module part), neurosci Master MLS (module part), cell biol Master Biophysics (module part), ad 	nning (module part), life scie ence, 3rd semester ogy, 2nd semester dvanced curriculum, 2nd sen	nces, 2nd semester nester		
Classes and lectures:		Workload:		
 Neuroscience 2 (lecture, 2 SWS) Neuroscience 2 (seminar, 2 SWS) 		120 Hours private60 Hours in-class	e studies room work	
Contents of teaching: Stem and progenitor cells Alzheimer's disease Pathophysiology of cerebrovascula Neuroimmunology of Multiple Scle Epilepsy Pahtogens of the brain Parkinson's disease and other move Neurogenetic diseases Schizophrenia Neuropathies Neurometabolic diseases Qualification-goals/Competencies: Introduction to neuronal stem cells Introduction to various neuropathoe Understanding molecular mechani 	r disorders prosis ement disorders s plogical diseases sms of neuropathological dis	seases		
Grading through: • presentation • continuous, successful participation • written exam	n in course, >80%			
Responsible for this module: • Prof. Ph.D. Tamás Laskay Teacher: • Department of Neurosurgery • Department of Neurology • Institute of Experimental and Clinic • Prof. Dr. med. Markus Schwaninger • PD Dr. rer. nat. Christina Zechel • Prof. Dr. rer. nat. Katja Lohmann • PD Dr. Sc. Ana Westenberger	al Pharmacology and Toxico	blogy		
Literature: • Purves: Neuroscience - ISBN-10: 08 • : Original publications and Reviews	78936955, Palgrave Macmilla	an; 5th edition. (2011)		
Language: • English, except in case of only Gerr	nan-speaking participants			
Notes:				



Part of the module MZ4120 BSc in Molecular Life Science or in related fields Choose one Modulpart of two